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RESEARCH ARTICLES

Lassa Fever Information, Consumers' Preference and Behaviour: The Case of Cassava Products in Lagos State

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ABSTRACT

The nature of information risk perception influences consumers' food choices and behaviour. Lassa fever and the risk of contracting it have long been in the news and other information sources. This study examines how information about Lassa fever affects consumers' perception of food safety, their preferences and behaviour towards gaari and other cassava products. Information was elicited using a well-structured questionnaire, from Three Hundred and Twenty respondents selected using a multi-stage sampling method for the study. Descriptive statistics such as mean and standard, plus linear and logistic regressions were deployed for the analyses. Results showed that the mean age of respondents was 40.843 and the standard deviation was 13.675. The highest level of their education was 19 years. Respondents were aware of Lassa fever information and the risk of contracting it. Based on this, respondents ranked gaari and cassava products from ogun states (Mean=5.495; SD=1.526) higher than the other four states (Mean between 3.1 and 3.5) on safety. Results further showed that respondents prefered gaari and cassava products packaged ceiled and state-of-original labelled (SOR7). The result of the regression analyses showed that the factors that affect consumers' attitudes toward state-of-origin information and safety labelling, showed that Level of education, Age, Household size, and gender (female) were the significant factors. Regression results also showed that older people tend to care more about SOR7 while consumers with higher consumption care more about Packaging and labelling for food safety. Good processing and storage of cassava products along the value chain and good food safety information management by marketers and government agencies would help to reduce the risk of contracting Lassa fever through gaari and other cassava products in Lagos state.

Keywords: Cassava, Lassa fever, Information, *gaari*, Lagos State

INTRODUCTION

Lassa fever (LF) is an intense viral hemorrhagic fever known to be endemic in a few West African nations, including Nigeria. As of June 9, 2017, a sum of 501 speculated cases, including 104 fatalities, had been advised since the beginning of the momentum Lassa fever episode season, in December 2016. In 2022 alone,

from 3 to 30 January 2022, 211 laboratory-confirmed Lassa fever cases including 40 deaths (case fatality ratio: 19%) have been cumulatively reported in 14 of the 36 Nigerian states. Worthy of note is the known fact of its incidences occurring in majorly agrarian societies, majorly cassava producing belts of Nigeria (Inclusive of Edo, Ondo, Delta, Kogi, Enugu etc. whose major cassava products market is in Lagos) and the Federal Capital Territory across the country (WHO, 2022). The annual peak of Lassa fever cases is typically observed during the dry season (December–April), which coincides with the period of harvesting and processing of cassava products and other farm produce. It has been reported that contamination of whole cassava dry roots is caused primarily by exogenous factors such as bacteria, fungi, insects and rodents. It is known that While fungi growth in dry cassava products happens during processing when slow drying or storage under humid conditions is carried out, resulting in mycotoxins formation, processing of *gaari* (cassava granules), a popular cassava product in Nigeria, (and staple food) involves roasting under intense heat generated by the stove, gas or traditional firewood which hardly condone survival/existent of any pathogens. The food safety issue in *gaari* contamination among the three earlier mentioned is a rodent, which normally happens during storage whether at the consumer's or marketers' custody. The urine of mastomys rat, a rampant rodent in a farming community and food stores in Nigeria has been implicated as a causal factor in the food-related transmission of LF. *Gaari* (cassava granules), a delicacy of many Yorubas of Ijebu dialect, is often soaked in cold water and relished with other proteinous accompaniments without going through heat transformation. Some people take it as *peselu.* Others just mixed it with palm oil or stew. The possibility of this kind of meal, which is very common among the local people in the rural, and peasant in the peri-urban areas constituting a precursor to LF is undeniable. LF is highly contagious and a deadly viral disease. This issue is particularly important in cassava products, as Lagos, as a market/hub is where cassava products from neighbouring states such as Ogun, Edo, Oyo, Osun and Ondo states are sold. Large supplies of cassava products are brought into Lagos state regularly, from these states. Food safety remains of public health concern, ensuring that consumed food substance is in risk-free condition (Ehirim, 2010). Food safety is the guarantee that ingested food does not create any harm to human health and well-being. Various laws and regulations have been enacted over the years to safeguard the safety and hygiene of the nation's food supply (Omojokun, 2013). However, Nigeria's food supply chain is increasingly becoming complex and information about food-related disease gain spread within a short period due to well-established communication networks, posing a significant threat to the economy (Rondon and Nzeka, 2011). The occurrence of the food-borne disease remains an important health issue in

both developed and developing *states*, and LF is particularly because of its endemic nature in Nigeria.

One of the policy challenges is to reduce or block the transmission of LF and make the consumption of cassava products free from fear amid the reported LF pandemic among the general public. Various types of information received by consumers may substantially change consumers' perceptions regarding LF and influence their choices of cassava products, especially *gaari* (cassava granules) consumption accordingly. But, as in the analysis of markets for almost any good or service, understanding the structure of the supply side does not provide enough information to forecast the impacts of changed market conditions. The potential threat to human life makes LF more than a productivity concern.

Conceivably, consumers could largely ignore LF outbreaks. If consumers felt that LF posed little to no risk to their health, they may not substantially alter their cassava product expenditures in response to news about outbreaks. In that case, productivity losses and/or additional disease prevention and control expenses may result in increased market prices for cassava products. On the other hand, if outbreak reports led consumers to significantly change their perceptions of health risks from consuming cassava products, large numbers of consumers could reduce processed cassava consumption or even stop eating cassava products on news of an outbreak. In that case, aggregate demand may fall along with the reduced supply, prices may fall, and direct production losses might account for only a small part of the reduction in cassava product sales.

Thus, information treatment affects consumers' food consumption choices. Peng et al. (2015) pointed out that consumers could easily notice food safety scandals disclosed by the media, which in turn affected their judgment of expected utility and purchase behaviour. This effect may even be more obvious in the case of serious information asymmetry between the public and food manufacturers or regulators. Information treatment would also affect consumer behaviours. Hence, the nature and degree of information risk perception had a direct impact on consumers' choices of consumption preferences (Petrolia, 2016). The transmission and expression of information would also affect the consistency of consumers' choices (Eppink et al., 2019). Sogari et al. (2019) used three different treatments of no-message condition, vitamin information, and fibre information to be allocated to whole-grain macaroni in turn to investigate the effect of whole-grain pasta labels showing health information descriptors on consumers' choices in a campus dining environment. Results show that only information about the benefits of vitamins had a significant impact on the choice

of whole-grain pasta. The probability of choosing this type of pasta was 7.4% higher than without information and 6.0% higher than with fibre information.

When consumers have relevant information, they are more likely to make informed choices (e.g., Cranage et al., 2005; Vlaeminck et al., 2014; Verbeke & Liu and Swallow, 2021). There is a gap in the literature regarding how consumers' perception of LF affects their preference for the state of origin of cassava products, and how consumers' behaviour and perception might be inconsistent, especially in cassava products. This study examines the situation of perception behaviour conflict and discusses some of the characteristics of this inconsistency. It also discusses how information about cassava products and how cassava products consumers' consumption behaviour and perceptions of Lassa fever information affect their attitude toward state-of-origin information and safety behaviour towards *gaari* and other cassava products. Furthermore, this study differentiates consumers' safety awareness toward several specific states and the underlying factors. The general objective of this study was to determine how information about Lassa fever affects consumers' perception of food safety, their preferences and behaviour towards *gaari* and other cassava products.

MATERIALS AND METHODS

The study was conducted in Lagos State, southwestern Nigeria. It is delineated into five administrative divisions, namely, Ikorodu, Ikeja, Epe, Badagry, and Lagos Island, with Ikeja being the capital. The five divisions consist of a total of 20 Local Government Areas (LGAs) and 37 Local Council Development Areas (LCDAs). Two Local governments, namely, Ikorodu and Epe were purposively selected for the study due to their peculiar nature of harbouring both rural and urban sectors, and also known for the production and consumption of cassava products. A total of Three hundred and twenty respondents were randomly selected from the two LGAs in equal proportion one hundred and seventy each. A well-structured questionnaire containing items of multiple-choice questions that seek to elicit information on the socio-demographic characteristics of the respondents' variables such as age, sex, family size and education, the purchase patterns, such as purchase frequency, purchase amount per visit, and total purchase per week. Respondents were requested to indicate if they would prefer that cassava products were packaged and labelled to show their origin and nutrition characteristics. Respondents were also requested to rank the level of importance that they place on the state of origin of cassava products, nutrition characteristics (carbohydrate and protein contents) and food safety, when purchasing *gaari* (cassava granules) and cassava products from 1 to 7, with 1, being the least important and 7 being the most important. Based on another variable revealing whether they ask a question about the state of origin

of *gaari* and cassava products before purchase or not (not reported in the table), we observe some respondents assigned a high rank (4 or 7) on the level of attribute importance but they didn't ask when purchasing the products. We define "inconsistent" for such respondents, and vice versa, for respondents who gave a lower rank (lower than 4) on the question but asked for cassava products' origin when purchasing. The variable "Inconsistency" is 1 when the respondent is inconsistent and 0 otherwise. The questionnaire also ranked the variance of the respondents' safety rank on cassava products from Edo, Delta, Ogun, Ondo and Oyo, five major suppliers of *gaari* and cassava products in Lagos markets. Those who are indifferent about product safety regarding different states will have a smaller variance and those who think products from these states are very different with regards to safety will have a larger variance. Information about the source of food safety was elicited to indicate if the respondent most frequently obtains information on food safety and is aware of the Lassa fever menace, from government agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC), Federal Ministry of Agriculture, other federal government agencies or state governmental agencies, University Scientists/Researchers, Producer Groups, Retailers (e.g., Supermarkets, Grocery) and Consumer Groups. The survey solicited information regarding respondents' purchasing behaviour about cassava products, and preferences for different cassava product attributes (such as fermented *gaari* or *fufu, lafun*, etc). Respondents were asked in the survey to rank the level of importance for the cassava product they purchase to be produced using environmentally sustainable practices (Environ), without modern technologies (Natural) or organic (Organic). Regarding safety, consumers were also asked to indicate the level of safety that they associate with *gaari* and other cassava products produced in different states, measured again with a 1 to 7 rank; 1 being extremely unsafe and 7 being extremely safe. To reduce the number of dummy variables, this paper assumes that each ranking variable takes a value of 1 representing important if the actual rank is above 4 out of 7 (inclusive), otherwise the variable takes a value of 0 representing unimportant. Descriptive statistics of these variables are also presented in Table 1. For Analysis, three econometric models namely, the Logit model, ordered logit model, and Least squares regression model was employed following Wang, Zhang, Ortega and Widmar (2013).

Logit model

Logistic regressions are a useful way of describing the relationship between independent variables e.g., age, income, etc.) and a binary response variable, expressed as a probability, which takes two values, often 0 and 1. The logistic function, like probabilities, always takes on values between zero and one:

$$f(z) = \exp(z)[\exp(z) + 1] \quad (1)$$

The logistic function is commonly used to form the Logit model because it can take as input any value from negative infinity to positive infinity, whereas the output is confined to values between 0 and 1. The variable z represents the exposure to some set of independent variables, while f(z) represents the probability of a particular outcome, given that set of explanatory variables. The variable z is a measure of the total contribution of all the independent variables used in the model. The variable z is usually defined as:

$$z = \beta_0 + \sum_{m=1}^{k} \beta_m X_m \qquad (2)$$

where β_0 is the "intercept", and β_1, β_2,…., β_k are the "regression coefficients" of X_1, X_2…, X_k respectively. Each of the regression coefficients describes the contribution of that corresponding factor. A positive regression coefficient means that the explanatory variable increases the probability of the outcome, while a negative regression coefficient means that the variable decreases the probability of that outcome; a large regression coefficient means that the factor strongly influences the probability of that outcome, while a near-zero regression coefficient means that that factor has little influence on the probability of that outcome. This model was used to analyse objective 2.

Ordered logit model

When the dependent variable takes more than two values, logistic regressions are no longer valid, and the Ordered logit model is often appropriate. In this model, the dependent variable is measured on an ordinal scale, and the ordinal scale represents a measurement of an underlying interval/ratio scale. For example, ordered logit models can be used when the dependent variables take the ordered, yet discrete, categories High, Medium, and Low. In the ordered logit model, there is an observed ordinal variable,

Y. Y, in turn, is a function of another latent variable, Y*, that is not observed. In the ordered logit model, Y* is continuous whose values determine what the observed ordinal variable Y equals. The continuous latent variable Y* has various threshold points. The value of the observed variable Y depends on whether or not Y* has crossed a particular threshold. For example, when s is the number

of different values Y takes, the *i*th observation should follow,

$$Y_{i=1 \ if \ Y_i^* \ is < \tau_1} \qquad (3)$$

$$Y_i = K \ if \ \tau_{k-1} < Y_i^* \leq \tau_{k,} \ for \ K = 2, \ldots . S - 1 \qquad (4)$$

$$Y_i = S \ if \ Y_i^* > \tau_{s-1} \qquad (5)$$

The continuous latent variable Y^* is equal to

$$Y_i^* = \beta_0 + \sum_{k=1}^{m} \beta_k X_{ki} \varepsilon_i \quad (6)$$

The m βs and S-1 τs are the parameters to be estimated. The Probability that Y will take on a particular value is given as,

$$Prob(Y = 1/X) = \frac{1}{[1+\exp(\times\beta - \tau_1)]} \quad (7)$$

$$Prob(Y = K/X) = \frac{1}{[1+\exp(\times\beta - \tau_k)]} \text{ - } Prob(Y = 1/X) = \frac{1}{[1+\exp(\times\beta - \tau_{k-1})]} \text{ for } k=2,., s-1 \quad (8)$$

$$Prob(Y = s/X) = 1 - \frac{1}{[1+\exp(\times\beta - \tau_{s-1})]} \quad (9)$$

Ordered logit regression model was used to analyse objectives 3 and 4.

Ordinary least squares model

When the dependent variable is a continuous quantitative variable, ordinary least squares (OLS) is the most commonly used method for estimating the unknown parameters in a linear regression model. The OLS estimator is consistent when the regressors are exogenous and there is no multicollinearity and is the best linear unbiased estimator when the errors are homoscedastic for cross-sectional data. Each observation includes a scalar response Y and a vector of predictors X. In a linear regression model the response variable is a linear function of the regressors:

$$Y_i = \beta_0 + \sum_{k=1}^{m} \beta_k X_{ki} + \varepsilon_i \quad (10)$$

Where β is the scalar coefficients; ε is the unobserved scalar random variables (errors) which account for the discrepancy between the observed responses and the predicted outcomes. However, if we have a heteroskedasticity problem, then the OLS standard errors of the estimates are biased, and thus we cannot use the usual t statistics or F statistics for drawing inferences. This introduces the robust standard error.

A valid estimator of Var $(\widehat{\beta_j})$ with heteroskedasticity is:

$$\widehat{Var}\left(\widehat{\beta_j}\right) = \frac{\sum \widehat{r_{ij} u_i^2}}{\left[\sum \hat{r}_{ij}^2\right]^2} \quad (11)$$

where $\widehat{r_{ij}}$ is the *i*th residual from regressing x_j on all other independent variables. With this consistent estimate of the variance, the square roots are the robust

standard errors and can be then used for inference. This model was used to analyse objective 1.

RESULTS AND DISCUSSION

Summary of descriptive variables

Table 1 shows the summary of descriptive statistics from the survey used in the analysis. "SOR7" and "SafetyR7" indicate respondents' rank for the level of importance that they place on state-of-origin and food safety, respectively. The mean and standard deviation for "SOR7" and "SafetyR7" were 4.276 and 1.653, and 5.467 and 1.836 respectively. "SafeVar" is the variance of the respondents' safety rank on cassava products from Ogun, Oyo, Edo, Delta, and Ondo, the five major suppliers of *gaari* (cassava granules) and other cassava products in the Lagos market. The mean and standard deviation were 5.467 and 1.836. Pertinent to know that respondents ranked gaari and other cassava products from Ogun state higher (Mean=5.495) than all other states (Mean between 3.1 and 3.5) in Lassa fever-related food safety. "Educ" shows how many years the respondent has received formal education. The data is continuous and computed out of discreet choices made by respondents. The mean was 14.357 and the standard deviation was 2.404. The highest level of education was 19 years, which translates to post-graduate level, using a 6-3-3-4 scale. "GaariConsum" shows the amount of *gaari* the household of the respondent purchase in a typical month in the market (i.e., traditional grocery store or local market), while "CassConsum" shows how much cassava products (for example *lafun*, *fufu*, starch and other varieties of cassava products) the household of the respondent purchase in a typical month in the market. Their mean and standard deviation were 2.991 and 2.848, and 1.798 and 2.452 for *gaari* and cassava products respectively. 12kg was the highest *gaari* and cassava products purchased per month by the respondents. Several variables about the source of food safety and Lassa fever information were included. "GovS" is a binary variable that indicates if the respondent most frequently obtains information on food safety from government agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC), Federal Ministry of Agriculture, other federal government agencies or state governmental agencies. "UnivS", "ProducerS", "RetailS", and "ConsumerS" are binary variables indicating if the respondent most frequently relies on information from University Scientists/Researchers, Producer Groups (e.g., Cooperatives and farmers groups), Retailers (e.g., Supermarkets, Grocery Stores, or local markets etc.), or Consumer Groups (e.g., Consumers Protection Agency, NGOs, etc.) respectively, when obtaining information on food safety. In lieu of changing nutrition patterns and increasing concern about healthy foods today, variables

such as “EnvironR”, NaturalR" and" OrganicR” were included in the survey to elicit information from consumers if they would prefer *gaari* and other cassava products they were buying were produced using environmentally sustainable practices (EnvironR), without modern technologies (NaturalR), or organic (OrganicR). As Table 1 shows, their Mean and standard deviations were 0.763 and 0.425, 0.862 and 0.346, and 0.613 and 0.487 for EnvironR, NaturalR and OrganicR, respectively (Table 1).

Table 1. Descriptive statistics of variables

Variable Code	Brief Explanation	Units	Mean	SD	Min	Max
SOR7	Rank importance of State of Origin	-	4.276	1.653	1	7
SafetyR7	Rank importance of SAFETY label	-	5.467	1.836	1	7
Inconsistency	Inconsistency on SAFETY labels	-	0.399	0.388	0	1
SafeVar	Variance of safety rank for States	-	1.624	1.498	0	7.9
Age	Years of age	Years	40.843	13.675	20	64
Gender	Male 1, 0, otherwise	-	0.481	0.500	0	1
MIncome	Annual income	₦10,000	5.546	4.288	1	24
Educ	Years of education	Years	14.357	2.404	8	19
Household size	Number in a household	-	0.586	1.011	2	8
GaariConsum	Monthly *gaari* consumption	Kg	2.991	2.848	0	12
CassConsum	Monthly cassava Prdts consum	Kg	1.798	2.452	0	12
GovS	Obtain information from govt agencies	-	0.718	0.450	0	1
UnivS	Obtain information from univ researchers	-	0.098	0.297	0	1
ProducerS	Obtain information from producer gr	-	0.080	0.271	0	1
RetailS	Obtain information from retailers	-	0.433	0.496	0	1
ConsumerS	Obtain information from consumer groups	-	0.179	0.384	0	1
EnvironR	Importance of environment sustainability	-	0.763	0.425	0	1
NaturalR	Importance of naturalness	-	0.862	0.346	0	1
OrganicR	Importance of organic	-	0.613	0.487	0	1
STATEL	Importance of state of origin label	-	0.745	0.436	0	1
Package	Importance regarding packaging and label	-	0.722	0.448	0	1
Quality	Importance of quality certification labels	-	0.855	0.353	0	1
Lagos	Safety rank of cassava products from Lagos	-	3.278	1.652	1	7
Ogun	Safety rank of cassava products from Ogun state	-	5.495	1.526	1	7
Oyo	Safety rank of cassava products from Oyo State	-	3.188	1.383	1	7
Edo	Safety rank of cassava products from Edo State	-	3.394	1.502	1	7
Delta	Safety rank of cassava products from Delta state	-	3.315	1.564	1	7
Ondo	Safety rank of cassava products from Ondo State	-	3.549	1.452	7	

This shows consumers prefer cassava products coming from nature-friendly cultural practices over others. Variables such as “Age”, “Male”, and “Household

size" are self-explained demographic variables as shown by their corresponding means and standard deviations (Table 1). The mean annual household income was 5.546 and the standard deviation was 4.288; as calibrated in tens of thousands, the minimum household income was ten thousand while the highest was two hundred and forty thousand nairas. These variables were utilised in the ensuing regression analyses.

Differences in the perception of food safety for different states

To assess the influence of information on consumers' perception of how safe cassava products coming from different states or sources are for consumption (objective 1), the Ordinary least squares model was employed. As the survey revealed, Consumers have different sources for obtaining information on food safety and have different perceptions of the safety associated with *gaari* and cassava products produced in different states based on these sources, which include University scientists/researchers, producer groups, retailers, consumer groups, and government sources. The news or information given out is what forms the basis of opinions consumers have about the safety of food. Since information about Lassa fever incidents and the affected states has been in the air, the food-related incidence has been a concern to everybody. To achieve objective one, the variance of safety, "SafeVar" formed the dependent variable (Those who are indifferent about cassava product safety regarding different states will have a smaller variance and those who think cassava products from these states are very different from regards to safety will have a larger variance), and the independent variables are Age, gender, Educ, household size, GaariConsum, CassConsum, GovS, UnivS, ProducerS, RetailS, and ConsumerS. Table 2 shows that out of the twelve fitted variables, only four were significant and positive namely Age, Male, *Gaari* consumption and Retailers. Positively significant Age indicates older people tend to think there is a bigger difference among different states than their younger counterparts about food safety. This is not surprising as aged people, apart from having current information, are replete with historical facts about many communities and states due to their senescent knowledge.

The significant and positive nature of males showed that males more than their female counterparts think that there exists a big difference among different states in their food hygiene and safety. For *RetailS*, it is expected that consumers who obtain food safety information from retailers instead of other sources will show more diversified rating over the safety of the cassava products from different states because some consumers may choose to disbelieve such information because of the belief that retailers can churn out information to their favour to sell their products while others may believe such information.

Table 2. Safety variance regression model

Variables	Coefficients (β)	Standard Error
Constant	-1373.56	2303.500
MIncome	-0.022	0.022
Age	0.016	0.002 ***
Male	0.012	0.083*
Educ	0.13	0.083
Household size	0.005	0.011
GaariConsum	0.08	0.026 ***
CassConsum	0.047	0.029
GovS	0.184	0.116
UnivS	0.157	0.186
ProducerS	0.058	0.215
RetailS	0.186	0.103 *
ConsumerS.	0.001	0.144
R^2	0.74	
Adjusted R^2	0.72	

Note: robust standard error was used in states Safety Variance Model due to the Heteroskedasticity problem.
*, **, and *** indicate corresponding variable is significant at the 10%, 5% and 1% level, correspondingly.

This is evidenced by the positive significance of *RetailS*. This shows that retailers tend to provide consumers with information about the difference in the safety of *gaari* and other cassava products produced in different states. When consumers obtain knowledge about cassava product safety from sources like this, they tend to believe in this difference, and thus have a larger variance. Fig. 1 shows the clear difference (though trivial) in the distributions of the variance from these two groups of consumers before controlling for other factors. Monthly *gaari* consumption is another significant variable. For *gaari* consumption, the result shows that those who consume more *gaari* per month will have a larger variance regarding different states' cassava products safety. This can be explained by the distinct nature and attributes of *gaari* as they possess different qualities and different tastes (sweet or fermented, tasteless etc.). Consumers may easily find differences between *gaari* and other cassava products produced in different states if they consume more. Thus, the more they consume the more differences they will find in safety issues.

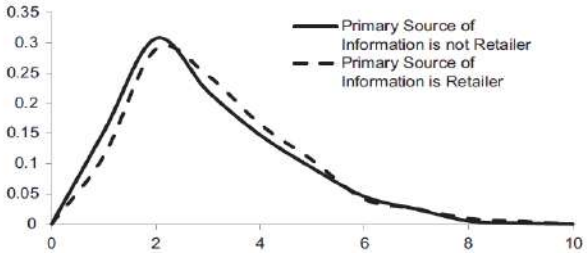

Figure 1. Distributions of the variance of the safety ranking of states by consumers whose primary source of information is from retailers or not

Fray between perception and behaviour model

Consumers may think that "state-of-origin" or source information is important, contradictorily, they may not check or ask a question marketers about "state-of-origin" information when buying *gaari* and cassava products. It is natural to expect those who believe the state-of-origin information is very important to confirm such information when purchasing, and vice versa; especially as it pertains to the ravaging information about Lassa fever. However, there are conflicts between the perception and the actual behaviour of some respondents. We calculate an inconsistency ratio, i.e., the number of inconsistent respondents over the total number of respondents. The survey result shows that out of 320 respondents, 138 have conflicts between perception and their actual behaviour regarding state-of-origin information, making the inconsistency rate 43.02%. This high inconsistency rate suggests that nearly half of the consumers don't check or ask a question about the origin of gaari and other cassava products although they think that state-of-origin (SOR7) is a relatively important attribute in this era. A logit regression of "Inconsistency" on "SafeVar" and demographic variables helps explain the occurrence of this perception behaviour conflict. The result of the analysis is shown in Table 3.

Age is found to be a significant factor in explaining the conflict between consumers' perceptions and behaviour. Older consumers tend to be more consistent regarding perception and actual behaviour. We also find that those who consume more *gaari* will be more consistent while there is a lack of indication that those who consume more of other cassava products will be of the same consistency. Perhaps this may not be far-fetched from the fact that no cassava product is eaten without going through transformation via cooking except *gaari*, because it can be soaked in cold water or chewed as it is; and probably because *gaari* from different states vary widely (for instance, *gaari* from Ogun state are generally desirable for its fermented/sweetness when

soaked in cold water; and has recorded no incidence of Lassa fever) and consumers pay more attention to SOR7 when purchasing *gaari* than they do when purchasing other cassava products.

Table 3. Perception behaviour fray model

Variables	Coefficients (β)	Standard Error	Probability
Constant	-1.373	2.303	1.113
SafeVar	0.159***	0.036	0.264
MIncome	-0.041	0.031	0.561
Age	0.016***	0.000	0.453
Male	0.17	0.083	0.234
Education	-0.13	0.083	1.342
Household size	-0.005	0.011	1.098
GaariConsum	-0.106***	0.027	5.925
CassConsum	0.026	0.017	15.294
Cox & Snell R^2:	0.231		

*, **, and *** indicate corresponding variable is significant at the 10%, 5% and 1% level, correspondingly.

Safety labelling preference

Table 1 show that respondents would like *gaari* and other cassava products packaged and labelled as shown by the mean of the variable- package (0.722). To examine factors that affect consumers' preference for packaging and labelling of *gaari* and other cassava products concerning food safety, the ordered logistic regression was deployed. SafetyR7 was the dependent variable while the independent variables are listed in Table 4.

As Table 4 shows, ten out of fifteen variables fitted were significant. They are: "Inconsistence'', ''SafeVar'', Age, "Educ", Household size, "GaariConsum", "CassConsum", "EnvironR", "NaturalR", "OrganicR" and "QualiR". This means that these factors relate to consumers' perceptions and preferences for the safe packaging and labelling of cassava products. For instance, the positive significance of inconsistencies and safety variance implies the higher the level of inconsistencies and safety variance, the higher the preference for packaging and labelling by consumers of *gaari* and other cassava products. The higher the level of importance consumers place on environmentally friendly cultural practices and the organic nature of cassava produced the more consumers of cassava products would prefer the packaging and labelling of these products. Age is also significant in explaining how consumers will rank the level of importance of packaging and labelling cassava products. The older the consumer

of *gaari* and other cassava products, the higher they would rank the packaging and labelling of *gaari* and cassava products. The higher the monthly quantity of

Table 4. Safety label preference model

Variables	Coefficients (β)	Standard Error	Probability
Constant	-1.583	3.403	1.443
Inconsistency	0.382**	0.045	8.488
SafeVar	0.292***	0.043	0.264
MIncome	-0.041	0.031	0.561
Age	.016***	0.000	0.453
Male	-0.679	0.138	0.234
Educ	0.046*	0.027	1.703
Household size	-0.036**	0.029	1.098
GaariConsum	0.074**	0.029	5.925
CassConsum	0.016*	0.034	1.094
EnvironR	0.392	0.108	3.627
NaturalR	0.413**	0.207	1.994
OrganicR	0.256*	0.144	1.777
PackR	0.798	0.153	5.216
QualiR	0.083***	0.151	0.548
Cox & Snell R^2: 0.431			

*, **, and *** indicate corresponding variable is significant at the 10%, 5% and 1% level, correspondingly

gaari and cassava products consumers purchased, the more they care about whether it should be well packaged and labelled when purchasing *gaari* and other cassava products. This is probably because when people consume more *gaari* and cassava products, their chance of encountering unsafe cassava products will be higher. Increasing news and information about the incidence of a disease that is endemic in a cassava-producing community should trigger a craving for food safety because people are currently very careful with health-related information.

State-of-origin specific safety preference

Table 1 shows that the safety rank of Ogun is 5 on average, while the ranks for all the other five *states* are between 3.1 and 3.5, very close to each other. This indicates that Lagos consumers are sceptical about the safety of cassava products imported from developing countries. Table 3 shows that consumers who believe that there is a large difference in the safety of cassava products produced in different countries will tend not to trust any of the five suppliers of

cassava products except Ogun. For Ogun, the larger the difference consumers think, the more they tend to trust in the safety of gaari and cassava products from the Ogun state. All cassava product suppliers in the Lagos market except Ogun have recorded incidences of Lassa fever. This indicates that Lagos consumers' trust levels in *gaari* and other cassava products from these Lassa fever-prone states are low. Older and female consumers are more sceptical than their counterparts, as indicated by the significant negative age and positive male coefficients. Consumers with higher income would not trust the safety of *gaari* and other cassava products from Edo and Ondo states: except Delta state, there is no clear sign that they would do the same for the other two states. While at the same time, consumers who have received more education in school will tend to believe in the safety of cassava products from Ogun, Oyo, and Delta, but not from Edo or Ondo. The more *gaari* and other cassava products people consume, the more confidence they will place in products from all five suppliers of these products. The only exception is that cassava products consumers' trust in Ogun state products is not much affected.

Table 5. Regression results of safety ranking for states supplying cassava products to the Lagos market

Variable	Ogun	Oyo	Edo	Delta	Ondo
SafeVar	0.91(0.05)***	-0.9(0.04)***	-0.652(0.04) ***	0.89(0.05)***	-1.04(0.05) ***
Age	0.015(0)	0.01(0)	0.003(0)	0.011(0)	-0.009(0)
Male	0.253(0.11)***	-0.377(0.11)***	0.403(0.11)***	-0.517(0.11)	-0.479(0.11) ***
MIncome	-0.015(0.01)	0.027(0.01)***	-0.003(0.01)*	0.033(0.01)**	-0.012(0.01)***
Educ	0.008(0.02)***	0.049(0.02)	-0.082(0.02)	0.061(0.02)***	-0.023(0.02)
Householdsize	0.066(0.06)	0.045(0.06)	0.031(0.06)	0.044(0.06)	0.071(0.06)***
GaariConsum	0.051(0.02)***	0.068(0.02)*	0.075(0.02) **	0.058(0.02) **	-0.081(0.02)
CassConsum	0.061(0.03)	0.064(0.03) *	0.028(0.03)*	0.087(0.03)**	0.071(0.03)
EnvironR	-0.216(0.17)	-0.078(0.17)	0.047(0.17)	0.083(0.17)	0.077(0.17)
NaturalR	-0.3(0.2)	-0.231(0.2)	0.201(0.2)	-0.33(0.2)	0.457(0.2)***
OrganicR	0.126(0.14)	0.18(0.14)	0.053(0.14)	0.082(0.14)	-0.122(0.14)
SOLR7	-0.52(0.15)*	-0.54(0.15) ***	-0.292(0.15)***	-0.228(0.15)	-0.239(0.15)**
PackR	0.34(0.15)	0.411(0.15) ***	0.058(0.14)***	0.259(0.15) *	0.307(0.15)**
QualiR	0.282(0.21)***	0.284(0.21)**	0.643(0.21)	0.402(0.21)*	0.354(0.21)

There are interesting results of the impact on safety ranking from alternative labels. Consumers' preference for state-of-origin information, ceteris paribus, will negatively affect their trust in the safety of most cassava products from the five states. This implies that those who care about SOR7 are usually very cautious and will typically not trust any state regarding safety issues as shown by the negative sign, even cassava products from Ogun and Lagos states.

Consumers who rank the packaging of *gaari* and other cassava products important usually believe the products from almost all five major suppliers are safer. This suggests that packaging is an important role in guiding consumers to believe in the safety of the product. If a supplier of gaari and cassava products can package and put quality labels on them, then will give consumers more confidence in the safety of the products from Ogun, Delta and Oyo. However, this may not be the case for Edo, or Ondo.

SUMMARY

In this study on preferences for different attributes of *gaari* and other cassava products, we have found that information from retailers tends to lead people to believe that there are safety differences among gaari and cassava product products supplied to the Lagos market from different states. The study also found that factors such as consumers' different perception of each state's cassava products' safety, their awareness of whether cassava product is produced using environmentally sustainable practices, whether it is all-natural, or organic, and whether they can be packaged with a quality label, all contribute to consumers' awareness of and emphasis on cassava products' state-of-origin information and safety labels. There were conflicts between the perception and the actual behaviour of some respondents. This study, following Wang *et al* (2013), introduced the concept of the perception behaviour conflict model and explored the characteristics of the inconsistent groups. The inconsistency rate, an indicator of this conflict, suggests that 43.02% of the consumers don't bother about SOR7 information when purchasing *gaari* and other cassava products although they think that SOR7 is a relatively important attribute or vice versa. Preference for state-of-origin labelling and safety labelling were examined. The two attributes are different in that the latter one directly reveals whether cassava product is safe but the former one does not, instead, it implies some safety and other social information. Females and less educated individuals tend to care more about the two attributes than their counterparts. Older people tend to care more about state-of-origin while consumers with more consumption will care more for safety. When studying the five *gaari* and other major cassava products in the Lagos market, the outcomes show that in most cases, older, female, and light cassava products consumers and those who think there exists a large difference among cassava product from different states tend to be more sceptical about *gaari* and cassava products from Edo, Ondo and Delta and Oyo states than the Ogun state. Because consumers who think the packaging is more important tend to trust the safety of these states suggests that more attention be given to the packaging and labelling *gaari* and cassava products. Implications of these results are: One, retailers play important role in *gaari* and cassava products safety, especially as it concerns Lassa fever because of their direct contact with

consumers and can be a very effective information disseminator to them to address consumers' concerns about fear of contamination and or safety of the product, especially those coming other states into Lagos market. Given the outcomes of this study, the government and other sectors, such as universities, should focus on the retail sector to monitor the storage of *gaari* and cassava products to curb mystomis rat contamination during storage and as well disseminate research-based accurate information about food safety to consumers and avoid misleading profit driven biased information. Two, the inconsistency between perception and behaviour contributed by younger consumers, especially the asymmetry toward under-checking behaviour, should be brought to the attention of the public and industry. For safety those who have concerns about gaari and cassava products' possible contamination by mystomis rat (Lassa fever-causing source) should always check for information about it by asking for state-of-origin and storage system used by retailers of these cassava products before purchase, otherwise, they would continue to contribute to this inconsistency. Packaging gaari with appropriate labelling though very new expectations from consumers may help them make better-informed decisions, and thus improve the safety of the *gaari* and other cassava products they choose to consume. Third, other than *Ogun*, consumers were sceptical about the safety of cassava products supplied from the other states considered in this study. Because the *gaari* and cassava products from these states are likely to be a substitute, the issue is how to improve the safety, and resulting reputation and trust of the cassava products from these states. Producers and marketers of *gaari* and cassava products should work to boost the safety and quality of their products, and adopt good storage systems and good information management about Lassa fever causal agents as consumers are now more food safety conscious.

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REFERENCES

Cranage, D. A., Conklin, M. T., & Lambert, C. U. (2005). Effect of nutrition information in perceptions of food quality, consumption behaviour and purchase intentions. *Journal of Foodservice Business Research, 7*(1), 43–61

Ehirim, N. C. (2010). Determinants of consumers' preference for safe chicken consumption in Imo state, Nigeria. *Science pub journal 2 (12), 2010*, 42-50. ISSN: 1553–9865.

Eppink, F. V., Hanley, N., & Tucker, S. (2019). How best to present complex ecosystem information in stated preference studies? *Ecological Economics*, *158*, 20–25.

Liu, P., & Swallow, S. K. (2021). Incentive compatibility and the consequences when it is missing: Experiments with water quality credits purchase. *Land Economics*, *97*(4), 893–910

Omojokun, J. (2013). Regulation and enforcement of legislation on food safety in Nigeria. *Mycotoxin and Food Safety in Developing States*, 251-268. Available: http://dx.doi.org/10.5772/54423 (Accessed June 12, 2020)

Peng, Y., Li, J., Xia, H., Qi, S., & Li, J. (2015). The effects of food safety issues released by we media on consumers' awareness and purchasing behaviour: A case study in China. *Food Policy*, *51*, 44–52

Petrolia, D. R. (2016). Risk preferences, risk perceptions, and risky food. *Food Policy*, *64*, 37–48.

Rondon M. & Nzeka U. (2011) Food and agricultural import regulations and standards – Narrative. *FAIRS country report; NI: 1-14, Nigeria, Global Agricultural Information Network.*

Sogari, G., Li, J., Lefebvre, M., Menozzi, D., Pellegrini, N., Cirelli, M., Gómez, M. I., & Mora, C. (2019) The influence of health messages in nudging consumption of whole grain pasta. *Nutrients*, *11*(12), 2993

Verbeke, W., & Liu, R. (2014). The impacts of information about the risks and benefits of pork consumption on Chinese consumers. Perceptions towards, and intention to eat, pork. *Meat Science*, 98(4), 766–772.

Vlaeminck, P., Jiang, T., & Vranken, L. (2014) Food labelling and eco-friendly consumption: Experimental evidence from a Belgian supermarket, *Ecological Economics*, *108*, 180–190

Wang, H.H., Zhang, X., Ortega, D. L., and Widmar, N. J (2013) Information on food safety, consumer preference and behaviour: The case of cassava product in the US. *Food Control 33 (2013) 293- 300. www.elsevier.com/locate/foodcont*

World Health Organisation (WHO) (2022) Lassa Fever, Nigeria. Available online: www.who.int/home/diseaseoutbreak news/Lassa fever-Nigeria

Examination of Biomaterial Samples Obtained from Coffee and Tangerine Plants at Nepal's Plantations Affected by Phytopathogens and Determination of The Efficiency of Their Suppression by The Biofungicide

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ABSTRACT

Infestation of plants with phytopathogenic infections brings great harm to agriculture. This is a global problem. Entire regions lose their business of growing coffee, date palms, various fruits and vegetables, as well as grain crops, fruit trees, shrubs and flowers. These phenomena are especially manifested in places where chemical pesticides, insecticides and herbicides are used in large amounts, where soils are depleted and where there is a lack of moisture. First of all, the weakened plants are susceptible to various diseases due to reduced immunity. This work examines biomaterial samples from infected coffee and tangerine plants taken from Nepal's plantations. Examination was conducted in the BIOIN-NOVO LTD laboratory. The isolated pathogens were purified, their biomass was built up, and molecular genetic examination was performed, the genus and species of the phytopathogens were determined. A collection of biofungicides based on the fungi of Trichoderma genus available at the company was screened, revealing the possibility of efficient suppression of phytopathogens by various strains. An experimental sample of a complex biopreparation was obtained from the most active strains using biotechnology techniques in order to test its efficiency under the conditions of these plants plantations.

Key words: Biopreparations, phytopathogen, plants, plant protection, rot

INTRODUCTION

Contamination of plants with phytopathogenic infections causes damage to agriculture in different countries, amounting to billions of dollars. The direct damage in the form of a lost crop is more than 25 %. Harvest laid for long-term storage becomes unusable due to rotting caused by phytopathogenic fungi.

Pathogens are also a danger to human and animal health. Commercial risk and losses are borne by companies - producers of vegetables, fruits, nuts and coffee. For countries with a cold climate and harsh winter, the maximum loss accounts for the winter storage of the crop. For countries with warm and humid climates, damage is observed during the period of plant cultivation and transportation of crops to consumers over long distances. The main reason for these phenomena is that farmers do not carry out biological protection of plants in the process of their cultivation, as well as the processing of seed and soil before planting. In addition to direct crop losses, it is very important to lose product quality and its safety for health. Thus, in fruits affected by phytopathogenic fungi, mycotoxins accumulate: zearalenone and its derivatives, aflatoxins: B1, B2, G1, ochratoxin, patulin. Company LTD BIOIN-NOVO for many years engaged in the development and production of various biological products. All bio-preparations are developed on the basis of use of microorganisms which extensive collections are available in the company.

MATERIALS AND METHODS

Selection of objects

During the period from February to September 2018, studies of tangerine and coffee pathogens from Nepal were carried out. Coffee Plantation: Eco Friendly Agro Organic Concept Pvt. Ltd, Palungtaar Municipality 9, Dhuwakot, Gorkha District State 4 Nepal; Tangerine Plantation: Gorkha distinct, Sahid Lakhanthapa village, Ghairung.1 phytopathogen was isolated from the object obtained from coffee, and 3 pathogenic fungi were isolated from the tangerines. A collection of fungi of the Trichoderma genus from 64 different strains was scanned in order to identify the most active options for fighting these infections.

Nutrient medium and method of analysis

To isolate the pathogens, agarized Czapek's nutrient medium of the following composition (g/l) was used: sucrose-30.0; $NaNO_3$ -3.0; KH_2PO_4- 1.0; $MgSO_4$ .7 H_2O; KCI-0.5; $FeSO_4$ .7H_2O-0.01; agar-agar-15.0. The objects were grown at T=24–26°C for 5–7 days in a germinator. Microscopic examination of the cultures was carried out with a Micromed microscope at 10x40 magnifications using a squashed drop method and at 10x90 with immersion. To obtain biomass for molecular genetic expertise, the producers were grown for 2-3 days.

DNA was isolated, and sequence analysis was performed. The method of molecular identification was based on Sanger sequencing of ITS1/2 fragment of a ribosomal genes cluster. Regions ITS1 and ITS2 flanking the 5.8S rDNA gene

show significant nucleotide divergence at the cross-species level. Comparison of the sequences obtained with databases (NCBI, ExTaxon, etc.) makes it possible to determine the species of a sample with high probability, so the method is acknowledged as the "gold standard" in identifying the species of fungi. The biological activity was determined using the method of "counter seeding", the time of complete absorption, growth rate and spore production were analyzed.

The prototypes of liquid biofungicide were accumulated using the most active strains identified in the process of analyzing the results of "counter seeding". Each strain was cultivated separately using complex culture media containing three different hydrolyzates of protein raw materials. The cultivation time amounted to 2 days at T=24-26°C. The state of the biomass and the formation of chlamydospores were monitored by the results of microscopic examination. After 48 hours, the cultivation process was completed and the components of the commercial form were added to the culture liquid: a stabilizer, a wetting agent, an adhesive, and a thickener.

RESULTS AND DISCUSSION

The samples of phytopathogens were subjected to both visual and microbiological analysis. Seeding samples onto selective culture media made it possible to detect infection with pathogenic fungi of tangerine and coffee plants. Phytopathogens were identified and then purified, Fig. 1-4. From tangerine, 3 major pathogens were identified, from coffee - 1 pathogen.

As a result of molecular genetic analysis, it was found that tangerine was affected by Aspergillus niger and Fusarium solani, widely known plant pathogens, and coffee was affected by *Cunninghamella echinulata* mucoral fungus. This is a species of mucosal zygomycete fungi, the most well-known species of the *Cunninghamella* genus. It is the heterothallic (diclinous) species. Colonies bred on potato-dextrose agar are whitish, becoming yellowish and smoky-gray as they mature. *Aseptated sporangiophores* (often referred to as conidiophores, since they carry monosporous sporangiola), 16-22 µm thick, dichotomously or corymbiformly branched; each branch ends with a wide claviform or almost spherical knob up to 50 µm in diameter (lateral - up to 30 µm). Sporangiola, spherical or nearly spherical, are formed on very short sterigmoid shoots on these knobs, aculeolate (occasionally smooth), 10-14 µm in diameter. Table 1 shows the results of molecular genetic analysis of coffee and tangerine pathogens. Chlamydospores are formed in the substrate mycelium; they are rare, with various shapes.

Table 1. Results of molecular genetic analysis of coffee and Mandarin pathogens

№ sample's	Sequence	Species affiliation
№ 2 - isolated from Mandarin	GTCACCTGGAAAGAATGGTTGGAAAACGTCGGCAGGCG CCGGCCAATCCTACAGAGCATGTGA CAAAKCCCCATACGCTCGAGGATCGGACGCGGTGCCGCC GCTGCCTTTCGGGCCCGTCCCCCCG GAGAGGGGGACGGCGACCCAACACACAAGCCGGGCTTG AGGGCAGCAATGACGCTCGGACAG GCATGCCCCCCCGGAATACCAGGGGGCGCAATGTGCGTTC AAAGACTCGATGATTCACTGAATTC TGCAATTCACATTAGTTATCGCATTTCGCTGCGTTCTTCA TCGATGCCGGAACCAAGAGATCCAT TGTTGAAAGTTTTAACTGATTGCATTCAATCAACTCAGA CTGCACGCTTTCARACAGTGTTCGTG TTGGGGTCTCCGGCGG	Aspergillus niger
№3- Mandarin,	TCTCCGTTGGTGTACCAGCGGAGGGATCATTACCGAGTT ATTCAACTCMTCAACCCTGTGAACT TACCTAAACGTTGCTTCGGCGGGAATAGACGGCCCCGTG AAACGGGCCGCCCCCGCCAGAGGA CCSTTAACTCTGTTTCTATAATGTTTCTTCTGAGTAAAAC AAGCAAATAAATTAAAACTTTCAWC AACGGATCTCTTGGCTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTG CAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTG CGCCCGCCAGTATTCTGGCGGGCATG CCTGTTCGAGCGTCATTACAACCCTCAGGCCCCCGGGCC TGGCGTTGGGGATCGGCGGAGCGCCC CTCGTGGGCACACGCCGTCCCCCAAATACAGTGGCGGTC CCGCCGCAGCTTCCATCGCGTAGTAG CTAACACCTCGCGACTGGAGAGCGGCGCGGCCACGCCGT AAACACCCAACTCTTCTGAAGTGAC CTCGAATCAGGTGAGGC	Fusarium solani
№ 4- Mandarin	CTCCGTTGGTGACCAGCGGAGGGatCATTACCGAGTTATT CAACTCaTCaaCCCTGTGAACTTACCT AAACGTTGCTTCGGCGGGAATAGACGGCCCCGTGAAAC GGGCCGCCCCCGCCAGAGGACCCTTA ACTCTGTTTCTATAATGTTTCTTCTGAGTAAAACAAGCAA ATAAATTAAAACTTTCAACAACGGA TCTCTTGGCTCTGGCATCGATGAAGAACGCAGCGAAATG CGATAAGTAATGTGAATTGCAGAAT TCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCG CCAGTATTCTGGCGGGCATGCCTGTT CGAGCGTCATTACAACCCTCAGGCCCCCGGGCCTGGCGT TGGGGATCGGCGGAGCGCCCCTCGT GGGCACACGCCGTCCCCCAAATACAGTGGCGGTCCCGCC GCAGCTTCCATCGCGTAGTAGCTAA CACCTCGCGACTGGAGAGCGGCGCGGCCACGCCGTAAA ACACCCAACTCTTCTGAAGTTGACCT	Fusarium solani

	CGAATCAGGTAGGAATACCCGCTGAACTTAAGCATATC	
№ 5- - isolated from coffee	GTGTACCTGCGGAGGWCATTAACTATTTGTGGGGGAAGT ATTCTATTCGAATCTTTCACCATTAA TTCATCCATAATGTGGGTCAAACCACATGCGCAATGTTT TTTTTAAAGGGTTAACTTTCGGGTTAC TACTCTTTATTTATTATAATATGGCCTAAAAAACCATATT ATTAATTTTTTTATACTAAATTTACT AATAAACGATTGACCATAATTTATGGTTGTTTTAAAAAT ATATTAATTTATATAAAAACAACTTT CAGCAATGGATCTCTCGGCTTTCGTATCGATGAAGAACG CAGCAAATCGCGATATTTAATGTGAT CTGCCTATAGTGAATCATCAAATCTTTGAACGCATCTTGC ACCCTATGGTATTCCGTAGGGTACAT CTGTTTCAGTACCATTCAAACATCTCCCTCAATCCTTTTT TTTTTTTTAAAAAAGA	Cunninghamella echinulata

Zygospores are 30-80 µm in diameter, spherical or somewhat flattened, warted. Suspensors are usually almost equal, 20-25 µm long and 10-20 µm in diameter, smooth, and uncoloured.

The results of the analysis of phytopathogenic activity of NIKFAN, F biopreparation using the method of “counter seeding” against these pathogens are presented in Figures 5, 6. Within 5 days, the biofungicide occupies almost the entire surface of the cup, absorbing the pathogen completely.

Biological activity of samples of NIKFAN, F biopreparation was studied. The biopreparation contained a complex of *Trichoderma asperellum* genus fungi, strains No. 16, 20, 27, 32, 47. The biopreparation showed high biological efficiency in suppressing infection. Specifically, complete absorption of the pathogen culture took 5 days.

Figure 1. Infected leaves of coffee

Figure 2. Pathogen extracted from coffee

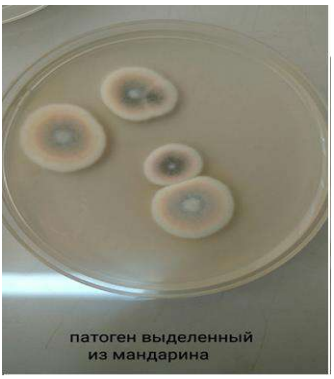

Figure 3. Pathogen extracted from tangerine

Figure 4..Pathogen extracted from tangerine

Figure 5. Effect of fungicide against pathogen in coffee;

Figure 6. Effect of fungicide against pathogen in tangerine

CONCLUSION

As a result of the study performed, pathogens of two plant species were analyzed: coffee and tangerine. Sources of diseases of fungal nature were identified. Molecular genetic examination of the pathogens was carried out, as a result of which the species and genera of these infections were determined. A collection of biofungicide available at the company was screened, and the most efficient producers were identified. An experimental composition of a complex biofungicide was developed that efficiently inhibits the growth and progression of infection on coffee and tangerine. Experimental samples of biofungicide were accumulated. As a result of this work, we may recommend testing experimental samples of NIKFAN, F biofungicide under the conditions of natural growth of coffee and tangerine plants on plantations in order to determine its biological and commercial efficiency.

REFERENCES

Nugmanova, T. (2017) Biopreperation for the production of environmentally safe food, Part 1. *Ecological engineering and environment protection*, 2017, #2, p.63-70, Bulgaria

Nugmanova, T; Chistyakova, L; Petra, I.; Shelepova, O. and Kondrat'eva, V. (2017) Biopreperation for the production of environmentally safe food Part 2.*Ecological engineering and environment protection*, 2017, #2, p.70-74, Bulgaria

Nugmanova, T.; Chistyakova, L.; Petra, I.; Shelepova, O.; Kondrat'eva, V. and Baklanova, O. (2017) Biopreparations in vegetable and potato growing. *Journal of Potatoes and vegetables*, № 6, pp. 2-4, Moscow.

Nugmanova, T. (2017) Nikfan for cucumber. *Journal of potatoes and vegetables*, № 10, p.17-18, Moscow

Nugmanova, T.; Chistyakova, L.; Petra I.; Grushina, O. and Imbia A-M. (2016) Nikfan-protection and harvest. *Journal of potatoes and vegetables*, № 11, стр. 20-21, Moscow

Evaluation of Advanced Faba Bean (*Vicia faba* L.) Genotypes for Seed and Seed Yield Components under Khumaltar Condition, Lalitpur

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ABSTRACT

*A field experimental entitled "Evaluation of Advanced Faba Bean Genotypes for Seed and Seed Yield Components under Khumaltar Condition," was carried out during October, 2021 to April, 2022 at National Horticulture Research Center (NHRC), Khumaltar, Lalitpur, Nepal. The main objective of this study was to assess the different advanced faba bean genotypes for seed and seed yield available in Nepal. Eight genotypes were selected from NHRC and one local variety 'Kathmandu Local' (FB014) was used in this study. The experiment was conducted in randomized complete block design (RCBD) with nine treatments and two replications. Seeds were sown at the distance of 70*20cm. The standard recommended dose of fertilizer 80:80:60 NPK kg/ha and 15-ton compost/ ha was applied. Different vegetative, reproductive and seed yielding characteristics were studied. The result reveal that, FB003 which is taller (162.5cm), more vigorous (5), higher no. of brancher per plant (8.4), less virus infection, higher number of pods per plant (32), longer pod length (9.47cm) and higher yield (9.784 ton/ha) as compared to Kathmandu local check (FB014) cultivar. Another superior genotype, FB002 was shorter (134.2 cm), less vigorous (3.5), more no. of branches per plant (8.1), less susceptible to pest and diseases, higher number of pods per plant (25), longer pod length 910.41cm) and higher adjusted yield (7.737 ton/ha) compared to Kathmandu local check (FB014) cultivar. The experiment concluded that genotype FB003 and FB002 has better yield and yield attributing characters than other genotypes.*

Keywords: Field experiment, legume, broad bean, crop rotation, protein source

INTRODUCTION

Faba bean (FB) (*Vicia faba* L.) is a cool-season, annual grain legume crop, traditionally used as a essential and convenient source of plant protein for human and livestock diets (Elsheikh et al., 1999; Gu et al., 2020). It is now cultivated worldwide (Prabhu & Rajeswari, 2018) and ranked as the third most important grain legume after soybean (*Glycine max* L.) and pea (*Pisum sativum*

L.) production (Mihailovic et al., 2005). Faba beans, formerly known as broad beans, are among the oldest crops in the world. It has in fact been claimed with some justification that the Pyramids were built on faba beans (Hawtin and Webb, 1981). According to Cubero, (1974) its center of origin was in the Near East, Iraq, and Iran, and secondary centers evolved later on in Afghanistan and Ethiopia. According to FAO, faba bean has spread around the world and grown in 50 countries.

Faba bean or broan bean is an important cash crop. Faba bean is consumed as dry green vegetable, dry seeds, processed food, canned (Rajbhandari, 2011). Faba bean has been considered as a meat extender or substitute and as a skim milk substitute; and its content makes a cheap alternative protein source compared to the highly priced animal or meat-protein sources for households in developing countries (Adamu et al., 2015). Roasted seeds are eaten like peanuts in India, Nepal. Haulm and straw from faba bean harvest fetches a premium in Egypt and Sudan and is considered as a cash crop and can also be used for brick making and as a fuel in parts of Sudan and Ethiopia (FAO, 2019).

Faba bean has high protein, dietary fiber, potassium, iron, and folic acid contents compared with cereals such as rice, corn and wheat (Howard et al., 2018; Gu et al., 2020). The total carbohydrate content of FB seeds ranges from 457 to 701 g/kg DM, with starch, total sugars, and fiber as the major carbohydrate components (Khan et al., 2015; Morales et al., 2008). FB seeds are also good sources of dietary minerals (Cazzato et al., 2014), notably potassium, phosphorus, iron, and zinc, while iron and zinc are essential for the sustenance and optimal physiological function of both humans and livestock (Bailey et al., 2015).

Faba bean can be used in the treatment of Parkinson's disease being a good source of levadopa (L- dopa). Faba beans are also used as natural alternative for drugs like Viagra, (Hulse, 1994). There are epidemiological and in vitro studies which suggest that the hemolysis resulting from favism acts as protection from malaria (Hussein and Saleh, 1985). Several health benefits such as reducing of colorectal cancer(Aune et al., 2011) improvement of gut health, reduced blood cholesterol levels (Clemente & Olias, 2017), and reduced risk of cardiovascular disease (Sharma, Srivastava and Prakash, 2011).

Leguminous crop such as faba bean plays an important role in crop rotation, improving soil texture, suppressing pest and weed population. Cultivating faba bean in cropping system involves several agronomic, environmental, and

ecological services which reduce the negative impact of agriculture by reducing the use of non-renewable energy and synthetic chemical (Hauggaard-Nielsen et al., 2010), and can substantially contribute to sustainable agriculture by reducing greenhouse gas emissions, providing excellent ecological services (Khazaei et al., 2019).

At present scenario, world average production of faba bean is 1.5 t/ha (FAOSTAT, 2009). They are major crop in several nations including China, Egypt and the Sudan; and are widely grown for human food throughout the Mediterranean region, in Ethiopia and in parts of Latin America. Europe, North America, and Australia have recently shown an increased interest in faba bean cultivation as a source of protein for livestock feed. China holds a 60% share of the production market (FAO, 2009). Ethiopia is second largest producer of faba bean in the world after China (Hawtin and Hebblethwaite, 1983). The world's largest collections of faba bean germplasm are found at the International Centre for Agricultural Re- search in the Dry Areas (ICARDA) in Syria, and at the Vavilov Institute in Russia. According to the FAO, there are about 26,000 accessions of faba bean held in gene banks around the world. According to FAO, 2019 area of faba bean cultivation has decreased drastically from 1960s to 2017. Even though, the area of production has decreased its production has increased in the same time.

In Nepal, Faba bean is an important vegetable crop and cultivated in a wide range of agro-climatic condition rom Terai to high hills in different seasons. Faba bean (bhakula) is cultivated in mid hills widely for green vegetable purposes (Shrestha, et al., 2011). According to Rajbhandari (2011) there are only two types of local cultivars of faba bean grown in Nepal which are well adapted to local environments. The big seed type is commonly known as "Thulo Bakula" or Kathmandu local (*V. faba* L. *var. major* Harz.) and the small seed types or "Sano Bakula" (*V. faba* L. *var. minor* Bock.). He (Ibid) has further noted that big seeded type is well suited in the hills and valleys, while small seeded type – in terai and inner terai.

Nepal is ranked 30th country in the world to produce faba bean (FAO, 2019). Faba bean alone contributes about 0.02% to National GDP in Nepal (MoALD, 2021). According to APSD, in Nepal faba bean is cultivated in 1252 ha land with production of 8449 tons with productivity of 6.78 t/ha where Bagmati province has 11.53 t/ ha (APSD, 2020). At present, vegetable seed is mostly marketed by traders and agro-vets. Over 1,854 seed entrepreneurs and 829 trained seed traders were registered with the NSB by 2010 (CASA, 2020).

MATERIALS AND METHODS

The seed sown in this study were collected from different research organization as well as local community. Eight genotypes viz. FB002, FB003, FB004, FB006, FB009, FB013, FB016 and FB017 were obtained from Grain Legumes Research Program, NARC Khajura, Banke, Nepalgunj which were received from The International Center for Agricultural Research in the Dry Areas (ICARDA) and evaluated with Kathmandu local check variety (FB014). The genotypes were cultivated in randomized complete block design (RCBD). Seeds were sown at the distance of 70*20cm. The standard recommended dose of fertilizer 80:80:60 NPK kg/ha and 15-ton compost/ ha was applied.

Observation on plant vegetative characters such as plant uniformity, vigor, height, no. of branches, and reproductive characters such as no of flowers and fruits per node, dry seed weight and total seed yield were recorded. Plant height and number of branches were measured from 5 plants in each plot and mean was calculated. Plant height was measured with the help of measuring tape from bottom to top. Plant uniformity and vigor was recorded in (1-5) scale; 1 for poor uniformity and vigor and 5 for excellent uniformity and vigorous plant. Insect pest and diseases were recorded in (0-9) scale; 0 for resistant and 9 for dead scale (Shrestha et al., 2021). Scoring was done visually. Days to flowering, pod set and maturity were recorded when 50% plants in the plot showed flowering, pod setting and maturity after seed sowing date respectively. The crop was harvested after the pods were dried. At the end, all the harvested number and weight of seed were added to calculate to total yield and adjusted yield of the genotypes.

RESULTS AND DISCUSSION

VEGETATIVE PARAMETERS

Survival Percentage

Analysis showed that percentage of survived plants was non- significant among the genotypes. The mean percentage of survived plants was the highest in FB013 (64.9%) followed by FB006 (59.94%), FB002 (56.67%) and FB017 (56.61%) (Table 1). The lowest percentage of survived plant was observed in FB003 (41.62%) from (Table 1).

Uniformity and Vigor

The mean of plant uniformity was non-significant among the genotypes. However, the mean of plant uniformity was the highest in FB002, FB003 and FB013 (4) (Table 1). The minimum uniform plant was observed in FB009 (2.5) (Table 1). The mean of plant vigor was significant among the genotypes. The

most vigorous plant was recorded in FB003 (5) followed by FB014 (4) and lowest in FB009 (2) (Table 1).

No. of branches/ plant

The mean of number of branches per plant was significant among the genotypes. The maximum number of branches per plant were recorded in FB017 (10.5) followed by FB016 (9.1) and minimum number of branches per plant was recorded in FB009 (4.9) (Table 1).

Table 1. Vegetative parameters

Genotypes	Survival %	Uniformity	Vigor	No of branch/ plt	Plt height (cm)
FB002	56.67 ab	4 a	3.5 b	8.1 abc	134.2 bc
FB003	41.625 b	4 a	5 a	8.4 abc	162.5 ab
FB004	46.62 ab	3.5 ab	3.5 b	5.6 cd	132.4 bc
FB006	59.94 ab	3.5 ab	3.5 b	6.4 bcd	139.9 abc
FB009	53.28 ab	2.5 b	2 c	4.9 d	125.7 c
FB013	64.9 a	4 a	3.5 b	7.2 bcd	169.4 a
FB014	53.28 ab	3.5 ab	4 ab	7.9 abc	137.1 abc
FB016	54.9 ab	3 ab	3.5 b	9.1 ab	135.8 bc
FB017	56.61 ab	3.5 ab	3.5 b	10.5 a	121.8 c
CV%	17.03	15.79	16.5	17.07	10.29
GM	41.07%	3.5	3.5	7.567	139.867
F-test	NS	NS	*	*	NS
LSD	6.391	1.276	1.358	2.979	33.19
EMS	7.681	0.306	0.347	1.669	207.132
Df	8	8	8	8	8

CV= Coefficient of variation, LSD= least significant difference,
*= Significant at P≤ 0.05, **= significant at P≤ 0.01 and NS= NON significant at 5%level of significance

Plant height (cm)

Plant height was measured from the bottom of the plant to its top, in the maturity stage with the help of measuring tape. The mean of plant height was non-significant among the genotypes. The tallest plant was observed in FB013 (169.4) followed by FB003 (162.5) and FB006 (139.9) and the shortest plant was observed in FB017 (121.8) (Table 1).

INSECT PEST AND DISEASE

Aphid was one of the most prevailing insects on faba bean during growing season and fungal disease such as anthracnose, chocolate leaf spot, rust. The

mean of insect damages, leaf minor, Alternaria leaf spot and chocolate spot was non-significant among the genotypes. The mean of anthracnose and percentage of plants virus is significant among genotypes. Genotype FB013 was least infected by both insect and leaf minor and less infected by insects comparing to check genotype FB014. Insect damages were highest in FB003 which was par with FB006 (2.5).

Check genotype FB014 which is par with FB002 was less susceptible to disease in comparison to other genotypes. Anthracnose was seen during maturing stage of faba bean. It was highest in FB004 (3) followed by FB013 (2) and lowest in FB009, FB017 (1) and none in FB014 and FB016 (Table 2). The mean of percentage of plant virus was the highest in FB017 (40%) and lowest in FB002, FB003and FB013 (5%) (Table 2). The mean of plant virus percentage was significant among the genotypes. The mean of percentage of plant virus was the highest in FB017 (40%) and lowest in FB002, FB003and FB013 (5%) (Table 2).

REPRODUCTIVE PARAMETERS

Days after flowering (DAF)

It is the number of days required for plants to initiate flower from the day of sowing. The mean of Days after flowering (DAF) was non- significant among the genotypes. FB017 (34 days) was the earliest genotype to initiate 50% flowering which was par with FB013 (34.5 day) and FB002 (38 day) had the late flowering was followed by FB003 and FB006(36.5 day) (Table 3).

Days after pod set

Days after pod set is a number of days required for plants to form pod from the day of planting. The mean of days after pod set was non- significant among the genotypes. Genotype FB004 which was par with FB016, FB017 (91 days) were the earliest genotypes to form pod (Table 3). FB013 (101 days) required the longest time to form pod (Table 3).

Days to maturity

After the pods matured, they were left to dry in the plant and harvested after drying. Delay in pod harvesting leads to reduce in total yield. Mean of days to maturity was non-significant among the genotypes. The genotype FB016 which was at par with FB017 (183 days) was the earliest genotype in maturity whereas, check genotype FB014 and FB013 (189 days) had delayed maturation (Table 3).

Pod length (cm)

The mean of Pod length (cm) was non-significant among the genotypes. The largest pod was observed in FB002 (10.41cm) followed by and FB006 (10.9cm)

and FB009 (10.15cm) and the smallest pod was observed in FB016 which was par with FB017 (8.3cm) (Table 4).

Table 2. Insect, pest and diseases of faba bean

Genotypes	Insect damage (1-9)	Leaf Minor (1-9)	Alt leaf spot (1-9)	Choco-spot (1-9)	Anthracnose (1-9)	Plt virus %
FB002	1.5 ab	1 b	0.5 b	1 b	0.5 cd	5 e
FB003	2.5 a	1.5 ab	2.5 a	2 ab	0.5 cd	5 e
FB004	2 ab	1.5 ab	1.5 ab	1.5 ab	3 a	10 de
FB006	2.5 a	1.5 ab	2.5 a	1.5 ab	0.5 cd	20 bc
FB009	2 ab	2.5 a	1.5 ab	2.5 a	1 c	15 cd
FB013	1 b	1 b	1.5 ab	1.5 ab	2 b	5 e
FB014	1.5 ab	1.5 ab	1.5 ab	2 ab	0 d	20 bc
FB016	2 ab	1.5 ab	1.5 ab	2 ab	0 d	25 b
FB017	2 ab	2 ab	2 a	2 ab	1 c	40 a
CV%	33.01	37.88	37.42	28.12	37.44	23.13
GM	1.889	1.556	1.667	1.778	0.944	18.33
F-test	NS	NS	NS	NS	**	**
LSD	1.438	1.358	1.438	1.153	0.815	0.859
EMS	0.389	0.347	0.389	0.25	0.125	0.125

CV= Coefficient of variation, LSD= least significant difference,
*= Significant at P≤ 0.05, **= significant at P≤ 0.01 and
NS= NON significant at 5%level of significance

Table 3. Days required for initiating flowering, pod set and maturing

Genotypes	DAF	DA pod set	Days to maturity
FB002	38 a	97.5 ab	187
FB003	36.5 a	97a b	187
FB004	35 a	91 b	187
FB006	36.5 a	98 ab	187
FB009	35 a	96 ab	187
FB013	34.5 a	101 a	189
FB014	36 a	93 b	189
FB016	36 a	91 b	183
FB017	34 a	91 b	183
CV%	5.15	3.58	0
GM	35.778	95.222	186.556
F-test	NS	NS	NS
LSD	4.245	7.867	
EMS	3.389	11.639	0
Df	8	8	

CV= Coefficient of variation, LSD= least significant difference,
*= Significant at P≤ 0.05, **= significant at P≤ 0.01 and

NS= NON significant at 5%level of significance

Number flowers per nodes

The number of flowers per node was non- significant among the genotypes. It was the highest in FB002 (6.5) followed by FB009 and FB013 (5.9) and the lowest was in FB017 (4.7) Table 4).

Number of seed/pods

The mean number of seed/ pods was significant among the genotypes. It was highest in FB013 (4.3) followed by FB002 (4) (Table 4). It was lowest in FB016 and FB017 (2.8) (Table 4).

Number of pods/ plants

The mean of number of pod/ plants was significant among the genotypes. The highest number of pods was recorded in FB003 (32.419) followed by Fb002 (25.596). It was recorded lowest in FB009 (14.063) (Table 4).

Table 4. Reproductive parameters

Genotypes	Pod length (cm)	No. of flower/ node	No of seed/ pod	No of pod/ plt
FB002	10.41 a	6.5 ab	4 ab	25.596 ab
FB003	9.47 ab	5.2 ab	3.2 cd	32.419 a
FB004	9.45 ab	5.4 ab	3.5 bcd	14.531 c
FB006	10.9 a	5.7 ab	3.3 bcd	15.9b c
FB009	10.15 ab	5.9 ab	3.6 abc	14.063 c
FB013	9.5 ab	5.9 ab	4.3 a	17.674 bc
FB014	8.45 b	4.8 b	2.9 cd	16.463 bc
FB016	9.9 ab	5.2 ab	3.6 abc	16.856 bc
FB017	8.3 b	4.7 b	2.8 d	14.319 c
CV%	8.46	12.91	9.57	22.99
GM	9.61	5.478	3.467	18.647
F-test	NS	NS	*	*
LSD	1.876	1.64	0.764	9.887
EMS	0.662	0.506	0.11	18.382

CV= Coefficient of variation, LSD= least significant difference,
*= Significant at P≤ 0.05, **= significant at P≤ 0.01 and
NS= NON significant at 5%level of significance.

SEED YIELD PARAMETERS

Total number of dried pods

The mean of total no of dried pods is significant among the genotypes. The highest number of dried pods was in recorded in FB002 (423), followed by FB003 (400) and the lowest number of dried pods was recorded in FB009 (222) (Table 5).

Dry pod harvest (g)

The mean of Dry pod harvest (g) was significant among the genotypes. The maximum weight of dry pod after harvesting was observed in FB002 (2572.5g) followed by FB003 (2197g and minimum weight was observed in FB009 (1377g) (Table 5).

Total dried seed weight (g)

The mean of total dried seed wt. (g) was non-significant among the genotypes. The highest weight of total dried sed was observed in FB002 (1785g) followed by FB003 (1690g) and FB013 (1499.5). The lowest seed weight was observed in FB009 (1020g) (Table 5).

Adjusted yield ton / ha

The mean of adjusted yield ton/ ha was non-significant among the genotypes. Among 9 genotypes, the highest adjusted yield ton per hectare was recorded in FB003 (9.784t/ha) followed by FB002 (7.737t/ha) and FB004 (5.8t/ha) and the lowest adjusted yield was recorded in FB006 (4.678t/ha) and FB009 (4.613t/ha) (Table 5).

Seed weight g/ plant

The mean of seed gm/ plant was non-significant among the genotypes. Maximum seed (g) per plant was observed in FB003 (136.95g) followed by FB002 (108.3g) and minimum in FB009 (64.6g) (Table 5).

Table 5. Seed yield parameters

Genotypes	Tot no dried pod	Dry pod harvest (g)	Tot. dried seed wt. (g)	Adj yldt/ ha	Seed g/ plt	1000 seed wt. (g)
FB002	423 a	2572.5 a	1785 a	7.737 ab	108.3 ab	786 a
FB003	400 a	2197 ab	1690 a	9.784 a	136.95 a	802 a
FB004	209.5 c	1531 bc	1175 c	5.81 b	81.335 b	880 a
FB006	282 bc	1626.5 bc	1165 c	4.678 b	65.5 b	768 ab
FB009	222 c	1377 c	1020 c	4.613 b	64.6 b	866 a
FB013	335 ab	1949.5 abc	1499.5 ab	5.622 b	78.7 b	772 ab
FB014	263 bc	1820 bc	1300 bc	5.798 b	81.2 b	872 a
FB016	275 c	1582.5 bc	1170 c	4.886 b	71.5 b	630 b
FB017	240 bc	1527.5 bc	1175 c	5 b	70 b	458 c
CV%	14.63	16.84	17.1	22.72 b	22.71	8.49
GM	294.444	1798.167	1331.056	5.992	84.273	759.333
F-test	**	*	NS	NS	NS	**
LSD	99.36	698.5	289.9	3.14	44.11	148.6
EMS	1856.625	91738.5	15809.2222	1.854	365.876	4151.556

CV= Coefficient of variation, LSD= least significant difference,

*= Significant at P≤ 0.05, **= significant at P≤ 0.01 and

NS= NON significant at 5%level of significance.

1000 seeds weight (g)

The mean of 1000 seed wt. (g) was significant among the genotypes. The greatest 1000 seed weight was recorded in FB004 (880g) followed by check genotype FB014 (872g) and FB009 (866) and the lowest weight was recorded in FB017 (458 g) (Table 5).

Estimation of correlation coefficients

Plant vigor was positively correlated with number of branches, plant height (cm), days after flowering, number of pod/plants, adjusted yield but negatively correlated with 100 seeds weight (g) (Table 6). Number of branches per plant was negatively correlated with plant height (cm), 100 seeds weight (g) and positively correlated with days after flowering, number of pods per plant and adjusted yield. Plant height (cm) is positively correlated with plant vigor and negatively correlated with number of branches. Days after flowering and number of pods per plant were positively correlated with all measured parameters.1000 seeds weight (g) showed positive correlation with plant height and days after flowering but negative correlation with plant vigor and number branches. Adjusted yield was positively correlated with all measured parameters (Table 6).

Table 6. Correlation of coefficient between the measured parameters

Parameters	Plant vigor	No. of branches/ plant	Plant height (cm)	Days after flowering	No. of pods/plant	1000 seeds weight (g)
Plant vigor	1					
No. of Branches/plant	0.5	1				
Plant height (cm)	0.55	-0.012	1			
Days after flowering	0.32	0.013	0.08	1		
No. of pods/plant	0.68	0.26	0.54	0.62	1	
1000 seeds weight(g)	-0.05	-0.8	0.25	0.34	0.15	1
Adjusted yield (t/ha)	0.72	0.21	0.5	0.52	0.96	0.23

The major parameters affecting the yield are number of pods harvested, vigor, no, of branches, total dried pod per plant, total seed gram per plant, pod length. The result of plant vigor and uniformity from this study was supported by (Shrestha & Shrestha, 2022).

The average no. of branches per plant in this study are 7.5 which is supported by Yasmin et al., 2020 but in contrast to Shrestha & Shrestha, 2022, Arya, 2018. The difference in result of no. of branches per plant may be due to time of sowing, different location, climatic condition, genotypes, layout design etc. The result of plant height was supported by Arya, 2018, but is greater than Shrestha & Shrestha, (2022) and Shrestha et al., (2021).

The major insect occurred during growing period was aphid, pod borer, leaf minor whereas fungal diseases such as Alternaria leaf spot, cholate leafspot, anthracnose, and virus were seen during maturing stages. Rust and chocolate spot infection can cause yield losses of 22–42% and 36–68%, respectively (Sahile et al., 2010; Emeran et al., 2011).

According to GRDC (2017) flowering usually begins from 29- 96 days of sowing. The results of days required to flower were supported by Labuda, 2012. It is affected by sowing time, climatic condition, genotypes etc. Faba bean plants generally produce many flowers; however, a large proportion (~80–90%) does not develop into pods, depending on the variety, sowing date and other environmental conditions (GRDC, 2017). The average days required to form pod was 95 days whereas, the study conducted by Shrestha et al., 2021 had 78 days and the study conducted by Labuda, 2012, had 44 days. Days to maturity was in contrast to supported by Labuda, 2012 and Arya, 2018. The findings do not support the result. It may be due to various factors such as, lack of pollination, moisture stress, extreme cool climate, short photoperiod, variation in time of sowing, space, seed rate, climate, location, genotypes etc. Once true flowers are produced in faba beans, a period of cool weather or lack of sunlight for 3 days can cause flower or pod abortion to varying degrees. There can be an early period of ineffective flowering, during which podset does not occur. In warmer environments, this period is minimal, but in colder temperate environments, it can be as long as 30 days. Faba bean require minimum of 10 degrees Celsius to initiate flowering (GRDC, 2017). The average pod length is 9.61 which were supported by Shrestha et al., 2021. The result of number of flowers per nodes is similar to Labuda, 2012.

The average number of seeds per pod and of pods per plant was supported by Arya, (2018); 1000 seed (g) is supported by Gereziher et al., (2017), study conducted in norther Ethiopia. The adjusted yield ton / hectare is supported by (Zebire & Tadesse, 2017). It obtained by calculating total yield production with total number of seeds planted divided by total no of plants survived. Theses parameters are correlated to determine yield.

Based on the result, FB003 which is taller (162.5cm), more vigorous (5), higher no. of brancher per plant (8.4), less virus infection, higher number of pods per plant (32), longer pod length (9.47 cm) and higher yield (9.784 ton/ha) as compared to Kathmandu local check (FB 014) cultivar. Another superior genotype, FB 002 was shorter (134.2 cm), less vigorous (3.5), more no. of branches per plant (8.1), less susceptible to pest and diseases, higher number of

pods per plant (25), longer pod length 910.41 cm) and higher adjusted yield (7.737 ton/ha) compared to Kathmandu local check (FB014) cultivar, whereas, a study conducted by Shrestha & Shrestha, 2022, the highest yielding genotype was FB016 followed by FB013 and another study conducted on 2021 concludes genotype FB016 and Fb008 as high yielding genotypes. The yield and quality of faba bean seeds are affected by soil type, climatic conditions, and agronomic factors (Ksiezak et al., 2009; Kulig et al., 2011; Barlog et al., 2018). Different studies conducted at different places such as Evaluation of faba bean genotype at Haryana, southern Ethiopia, India had also observed wide genetic variability on seed yield per hectare. Genotypes showed variation from each other in yield production.

CONCLUSION

The result reveal that, FB003 which was taller (162.5cm), more vigorous (5), higher no. of brancher per plant (8.4), less virus infection, higher number of pods per plant (32), longer pod length (9.47cm) and higher yield (9.784 ton/ha) as compared to Kathmandu local check (FB014) cultivar. Another superior genotype, FB002 was shorter (134.2 cm), less vigorous (3.5), more no. of branches per plant (8.1), less susceptible to pest and diseases, higher number of pods per plant (25), longer pod length 910.41cm) and higher adjusted yield (7.737 ton/ha) compared to Kathmandu local check (FB014) cultivar. Hence, the experiment concluded that genotype FB003 and FB002 has better yield and yield attributing characters than other genotypes and is recommended to farmers of Midhills.

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REFERENCES

Adamu, G. O. L , Ezeokoli, O. T., Dawodu, A. O., Adebayo-Oyetoro, A. O. and Fodile, L. N., (2015). Macronutrients and Micronutrients Profile of Some Underutilized Beans in South Western Nigeria. *International Journal of Biochemistry Research & Review*. 7(*2*): 80-89.

Álvarez-Iglesias, L., Puig, C. G., Revilla, P., Reigosa, M. J., & Pedrol, N. (2018). Faba bean as green manure for field weed control in maize. *Weed Research*, *58*, 437– 449.

Arya. (2018). Evaluation of faba bean genotypes for seed yield under Haryana conditions. *Forage Research*. *44*, pp. 66-62.

Aune D. , Chan D.S.M. , Lau, R., Vieira R., Greenwood, D.C. , Kampman E. , Norat T. (2011). Dietary fibre, whole grains, and risk of colorectal cancer: Systematic review and dose-response meta-analysis of prospective studies, *BMJ*, 343 (2011)

Bailey, R. L., West, K. P. Jr, & Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. *Annals of Nutrition and Metabolism, 66*, 22– 33

Barlog P., Grzebisz W. and Lukowiak R. (2018) Faba bean yield and growth dynamics in response to soil potassium availability and sulfur application, *Field Crops Research*, 219*:87-97*

Cazzato, E., Laudadio, V., Ceci, E., & Tufarelli, V. (2014) Effect of sulphur fertilization on fatty acid composition of faba bean (Vicia faba L.), white lupin (Lupinus albus L.) and pea (Pisum sativum L.) grains. *Journal of Food Agriculture and Environment*, 12: 136– 138.

Clemente, R. Olias. (2017) Beneficial effects of legumes in gut health. *Current Opinion in Food Science*, 14:32-36.

Commercial Agriculture for Smallholders and Agribusiness (CASA), 2020 *Vegetable sector Strategy*, Nepal

Cubero, (1974) On the Evolution of Vicia Faba L. *theoretical and Applied Genetics*. 45, 47-51

Elsheikh, E. A. E., Fadul, I. A., & El Tinay, A. H. (1999) Effect of nutritional status of faba bean on proximate composition, anti-nutritional factors and *in vitro*protein digestibility (IVPD). *Food Chemistry*, 67, 379–383. 10.1016/S0308-8146(99)00127-2

Etemadi, F., Hashemi, M., Mangan F., Weis, S., (2015) *Faba beans; Growers guide in New England*.

Food and Agriculture Organization (FAO). (2019) *FAOSTAT Statistical Database of the United Nation Food and Agriculture Organization (FAO) statistical division*. Rome.

Hawtin G. and Webb, C., (1981). *Proceedings of the aba Bean Conference held in Cairo, Egypt*

GRDC (2017) *Faba bean, plant growth and physiology*, Grains Research and Development Corporation

Gu, B., Masli, M. D. P., & Ganjyal, G. M. (2020). Whole faba bean flour exhibits unique expansion characteristics relative to the whole flours of lima, pinto, and red kidney beans during extrusion. *Journal of Food Science*, 85(2):404–413.

Hauggaard-Nielsen H, Holdensen L, Wulfsohn D, JensenES (2010).. Spatial variation of N2-fixation in field pea(Pisum sativum L.) at the field scale determined by the15 N natural abundance method. Plant Soil *327*:167–184.

Howard, L. R., White, B. L., Uebersax, M. A., & Siddiq, M. (2018). Dry beans processing, quality evaluation, and nutrition. In: *M. Siddiq, & M. A. Uebersax (eds.), Handbook of vegetables and vegetable processing* (vol. *24*:559- 587)

Hulse JH (1994). Nature, composition and utilization of food legumes.In: *F.J. Muehlbauer and W.J. Kaiser (eds.), Expanding the Productionand Use of Cool Season Food Legumes*. Kluwer AcademicPublishers, Dordrecht, The Netherlands, pp. 77-79.

Hussein LA, Saleh M (1985). Antinutritional factors in faba bean. In:M.C. Saxena and S. Verma (eds.), *Proceedings of the InternationalWorkshop onfaba bean, Kabuli Chickpeas and Lentils in the 1980s*.ICARDA, 16-20 May, 1983. Aleppo, Syria, pp. 257-26

Khan, M. A., Ammar, M. H., Migdadi, H. M., El-Harty, E. H., Osman, M. A., Farooq, M., & Alghamdi, S. S. (2015) Comparative nutritional profiles of various faba bean and chickpea genotypes. *International Journal of Agricultural and Biological*, *17*, 449– 457

Khazaei, H., Wach, D., Pecio, A., Vandenberg, A., & Stoddard, F. L. (2019 Genetic analysis of photosynthesis-related traits in faba bean (*Vicia faba*) for crop improvement. *Plant Breeding*, 138, 761–769

Ksiezak J., Staniak M. and Bojarszczuk J. (2009) The regional dierentiation of legumes cropping area in Poland between 2001 and 2007. *Pol. J. Agronom*. 1, 25–31.

Labuda, V. (2012) Flowering characteristics of useful traits of some faba bean cultivars and breeding lines. *Acta Agrobotanica*. Vol. *65(4)*, pp. 139-148.

Mihailovic V, Mikic A. Cupina B, Eric P (2005) Field pea and vetches inserbia and Montenegro. Grain Legumes 44:25-26

MoALD (2021). *Statistical Information on Nepalese Agriculture* 2077/78 (2020/21). Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.

Prabhu, S., & Rajeswari, D. (2018). Nutritional and biological properties of *Vicia faba* L.: A perspective review. *International Food Research Journal*, *25*, 1332–1340.

Rajbhandari, B.P. (2011). *Grain Legumes of Nepal, 2nd Edition.* Kathmandu, Himalayan College of Agricultural Sciences and Technology Publ.

Rubiales, M, D. (2010). Faba bean breeding for disease resistance. *Field Crop Research* 115:297-307.

Sahile S., Fininsa C., Sakhuja P. K., Ahmed S. (2010). Yield loss of faba bean (*Vicia faba*) due to chocolate spot (*Botrytis fabae*) in sole and mixed cropping systems in Ethiopia. *Arch. Phytopathol. Plant Prot.* 43 1144–1159. 10.1080/03235400802343791

Shrestha, S and Shrestha, YP. (2022.) *Growth, Yield and Quality Evaluation of Faba Bean Genotypes in Farmers Condition at Kathmandu Valley, Province 3 of Nepal.* Proceedings of 14th National Outreach Research workshop.

Shrestha, S, Paudel, S, and Gautam, IP. (2021). *Performance of Faba bean at Kathmandu Valley Condition of Nepal.* Proceedings of tenth National Horticulture workshop,

Singh, A.K., Bhatt, B.P. (2012). Faba Bean (Vicia faba L.): *A potential leguminous crop of India*.

White Spot (*Ichthyophthirius Multifiliis)* in Rainbow Trout and its Treatment Trial by Different Therapeutic Agents in Controlled Environment

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ABSTRACTS

The commercial significance of rainbow trout (Oncorhynchus mykiss), particularly in the aquaculture sector, is globally recognized, with it being widely cultivated across the world. Notably, it has emerged as a primary cold-water species suitable for culture in the Himalayan regions, with commercial cultivation taking place in Nepal. Despite the growing success of intensive fish farming methods, these practices have led to an increase in disease occurrences, such as bacterial, viral, and parasitic diseases, including Ichthyophthiriasis caused by the parasite Ichthyophthirius multifiliis, commonly known as "Ich". In the present study, rainbow trout fingerlings were stocked 100 fish/m^2 in cemented rectangular tank for rearing purpose in Rainbow Trout Fishery Research Station, Dhunche, Rasuwa. During the rearing period, abnormal behavior was observed in the fish. Through careful examination of clinical signs, wet mount, and histopathological analysis, the presence of Ichthyophthirius multifiliis, a parasitic organism, was identified as the causative agent. A total 1260 fish with mean weight (g) ranging from 1.423±0.002 g, 1.412±0.096 g, 1.451±0.136 g and 1.477±0.118 g were examined. This study aimed to identify effective treatments for Ichthyophthiriasis in rainbow trout by comparing the efficacy of different therapeutic agents, including Salt (T1), Formalin (T2) and a combination of malachite green with formalin (T3). The results showed a significant difference in the survival rates of the fish across the different treatment groups, with the highest survival rate (82.53%) observed in the group treated with a combination of malachite green and formalin (T3).

Keywords: Rainbow trout, white spot, *Ichthyophthirius multifiliis, Nepal*

INTRODUCTION

The rainbow trout *(Oncorhynchus mykiss)* belongs to the salmonid family and holds great commercial significance as a major aquaculture species. It is widely cultivated on all continents in both the northern and southern hemispheres (Kibenge, 2019). Rainbow trout *(Oncorhynchus mykiss)* has emerged as a major

cold-water species appropriate for culture in the Himalayan regions, and it is commercially cultivated on a large scale in Nepal (Gurung et al., 2014). In Nepal, the production of rainbow trout reached 668 metric tons (CFPCC, 2020). In aquaculture practices in Nepal, rainbow trout typically reach an individual body weight of around 200-300 grams within a year. Successful farming of trout requires clean, cold water with high dissolved oxygen levels. It is feasible to farm them at high densities, with approximately 75 or more fish per square meter, and obtain a high production rate of about 10-15 kilograms per square meter per year. The quality of seed, feed, and water used has a considerable impact on the production rate (Gurung et al., 2014). As the demand for fish continues to surge, the expansion of fish farming has been remarkable (Mukherjee, 2002). The adoption of intensive fish farming methods, characterized by increased stocking rates and additional feeding, has greatly amplified the occurrence of diseases like bacterial disease (Kayis et al., 2009), viral disease (Olsen et al., 2015) and parasitic disease (Hare and Frantsi, 1974) among the rainbow trout. Furthermore, densely populated aquaculture environments can have a negative impact the health, survival rate, growth potential, and product quality of rainbow trout (Nepal et al., 2022).

Ichthyophthiriasis, is a parasitic disease of fish which is caused by *Ichthyophthirius multifiliis* (Noga, 2010), results in significant mortality rates and considerable economic losses in various types of aquaculture like grass carp (Yulin, 1996), snow trout (Mallik et al., 2015), striped catfish (Mamun et al., 2019), as well as ornamental fish species (Zhang et al., 2009). The disease is highly infectious that quickly transmits among fish, infiltrating their gill epithelia, skin and fin. While appearing as a white spot on the fish surface, it lives within the epidermis, indicating an internal microhabitat asserts that it's a true endoparasite, not an ectoparasite (Azimzadeh, 2020). The disease, often known as "white spot disease," is characterized by visible trophonts up to 1mm in diameter on the skin and fins (Buchmann et al., 2022). The trophont, persistently spinning, is encapsulated by host cells, including epidermal cells and leukocytes, creating a tiny skin bump. These reflective nodules are identified as the white spots typical of the disease (Chen et al., 2021). Fish infected with Ich may show a behavior called "flashing," where they make swift rubbing or scratching movements on objects or the pond floor, exposing their light-colored bellies. This erratic behavior can even mimic trout striking at insects on the water's surface. As the disease progresses to its final stages, Ich-infected fish may appear increasingly lethargic and refuse to eat (Durborow *et al*., 2000). The treatment of *I. multifiliis* poses significant challenges due to its unusual life cycle, which includes of multiple stages. Additionally, the life cycle

pattern of *I. multifiliis* is influenced by temperature, making it even more difficult to effectively treat using single doses or therapeutic agents (Murphy & Lewbart, 1995; Wang, 2019). In both laboratory and field settings, various drugs have been found for managing *I. multifiliis* (Ruider et al., 1997). Malachite green stands out among them as an important treatment alternative for treating ectoparasites in fish. It has been proposed that, in more severe instances, a combination of formalin and malachite green could be advantageous due to their synergistic effects. The objective of this study is to identify the cure for white spot (*Ichthyophthirius multifiliis)* in Rainbow Trout, by employing various treatment methods within a regulated environment.

MATERIALS AND METHOD

The research was carried out at the Rainbow Trout Fishery Research Station in Dhunche, Rasuwa. The rainbow trout used for the research were obtained from the same research hatchery. Each raceway used in the study had dimensions of 120 × 75 × 55 cm and was filled with water to a depth of 30 cm. the average stock size of fish in Control, T_1, T_2, and T_3 was 1.423±0.002 g, 1.412±0.096 g, 1.451±0.136 g and 1.477±0.118 g respectively. The fish were fed a commercial diet containing 45% CP, twice daily, at 09:00 and 16:00 hours, at a feed rate of 3% of their body weight. Throughout the study period, fish health was monitored. We noticed white patches on the entire body surfaces during the cultural time. For a more detailed examination, samples of mucous were taken from the infected fish and scrutinized at various magnification levels with the use of an Olympus CX41 microscope.

Table 1. Combination of therapeutic agent in different treatments

Treatments	Combination of Therapeutic agents	Dose
Control	No treatment	0
Treatment 1(T1)	Salt dipping treatment	0.3 ppm
Treatment 2 (T2)	Formalin dipping	10 ppm
Treatment 3(T3)	Malachite with Formalin	0.25 ppm with 15 ppm formalin

In total, 1260 diseased fishew were transferred and distributed evenly across cement tanks, with each tank holding 315 fish. This procedure was repeated three times, and the fish were subsequently given three different treatments. Over the course of a week, the application of chemicals was carried out on a daily basis to determine the most effective treatment. Every day, waste material was siphoned from the base of the tanks to clear away cysts. Throughout the duration of the experiment, the water quality parameters, including pH,

dissolved oxygen, and temperature, were regularly monitored and kept within the standard range. Thaat was achieved by using instruments like Dissolved oxygen analyzer and pHep meter on a weekly basis. Starting from the fourth day, an external examination of the fish was carried out to monitor any reduction in the white spots found on the infected specimens. For statistical analysis, a one-way ANOVA was performed using Genstat, with a significance level of 5%.

RESULTS AND DISCUSSION

During rearing period, white spots became noticeable on the fish's skin. Based on clinical signs, wet mount examination, and histopathological inspection, the ciliate pathogen *I.multifiliis* was identified as the cause of this disease. During the monsoon season, the water in our farm typically becomes muddy, and there's a significant drop in temperature compared to usual levels. These conditions tend to increase the susceptibility of the fish to disease. Fishes that were infected demonstrated various symptomatic behaviors. These included frenzied swimming and the tendency to scrape their bodies against the tank walls. They were observed gasping at the water's surface and gradually became less active. Ultimately, they ceased their intake of food, a set of behaviors that aligns with the symptoms reported by Mamun (2020). Upon examination of the skin, gills and fins of the infected fish, trophonts measuring between 0.3 and 0.09 mm were detected.

Table 2. Water quality parameter of the research tank and survival of rainbow trout fingerlings in different treatment trials

Parameters	Units	Average			
		Control	T1	T2	T3
Dissolved Oxygen	Mg/L	8.2±0.4	8.4±0.5	8.4±0.5	8.5±0.6
Temperature	℃	14.5±1.6	14.5±1.7	14.4±1.8	14.5±1.8
pH		8	8	8	8
Survival	%	26.33^{d}	52.78^{c}	62.38^{b}	82.53^{a}

Note: Different superscripts (a,b,c,d) in a column vary significantly ($P<0.05$). Data expressed as Mean±SE

The findings of the present study suggested a significant difference in the survival rates of fingerlings across the control group (C1) and the T1, T2, and T3 treatment groups ($P<0.05$). The highest survival rate among the fish was observed in the T3 group, which was treated with a combination of malachite green and formalin. Conversely, the lowest survival rate was noted in the group where no chemicals were used.

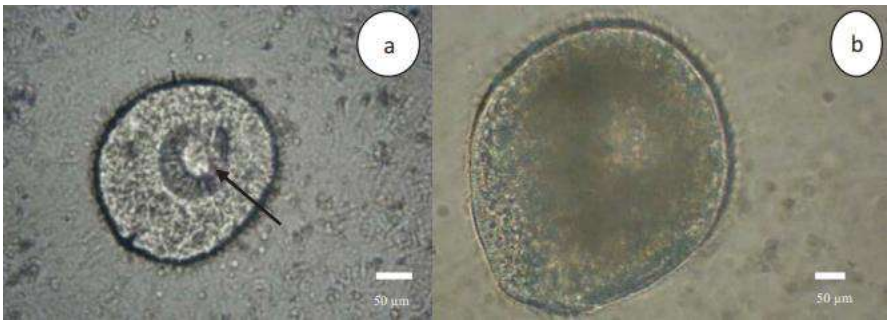

Figure 1. (a) C-shaped macronucleus in a mature trophont of *I. Multifiliis.* (b). The C-shaped nucleus was not visible in all parasites. Wet mount of a skin scraping

Various chemicals, such as malachite green, malachite green mixed with either salt or formalin, formalin alone, chloramine-T, potassium permanganate, and copper sulphate, have been experimented with in the efforts to prevent ichthyophthiriasis (Straus and Griffin, 2002). Malachite has been found to be the most effective treatment for white spot disease among these chemicals (Tieman and Goodwin, 2001). However, multiple studies have found that malachite green has a deleterious effect on fish. As a result, finding an alternative to malachite green is critical.

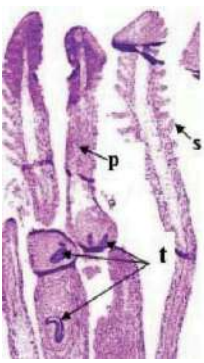

Figure 2: (A) Histological section through trophont (t). Mature trophonts of *I.mutifiliis* in the gills (C-shaped nucleus; arrow) p= primary gill lamella; s= secondary gill lamella.

CONCLUSION

In conclusion, the parasitic disease Ichthyophthiriasis, caused by *Ichthyophthirius multifiliis*, poses a significant threat to the aquaculture of

Rainbow Trout (Oncorhynchus mykiss) - a species with high commercial value. Our study revealed that a combination of malachite green and formalin was the most effective treatment in managing this disease, achieving the highest survival rate among the tested therapeutic agents. However, prior research had indicated potential negative side effects of malachite green on fish health, emphasizing the necessity of finding safer, alternative treatments. Continued exploration into effective and sustainable treatments for diseases in aquaculture is vital for the growth of this industry and to ensure the health and survival of species like the rainbow trout.

REFERENCES

Azimzadeh, K., (2020) Ichthyophthiriasis (White Spot disease) alters plasma levels of Homocysteine, Heat Shock Protein-27, Cholinesterase, Adenosine deaminase and some blood parameters in Rainbow Trout (Oncorhynchus mykiss W., 1792). *Turkish Journal of Fisheries and Aquatic Sciences*, *20*(11)

Buchmann, K., Nielsen, T., Mathiessen, H., Marana, M.H., Duan, Y., Jørgensen, L.V., Zuo, S., Karami, A.M. and Kania, P.W., (2022) Validation of two QTL associated with lower Ichthyophthirius multifiliis infection and delayed-time-to-death in rainbow trout. *Aquaculture Reports*, *23*, p.101078

CFPCC. (2020). *Anual Report* . Central Fisheries Promotion aand Conservation Center, Dept of Livestock Services, MoALD

Chen, H., Wang, Y., Zhang, J. and Bao, J., (2021) Intestinal microbiota in white spot syndrome virus infected red swamp crayfish (Procambarus clarkii) at different health statuses. *Aquaculture*, *542*, p.736826

Durborow, R.M., Mitchell, A.J. and Crosby, M.D., (2000) *Ich (White Spot Disease)*. Southern Regional Aquaculture Center

Gurung, T.B., (2010) Rainbow trout: precious souvenir from Japan, Milan. *37th Annual Issue*, pp.15-17

Gurung, T.B., Wagle, S.K., Nepal, A.P. and Lamsal, G.P., (2014) Emerging trends of rainbow trout (Oncorhynchus mykiss) aquaculture in Nepal Himalaya, *Nepalese Journal of Biosciences*, *4*(1), pp.7-15

Hare, GM and Fransi, C., (1974) Abundance and potential pathology of parasites infecting salmonids in Canadian maritime hatcheries, *Journal of the Fisheries Board of Canada* , *31* (6), pp.1031-1036

Kayis, S., Capkin, E. and Altinok, I., (2009) Bacteria in rainbow trout (Oncorhynchus mykiss) in the Southern Black Sea Region of Turkey-a survey

Kibenge, F.S., (2019) Emerging viruses in aquaculture. *Current opinion in virology*, *34*, pp.97-103

Mallik, S.K., Shahi, N., Das, P., Pandey, N.N., Haldar, R.S., Kumar, B.S. and Chandra, S., (2015) Occurrence of Ichthyophthirius multifiliis (White spot) infection in snow trout, Schizothorax richardsonii (Gray) and its treatment trial in control condition. *Indian Journal of Animal Research*, *49*(2), pp.227-230

Mamun, M.A.A., Nasren, S., Srinivasa, K.H., Rathore, S.S., Abhiman, P.B. and Rakesh, K., (2020) Heavy infection of Ichthyophthirius multifiliis in striped catfish (Pangasianodon hypophthalmus, Sauvage 1878) and its treatment trial by different therapeutic agents in a control environment. *Journal of Applied Aquaculture*, *32*(1), pp.81-93

Mukherjee, S.C., (2002) Fish diseases in India, their causes and control measures-Winter school on recent advances in diagnosis and management of diseases in mariculture, 7th to 27th November 2002, Course Manual

Murphy, K.M. and Lewbart, G.A., (1995) October. Aquarium fish dermatologic diseases. In *Seminars in Avian and Exotic pet medicine* (Vol. 4, No. 4, pp. 220-233). WB Saunders

Nepal, A.P., Sharma, S., Bhujel, R.C. and Bahadur, T., (2021) Condition factor, growth performance, and production of Rainbow trout (Oncorhynchus mykiss) in floating cages in a shallow reservoir in Panauti, Nepal: A preliminary study

Noga, E.J., (2010) *Fish disease: diagnosis and treatment*. John Wiley & Sons

Olsen, A.B., Hjortaas, M., Tengs, T., Hellberg, H. and Johansen, R., (2015) First description of a new disease in rainbow trout (Oncorhynchus mykiss (Walbaum)) similar to heart and skeletal muscle inflammation (HSMI) and detection of a gene sequence related to piscine orthoreovirus (PRV). *PloS one*, *10*(7), p.e0131638

Ruider, S., Schmahl, G., Mehlhorn, H., Schmidt, H. and Ritter, G., (1997) Effects of different malachite green derivatives and metabolites on the fish ectoparasite, Ichthyophthirius multifiliis, Fouquet 1876 (Hymenostomatida, Ciliophora), *European Journal of Protistology*, *33*(4), pp.375-388

Straus, D.L. and Griffin, B.R., (2002) Efficacy of potassium permanganate in treating ichthyophthiriasis in channel catfish. *Journal of Aquatic Animal Health*, *14*(2), pp.145-148

Tieman, D.M. and Goodwin, A.E., (2001) Treatments for ich infestations in channel catfish evaluated under static and flow-through water conditions. *North American journal of aquaculture*, *63*(4), pp.293-299

Wang, Q., Yu, Y., Zhang, X. and Xu, Z., (2019) Immune responses of fish to Ichthyophthirius multifiliis (Ich): A model for understanding immunity against protozoan parasites, *Developmental & Comparative Immunology*, *93*, pp.93-102

Yulin, J., 1996. A review of traditional and innovative aquaculture health management in the People's Republic of China, *FAO Fisheries Technical Paper (FAO)*

Zhang, Q., Chen, D. and Liu, Q., (2009) Protective immunity of goldfish against Ichthyophthirius multifiliis infection induced by different trophont vaccine preparations. *Journal of the World Aquaculture Society*, *40*(4), pp.561-566

A Study on Helminth Infestation of Equines in Kathmandu, Nepal

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ABSTRACT

A study on helminth infestation in equines of Kathmandu valley was conducted from March to mid May 2021. A total of 83 randomly selected fecal samples were collected for this study. The samples were examined qualitatively by sedimentation and floatation method. Out of 83 samples, 23 samples were found positive and revealed the occurrence of 27.71%. Overall Nematodal infestation was found rather than Trematodal and Cestodal. Among nematodes helminth eggs; the highest prevalence was of Parascaris equorum 22.89% (19/83) followed by Strongyloides spp. 3.61% (3/83) and Strongyles spp. 1.20% (1/83). Occurrence of parasite in different management and working condition were found to be brick kiln (18.07%), Nepal army army cavalary (6.02%), Donkey sanctuary (3.61%) Nepal police (0%) with significant association between work load of equine and prevalence of helminth parasite. Prevalence was higher in Horse (38%) than Donkey (22.22%) and Mule (8.33%) with significant association between Horses and Mules. Higher occurrence of helminth infestation was found in male (28.57%) than female (26.47%) with no significant association between sex of equine and prevalence of helminths. The population was divided into young, adult and old aged group with higher occurrence in young animals (76.92%) than adult age group of animals (12.19%) and old animals (34.48%) with significant association between young and old age groups.

Keywords: Equine, helminth, parasites, nematodes,

INTRODUCTION

Equine endoparasites have been divided into three categories: Nematodes or roundworms, Cestodes or tapeworms and Trematodes or flukes. Parasites are arranged in these categories on the basis of their morphology, growth and lifecycle pattern which are distinct from those of other groups. The nematodes roundworms are the most economically important endoparasites in equines (Khan et al, 2015). Equids get parasitic infection when they are grazing in

contaminated open grass field and nearby rivers and through intermediate hosts such as Orbatid mites. Parasitic helminths are one of the most common factors that constrain the health and working performance of donkeys and horses worldwide. They cause various degrees of damage depending on the species and number at present, nutritional and the immune status of equids. Gastrointestinal parasitism is a major cause of economic loss in equine husbandry (Asefa *et al*., 2011). The limiting of gastrointestinal parasitism has seem to be improved the production, reproduction and performance of horses in the study areas. Parasitic infestation decreases production and productivity mainly decreasing body weight or failure to gain weight. Very few studies had been conducted in the study area. Thus, a need is felt to conduct a study regarding parasitic prevalence which gives the suggestive guideline for its control furthermore, this study was conducted within a limited period among the limited equine population of the area. It provides only a fair idea on the prevalence however, all efforts has made to fulfill the objective of study.

MATERIALS AND METHODS

Study site

Site of sample collection Kathmandu valley lies between the latitudes 270 32' 13" and 270 49' 10" north and longitudes 850 11' 31" and 850 31' 38" east. It covers an area of about 667 sq. km and its mean elevation is about 1350 m.a.s.l. The cross section of the Kathmandu Valley that is oval in shape is about 20 km from north to south and 30 km from east to west. (Regmi, 2010) The climate of Kathmandu is subtropical cool temperate with maximum of 36.5°C in April and minimum of -3°C in January and 75% annual average humidity. The average rainfall is 1400 millimeter most of which falls during June to August. The total area of Kathmandu is 899 square kilometer comprising of three districts Kathmandu, Bhaktapur, Areas with different purpose of rearing of equids in Kathmandu, Nepal were selected as site of study: Nepal Army cavalry, Nepal police, Animal Nepal donkey sanctuary and Brick kilns of Kathmandu from March to mid-May (spring) 2021.

Site profile

Nepal Army and Nepal Police: The Nepal Army owns the greatest number of horses in Nepal with 110. At the Nepal Cavalry grounds, located on the former site of the royal palace in Kathmandu, Nepal's capital, riders spend time bonding with the horses. Every day, the soldiers bathe, groom and feed the horses, which are raced and tested to check their skills and ability. As per Kandel, 2019, the animals now have a largely ceremonial role, as mechanized transport takes over military and civilian roles of the animals. In Nepal Police canine division, there

were 10 horses of two breeds thourough and country bred used in traffic management. In Nepal Police and Nepal Army cavalry equines are well managed by caretakers and provided with proper health care and treatment by professionals.

Animal Nepal Donkey Sanctuary: Donkey sanctuary located at Dukuchaap provides shelter to discarded, old and handicapped equines. They are provided with good nutrition and necessary treatment. There were 20 equines (7 Horses, 4 Mules, 9 Donkeys).

Brick kilns: There are more than 500 brick factories in Nepal which falls under small/cottage industry despite the investment being very large. It is a seasonal industry with seasonal opportunity. (Anon, 2007) About 1000 equines are employed in brick kilns. Every year around 25 donkeys die from exhaustion. There are more than 125 brick kilns in Kathmandu valley. After off season May-December equines are brought to the brick kilns in Kathmandu valley from Nepalganj. The working equines are underfed, overworked, over loaded. As a major treatment deworming adopted in 15 brick kilns of Kathmandu covering 585 working animals (Animal Nepal, 2015).

Management system

Nepal army and Nepal police: At the Nepal Cavalry equines are trained and are raced to check their skills and ability. Every day the soldiers bathe, groom and feed the horses daily. There are more than 200 caretakers for equines. A separate stall was provided to each animal. They were given grams, straw, mesh, oats. There was availability of bedding in the stalls bedding was changed daily. Stables were properly cleaned and managed daily. Equines were provided with proper health care and treatment by professionals. The equines were dewormed yearly. In Nepal Police equines were well managed by caretakers and provided with proper health care and treatment by professionals. A separate stall was provided to each animal which was facilitated with individual manger and water trough. Roofing was made of galvanized steel. Flooring was cemented. There was availability of straw bedding in the stalls, bedding was changed daily. Stables were properly cleaned and managed daily. Deworming was not practiced.

Brick kilns: The animals were raised in loose housing system and all animals were kept in a single shed at night. The equines work for as long as daylight, hauling loads of bricks from place to place. Deworming was practiced once yearly.

Animal Nepal Donkey Sanctuary: Donkey sanctuary provides shelter to discarded, old and handicapped equines. They were provided with good nutrition and necessary treatment. Deworming was done once yearly.

Sampling of animals

Random sampling techniques were used to select the animals for collection of fecal sample in this study. Samples were collected per-rectally using surgical gloves or collected opportunistic fresh fecal samples. Collected sample were kept in labelled, individual, clean sample collecting plastic zip lock bags each sample was labeled with description of the animal which include: name, species, age, sex. It was preserved with an equal volume of 5%-10% buffered formalin for fixation of samples. (Hendrix, 2006) Collected fecal samples were stored inside refrigerator at 4°C until the time of examination if processing was not possible to prevent the development and hatching of the egg. (Kassa, et al., 2016) The plastic bags were kept in ice box and transported to parasitology lab of HICAST for laboratory examination.

Qualitative fecal examination

The qualitative parasitic investigation was carried out through the fecal examination by sedimentation and passive floatation parasitological techniques. Then examined microscopically for presence of parasite and identification of the eggs was made on the basis of their morphology.

Sedimentation method

Principle: this technique concentrates eggs in the sediment and is primarily used to detect eggs or cysts that have too high specific gravity to float or these would be severely distort by flotation solution. Sedimentation procedures concentrate both feces and eggs at the bottom of liquid medium, usually water. Sedimentation can be used for round worm and tape worm eggs. (Kassa D, et.al. 2016). About 3 gm of grinded fecal sample was placed in 100 mL beaker and water added. The mixture was poured through a tea strainer and the material left in the strainer discarded. After 25 minutes supernatant discarded and refilled with fresh water until the supernatant was clear. Then sediment left in bottom was examined under microscope (Urquhart et.al, 1996).

Flotation method: Principle: Most parasite eggs have a specific gravity between 1.1 and 1.2 g/ml whereas tap water only slightly higher than 1 g/ml. parasite egg can float in a liquid with a higher specific gravity than that of the egg has (Christie, 2011).

Differential flotation method

About 3 gm of grinded fecal sample was placed in 100 mL beaker and water added. The mixture was poured into another beaker through a tea strainer and the material left in the strainer discarded. After 25 minutes supernatant discarded and refilled with fresh water 2-3 times until the supernatant being cleared/fresh. Then, the sediment content mixed with 10-20 times of its volume of Flotation solution: Saturated salt 305g NaCl Solute in 1000 ml tap water as solvent with 1.18-1.2 specific gravity (Dryden, et al., 2005). It will be allowed to stand in a specimen tube for 30 minutes. The surface touched with cover slip and transferred to a grease free slide and examined under microscope (Urquhart, 1996).

Data analysis

The collected sample data was entered into Microsoft excel 2016. Descriptive statics percentage was used to determine the prevalence of GIT helminth, presentation was done in bar-graph, pie-chart and tables using Microsoft Excel 2016. Data analysis on the relation to management practices and helminth parasites seen in fecal sample was carried out in and open-epi. Chi- square ($\chi 2$) was used to look into the association of between prevalence of GIT helminths with breed, sex and age of equids. In this analysis, confidence level was held at 95% and p-value <0.05 was set for significance.

RESULTS

Prevalence of helminth parasites

Out of 83 randomly selected samples from equines of Kathmandu 23 samples were found positive for different helminth eggs with overall prevalence of 27.71% and 72.29% negative (Figure:1). Helminth eggs found in the fecal examination were of nematode. Different species of nematode helminths were revealed from fecal examination they were *Strongyloid* sp., *Trichostrongylus* sp., *Parascaris equorum* where *Parascaris equorum* showed highest prevalence 22.89% (19/83) followed by *Strongyloid* sp. 3.61% (3/83) and in *Trichostrongylus* sp 1.20% (1/83).

Occurrence of helminth parasites in between different management and rearing conditions

Brick kilns 18.07% (15/33), Nepal army cavalry 6.02% (5/20), donkey sanctuary 3.61% (3/20), Nepal police 0% (0/10) (figure: 2). Where deworming was done yearly in the brick kilns, Nepal army cavalry and Donkey sanctuary where work load and working hour was higher for equines working in brick kilns and Nepal

army cavalry work load was lower for equines of Nepal police and donkey sanctuary.

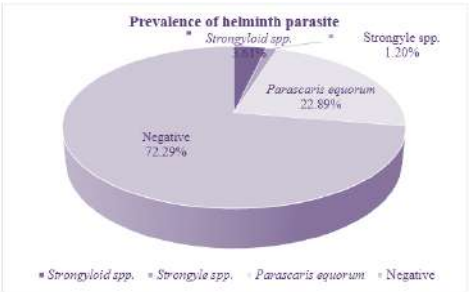

Figure 1. Prevalence of helminth parasite in sampled population

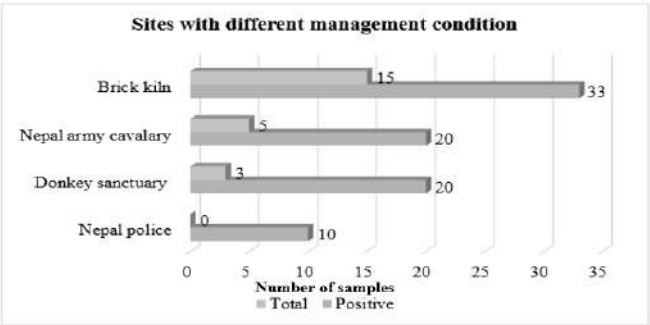

Figure 2. Occurrence of helminth in different management sites

From table 3, we see that there is significant association between prevalence of helminth and management in brick kiln and donkey sanctuary P value = 0.02 which is < 0.05 i.e. Accept alternative hypothesis.

From table 2 and 3 we found no significant association between different site and prevalence of parasite. It was found that there was significant association between workload of equine and prevalence of helminth parasite (Table 3).

Table 1. 2 by 2 table for association between sites: Brick kiln and Donkey sanctuary and its prevalence

Site	Positive	Negative	P value	Significance
Brick kiln	15	18	0.02591	95%
Donkey sanctuary	3	17		

Table 2. 2 by 2 table for association between sites: brick kiln and army cavalry and parasite prevalence

Site	Positive	Negative	P value	Significance
Brick kiln	15	18	0.1506	95%
Army cavalry	5	15		

Table 3. 2 by 2 table for association between sites: Army cavalry Donkey sanctuary and parasite prevalence

Site	Positive	Negative	P value	Significance
Army cavalry	5	15	0.4649	95%
Donkey sanctuary	3	17		

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Equine species wise prevalence of helminths

Out of 50 samples from Horse 19 (38%) were found positive. Out of 9 samples of Donkey 2 were found positive with (22.22%) prevalence. Out of 24 samples of Mules (8.33%) were found positive (Figure 3).

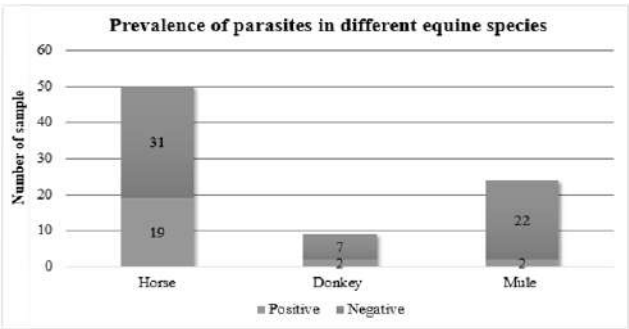

Figure 3. Equine species wise prevalence of helminth

On calculation, it was found that there was significant association between equine species Horse and Mule in prevalence of helminth parasite (table 4).
Sex wise prevalence of helminth parasites.

Table 4. 2 by 2 table for association between Equine species and prevalence

Equine species	Positive	Negative	P value	Significance
Horse	19	31	0.007124	95%
Mule	2	22		

P value= 0.0071which is <0.05 so Accept alternative hypothesis

The sex-wise prevalence in total sampled 49 males 28.57% (14) were positive which and in total sampled 34 females 26.47% (9) were positive (Figure 4).

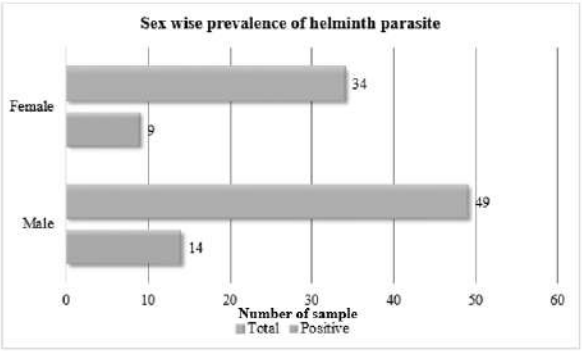

Figure 4. Sex-wise prevalence of helminth parasite

On calculation, it was found that there was no significant association between gender of equine and prevalence of helminth parasite (Table 5).

Table 5. 2 by 2 table for association between sex and prevalence

Sex	Positive	Negative	P value	Significance
Female	9	25	0.8434	95%
Male	14	35		

P value= 0.84 which is >0.05 i.e. Accept null hypothesis

Age wise prevalence of helminths

The total population was divided into three groups according to age grouped into young as less than or equal to 5 years, adult 5-10 years, and old above 10 years. In 13 young; 10 were tested positive (76.92%), in 41 adult; 5 were positive (12.19%) and among 29 old aged; 8 were positive (34.48%).

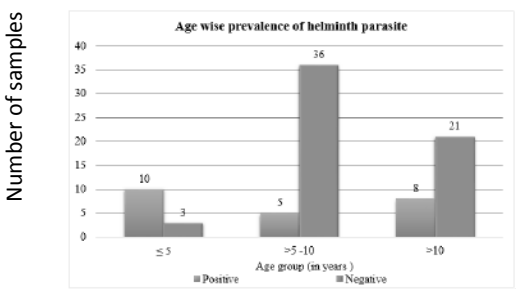

Figure 5. Age-wise prevalence of helminth parasites

It was found that there was no significant association old and adult equine in prevalence of helminth parasite (Table 6).

Table 6. 2 by 2 table for association between age and prevalence

Age group	Positive	Negative	P value
Old	8	21	0.1208
Adult	5	36	

P value 0.1208 which is > 0.05 i.e. Accept null hypothesis

Table 7. 2 by 2 table for association between age and prevalence

Age group	Positive	Negative	P value
Young	10	3	0.004195
Old	8	21	

P value =0.004195 which is < 0.05 i.e. Accept alternative hypothesis.

It was found that there was significant association between age group young and old in prevalence of helminth parasite (Table 7).

DISCUSION

In the present study, the prevalence of gastro-intestinal helminth parasites of equine was (27.71%) (23/83) which is lower than reported previously in the different districts of Nepal Kathmandu, Rukum and Manang districts lower than reported previously by Khatri (2016) (63.33%) (114/180) in Kathmandu, (49.04%) (Dangol, 2012) in Kathmandu district, (51.81%) of 110 samples (Marasini, 2010) in Manang and Kathmandu, 45 % (Sapkota, 2009) in Lalitpur and 72.80% (Belay and Teshome, 2016) in Kombolcha, Ethiopia, (65.5%) (Saeed *et al.,* 2010) in Lahore, (84%) in Schimoga of Karnataka (Adeppa *et al.*,2016). The lower prevalence rate of present study could be due to improved management and yearly deworming practice. The differences among these findings from different regions might be due to variation in management system, geo-graphical climatic condition, sample size, sample collection period and sampling method differences.

There was significant association between equine species Horse and Mule in prevalence of helminth parasite in this study. Horses (38%) (19/50) lesser in Donkeys (22.22%) (2/9) and Mules (8.33%) 2/24 Donkeys were more infested than Mules. The species-wise analysis this study showed greater occurrence in Horses 19/50 (38%) than (Khatri, 2016) (43.33%) (26/60). Lower percentage of Mules (8.33%) were found positive in this study whereas parasitic prevalence in mules of Lalitpur was higher (45%) (Sapkota, 2009). Prevalence was lesser in Donkey 22.22% (2/9) prevalence than (51.81%) in 110 samples (Marasini, 2010). The overall prevalence of gastrointestinal parasites was 73.2% (281 from 384) with 57.0% (73 from 128), 82.5% (160 from 194) and 77.4% (48 from 62) in horses, donkeys and mules respectively in the study of Belay and Teshome

(2016) which is greater occurrence than this study. Unlike this study where Horses were more infested , Donkeys and Mules were more infested as compared to horse in (Dangol, 2012) This might be due to difference in sample size, difference in species-wise prevalence of helminths. This could also be due to the ability of the equine species to work carry load.

This study showed higher infection rate in male horses 49 male (28.57%) than in females (26.47%) out of 34 similar to (Oli and Subedi, 2018) with higher infection rate in females (92.30%) than in male horses (82.27%) with no significant association observed between the prevalence of parasite rate with sex of animals in which also not seen in study of (Belay and Teshome, 2016). Similarly, Females (59.30%) had higher prevalence than males (40.70%) in (Marasini, 2010) whereas, (Khatri, 2016) study showed a higher prevalence in males (66.66%) than in females (57.57%).

In this study, Higher prevalence was seen young (76.92%) and old aged (34.48%) than adult (12.19%). There was significant association was found between age groups young and old in prevalence of helminth parasite. In (Dangol, 2012)Young and adult animals showed high infestation. (Marasini, 2010) Highest prevalence was seen in animals of old age (Sapkota, 2009) highest prevalence seen in the animals of age group 11 years and above. This could be due to development of immunity and resistant of old animals, and parasites spreading to young aged animals. This could also be due to the ability of different age group of equines to work carry load.

In this study, helminths Trematode and Cestode parasites were not observed only nematode were observed Nematode (27.71%) 23/83. Nematode infestation was also found higher by Dangol (2012), infestation was seen high in (Khatri, 2016) (55.55%) nematodes 100/180. Whereas, in (Febriyanti et al., 2019) study the prevalence of nematodes was lower (12.03%).

Different nematode helminths were revealed from fecal examination of the *Strongyloid* sp., *Trichostrongylus* sp., *Parascaris equorum.* Where *Parascaris equorum* showed highest prevalence 22.89%, then 3.61% *Strongyloid* sp and lowest prevalence was seen in strongyle, *Trichostrongylus* sp 1.20%. *Parascaris equorum* in this study was higher than Oli and Subedi (2018) (10.47%) and (Hinney *et al*., 2010) ascarids 16.7%. Lower prevalence 3.1%, 8.6%,12.9%, in horses, donkeys, and mules respectively in Belay and Teshome (2016). In this study 3.61% *Strongyloid* sp were observed i.e. lower than (Hinney *et al*., 2010) (4.0%), and 38.59% (Khatri, 2016). In this study *Trichostrongylus* sp 1.20%.i.e.

lower than (Oli and Subedi, 2018) in seven Village Development Committee (VDC) of Rukum *Trichostrongylus* sp. (14.28%). (Oli and Subedi, 2018) Strongylus sp. showed the highest prevalence (51.42%), (Saeed *et al.*, 2010) in Lahore 117/200 (58.5%) The differences among these findings from different regions might be due to variation in management system, geo-graphical, climatic condition, sample size, sample collection period and sampling method differences.

CONCLUSION

From equines investigated Nematodal infestation was found rather than Trematodal and Cestodal. The prevalent species were *Parascaris equorum*, *Strongyloides* spp., Strongyles spp. Among them *Parascaris equorum* showed the highest prevalence followed by *Strongyloides* spp. and Strongyles spp. Prevalence was higher in Horses than Donkeys and Mules. Higher occurrence of helminth infestation was found in males than females. The population with higher occurrence was in young animals than adult and old animals age group of animals.

Statistically, there was significant association between workload and prevalence of helminth parasite, there was significant association between equine species horse and mules, age (young and old), in prevalence of equine gastrointestinal helminth parasites ($p<0.05$). However, there was no statistically significant association in prevalence of gastrointestinal parasites based on age (young and adult) and sex (male and female).

SUGGESTIONS

This finding might be considered while designing control strategies of gastro-intestinal equines and ruminants as well. It is necessary to improve animal management system for reduction of parasites. In equids regular anthelmintic administration and performing routine fecal egg counts must be done to determine the efficacy of treatment and control programs. Anti-helminthic should be chosen conscientiously and their use should be rotated slowly to decrease the occurrence of resistance.

- It is recommended that all animals deworm at the same time, deworm newcomers on arrival should isolate for quarantine period
- Determining the weight of the animal for anti-helminthic administration.
- Along with deworming removal of manure from all areas regularly every 24–72 hour.
- Sufficient feed supply as nutrition plays a crucial role to increase resistance for parasitic infestation of the host.

- Balancing of the work load and duration. They should not be forced to carry loads more than the general rule i.e.1/3rd of their body weight.
- Sick animals should be given proper attention and treatment.
- It is recommended to deworm all equines every three months, full dose with broad spectrum anti-helminthics where working hours and load is high as the continuous heavy work makes them feeble and immunocompromised.
- Cross-graze pastures with other species such as cattle, sheep, and goats.
- Regular checking of the efficiency of deworming for worm egg counts.

REFERENCES

Adeppa, J.; Ananda, K. J.; Krishna C. M. and Satheesha, G.M., (2016). Incidence of gastrointestinal parasites in horses of schimoga region, Karnataka state. *J. Parasit. Dis.* 40, 919–921.

Animal Nepal, (2015). *Annual report 2015* [WWW Document]. *Anim. nepal*. URL https://animalnepal.files.wordpress.com/2012/01/an_ar_2015.pdf (accessed 6.22.21).

Animal Nepal, (2009) *BEASTS of BURDEN Equine Abuse in Nepalgunj* [WWW Document].

Anon, (2007) *Labour under the chimney, a study on the brick klins of Nepal*. GEFONT.

Belay, W., Teshome, D., (2016). Study on the Prevalance of Gastrointestinal Helminthes Infection in Equines in and around Kombolcha. *J. Vet. Sci. Technol*. 7. https://doi.org/10.4172/2157-7579.1000372

Christie, J., Schwann, E. V., Bodensteie, L.L., Sommerville, J. E. M. and Vandermerwe, L.L., (2011). *The sensitive of direct fecal examination, direct fecal flotation*, modified centrifugal fecal flotation, centrifugal sedimentation in the diagnosis of canine Spirocercosis.

Dangol, S., (2012). study on helminth infestation in equines of kathmandu valley.

Dryden, M. W., Payne, A. A., Ridley, R. and, Smith, V., (2005). Comparison of common fecal flotation techniques for the recovery of parasitic eggs and Oocyst,. *Vet Ther* 6, 15–28.

Febriyanti, S.P., Suwanti, L.T., Hestinah, E.P., Koesdarto, S., Setiawan, B., Kusnoto, K., (2019). Prevalence and Intensity of Nematode Infection on The Crossbreed Horse in Detasemen Kaveleri Berkuda Parongpong Bandung West Java. *J. Parasite Sci.* 3, 27. https://doi.org/10.20473/jops.v3i1.16430

Foreyt, W.J., (2001). Veterinary parasitology reference manual, Journal of Equine Veterinary Science. https://doi.org/10.1016/s0737-0806(01)80018-6

Hendrix, C.M., (2006). *Diagnostic parasitology for veterinary technician*., 3rd Ed. China.

Hinney, h., Wirtherle. N.C., Kyule, M., MIETHE, N., Zessin, K, H, AND Clausen, P.H., (2010). Prevalence of helminths in horses in the satte of Brandenburg, Germany. Parasitol. Res. 108, 1083–1091.

Kandel, P., (2019). Developing a horse sense in Kathmandu | Nepali Times [WWW Document]. nepali times. URL https://www.nepalitimes.com/banner/developing-a-horse-sense-in-kathmandu/ (accessed 6.22.21).

Kassa D, Mengestie A, Ayalew N, Belaynew A, Mebrie Z, M.T., 2016. A Review on Diagnostic Techniques in Veterinary Helminthlogy. Nat. Sci. 14, 109–118. https://doi.org/10.7537/marsnsj140716.15.Key

Khan, M.A.; Roohi, N. and Rana, M.A.A., (2015). Strongylosis in equines: A review. *J. Anim. Plant Sci.* 25, 1–9.

Khatri, B., (2016). Study on helminth infestation in equines of Kathmandu valley. Purbanchal University.

Lin, Z., (2017) Equus | Nepali Times Buzz | Nepali Times [WWW Document]. nepali times. *URL http://archive.nepalitimes.com/article/Nepali-Times-Buzz/Equus*-in-brick-kilns-kathmandu,4085 (accessed 6.22.21).

Marasini, (2010) *Prevalence of helminths in the donkeys of Kathmandu and Manang district.* Purbanchal University.

MOALD, (2017) *Statistical Information in Nepalese Agriculture*. Minist. Agric. Livest. 290.

Moure, Z., Zarzuela, F., Espasa, M., Pou, D., Serre-Delcor, N., Treviño, B., Bocanegra, C., Molina, I., Pumarola, T., & Sulleiro, E., (2017). Dicrocoelium dendriticum: An Unusual Parasitological Diagnosis in a Reference International Health Unit. *Am. J. Trop. Med. Hyg*. 96, 355–375. https://doi.org/https://doi.org/10.4269/ajtmh.16-0549

Ola-Fadunsin, S.D., Daodu, O.B., Hussain, K., Ganiyu, I.A., Rabiu, M., Sanda, I.M., Adah, A.S., Adah, A.D., Aiyedun, J.O., (2020). Gastrointestinal parasites of horses (*Equus caballus* Linnaeus, 1758) and risk factors associated with equine coccidiosis in Kwara and Niger States, Nigeria. Sokoto *J. Vet. Sci*. 17, 35. https://doi.org/10.4314/sokjvs.v17i3.6

Oli, N., Subedi, J.R., (2018) Prevalence of Gastro-Intestinal Parasites of Horse (Equus Caballus Linnaeus, 1758) In Seven Village Development Committee of Rukum District, Nepal. *J. Inst. Sci. Technol*. 22, 70–75. https://doi.org/10.3126/jist.v22i2.19596

Pant, P.R.and Dangol, D., (2009). Kathmandu Valley Profile. J. Gov. Infrastruct. Dev. challenges Kathmandu Val. 4.

Regmi, S., (2010). *Renewable energy potential and environmental issues in Nepal*. T.U., Kirtipur, Kathmandu.

Regmi, S., Adhikary, S., (2016). Solar Energy Potential in Kathmandu Valley, Nepal. *J. Hydrol. Meteorol.* 8, 77–82. https://doi.org/10.3126/jhm.v8i1.15576

Saeed, K. Ashraf, K. and Ahmad, N., (2010) Role of intrinsic and epidimological factors on strongylosis in horses. *J. Anim. plant Sci*. , Lahore 20, 277–280.

Sapkota, R. chandra, (2009). *Report on Prevalence of Helminths Parasites in Mules of Brick Kiln of Lalitpur District*.

Sazmand, A., Bahari, A., Papi, S., Otranto, D., (2020). Parasitic diseases of equids in Iran (1931–2020): a literature review. *Parasites and Vectors* 13, 1–19. https://doi.org/10.1186/s13071-020-04472-w

Taylor, M.A., Coop, R.L. and Wall, R.L. (2007). *Text book of veterinary parasitology*, 3rd editio. ed. Blackwell publishing Ltd. Oxford, U.K.

Thienpont , D., Rochette, F., and Vanparijs, O.F.J., (1986). *Diagnosis of helminthiasis by coprological examination.* Jansen Res. Found. Besee, Begium 2nd editio.

Urquhart, G. M., Amour, J. L., Dunn A. M, A., Jennings, F.G., (1996). *Veterinary parasitology*, 2nd ed. US. ed. Black well science.

Zajac, A.M., Conboy, G.A., (2007). Veterinary Clinical Parasitology, 7th ed. Edition, Eighth, *The Canadian Veterinary Journal*. la Revue Veterinaire Canadienne Blackwell Publishing.

Economics of Tiger Nut (*Cyperus Esculentus*) Value Chain in Katsina State, Nigeria: Socio-Economic Drivers and Implications for Food Security Sustainability

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ABSTRACT

This study evaluated economics of tiger nut (Cyperus esculentus) value chain in Katsina State, Nigeria: socio-economic drivers and implications for food security sustainability. Multi-stage sampling technique was used. A total sample size of 130 tiger nut flour processors was used. Primary data were collected using structured and well-designed questionnaire. Data were analyzed using descriptive statistics, gross margin analysis, stochastic cost efficiency frontier model, and principal component model. The results show that 83.85% of tiger nut flour processors were male, while 16.15% were female. Also, 80.77% were less than 50 years of age. The mean age was 43 years. The household sizes were large with an average of 7 people per household. The tiger nut flour processing was profitable with a gross margin and net income of 740,800 Naira and 698, 950 Naira per processor per annum respectively. The factors influencing cost efficiency of tiger nut flour processing were: cost of tiger nut ($P < 0.05$), cost incurred in milling ($P < 0.01$), cost of labour input ($P < 0.01$), total output ($P < 0.05$), and annual depreciation cost on capital ($P < 0.10$). The socio-economic factors influencing cost inefficiency of tiger nut flour processing were: age ($P < 0.01$), marital status ($P < 0.05$), educational level ($P < 0.01$), processing experience ($P < 0.01$), access to credit ($P < 0.05$), cooperative membership ($P < 0.10$), and extension contact ($P < 0.10$). The mean cost efficiency score of tiger nut flour processors was 1.4161. The major constraints facing tiger nut flour processors were: lack of credit facilities, high cost of milling equipment, high cost of diesel, inadequate extension services, and bad road infrastructures. The study recommended that credit facilities should be provided, and made accessible by government for tiger nut processor at affordable interest rate. Policies should be designed by government to educate rural farmers through proper agricultural extension services. The milling equipment and diesel should be made available at affordable prices. Feeder roads should be constructed for easy evacuation of agricultural produce from producing areas to nearby market centers.

Keywords: Economics, Tiger Nut Value Chain, Tiger Nut Flour Processing, Katsina State, Nigeria

INTRODUCTION

Tiger nut (*Cyperus esculentus*) is nut a real nut but a spherical tuber, commonly cultivated in Northern Nigeria, which can be eaten fresh (raw), roasted, boiled, dried, or processed into tiger nut flour, tiger nut oil, tiger nut milk (non-alcoholic), or a fermented alcoholic drink (with some additives) along its value chain (Oladele and Aina, 2007; Bamishaiye and Bamishaiye, 2011). The waste products obtained after processing tiger nuts are used for making bioethanol or as supplements in animal feeds (Nata'ala *et al*., 2018). Studies have shown that tiger nut is a possible good source of fuel which is environmental friendly, cheaper, and safer (Wongnaa *et al*., 2019). Tiger nut milk is a healthy drink, with rich source of vitamin C, vitamin E, phosphorus, potassium, magnesium, iron, calcium, unsaturated fats, carbohydrates, protein, and enzymes which can help in digestion, it has advantage of not containing sugar, lactose, cholesterol, casein, or proteins of the milk, and is ideal for people who do not tolerate cow milk or gluten (Belewu and Abodunrin, 2006). Tiger nut flour has unique sweet taste and it is good substitute to other flour like wheat flour. Tiger nut flour is free from gluten and it is good for people who cannot take or tolerate gluten in their diets. Tiger nut flour is used as an additive in bakery industry and is used as flavoring agents for biscuits and ice creams. Tiger nut flour has in-built therapeutic and nutritional advantage and could serve as good substitute to cassava in the baking industries (Ade-Omowaye e*t al*., 2008). Tiger nut oil is stable and edible oil obtained from tiger nut tuber. Tiger nut oil is suitable for making salad. Tiger nut oil is used in the textile industry to waterproof textile fibres. Tiger nut oil compares favorably well with corn, cotton seed oil, soybean, and olive oil and can be used as an alternative for these oils when they are scarce. Tiger nut oil has low polyunsaturated fatty acid and high oleic acid. Value chain can be defined as the set of actors (which involves the public, service providers, and private) and the various value adding activities that are involved in bringing the tiger nut product from farm production to the end (final) consumers. In agriculture, value chain can be described as 'farm to end consumers' flows and set of processes (Miller and da Silva, 2007). A value chain can also be defined as the entire range of activities involved in bringing a tiger nut product from input-supply initial stage through processing phase to the final destination which is the market, these activities also includes the disposal after use (United Nations Industrial Development Organization (UNIDO, 2009). It is a chain of various activities where tiger nut products or agricultural products pass through the various activities of the chain sequences such that at each activity, the tiger nut products gain some value (Russell & Hanoomanjee, 2012). Tiger nut can also be processed into milk, oil, soap, and starch, in addition, the tubers are milled into flour and used as thickeners or mixed with

sugar to prepare biscuits (Bado *et al*., 2015; Bori *et al*., 2018). Tiger nut is a great source of starch, sugar, fat, and minerals (Ban-Koffi *et al*., 2005). Despite these great potentials, tiger nut remains a neglected and underutilized crop in the world (Bado *et al*., 2015). Therefore, finding another form in which the health and nutritional benefits of tiger nuts could be explored with high demand will encourage farmers to go into more massive production. This will decrease unemployment especially in the production, marketing and processing areas. The farmers will be able to maximize their income or revenue, this will enhance their livelihood, poverty will be eradicated and consumers will be assured of their good health.

METHODOLOGY

This study was conducted in Katsina state, Nigeria. Katsina state is located between Latitudes 11° 08′ North and 13° 22′ North and Longitudes 6° 52′ East and 9° 20′ East. The state is bounded by Niger Republic to the north, Kano and Jigawa states to the east, Kaduna state to the south, and Zamfara state to the west. There are 34 Local Government Areas in the State. The land area was 24, 235 Sq Km. The population of the state in 2006 was 5, 801, 584 people, the population projection of the state in 2016, 2019 and 2022 were 7,831,319 people, 9,300,382 people and 10,368,500 people respectively. The state extends from the tropical grassland known as the savannah to the arid zone to the north. There are two (2) main seasons, dry and wet seasons. The average temperature of the state is between 21 – 30 °C. Agriculture is the main occupation of the people. Crops produced in the state include: maize, tiger nut, guinea corn, millet, groundnut, cassava, rice, beans, sugarcane, cocoyam, cotton, and wheat. Livestock production is also a major occupation of the people.

Research design

A descriptive cross-sectional research design was employed in this study with the aim of describing the socio-economic profiles or characteristics of tiger nut flour processors, and to evaluate factors influencing cost efficiency and socio-economic factors influencing cost inefficiency of tiger nut flour processing.

Sampling techniques and sample size

A multi-stage sampling technique was adopted for this study. In the first stage, purposive sampling procedure was used to select Katsina State based of the numerous numbers and concentration of tiger nut processing in the area. The second stage involved random selection of four (4) local government area using ballot box method. In the third stage, three (3) villages were selected randomly from each local government areas (LGAs) based on the intensity of tiger nut flour processing. In the fourth stage, from sampling frame of 192 tiger nut flour

processors, proportionate and simple random sampling technique was used to select the desired sample size of 130 tiger nut flour processors. This study employed the formula earlier advanced by Yamane (1967) in the estimation and determination of the sample size. The formula is stated thus:

$$n = \frac{N}{1+N(e^2)}$$

=130……(1)

Where,

n = Desired Sample Size

N = Finite Size of the Population

e =Maximum Acceptable Margin of Error as Determined by the Researcher (5%)

Methods of data collection

The data for this study was collected through the use of structured and well-designed questionnaire. The data collected were cross sectional data from primary source, the data collected from the tiger nut flour processors were socio-economic profiles of the processors, prices of processing inputs, quantity of inputs used and constraints faced by processors in the course of tiger nut processing in the study area. Data were analyzed using the following descriptive and inferential tools:

Descriptive statistics: Data collected from field survey on tiger nut flour processors were summarized through the use of mean, frequency distributions, and percentages. Descriptive statistics was used to summarize the socio-economic profiles of tiger nut flour processors as specifically stated in objective one (i).

Gross Margin Analysis: Gross margin (GM) and net income (NI) analysis of tiger nut flour processing was estimated using the following models: $GM = TR - TVC$ ……(2) $GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j=1}^{m} P_j X_j$ ……(3)

$$NI = TR - TC \text{ ……}(4)$$

$$NI = \sum_{i=1}^{n} P_i Q_i - \left[\sum_{j=1}^{m} P_j X_j + \sum_{k=1}^{k} GK\right] \text{ ……}(5)$$

Where

P_i = Price of Tiger Nut Flour Products ($\frac{₦}{\text{Unit}}$),

Q_i =Quantity of Tiger Nut Flour Products (Units),

P_j = Price of Variable Inputs ($\frac{₦}{Unit}$),

X_j = Quantity of Variable Inputs (Units),

TR = Total Revenue obtained from Sales from Tiger Nut Flour Products (₦),

TVC = Total Variable Cost (₦),
GK = Cost of all Fixed Inputs (Naira)
NI = Net Income (Naira)
The gross margin analysis was used to analyze the profitability of tiger nut flour processing as specifically stated in objective two (ii).

Financial analysis: According to Alabi *et al.*(2020[a]), gross margin ratio (GMR) is defined as:

$$\text{Gross Margin Ratio} = \frac{\text{Gross Margin}}{\text{Total Tevenue}} \ldots\ldots\ldots\ldots (6)$$

According to Olukosi and Erhabor (2015), operating ratio (OR) is defined as:

$$\text{Operating Ratio} = \frac{\text{TVC}}{\text{GI}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where,
TVC = Total Variable Cost (Naira),
GI = Gross Income (Naira),
The financial analysis was used to analyze the profitability of tiger nut flour processing as specifically stated in objective two (ii).

Stochastic Cost Efficiency Frontier Method
Stochastic Cost Efficiency Frontier Function is stated thus:

$$\mathrm{C_i} = \mathrm{f}(\mathrm{P_i}, \mathrm{Y_i};\ \beta_j) + (\mathrm{V_i} + \mathrm{U_i});\ \mathrm{i} = 1, 2, \ldots, \mathrm{n}\ \ldots\ldots (8)$$

$$lnC_i = \beta_0 + \beta_q lnY_i + \sum_j^k \beta_j\, ln(P_{ij}) + V_i + U_i \ldots\ldots (9)$$

where, C_i is total cost of production Y_i is total output, X_{ij} are input quantities, and the P_{ij} are input prices. V_i assumed to be independently distributed random errors. The cost efficiency of individual processors is defined in terms of the ratio of the predicted minimum cost C_i^* to observed cost C_i that is

$$CE = \frac{C^*}{C_i} \ldots\ldots\ldots\ldots\ldots (10)$$

The explicit form of the stochastic cost efficiency frontier function is specified as shown below as used by Coelli *et al.* (2002), Aboaba (2020), and Bitrus *et al.* (2020) :

$$L_nC_i = \beta_0 + \beta_1 L_nX_1 + \beta_2 L_nX_2 + \beta_3 L_nX_3 + \beta_4 L_nX_4 + \beta_5 L_nX_5 + \beta_6 L_nX_6 + \beta_7 L_nX_7 + V_i + U_i\ \ldots\ldots (11)$$

LnC_i = Total Cost of Tiger Nut Flour Processing (Naira)
X_1= Cost of Tiger Nut (Naira)
X_2 = Cost of Transportation (Naira)
X_3 = Cost Incurred in Milling (Naira)
X_4 = Cost of Labour Input (Naira)

X_5 = Total Tiger Nut Output (Kg)
X_6 =Annual Depreciation Cost on Capital (Naira)
X_7 = Cost of Loading and Off-Loading (Naira)

The Cost Inefficiency Component of the Stochastic Cost Efficiency Frontier Model is stated thus:

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \cdots + \alpha_8 Z_8 \ldots\ldots\ldots (12)$$

Where,
$U_i =$ Cost Inefficiency Component
Z_1= Age of Tiger Nut Flour Processors (Years)
Z_2= Marital Status (1, Married; 0, Otherwise)
Z_3= Education Level of Tiger Nut Flour Processors (Years Spent Schooling)
Z_4= Processing Experience (Years)
Z_5= Access to Credit (₦)
Z_6= Household Size (Number)
Z_7= Cooperative Memberships (1, Member; 0, Otherwise)
Z_8= Extension Contact (Number of Contact per Month)
$\alpha_0 =$ Constant Term
$\alpha_1 - \alpha_6 =$ Regression Coefficients
$V_i =$ Random Noise

This was used to specifically achieve objective three (iii), which is to evaluate factors influencing CE of tiger nut flour processing, objective four (iv), which is to evaluate socio-economic factors influencing CIE of tiger nut flour processing and objective five (v) which is to estimate the CES of tiger nut flour processors.

Economies of scale (ES) or scale effects (SE) and return to scale (RTS): Economies of scale (ES) may be defined in terms of elasticities of cost with respect to output. According to Ogundari *et al*. (2016), and Paudel and Matsuoka (2009) who reported that in a multi-product setting, ES is defined as those reductions in cost of production of the given output level while holding all other input prices constant. Mathematically, ES is equal to the inverse of the sum of all the elasticities of total production cost with respect to all outputs included in the regression.

If, ES > 1 (Positive ES Prevails or Increasing RTS)
ES < 1 (Diseconomies of Scale Prevails or Decreasing RTS)
ES = 1 (Diseconomies of Scale or No ES Prevails or Constant RTS)

The RTS and SE are equal provided that the product is homothetic, an underlying assumption that applies to and is implicit in the Cobb-Douglas model structures (Chambers, 1988). If costs increase or rise proportionately with output, there are no ES this shows that there is constant RTS. If costs increase or rise by a greater amount than output, there are diseconomies of scale which

signifies that there is a decrease RTS, if costs increase or rise by a lesser amount than the output, there are positive ES or simply refers to as ES (economies of scale) which connotes increasing RTS. Here, the Cobb-Douglas model was used, this assumption is enacted.

Principal component analysis: The constraints facing tiger nut flour processors and militating against tiger nut processing were subjected to principal component model. This was used to specifically achieve objective six (vi).

RESULTS AND DISCUSSION

Socio-economic profiles of tiger nut flour processors

The socio-economic profiles of tiger nut flour processors under considerations were: gender, marital status age, level of education, household size, processing experience, extension contact, and membership of cooperatives (Table 1). About 83.85% of tiger nut flour processors were male, while 16.15% were female. The distributions of marital status show that 53.84% were married, 33.08% were single, while 13.08% were divorced. Furthermore, 80.77% of tiger nut flour processors were less than 50 years of age. The age distributions include: 31 – 40 years (36.15%), 41 – 50 years (44.62%), and 51 – 60 (19.23%) (Figure 1). The mean age of tiger nut flour processors was 43 years. This implies that tiger nut flour processors were young, active, resourceful, energetic, in their youthful age. This is in consonance with results of Akerele *et al*. (2020) who obtained mean age of 43 years among tiger nut consumers in Ogun state, Nigeria. About 88.46% of tiger nut flour processors were literate and had formal education, this include: primary (27.69%), secondary (43.85%), and tertiary (16.92%). Also, 11.54% of tiger nut flour processors were illiterate and had no formal education. This means that they will be able to easily adopt innovations and research findings. This result is in consonance with findings of Wongnaa *et al*. (2019) who obtained low illiteracy (8%) rate, and high literacy rate of 92% of respondents having at least primary level of education among tiger nut consumers in Kumasi, Ghana. The mean household size was 7 people per household. The distributions of household size show that 70.76% of tiger nut flour processors had less than 10 members per household, while 29.23% had between 11 – 15 members per household. This result is in consonance with findings of Bee and Selamat (2010). In addition, 63.85% of tiger nut flour processors had less than 10 years processing experiences, 26.92% had 11 – 15 years' experiences, while 09.23% had between 16 – 20 years' experiences in tiger nut flour processing (Figure 2). Averagely processors had 9 years' experiences in tiger nut flour processing. Also, 68.46% had contact with extension officers, while 31.53% do not have any contact with extension agents.

About 70.77% of tiger nut flour processors were members of cooperative organizations, while 29.23% do not belong to any cooperative organizations.

Table 1. Socio-economic profiles of tiger nut flour processors

Variables	Frequency	Percentage	Mean
Gender			
Male	109	83.85	
Female	21	16.15	
Marital Status			
Single	43	33.08	
Divorced	17	13.08	
Married	70	53.84	
Age (Years)			
31 – 40	47	36.15	
41 – 50	58	44.62	43.80
51 – 60	25	19.23	
Level of Education			
Non-Formal	15	11.54	
Tertiary	22	16.92	
Secondary	57	43.85	
Primary	36	27.69	
Household Size (Units)			
1 – 5	54	41.53	7.0
6 – 10	38	29.23	
11 – 15	38	29.23	
Processing Experience (Years)			
1 – 5	31	23.85	
6 – 10	52	40.00	9.0
11 – 15	35	26.92	
16 – 20	12	09.23	
Extension Contact			
Yes	89	68.46	
No	41	31.53	
Memberships of Cooperative			
Yes	92	70.77	
No	38	29.23	
Total	130	100.00	

Source: Field survey (2021)

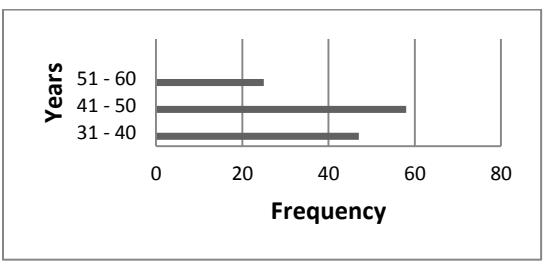

Figure 1. Age distributions of tiger nut flour processors

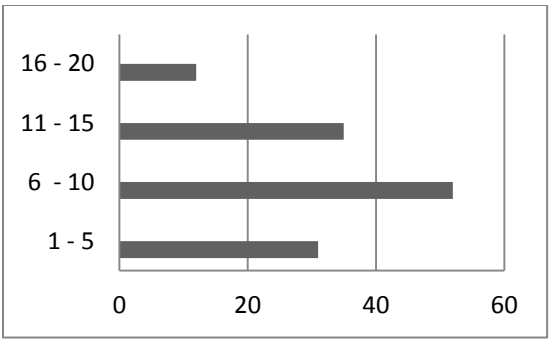

Figure 2. Processing experience in years of tiger nut flour processors

Profitability analysis of tiger nut flour processing per processor per annum

The cost, returns and profitability analysis of tiger nut flour processing was shown in Table 2. The costs involved and revenue obtained was based on the prevailing market price at the time of the field survey. The TVC was estimated at 39, 200 Naira and this was about 48.85% of the total cost. The TVC includes: cost of purchase of tiger nut (31.15%), cost incurred in cleaning and milling (03.98%), cost of diesel and petrol (03.49%), loading and offloading cost (01.49%), transportation cost (02.74%), and labour cost (05.98%). The TFC of 41, 050 Naira accounted for 51.15% of total cost. The TFC includes: cost of machinery and equipment (40.95), depreciation on tools and equipment (01.68%), taxes (01.58%), interest (01.32%), and rent on land (05.60%). The GM and NI of tiger nut flour processing were calculated at 740,800 Naira and 698,950 Naira per processor per annum respectively. This shows that tiger nut flour processing was profitable. The GMR was estimated at 0.9497, this implies that for every one naira invested in tiger flour processing, 94 kobo covered taxes, depreciation, interest, profits, and expenses. Operating ratio of tiger nut flour processing was estimated at 0.0490, this means that 4% of sales revenue from tiger nut flour processing was used to cover cost of tiger nut flour processed and other operating expenses. Operating ratio is used to measure operating efficiency and profitability of tiger nut flour processing, low operating ratio is preferable and it's reported to be a positive sign. This is similar to result of Alabi and Chiogor (2023) who reported gross margin and net farm income of 939, 480 Naira and 933, 790 Naira for tiger nut producers in Katsina State, Nigeria, respectively.

Factors influencing cost efficiency (CE) of tiger nut flour processing

The maximum likelihood estimates (MLE) of the parameters for the cost efficiency frontier model used in evaluating factors influencing CE of tiger nut flour processing is shown in Table 3. The estimated parameters have the expected sign, the cost model is a function of all input prices, the percentage (%) increase in

the total production stands on the interpretation of the estimated coefficient of the Cobb-Douglas model as the elasticity of production. The cost model monotonically increases as input prices increase as shown by the positive signs of all the monetary (cost) explanatory parameters.

Table 2. Cost, returns and profitability analysis of tiger nut flour processing per processor

Items	Amount (Naira)	% of Total Cost
Total Revenue	780,000	
Price per Kg	5,200.00	
Output in Kg = 150Kg	------	
Gross Income	800,000	
Variable Cost		
Cost of Purchase of Tiger Nuts	25,000	31.15
Cost Incurred in Cleaning + Milling	3,200	03.98
	2,800	03.49
Cost of Diesel and Petrol	1,200	01.49
Loading and Offloading Cost	2,200	02.74
Transportation Cost	4,800	05.98
Labour Cost	39,200	48.85
Total Variable Cost (TVC)		
Fixed Cost (FC)	32,870	40.95
Cost of Machinery + Equipment	1,350	01.68
Depreciation on Tools and Equipment,	1,270	01.58
Taxes,	1,060	01.32
Interest	4,500	05.60
Rent on Land	41,050	51.15
Total Fixed Cost(TFC)	80,250	100.00
Total Cost (TC)	740,800	
Gross Margin (GM)	0.9497	
Gross Margin Ratio (GMR)	698,950	
Net Income (NI)	0.0490	
Operating Ratio (OR)		

Source: Field Survey (2021) 1 USD @ 760 Naira

Also, all the cost-explanatory parameter estimates were different from zero as shown by their various coefficients estimated that are within the limits of acceptable margin of the probability level, thus have significant effects on the total production and processing cost. The cost elasticities (CEL) with respect to all the cost independent variables been positive signify that an increase in each of these inputs will lead to an increase in the total processing cost. The coefficient of the cost function represents the cost elasticity (CEL) of the production. The significant factors include: cost of tiger nut ($P < 0.05$), cost incurred in milling ($P < 0.01$), cost of labour input ($P < 0.01$), total output ($P< 0.05$), and annual depreciation cost on capital ($P < 0.10$). The estimated gamma

(γ) parameter (0.7201) was highly significant at 1% level of probability, this shows that 72.01% of the variations in the TC of production and processing among sampled flour processors was due to differences in their cost efficiencies, indicating the presence of cost inefficiency. The sigma squared (σ^2) of 1.4311 was significant at 1 percent level of probability indicating correctness of fit of the model as assumed for the composite error term. The coefficient of cost of labour input (β_4) was estimated to be 0.1603. This implies that an increase in the cost of labour input by 1% will cause the TC of processing to increase by 0.1606%. Similarly, the coefficient of cost of tiger nut was estimated at 0.2704, this means that if the cost of tiger nut increases by 1%, the total cost of processing will rise by 0.2704% and 1 percent increase in the total output of tiger nut will lead to increase in the total processing cost by 0.1927%. This result is in consonance with findings of Alabi *et al.* (2023), Paudel and Matsuoka (2009), Ogundari *et al.* (2006).

Scale effect (SE) or economies of scale (ES) of tiger nut flour processors

The SE among tiger nut flour processors was estimated as the inverse coefficient of cost elasticities with respect to the tiger nut output in kilogram as the only output in the model that indicates the SE among the sampled processors. The calculated estimate of the SE was 5.1894 which signifies that there is a positive ES (Table 3). The calculated estimate of the SE is greater than one, this means that 1 percent increase in the total processing cost increased the total tiger nut production by 5.19% during the course of tiger nut flour processing. The economic implication is that the tiger nut flour processors expand their processing capacities in order to decrease their cost to the lowest minimum in course of processing irrespective of their size of operation which signifies that the processors are experiencing decreasing but positive RTS, since RTS and ES are equal measures (Chambers,1988). This signifies that the tiger nut flour processors tend to expand their processing capacity in order to decrease their processing cost to the barest minimum. The result obtained shows that there are positive ES, this signifies that averagely, tiger nut processor experiences a decrease in the total processing cost in the course of processing irrespective of capacity of tiger nut flour processing. It revealed that tiger nut flour processors are experiencing increasing RTS which is stage II of the processing surface. According to Reddy *et al*. (2004) stage II can be explained as the sub-optimal stage, at this stage, the fixed resources are abundant relative to the variable resources.

Socio-economic factors influencing cost inefficiency (cie) of tiger nut flour processing

The analysis of CIE model showed that marital status, age, educational level, processing experience, access to credit, cooperative memberships, and extension contact to be the driving factors behind cost inefficiency as signifies by each respective estimated coefficients that are statistically different from zero (Table 3). Furthermore, the driving factors decreases cost inefficiency as shows by the negative sign associated with each respective estimated coefficients. The predictor variables signify that the significance and signs of the coefficients estimated in the CIE model have significant economic meaning on the CE of the tiger nut flour processing. The negative coefficients of age and processing experience signifies that the aged processors and the most experience processors in tiger nut flour processors are more cost efficient than the younger and inexperienced ones. This signifies that as the age and processing experience of processors increases the CIE of the processors decrease. This is in consonance with the underlining assumptions as reported by Ogundari *et al.* (2006), that farmers' age affects the production and cost efficiencies since farmers' different ages have different levels of experience ability to obtain and process information. The significant and negative coefficient for household size with the members of working age group signifies that CE rises with the increase in household size. This is due to the fact that the processors with a larger household size rely on family labour and subsequently reduce the CIE for tiger nut flour processing. Similarly, the significant and negative coefficient for the education level of the processor shows that the higher or increase in the number of the years of schooling, the lower is the CIE of the tiger nut flour processors. The positive relationship between education level and CE signifies that the processors with additional years of education are more economically efficient. The apriori expectation is that CE would increase with the increase in the years of schooling, since education level is expected to be positively (+vely) related with the adoption of the improved techniques and technology of processing (Ojo and Ajibefun, 2000). An increase in the years of schooling may positively change the attitude, increase the skill, and knowledge, and therefore enhance the adoption of more improved and efficient technology and enables them to allocate the inputs of processing of the enterprises more efficiently.

Cost efficiency scores (ces) of tiger nut flour processors

Table 4 depicts the distributions of CES of tiger nut flour processors. The predicted CES of tiger nut flour processors ranged from 1.0 to 3.3. The mean CE of an average processing enterprise was estimated as 1.4161.

Table 3. Maximum likelihood results of the stochastic cost efficiency frontier model of tiger nut flour processing

Variables	Parameters	Coefficient	Standard Error	t-Value
Cost Efficiency				
Constant	β_0	1.2107***	0.3298	3.67
Cost of Tiger Nut	β_1	0.2704**	0.1052	2.57
Cost of Transportation	β_2	0.1476	0.0873	1.69
Cost of Milling	β_3	0.3104***	0.0686	4.52
Cost of Labour Inputs	β_4	0.1603***	0.0430	3.72
Total Output	β_5	0.1927**	0.0662	2.91
Annual Dep Cost on Capital	β_6	0.2726*	0.1233	2.21
Cost of Loading and Off-Loading	β_7	0.1092	0.0700	1.56
Economies of Scale		5.1894		
Cost Inefficiency (CIE)				
Component	α_0	-3.6429***	0.7902	4.61
Constant	α_1	-2.3274***	0.6341	3.67
Age	α_2	-2.0825**	0.9015	2.31
Marital Status	α_3	-1.9452***	0.4069	4.78
Educational Level	α_4	-2.0436***	0.5147	3.97
Processing Experience	α_5	-2.0437**	0.8142	2.51
Access to Credit	α_6	-1.5692	0.9396	1.67
Household Size	α_7	-1.3428*	0.5863	2.29
Cooperative Memberships	α_8	-1.7821*	0.6674	2.67
Extension Contact				
Diagnostic Statistics	σ^2	1.4311***		
Total Variance (Sigma^2)	γ	0.7201***		
Variance Ratio (Gamma)		278.41		
Log-Likelihood Function				

Source: Data Analysis (2021)

*Significant at($P < 0.10$), **Significant at($P < 0.05$), ***Significant at ($P < 0.01$).

This signifies that an average tiger nut flour processing enterprise incurred costs that are about 41% above the minimum cost defined by the stochastic frontier. This signifies that over 41% of the processing enterprise costs are wasted when compared with the best practice enterprise facing the same technology and producing the same output. In addition, the higher value of CE represents the more inefficient enterprise during the course of tiger nut flour processing. The frequencies of the CES range between 1.0 and 1.1 representing about 66.92% of the sampled processing enterprise, this signifies that more than half of the processors were moderately efficient in processing using the cost minimizing input ratios at the given level of output. This shows that 33.08% of processing enterprises need to minimize the waste of resources associated with tiger nut flour processing. This is in consonance to the findings of Ogundari *et al.* (2006) obtained the result that a relatively larger proportion of farms were moderately efficient to minimize the resources wasted during with the production process

among smallscale maize production in Nigeria. According to Paudel and Matsuoka (2009) this might have resulted from a higher education level of the farmers. This is in consonance with Rahman *et al*. (2021), Backson *et al*. (2020), and Okello *et al*. (2019).

Table 4. Distribution of cost efficiency scores (CES) among tiger nut flour processors

Cost Efficiency Score	Frequency	Percentage
1.0 – 1.1	87	66.92
1.2 – 1.3	09	06.92
1.4 – 1.5	04	03.07
1.6 – 1.7	03	02.31
1.8 – 1.9	02	01.54
2.0 – 2.1	03	02.31
2.2 – 2.3	04	03.07
2.4 – 2.5	07	05.38
3.0 – 3.1	05	03.85
3.2 – 3.3	06	04.61
Mean CE	1.4161	
Standard Deviation	0.66735	
Minimum	1.031	
Maximum	3.270	

Source: Field Survey (2021)

Principal component analysis of the constraints faced tiger nut processors

Table 5 shows the results of the principal components analysis of constraints faced by tiger nut flour processors, PCA is a statistical technique that transform interrelated data with many variables into few number of uncorrelated variables. From the results the number of principal components retained using the Kaiser Meyer criterion were five (5) based on the Eigen values greater than 1. The retained components explained about 69.85% of the variations of the components included in the model analyzed. The Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) of 0.6807 and Bartlett test of sphericity of 704.08 were statistically significant at 1 % probability level which demonstrated that the variables were feasible for principal component analysis. Lack of credit facilities and high cost of milling equipment had an Eigen values of 3.0472 and 2.9041 and they are ranked 1st and 2nd in the order of importance based on the perception of the tiger nut flour processors. Lack of credit facilities explained 16.74% of all the constraints included and retained by the principal component analysis. High cost of diesel and inadequate extension services with Eigen values of 2.8029 and 2.6704 were ranked 3rd and 4th respectively in the order of occurrence based on the perception of the tiger nut flour processors. This result

is also in line with Alabi *et al.* (2020[b]) and Paryeen *et al.* (2020) who reported similar challenges faced by farmers.

Table 5. Principal component model of constraints encountered by tiger nut flour processors

Constraints	Eigen-Value	Difference	Proportion	Cumulative
Lack of Credit Facilities	3.0472	0.3427	0.1674	0.1674
High Cost of Milling Equipment	2.9041	0.3289	0.1439	0.3113
High Cost of Diesel	2.8029	0.3197	0.1393	0.4506
Inadequate Extension Services	2.6704	0.2845	0.1275	0.5781
Bad Road Infrastructures	2.5903	0.2257	0.1204	0.6985
Bartlett Test of Sphericity				
Chi Square	704.08***			
KMO	0.6807			
Rho	1.00000			

CONCLUSION

This research article has established that tiger nut flour processors were young, active, and energetic, in their youthful age. Majority of the tiger nut flour processors were literate and had formal education. The household sizes were large with an average of 7 members per household. Averagely, they have nine years processing experience. The tiger nut flour processing was profitable with a GM and NI of 740, 800 Naira and 698, 950 Naira per processors per annum respectively. The study employs the stochastic frontier model to observe the CE among the tiger nut flour processing. A Cobb-Douglas model form was used to enact the underlying assumption of CEL (cost elasticity) and ES, the assumption that RTS and ES are equal estimates provided the production is homothetic. The estimated coefficients of the cost of different inputs like tiger nut, transportation, milling, labour inputs, loading and offloading, annual depreciation on capital, as well as total tiger nut output gave the positive (+ve) coefficients this signifies that as these predictors increased, the TC of tiger nut flour processing increased. Among the different predictors of processing, the cost of tiger nut accounted the largest share (31.15%) in tiger nut flour processing, and 1 percent increase in the cost of tiger nut will increase the total processing cost by 0.27%. The mean CE from the stochastic cost frontier model shows the mean CE of 1.4161 indicating that about 41% of the tiger nut processing enterprises cost were wasted in relation to the enterprise adopting the best practices while processing the same level of tiger nut flour output. The outcome of the CE analysis indicates that more than half of the processors (66.92%) were moderately efficient in processing using the cost minimizing input ratios at the given level of output. About 72% of the variation in the TC of tiger nut flour processing resulted from

the differences in their CEs. The significant and negative estimated coefficients of educational level and access to credit in the CIE model implies that CE rises as these two (2) parameters improved. Also, the estimation of SE or ES signifies that the average tiger nut flour processors operate in stage II of the production surface which clearly shows inefficiency in the allocation of resources and production.

RECOMMENDATIONS

Based on the findings, the following policy recommendations were made: considering the significance of the educational level, this signifies that the availability of educational facilities as well as the addition of the younger generation that are more educated will significantly increase the CE of tiger nut flour processing. Policies programs designed to educate rural people through agricultural extension services could also have a great effect in raising the level of efficiency and to optimize the farm resources which will increase tiger nut productivity. The economic implications require the need to bring more areas under tiger nut cultivation to improve the ES or SE which will allow the tiger nut farmers and hence tiger nut flour processors to achieve the maximum or highest possible output at the minimum cost of production or processing. Also, government should make credit facilities available, accessible and affordable for the tiger nut flour processors. Government through policies should direct its agricultural development program to include youth participation in tiger nut farming and expand the tiger nut growing area through the timely and adequate provision of facilities.

REFERENCES

Ade-Omowaye, B.I., Akinwande, B.A., Bolarinwa,I.F and Adebiyi,A.O (2008). Evaluation of Tiger Nut (Cyperus esculentus)-Wheat Composite Flour and Bread. *African Journal of Food Science*, 2: 087 – 097.

Aboaba K. O. (2020). Economic Efficiency of Rice Farming: A Stochastic Frontier Analysis Approach. *Journal of Agribus. Rural Development, 4(58), 423–435*. https://dx.doi.org/10.17306/J.JARD.2020.01377

Akerele, D., Ayinde, A.F.O., Alabi, K.J., Ogunmola, O.O and Ibrahim, S.B (2020). Tiger Nut Consumption in Ogun State, Nigeria: Socio-Economic Drivers and Implications for Consumer Marketing. *Nigerian Journal of Agricultural Economics* 10 (1): 29 – 39.

Alabi, O.O and Chiogor, O.H (2023). Technical Efficiency of Tiger Nut (*Cyperus esculentus*) Production in Katsina State: Socio-Economic Drivers and Implications for Consumers Health Benefits. *Australian Journal of Science and Technology*, 7 (1): 46 – 53**.**

Alabi, O.O., Oladele, A.O & Oladele, N.O (2020[a]). Economic Market Decisions among Marginal Maize Farmers in Abuja, Nigeria: Applications of Double Hurdle Model and Factor Analysis. *Russian Journal of Agricultural and Socio-Economic Sciences*, 8(104), 114 – 125.
DOI: https://doi.org/ 10.18551/rjoas.2020-08.14.

Alabi, O.O., Safugha, G.F., and Aluwong, S.J (2023). Cost Efficiency and rofitability Analysis of Rice (*Oryza sativa*) Production among Smallholder Farmers in Federal Capital Territory, Nigeria. *Australian Journal of Science and Technology*, 7 (1): 21 – 29**.**

Alabi, O.O., Oladele, A.O., & Oladele, N.O. (2020[b]). Socio-Economic Factors Influencing Perception and Adaptability of Rural Rice Farmers to Climate Change, Abuja, Nigeria: Applications of Heckman Two –Stage Model. *Russ. J. Agric. Soc.-Econ. Sci.*, 8(104), 45–56.

Backson, M. Ibrahim, M. & Reic, B. (2020). Analysis of economic Efficiency Among Smallholder Sorghum Producers in Kenya. *Journal of Development and Agricultural Economics*, 12, 95-103. DOI: https://dx.doi.org/10.5897/jdae2020.1162

Bado, S., Bazongo, P. Son, G., Kyaw,M.T., Foster,B.P. Nielen,S., Bassole,I.H.N (2015). Physicochemical Characteristics and Composition of three Morphoytpes of Cyperus esculentus Tubers and Tuber Oil. *Journal of Anal Methods Chem*. DOI: https://dx.doi.org/10.1155/2015/673547

Ban-Koffi, I., Nemlin, G.J. Le Fevie,S., Kamenan, A (2005). Caracterisation Physico-Chimique et Potentialites Therapeutiques du pois sucre (*Cyperus esculentus*, L (*Cyperaceae)*). *Agron Afr.*, 17 (1): 63 -71. DOI: https://dx.doi.org/10.4314/aga.v17i1.1658

Bamishaiye, E.I and Bamishaiye,O.M (2011). Tiger Nut: As a Plant,its Derivatives and Benefits. *African Journal of Food, Agriculture, Nutrition and Development*, 11 (5): 5157 – 5170.

Bee, T and Selamat, J (2020). Consumers' Perceptions, Attitudes and Willingness to Pay towards Food Products with No added Msg Labelling. *International Journal of Marketing Studies*, 2 (1), 65 – 77.

Belewu, M.A and Abodunrin,O.A (2011). Preparation of Kunnu from Unexploited Rich Food Source: Tiger Nut (Cyperus esculentus). *World Journal of Diary Food Science*, 1:19– 21

Bori, H., Karim, T.D.A.,Mairo,M.D., and Adam, A (2018). La Culture de Souchet (*Cyperus esculentus*) au Niger. Origine, atouts et Contrantes. *J. Anim Plant Sci., 37* (1): 5997 – 6007.

Chambers, R.G (1988). *Applied Production Analysis: A Dual Approach*. Cambridge University Press, Cambridge, UK.

Bitrus, A. Yakubu, H. Patrick, T. & Stephen, S. F. (2020). Economics of Rice Production among Beneficiaries of Anchor Borrowers Programme in Gerie Local Government Area of Adamawa State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology, 39(1),82-95.*

Coelli, T, Rahman, S, & Thirtle, C. (2002). Technical, Allocative, Cost and Scale Efficiencies in Bangladesh rice cultivation: A Non-Parametric Approach. *Journal of Agricultural Economics*, 53,607–626. https://dx.doi.org/10.1111/j.1477-9552.2002.tb00040.x.

Miller, C. & da Silva, C. (2007). *Value chain financing in agriculture, Enterprise Development and Microfinance* 13(2/3), Practical Action Publishing, Rugby.

Nata'ala, M.K., Farouq, A.A., Magashi, A.M. and Liman,M.G (2018). Assessment of the Potentials of Production of Bioethanol u\sing *Cyperus esculentus* L. (Tiger Nut) Residue by Simultaneous Saccharification and Fermentation. *Asian Journal of Biotechnology and Bioresource Technology*, 3 (3): 1– 10

Ogundari, K., Ojo, S.O and Ajibefun, I.A (2006). Economics of Scale and Cost Efficiency in Small Scale Maize Production: Empirical Evidence from Nigeria. *Journal of Social Sciences, 1*3 (2): 131 – 136.

Ojo, S.O and Ajibefun, I.A (2000). Effects of Training on Labour Productivity and Efficiency in Oil Palm Production in Ondo State, Nigeria. *Journal of Sustainable Agriculture and Environment*, 2: 275– 279.

Okello, D.M, Bonabana- Wabbi, J.& Mugonola, B. (2019). Farm Level Allocative Efficiency of Rice Production in Gulu and Amuru Districts, Northern Uganda. *Agricultural and Food Economics*, 7.DOI : http://dx.doi.org/ 10.1186/s40100-01940=x

Oladele, A.K. and Aina, J.O. (2007). Chemical Composition and Functional Properties of Flour Produced from Two Varieties of Tiger Nut (*Cyperus esculentus*). *African Journal of Biotechnology*, 6 (21), 2473 – 2476

Olukosi, J.O & Erhabor, P.O (2015). *Introduction to Farm Management Economics: Principles and Applications*. Agitab Publishers Limited, Zaria, Kaduna, Nigeria pp77 – 83

Paryeen, K,. Chauhan, R. S & Grover, R. K. (2020). Economics Analysis of Tomato Cultivation Under Poly House and Open Field Conditions in Haryana, India. *Journal of Applied and Natural Science*, 8 (2), 846 – 848.

Paudel, Pand Matsuoka, A (2009). Cost Efficiency Estimates of Maize Production in Nepal: A Case Study of the Chitwan District. *Agric.econs-czech*, 55(3): 139 – 148.

Rahman, M.S, Haque, S. Sakar, MAR, SR, Rahman, M.C, Reza, M.S, Islam, M.A & Siddique M.A.B. (2021). A Cost Efficiency Analysis of Boro Rice Production in Dinajpur District of Bangladesh. *Fundamental and Applied Agriculture*, 6(1), 67-77.
DOI: http://dx.doi.org/10.5455/faa.137178

Reddy, S.S., Ram, P.R., Sastry, T.V.N and Devi, I.B (2004). *Agricultural Economics*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.

Russell, D. & Hanoomanjee, S. (2012). Manual on value chain analysis and promotion. Regional training on value chain analysis. Pescares Italia SRL, pp 37.

United Nations Industrial Development Organization (UNIDO) (2009). Competitiveness of rice processing and marketing in Ebonyi State: A Policy Analysis Approach. In: M. Ude, I.B. Adeoye, S.A. Yusuf, O.L. Balogun & R.J. Akinlade (Eds.). *International Journal of Agricultural Sciences, 3 (2), 410-418.*

Wongnaa, C.A., Adams, F., Bannor, R.K., Awunyo-Vitor, D., Mahama, I., Osei, B.A., Owusu-Ansah, Y., and Ackon, A (2019). Job Creation and Improved Consumer Health through Commercialisation of Tiger Nut Yoghurt: A Willingness to Pay Analysis. *Journal of Global Entrepreneurship Research*, 9 (4): 1 -16.

DOI: https://dx.doi.org/10.1186/s40497-018-0139-x

Yamane, T (1967). *Elementary Sampling Theory*, Volume 1: 371 – 390, Englewood Cliff: Prentice Inc.

Small-Scale Farmers' Choice of Improved Climate Change Adaptation Strategy in Anambra State Nigeria

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ABSTRACT

This study assessed small-scale farmers 'choice of improved climate change adaptation strategy in Anambra State Nigeria. Multi-stage sampling technique was employed to select 100 small scale farmers using a well-structured questionnaire. The data were analyzed using both descriptive and inferential statistics; such as multinomial logistic regression model. The multinomial logistic regression model was used to analyze the relationship between the socioeconomic characteristics and farmers' choices of adaptation strategies to climate change indicate that marital status influences farmers' choice for early and late planting, age influences farmers' choice for mixed cropping and mixed farming; total land size influenced farmers' choice for early and late planting, mixed cropping as well as mixed farming. Gender influenced farmers' choice for use of improved crop varieties as family size influenced farmers' choice for use of improved varieties, soil and water conservation and mixed cropping while annual farm income influenced farmers' choice for use of improved crop varieties and use of irrigation. The study recommended encouragement of small-scale farmers in the use more improved climate change adaptation strategy, as well as teaching female small scale farmers the use of these relevant improved climate change adaptation strategy and provision of training related to climate change issues at a subsidized rate for the small-scale farmers by extension agents.

Key words: Climate change, choice, adaptation strategy, small-scale farmers

INTRODUCTION

The concern about the impact of climate change on sub-Saharan African agriculture stems from its potential to undermine the local economy and livelihoods in farming communities heavily depend on crop production for food and incomes (Chete, 2019). The seasonality of most agricultural activities and limited use of inputs in Africa, make it especially vulnerable to weather or

climate-related challenges across the various stages of the production cycle (Osuafor & Ude**,** 2021). Sub-Saharan Africa suffers disproportionately from climate change due to its huge dependence on rain-fed agriculture and inadequate adaptive capacities for anticipating these events and attenuating their impacts (Adimassu & Kessler, 2016). The impacts could be measured in terms of effects on crop growth, availability of soil water, health and availability of farm labour, soil fertility, soil erosion, incidents of pests and diseases, and sea-level rise (Osuafor *et al,* 2021). Climate change is a global phenomenon that results in global warming, droughts, flooding and depletion of natural resources (Adepoju *et al,* 2011). According to Ibe & Amikuzuno (2019), Africa is one of the continents worst hit by climate change with an increase in severe droughts, floods and storms expected to threaten the health of populations and economies. In the same vein, Chen *et al.* (2018) noted that extreme climate events such as droughts and heavy rainfall are becoming more frequent over the last decades, especially in areas such as Sub-Saharan Africa. Traditional farming systems practised, which have low technological capacity, cannot help to adapt and mitigate drastic climate change (Awe *et al,* 2018). The harsh seasonal variations in rainfall and temperature that have come as a result of climate change expose farmers, mostly those in rural areas, to intense risks and this, in turn, has a major bearing on the production outcome. Considering the fact that a larger proportion of the local population in Nigeria operates under rain-fed agriculture, rainfall and temperature variations have severe implications on production (Asiga, 2013). Nigeria has to adapt to the expected impacts of anticipated climate change, this makes adaptation the major response option to climate change in the nation (Oladipo, 2010). Small scale farmers, who constitute the bulk of the poor in Africa and especially Nigeria, face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Osuafor *et al,* 2021). It is projected that crop yield in Nigeria may fall by 10-20% by the year 2050 or even up to 50% due to climate change (Osuafor & Ude**,** 2021). There is thus need for small scale farmers to engage in improved climate change adaptation strategies and as such the research question suffices: what are the determinants of small-scale farmers' choice and adoption decision of improved climate change adaptation strategy in Anambra state, Nigeria. The study analyzed determinants of small-scale farmers' choice of improved climate change adaptation strategy in Anambra state, Nigeria.

METHODOLOGY

The study was conducted in Anambra State. It is located in the Southeast geopolitical zone of Nigeria. The state is located between latitudes $5^{0}40^{1}$ North and $6^{0}48^{1}$ North and between longitudes $6^{0}35^{1}$ East and $7^{0}30^{1}$ East. The state is

bounded by Rivers State to the west, Imo State to the south, Enugu State to the east and Kogi State to the North. It has a land area of about 4,415.54 square kilometers (Anambra State Government, 2007) and a population of 4,182,032 (NPC, 2006). The state has twenty-one local government areas (LGAs) grouped into four agricultural zones namely: Anambra zone; Awka zone; Aguata zone and Onitsha zone. Agriculture, therefore, remains a major source of employment especially in the areas where the economy is still at subsistence level. The predominant food crops grown in the state include yam, cassava, maize, cocoyam and vegetables.

Table 1. Distribution of the local government areas according to agricultural zones

Anambra zone	Awka zone	Aguata zone	Onitsha zone
Oyi	Awka North	Aguata	Ekwusigo
Ayamelum Anambra-East Anambra West	Awka South	Orumba south	Ogbaru
	Njikoka		Ihiala
	Dunukofia Aniocha	Orumba North	Onitsha South
		Nnewi South	Onitsha North
		Nnewi North	Idemili North
			Idemili South

Source: Anambra State Agricultural Development Programme (ANADEP) Report, 2007

Sampling procedure

The sampling was centered on all the four agricultural zones in the state. A multistage random sampling technique was adopted in the research. At the first stage, five Local Government Areas were randomly selected from the zones Awka, Aguata, Anambra and Onitsha zones. One local government area each was randomly selected from Awka zone, Aguata zone and Anambra zone while two local government areas were selected from Onitsha zone (due to large population of this zone). The second stage involved a random selection of two autonomous communities in each of the sampled local government areas which gave a total of ten (10) communities for the study. In the third stage, ten (10) crop farming households were selected from each of the ten communities already sampled. The list of the crop farming households was gotten from Anambra State Agricultural Development Programme (ANADEP). In all, a total of 100 crop farm households were selected and the questionnaires were administered to them. Primary data were used for this study. The data were collected using a set of pre-tested structured questionnaire coupled with interview schedule. Data collected were analyzed using multinomial logit regression model.

Model specification

Multinomial Logistic Regression Models

The multinomial logistic regression model was used to analyze the relationship between the socio-economic characteristics and farmers' choices of adaptation strategies to climate change. Based on the review of past studies on adaptation strategies the following explanatory variables were considered in this study and examined for their effect in farmers' choice of adaptation strategies to climate change (Table 2). According to Osuafor and Ude (2021), a multinomial logistic model specification is employed to model small scale farmers' choice for improved climate change adaptation strategies involving categorical dependent variables. Therefore, the multinomial logit model used was written as follows:

$$pr\ (Yi = j) = \frac{e^{\beta jxi}}{\sum_{k=0}^{j} e^{\beta jxi}}\ j = 0, 1,2 \ldots . n \ldots \ldots \ldots . . (1)$$

where βj is a vector of coefficients on each of the independent variables X (Hausman & McFadden, 1984):

$$pr(Yi = j\ Xi) = \frac{e^{\beta \prime xi}}{1 + \sum_{k=0}^{j} e^{\beta} Xi}\ , j = 1,2 \ldots . n; \beta = 0 \ldots \ldots \ldots \ldots (2)$$

RESULTS AND DISCUSSION

Determinants influencing crop farmers' choice and adoption decision of adaptation strategies

The multinomial logistic regression model was used to estimate the effect of the socio-economic characteristics of sample crop farmer's decision to choose climate change adaptation strategies (Table 1). The result indicated that marital status had positively impact the decision to early and late planting of the adaptation strategies and negatively in the case of others. The result also revealed that gender of the crop farmer's had a positive impact on their decision to choose adaptation options in all cases but it was statistically significant in the choice of use and growing of improved crop varieties. This implies that male-headed crop farmers' had better opportunities to practice adaptation measures than female-headed crop farmers'. It showed that male-headed small-scale farmers could be more likely to have access to technologies and climate change information than female-headed crop farmers'. As a result, they were in a better position to practice diverse adaptation strategies than female-headed ones. This result is in agreement with the study by Mandleni & Anim (2011). The result indicated that the family size of the small-scale farmers had a positive impact on their decision to choose adaptation options in all cases but it was negative in the

mixed farming climate change adaptation strategy. This implied that the crop farmer's choice of adaptation strategy to climate change was affected by the number of family size.

A large number of active small-scale farmers' crop farmer members had increased adaptation decision mechanisms to reduce the impact of climate change. This result agreed with the finding of Awe *et al.* (2018). The total land size of the crop farmer had a positive effect on crop farmer's choices of adaptation strategies to the adverse effects of climate change in all cases but statistically influenced their choice of early and late planting. This means the amount of crop farmer's land size positively affect these farmers who are using choice of early and late planting, mixed cropping and mixed farming as an adaptation to climatic change. As such, farmers who have adequate amount of farming land size are more likely to take adaptation decisions because they have resources to implement new agricultural technology. This result is in agreement with the study by Nwajiuba *et al.* (2008) who pointed out crop farmers' with relatively large farm sizes were more likely to take up new adaptation strategies when compared to farmers with small farm sizes.

The result revealed that total farm income had positively affected these farmers' decisions to choose adaptation methods to climatic change. This implies that farmers who have high amount of annual total farm income, are more likely to take any adaptation decisions (use of improved crop varieties and use of irrigation) because they have adequate income to implement adaptation strategies against the negative effects of climate change. The age of the farmers was one of a statistically significant explanatory variable that had a positive coefficient. The positive sign indicates that it has a positive influence on taking an adaptation strategy (specifically use of improved crop varieties, mixed cropping and mixed farming) to climate change. According to Table 2, the age of the small-scale farmers was one of the statistically significant explanatory variables that have a negative and a positive coefficient. The positive sign indicates that it has a positive influence on taking an adaptation strategy to climate change. As the age of the crop farmer's increase by one year, the probability of crop farmer's using improved crop varieties as an adaptation strategy to climate change was increased by 9.1% with the p-value of 0.015, keeping other variables constant. Similarly, as one year increased in the age of the small-scale farmers, the probability of farmers to use mixed cropping as adaptation strategy increased by 7.4% with the p-value of 0.000 keeping the other variables constant. The result indicates that as the age of the crop farmer's increases by one year the probability of not using mixed farming adaptation strategy to climate change decrease by 2.5%.

The amount of crop farmer's land size had a positive impact and significantly affects these farmers' choice of adaptation methods to climatic change. As farm size of crop farmer's increase by one hectare, the probability of the farmers uses early and late planting adaptation option of climate change increased by 90.2% with the p-value of 0.000, keeping other variables constant. In addition, as farm size of the crop farmer's increases by one hectare, the probability of farmers to use mixed cropping and mixed farming as adaptation strategy increase by 6.2% with the p-value of 0.075 and 14.6% with the p-value of 0.001 respectively, keeping other variables are constant. This implies that farmers, who have a large amount of farming land size, are more likely taking any adaptation decisions because they have resources to implement new agricultural technology. This result is in agreement with the study by Oku (2011).

The findings of the marginal effects showed that the probability of male-headed crop farmer's used improved crop varieties as an adaptation strategy to climate change increased by 2.3% with the p-value of 0.001 than female-headed crop farmers'. In this case, male-headed small-scale farmers are often considered less likely to gain information about new technologies and take on risk than female-headed crop farmers. This finding is in line with the findings of Okuli *et al.* (2012) that reported male-headed small-scale farmers were more likely to apply adaptation strategies to adapt to climate change. The family size of the crop farmer's was a statistically significant explanatory variable in this model, which indicates farmers' adaptation strategy to climate change is also significantly affected by the number of family size. A large number of active crop farmer members had increased adaptation decisions mechanism to reduce the impact of climate change.

A one-unit increase from the member of the family resulted in a 2.0% increase in the probability of small-scale farmers using improved crop varieties as adaptation strategy with the p-value of 0.004, holding other variables constant. The result indicated that one unit increases from the member of the family resulted in a 3.9% and 1.8% increase in the probability of farmers' implementing soil and conservation techniques and mixed cropping as adaptation strategy with the p-value of 0.000 and 0.004, respectively. This is in agreement with the study reported by Haruna (2019) study. The result of the analysis reveals that the total annual farm income of a crop farmer had a positive and significant influence on using use of improved varieties and irrigation systems.

Table 2. The effect of the socio-economic characteristics on the crop farmer's decision to choice of adaptation strategies

Explanatory variable	Use of improved crop varieties	Early and late planting	Soil and water conservation	Mixed cropping	Mixed farming	Use of irrigation	Income source diversifica-tion
Marital status	-0.290 (0.612)	0.192 (0.900)	-0.393 (0.255)	-0.028 (0.301)	-0.210 (0.217)	-1.192 (0.212)	4.203 (0.291)
Age	0.039 (0.821)	0.019 (0.068)	0.029 (0.768)	0.048 (0.592)	-0.002 (0.595)	0.031 (0.672)	0.235 (0.035)
Total land size	0.029 (0.182)	0.592 (0.352)	0.091 (0.690)	0.103 (0.390)	0.921 (0.499)	0.892 (0.901)	0.986 (0.642)
Gender	1.791 (0.290)	0.512 (0.590)	0.960 (0.142)	1.193 (0.042)	6.403 (0.300)	1.357 (0.072)	12.675 (0.119)
Family size	0.859 (0.211)	0.012 (0.301)	0.452 (0.288)	0.023 (0.299)	-0.290 (0.392)	0.494 (0.012)	1.040 (0.034)
Annual farm income	1.490 (0.490)	0.401 (0.690)	0.290 (0.503)	4.41 (0.390)	0.492 (0.189)	0.684 (0.327)	0.0183 (0.680)
Diagnostics							
Observations	100						
LR Chi2(36)	57.20						
Prob > Chi2	0.001						
Pseudo R2	0.7891						
Log likelihood	183.30234						

Source: Computed from field survey, 2021.

Notes: * denote significant at 10%. The values indicate coefficient (P-value)

Table 2. The marginal effect of the explanatory variable of the multinomial Logit model

Variables	Use of improved crop varieties	Early and late planting	Soil and water conservation	Mixed cropping	Mixed farming	Use of irrigation	Income source diversification
Marital status	0.390 (0.390)	0.051 (0.002)***	0.489 (0.716)	0.002 (0.389)	1.529 (0.462)	1.948 (0.452)	2.234 (0.195)
Age	0.091 (0.015)*	0.230 (0.940)	-0.049 (0.538)	0.074 (0.000)***	-0.025 (0.001)**	-0.029 (0.222)	-0.862 (0.108)
Total land size	0.014 (0.147)	0.902 (0.000)***	0.019 (0.663)	0.062 (0.075)*	0.146 (0.001)**	1.165 (0.375)	0.260 (0.284)
Gender	0.023 (0.001)**	0.843 (0.721)	0.492 (0.499)	2.392 (0.198)	1.274 (0.194)	0.674 (0.747)	1.122 (0.852)
Family size	0.020 (0.004)**	0.092 (0.343)	0.039 (0.000) ***	0.018 (0.004)**	0.086 (0.831)	0.751 (0.381)	1.254 (0.271)
Annual farm income	0.012 (0.000)***	0.504 (0.262)	0.082 (0.389)	0.089 (0.708)	0.045 (0.696)	0.102 (0.073)*	0.003 (0.517)

Source: computed from field survey, 2021

Notes: ***, **, * denote significant at 1%, 5% and 10% , respectively.

One unit of Naira increase in the farm income of the small-scale farmers was associated with probabilities of using improved crop varieties and irrigation management which increased by 1.2% and 10.2% with the p-value of 0.000 and 0.073, respectively keeping other variables constant. When the main source of income in farming would be increased, farmers incline to participate in productivity smoothing options such as improved crop varieties and using an irrigation system. This result is also in agreement with the studies reported by Enete *et al.* (2011).

CONCLUSION AND RECOMMENDATIONS

The study concludes that the following factors influences small scale farmers' choice to adaptation strategy, marital status influences farmers' choice for early and late planting, age influences farmers' choice for mixed cropping and mixed farming; total land size influenced farmers' choice for early and late planting, mixed cropping as well as mixed farming. Gender influenced farmers' choice for use of improved crop varieties as family size influenced farmers' choice for use of improved varieties, soil and water conservation and mixed cropping while annual farm income influenced farmers' choice for use of improved crop varieties and use of irrigation.

Based on the findings of this study the following recommendations were made:

i. Male farmers are to be encouraged by extension agents to use more improved climate change adaptation strategy, and they can in turn teach the female farmers the use of these relevant practices, which symbolise farmer-to-farmer paradigm in adoption of agricultural practices.
ii. Provision of training related to climate change issues should be enhanced by extension agents
iii. Also, improved climate change adaptation strategy like weather forecasting technologies, supercomputing and use of sensors are to be encouraged among the small-scale farmers in the study so that flood can be mitigated and their income enhanced.

REFERENCES

Adepoju, A. O., Yusuf, S. A., Omonona, B. T & Okunmadewa, F. Y. (2011). Vulnerability Profile of Rural Households in South West Nigeria. *Journal of Agricultural Science, 3*(1)

Adimassu, Z. & Kessler, A. (2016). Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift valley of Ethiopia. *Environmental Systems Research, 5*(13): 1-16.

Asiga, D.A. (2013). Multi-local livelihoods and food security in rural Africa. *Journal of International Development,* 14(1): 1-3.

Awe, F., Olarewaju, T. O., Fatoki, O.A. & Ogunsola, A.J. (2018). Analysis of the determinants of rural households' adaptation to climate change in Ibarapa area of Oyo State, Nigeria. *Journal of Research in Forestry, Wildlife & Environment, 10(4)*

Chen M., Wichmann B., Luckert M., Winowiecki L, Förch W & Läderach P (2018). Diversification and intensification of agricultural adaptation from global to local scales. Retrieved from *https://doi.org/10.1371/journal.pone.0196392*

Chete, O.B. (2019). Factors influencing adaptation to climate change among smallholder farming communities in Nigeria. *African Crop Science Journal*, 27(1): 45-57

Enete, A.A., Madu, I.I., Mojekwu, J.C., Onyekuru, A.N., Onwubuya, A.A. & Eze, F. (2011). Indigenous Agricultural Adaptation to Climate Change: Study of Southeast Nigeria. African Technology Policy Studies Network, Research paper 6.

Hassan, R. & Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *African Journal of Agricultural and Resource Economics, 2*(1): 83-104.

Hausman, J. & McFadden, D. (1984). Specification tests for the multinomial logit model. *Econometrica*, 52(5): 1219-1240.

Ibe, G.O. & Amikuzuno, J. (2019). Climate Change in Sub-Saharan Africa: A menace to Agricultural productivity and Ecological protection. *Journal of Applied Science and Environmental Management, 23*(2): 329-335.

Mandleni, B. & Anim, F.D.K. (2011). Climate Change Awareness and Decision on Adaptation Measures by Livestock Farmers. *A paper presented at 85rd Annual Conference of the Agricultural Economics Society Warwick University*, 18-20.

Nwajiuba C.U., Onyeneke, R. & Munonye, J. (2008). Climate Change: Perception and Adaptation by Poultry Farmers in Imo State. In: *Nwajiuba C. (Ed). Climate Change and Adaptation in Nigeria: Farming and Rural Systems Economics* by Doppler W. and BauerS., Margraf Publishers, Hohenheim, Germany.

Oku, D.H. (2011). Seasonality and farm/non-farm internationals in western Kenya. *The Journal of Modern African Studies*, 50(1): 1-23.

Okuli, W.S., Jonathan, S.M. & Flavianus, T.M. (2012). Gender and Adaptation Practices to the Effects of Climate Change in Bahi and Kondoa Districts Dodoma Region, Tanzania. *Journal of Sustainable Development*, *5*(12): 65-77.

Oladipo. E. (2010). Towards enhancing the adaptive capacity of Nigeria. A review of the country's state of preparedness for climate change adaptation. Heinrich Boll Foundation,Nigeria.

Osuafor, O.O., Umeukeje, A.P. & Ude, K.D. (2021). Constraints to use of risk-smart options among crop producers in Enugu State of Nigeria: A principal component analysis. *Himalayan Journal of Agriculture, 2*(6), 8-16.

Osuafor, O.O., Obiekwe, N.J. Obot, A.P. & Ude, K.D. (2021). Determinant of risk-smart options among cassava farm households in Enugu State Nigeria. In G.S. Umoh, E.J. Udoh, G.E. Edet, S.B. Akpan, O.D. Akpan & U.E. Okon (eds). *Agricultural Risk and Management in Nigeria.* Proceedings of the 20th Annual Conference of Nigerian Association of Agricultural Economists (NAAE) held at University of Uyo, Uyo, Akwa Ibom State, 15th-16th March, 305-315.

Osuafor, O.O. & Ude, K.D. (2021). Valuation of rice farmers' preferences and willingness to pay for climate-smart agricultural technologies in Southeast, Nigeria. *Asian Journal of Economic Modelling, 9*(1): 48-57.

REVIEW ARTICLES

Hydroponics: An Innovative Approach to Urban Agriculture

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ABSTRACT

This comprehensive review paper explores hydroponics as an innovative approach to urban agriculture, addressing the challenges of limited land availability, food insecurity, and environmental concerns resulting from urbanization. Hydroponics, a soilless cultivation method, offers a promising alternative to traditional agriculture. The paper provides an overview of various types and techniques of hydroponics and discusses the crops that can be grown using this method. It also reviews the nutrient solutions used in hydroponics and compares the yields of crops grown using hydroponics with traditional methods. In addition, the paper highlights the role of hydroponics in promoting water conservation and sustainability. The feasibility and adoption of hydroponics in Nepal are assessed, along with the challenges associated with this technology. The review concludes that hydroponics holds great potential for crop production but requires further research and development to improve accessibility and sustainability.

Keywords: Hydroponics, urban agriculture, sustainability, water use

INTRODUCTION

The world's population is currently estimated to be around 8 billion, and it is projected to reach around 9.7 billion by 2050 (Worldometer, 2023). This growing population presents a significant challenge for the agriculture industry, as it means that food production needs to increase to meet the rising demand. According to FAO, global food production needs to increase by 70% to feed the projected 9.7 billion people in 2050. Compared to other areas, urban areas have a higher population density and are therefore not conducive to traditional soil-based farming practices. Hydroponics, on the other hand, can provide a solution to this challenge by allowing plants to be grown in a water-based nutrient

solution, eliminating the need for soil and allowing for greater flexibility in location and space usage (Rash, 2013).

Hydroponics

Hydroponics is defined as "the science of growing plants without soil, in which the nutrients required by the plants are supplied in a water-based solution."(Agronomy Journal, 2020)

Crops that can be grown under Hydroponics

Leafy greens, herbs, strawberries, tomatoes, and peppers are among the most suitable crops for hydroponic systems. According to a study published in the Agronomy journal in 2020, hydroponic lettuce had superior quality and higher yields than conventionally grown lettuce, leading to its popularity among hydroponic cultivators. Likewise, another study in the same journal in 2019 revealed that hydroponic basil had higher levels of essential oils and antioxidants than traditional basil. The cultivation of hydroponic strawberries has also shown higher yields and quality compared to field-grown varieties, as demonstrated by a 2020 study in the Scientia Horticulturae journal.

DIFFERENT TYPES AND TECHNIQUES OF HYDROPONICS

Deep water culture (DWC)

Deep Water Culture is a hydroponic technique that involves suspending plant roots in a nutrient-rich solution. The plants are usually placed in net pots that are suspended in the nutrient solution. An air pump is used to deliver oxygen to the roots by creating bubbles in the solution. The nutrient solution is replenished periodically to ensure the plants have the necessary nutrients to continue growing.

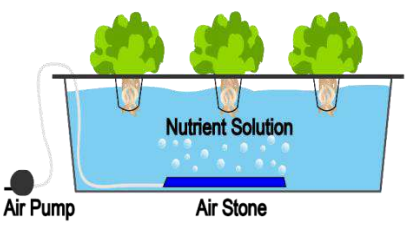

Figure 1. Deep water culture

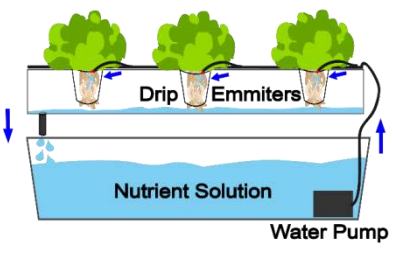

Figure 2. Drip hydroponics

Drip Hydroponics

Drip hydroponics, which is also referred to as trickle irrigation or drip irrigation, is a hydroponic technique that employs a drip emitter to supply nutrient-rich water to the plant's roots.

Aeroponics

Aeroponics is a type of hydroponic system that suspends plants in the air and delivers nutrients through a mist or spray.

Ebb and Flow

Ebb and Flow, also known as Flood and Drain, is a type of hydroponic system that intermittently floods the plants' roots with nutrient-rich water and then drains it back into a reservoir.

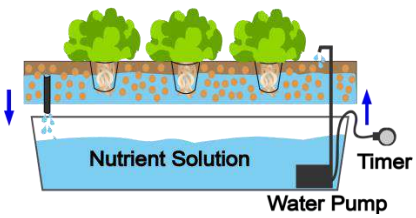

Fig 3. Aeroponics

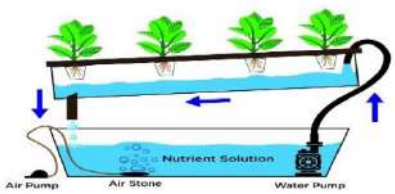

Fig. 4. Ebb and flow

Aquaponics

Aquaponics is a sustainable agricultural system that combines hydroponics and aquaculture. It is a closed-loop system that uses waste generated by aquatic animals, such as fish, to provide nutrients for plants grown hydroponically. In turn, the plants purify the water is then circulated back into the fish tank.

Nutrient Film Technique

The nutrient Film Technique (NFT) is a type of hydroponic system that involves a thin film of nutrient-rich water flowing over the roots of plants, providing them with the necessary nutrients for growth. The excess nutrient solution is collected and recirculated back to the reservoir for reuse.

Nutrient Solution

The nutrient solution used for hydroponics typically contains a mix of essential nutrients that plants need to grow, such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and trace elements like iron, manganese, and zinc. The specific nutrient solution used can vary depending on the type of plant being grown and the growth stage of the plant.

Here are a few examples of nutrient solutions that are commonly used in hydroponics:

- **The General Hydroponics Flora Series:** It consists of three parts (FloraGro, FloraBloom, and FloraMicro) that can be combined to create a complete nutrient solution. This solution contains a balanced mix of macro and micronutrients that are essential for plant growth. (Source: Marschner, H., 2012).
- **MaxiGro** and **MaxiBloom** are dry nutrient concentrates that can be mixed with water to create a nutrient solution for hydroponics. They are designed to provide plants with a complete nutrient profile, including all the necessary macro and micronutrients. (Earth Juice, 2022)
- **The Hoagland solution** is a nutrient solution that has been used for research purposes since the 1930s. It contains all the essential nutrients that plants need to grow, including nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and trace elements such as iron, manganese, and zinc. (Hoagland, D. R., & Arnon, D. I. ,1950)

pH requirements for different crops under Hydroponics

A review paper published in the Journal of Agronomy examined the effects of pH on plant growth and nutrient uptake in hydroponic systems. The authors found that maintaining the pH within the optimal range can improve nutrient availability, uptake, and utilization by plants, leading to improved growth and yield. However, if the pH is too high or too low, certain nutrients can become less available or even toxic to plants, negatively impacting their growth and yield.

Table 1. pH requirements for different crops under Hydroponics

Crops	pH
Tomato	6.0-6.5
Lettuce	6.0-7.0
Spinach	6.0-7.0
Asparagus	6.0-6.8
Bean	6.0
Broccoli	6.0-6.8
Cabbage	6.5-7.0
Cucumber	5.0-5.5
Eggplant	6.0
Pak choi	7.0
Strawberry	6.0

Source: Sharma et al. (2019)

Temperature requirement

Temperature requirements for crops grown under hydroponic systems can vary depending on the crop and growth stage. However, in general, most hydroponic crops premature between 18-27°C during the day and 16-20°C at night. Optimal temperature range for tomato growth was 20-30°C during the day and 16-22°C at night(Liu et al.,2018). A study by Lee et al.,2012, showed that the optimal temperature range for lettuce growth was 20-25°C during the day and 15-18°C at night.

Light Intensity

Several studies have investigated the effects of light intensity on hydroponic crop production, and the results suggest that optimal light intensity ranges can vary widely depending on the crop and growth stage. For example, a study on the effects of light intensity on hydroponic lettuce production found that the optimal light intensity for lettuce growth was between 100 and 400 µmol m^2 s^-1, depending on the growth stage (Kopsell and Sams, 2013).

Similarly, a study on the effects of light intensity on hydroponic tomato production found that the optimal light intensity for tomato growth was between 400 and 800 µmol m^2 s^-1 during the vegetative stage and between 800 and 1200 µmol m^2 s^-1 during the reproductive stage (Alrifai et al., 2020). It's worth noting that light quality and duration also play important roles in hydroponic crop production, and growers must carefully manage all of these factors to optimize crop growth and yield. Some studies have shown that the use of LED lighting can improve crop yields by providing a more tailored light spectrum (Sousa et al., 2020).

Relative Humidity

The optimal relative humidity levels for hydroponic crops can vary depending on the crop, growth stage, and other environmental factors. A study on hydroponic tomato production found that relative humidity levels between 70% and 80% during the vegetative stage and between 60% and 70% during the reproductive stage were optimal for growth and yield (Kumar et al., 2019). Similarly, a study on hydroponic lettuce production found that a relative humidity level of 85% during the germination stage and 60-70% during the growth stage were optimal for growth and yield (Lin et al., 2018). However, high relative humidity levels can increase the risk of disease in hydroponic crops, particularly fungal diseases such as powdery mildew. To reduce the risk of disease, growers should aim to maintain relative humidity levels below 70% (Jensen et al., 2019).

Hydroponics and water conservation

Hydroponics plays a significant role in water conservation by using substantially less water than traditional soil farming methods. In soil farming, much of the water supplied to plants gets leached deep into the soil and becomes unavailable to the plant roots. In contrast, hydroponics allows for precise control of water usage, with plant roots either submerged in water or a film of nutrient-rich water constantly surrounding the root zone.

A study published in the Journal of Cleaner Production compared the water use efficiency of hydroponics and soil-based agriculture in the production of lettuce and found that hydroponic systems used 80-90% less water compared to soil-based systems for the same yield of lettuce. Additionally, the study noted that hydroponic systems were able to produce more lettuce per unit of water used compared to soil-based systems.

NFT-based hydroponics can reduce irrigation water wastage by 70%-90% by recycling the run-off water (Sharma et al., 2019). In hydroponic systems, water and nutrients are delivered directly to the roots of plants, which reduces the amount of water needed to grow plants. Additionally, hydroponic systems can be equipped with sensors and automation technology that allow for precise control of water delivery, further reducing water waste.

Hydroponics and sustainability

Hydroponics requires energy for water circulation, lighting, and temperature control. However, the energy consumption in hydroponics can be offset by increased crop yields and reduced transportation costs (Bhattacharyya et al., 2021). Using renewable energy sources, such as solar and wind power, can further enhance the sustainability of hydroponics (Gómez-López et al., 2021).

Hydroponics is a land-efficient agriculture technique that can produce more food per unit of land compared to traditional soil-based agriculture (FAO, 2019). This efficiency is due to the vertical stacking of plants in hydroponic systems, allowing for more plants to grow in a limited space. Additionally, hydroponic systems can be set up in urban areas, reducing transportation costs and carbon emissions associated with food production and distribution (Niederwieser et al., 2020).

Hydroponics allows for the recycling of nutrients and water, reducing waste and increasing resource efficiency. Hydroponics can reduce fertilizer and pesticide use by up to 60% compared to traditional soil-based agriculture (Bhattacharyya et al., 2021). Nutrient-rich wastewater from hydroponic systems can be used to fertilize soil-based agriculture, closing nutrient loops and reducing the need for

synthetic fertilizers (Niederwieser et al., 2020). Additionally, organic waste from hydroponic systems can be composted and used as soil amendments, further reducing waste and increasing resource efficiency.

Adoption of hydroponics in Nepal

Agri Tech Nepal, an agricultural company situated in Kathmandu, Nepal, specializes in hydroponic farming and was established in 2016 to promote sustainable and innovative farming practices in Neto promote a hydroponic farm in Kathmandu where a range of herbs and vegetables, such as lettuce, kale, parsley, and basil, are grown. Agri Tech Nepal also offers training and assistance to farmers who are interested in adopting hydroponic farming, providing them with workshops and consulting services to help them set up their hydroponic systems and improve crop yields. Laxmi Hydroponics, located in Chitwan, employs a deep water culture system to grow vegetables, while Green Farm Nepal, located in Kathmandu, utilizes a nutrient film technique (NFT) system to cultivate their crops. My Republica reports that Green Farm Nepal produces approximately 800 kg of vegetables per month and is planning to expand production. Additionally, Agri-Greens Hydroponic Farm, a family-owned hydroponic farm situated in Kavre, grows a variety of crops using different hydroponic systems.

Table 2. Yield Comparison in open field Condition and Hydroponics

Name of crop	Hydroponics cultivation (Yield Kg/ha)	Open field cultivation (Yield Kg/ha)
Lettuce	23548.98	10,092.42
Tomato	403,335.81	11,203.75-22,407.47
Potato	156,852.29	17,925.98
Cabbage	20,184.84	14,577.94
Cauliflower	33,641.4	11,213.8-16,820.7

(Source: Kumar et al., 2020)

Challenges of hydroponics

One of the biggest challenges of hydroponics is disease management, as pathogens can easily spread through nutrient-rich water. According to Nechwatal and Plochl (2018), some of the common pathogens in hydroponic systems include *Pythium*, *Fusarium*, and *Phytophthora*, which can cause root rot, wilting, and stunted growth. Proper sanitation and equipment and water sources disinfection are essential to prevent disease outbreaks in hydroponic systems.

Another challenge of hydroponics is managing pH and nutrient levels in the water. In hydroponic systems, plants rely on the nutrient solution for their

growth, and any imbalances or fluctuations in pH and nutrient levels can affect plant growth and yield. Resh (2018) explains that hydroponic growers must carefully monitor and adjust the pH and nutrient levels regularly to maintain optimal growing conditions. Additionally, the type and concentration of nutrients in the solution can also affect plant growth and must be carefully selected based on the plant species and growth stage. Over-fertilization can lead to nutrient toxicity, while under-fertilization can result in nutrient deficiencies, both of which can negatively impact plant growth and yield.

The initial investment for a hydroponics farm can be relatively high compared to traditional farming methods. However, the long-term benefits of hydroponics farming can often outweigh the initial costs.

Feasibility of hydroponics in urban areas of Nepal

Hydroponics is a boon for urban communities (Subedi and Paudel, 2020). A study conducted by Gorkhapatra Corporation in 2017 found that hydroponics could be a viable option for Nepalese farmers, particularly for those living in urban areas with limited access to land for traditional farming. The study concluded that hydroponics could help increase crop yields, reduce water usage, and minimize the impact of weather-related disasters on crop production.

Another study published in the International Journal of Research Studies in Agricultural Sciences in 2017 explored the potential for hydroponic strawberry production in Nepal. The study found that hydroponic strawberry production was feasible in Nepal, and could offer a way to increase the production of high-value crops in the country.

However, some studies have raised concerns about the feasibility of hydroponics in Nepal due to the high initial investment required to set up a hydroponic system, as well as the ongoing costs associated with maintaining the system. Additionally, some researchers have noted that hydroponics may not be well-suited to certain crops grown in Nepal, such as rice, which require large amounts of water and may be better suited to traditional farming methods.

CONCLUSION

Based on the review papers on hydroponics, it can be concluded that hydroponics is a promising approach to agriculture that offers several potential benefits, including increased crop yields, reduced water usage, and year-round crop production.

However, the feasibility of hydroponics can depend on several factors, such as the availability of resources, the specific crops being grown, and the market

demand for those crops. Additionally, the initial investment required to set up a hydroponic system can be high, and ongoing maintenance costs can also be a challenge.The potential benefits of hydroponics make it a promising option for agricultural production, particularly in areas with limited access to arable land or water resources. However, more research is needed to fully understand the feasibility and potential of hydroponics in different regions and for different crops, as well as to develop strategies for making hydroponics more accessible and affordable to small-scale farmers.

REFERENCES

Agritech Tomorrow. (2021, January 12). *How Hydroponics May Be Essential for Urban Agriculture.[*online]Available at: *https://www.agritechtomorrow.com/story/2021/01/how-hydroponics-may-be-essential-for-urban-agriculture/12641/*

Alrifai, R., Aghdam, M. S., Motallebi-Azar, A., Naseri, R., & Mohsenzadeh, S. (2020). Effects of different light intensities on morphological and physiological traits of tomato plants grown under hydroponic conditions. Acta Horticulturae, 1272, 345-350. doi: 10.17660/ActaHortic.2020.1272.47

A review on hydroponic greenhouse cultivation for sustainable agriculture (2018). Available at: *https://pdfs.semanticscholar.org/0470/86269de18c467e2999951c29b5c6e9fdb15f.pdf?_gl=1*7tu97f*_ga*NzA5NzAxNzMyLjE2NjM1NjQ0MDM.*_ga_H7P4ZT52H5*MTY3ODY4NzQwNy40LjAuMTY3ODY4NzQwNy4wLjAuMA* (Accessed: 3rd March, 2023)

Chen, Y., Luo, W., & Huang, Y. (2020). Effects of Water Temperature on Growth and Nutrient Uptake of Hydroponic Lettuce. Agricultural Water Management, 238, 106230. doi: 10.1016/j.agwat.2020.106230

Chong, K. P., Yusof, Y. A., Khairuddin, N., & Redzwan, N. (2020). Hydroponics in modern agriculture: a review of systems and technologies. Engineering Science and Technology, an International Journal, 23(4), 941-949.

How do drip hydroponic system work? [online]Available at: *https://www.nosoilsolutions.com/drip-hydroponics/*(Accessed:23rd March,2023)

How does the Ebb and flow hydroponics system work?[online]Available at: *https://www.nosoilsolutions.com/ebb-flow-hydroponics/* (Accessed: 23rd March,2023)

Hydroponic Nutrient Solutions by University of Florida IFAS Extension (2021), Available at: *https://edis.ifas.ufl.edu/pdffiles/HS/HS14100.pdf* (Accessed: 3rd March, 2023)

Jensen, M. H., Korsgaard, M., & Ottosen, C. O. (2019). Prevention and control of diseases in hydroponic systems. In Hydroponic production of vegetables and ornamentals (pp. 293-317). CAB International. doi: 10.1079/9781789241677.0293

Kopsell, D. A., & Sams, C. E. (2013). Increases in shoot tissue pigments, glucosinolates, and mineral elements in sprouting broccoli after exposure to short-duration blue

light from light emitting diodes. *Journal of the American Society for Horticultural Science*, 138(1), 31-37. doi: 10.21273/JASHS.138.1.31

Kumar, V., Singh, B., Jha, S. K., Dubey, S. K., & Banerjee, S. (2019). Influence of relative humidity and nutrient solution concentration on growth, yield and quality of hydroponic tomato. *Journal of Pharmacognosy and Phytochemistry*, 8(6), 1296-1300.

Lee, J. M., & Son, J. E. (2012). Leaf lettuce yield, quality, and nutritional status responses to hydroponic system and nutrient solution pH and temperature. *HortScience*, 47(7), 952-959. doi: 10.21273/HORTSCI.47.7.952

Lin, K. H., Huang, M. Y., Huang, W. D., & Hsu, M. H. (2018). Effects of germination and growing environment on yield and quality of hydroponic lettuce. *Horticulturae*, 4(1), 8. doi: 10.3390/horticulturae4010008

Liu, L., Tang, Y., & Gong, X. (2018). Effect of Temperature on Growth and Yield of Hydroponic Tomato. IOP Conference Series: *Earth and Environmental Science*, 143, 012102. doi: 10.1088/1755-1315/143/1/012102

Lopez, R.G. et al. (2018). Hydroponics: A Versatile System to Study Nutrient Management in Horticultural Crops. *Journal of Agricultural Science*, vol. 10(3), pp. 246-258. doi: 10.5539/jas.v10n3p246.

Resh, H. M. (2013). *Hydroponic food production: A definitive guidebook for the advanced home gardener and the commercial hydroponic grower*. CRC Press

Saha, S., Chakraborty, I., & Das, P. K. (2020). The influence of environmental factors on hydroponic tomato production: A review. *Environmental Sustainability*, 3(2), 81-92. doi: 10.1007/s42398-020-00047-1

Sousa, A. C., Farnese, F. S., Cássio, F., & Torres, L. G. (2020). LED lighting on hydroponic crops. In: *Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production* (pp. 207-225). Springer. doi: 10.1007/978-3-030-19342-3_8

The Weather Channel. (2019, October 7). Urban Farming and Hydroponics Could Help Feed the World
(Accessed: 3rd March,2023)

What is an example of deep water culture hydroponic system?[online]Available at: *https://www.nosoilsolutions.com/deep-water-culture-hydroponics/* (Accessed: 23rd March,2023)

While Saving Water [online] Available at: *https://weather.com/forecast-change/news/2019-10-07-urban-farming-hydroponics-help-feed-world-saving-water (*Accessed: 3rd March,2023)

World population projected to reach 9.8 billion in 2050, and 11.2 billion in 2100.(Not dated) Available at: https://www.un.org/en/desa/world-population-projected-reach-98-billion-2050-and-112-billion-2100#:~:text=World%20population%20projected%20to%20reach%209.8%20billion%20in,a%20new%20United%20Nations%20report%20being%20launched%20today (Accessed: March 3, 2023).

A Review on Food and Nutritional Security: Global and Nepalese Context

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ABSTRACT

Today hunger, poverty and livelihoods insecurity have been ragraded as major challenges for development. This article briefly discusses on situation and pillars of food security. Further more, food security status at global level and in Nepal is discussed. Various factors causing food security in Nepal and the way forward are well discussed.

Key words: Food / nutrition security, availability, utilization, stability, access

INTRODUCTION

Food is the source of nutrition i.e., required by all ages of people regardless of sex, ethnicities for normal growth, development and health. Food Security is the "Basic Human right" and is also assured by the Interim constitution of Nepal. Food security has always been a crucial issue with rapidly increasing global population and gets reinforced whenever food prices start rising.

The concept of food security was originated in the mid-1970s with the initial focus on food supply problems – of assuring the availability and to some degree the price stability of basic foodstuffs at the international and national level. In the 1974 World Food Summit, food security was defined as: "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices". According to FAO; Food security is defined as "When all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". Likewise, Food insecurity is defined by USDA as "a situation of limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways".

There are four major pillars of food security (Figure 1) without which a place or a country or even a small household is considered to be food insecured;

1. Availability

It refers to the physical existence of food. On a national level food availability is a combination of domestic food production, commercial food imports and exports, food aid and domestic food stocks. On household level, food could be from own production or brought from the local markets. Status: Due to population growth and climate change, the pressure on existing natural resources, namely land and water has increased. The impacts of climate change has lead to land degradation, lack of irrigation water, reduced soil moisture and therefore losses of economic livelihoods.

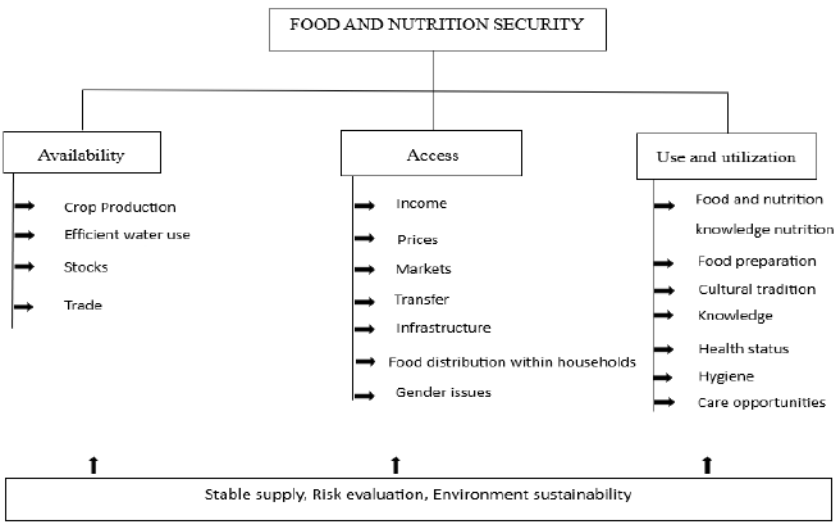

Figure 1. Pillars of food security

2. Access

Access is ensured when all households have enough resources to obtain food in sufficient quantity, quality and diversity for a nutritious diet which depends mainly on the amount of household resources and on prices. It is also a question of the physical, social and policy environment. Drastic changes in these dimensions may seriously disrupt production strategies and threaten food access of affected households. For e.g., in developing countries we may get affected by severe droughts or floods more frequently along with that the harvest volume shrinks and the prices for food increases, affecting the availability and accessibility of food for households.

3. Use and Utilization

The term utilization decribes the socio-economic aspects of household food and nutrition security, determined by knowledge and habits. Assuming that

nutritious food is available and accessible, the household has to decide what food to purchase and how to prepare it as well as how to consume and allocate it within the household.For instance; Traditional fermented foods such as Dahi (curd), Masyaura (a sun dried product of black gram paste mixed with vegetables or tubers), Gundruk (a sun dried product after fermenting Broad leaf mustard etc which has been a good source of household incomes in Nepal (Rajbhandari, 2015). Utilization relates to the ability of the humanbody to take food and convert it. This gained energy is very important when it comes to daily physical activities. For e.g., working/ drudgery in agriculture. Utilization requires a healthy physical environment and adequate sanitary facilities as well as the understanding and awareness of proper health care, food preparation, and storage processes.

4. Stability

Stability describes the temporal dimension of food and nutrition security, respectively the time frame over which food and nutrition security is being considered. Stability is given when the supply on household level remains constant during the year and in the long term. That includes food, income and economic resources.

Furthermore, it is important to minimize external risks such as natural disaster and climate change, price volatility, conflicts or epidemics through activities and implementations improving the resilience of households. Such measure include insurances e.g., against drought and crop failure as well as the protection of the environment and the sustainable use of natural resources like land, soil and water. It is important to understand that food security doesnot only mean an increase in the aggregate food supply, it should apply to physical and economic access as well as entitlement to food for all. Any diet is considered balanced when wide variety of foods in the right proportions, and consuming the right amount of food and drink to achieve and maintain a healthy body weight. However, in case of a typical Nepali household the diet consists of rice, pulses, leafy vegetables and some pickles lacking the major sources of vitamins and minerals i.e., fruits. The recommended average consumption per person is 400 gram fruits per day as per Our world in Data, Oxford Martin School while only 138.11 g/day fruits are being consumed by the Nepalese per person in 2020. Hence, the question remains “Are we food secure?”.

Global food security status

The World Food Program (WFP) has considered 2023 as a year of global food crisis stating; “2023, another year of extreme jeopardy for those struggling to

feed their families." Despite hopes that the world would emerge from the COVID-19 pandemic in 2021, and food security would begin to improve, world hunger rose further in 2021. After remaining relatively unchanged since 2015, prevalence of undernourishment jumped from 8.0 to 9.3 percent from 2019 to 2020; and rose at a slower pace in 2021 to 9.8 percent. It is estimated that between 702 and 828 million people were affected by hunger in 2021. The number has grown by about 150 million since the outbreak of the COVID-19 pandemic – 103 million more people between 2019 and 2020 and 46 million more in 2021, considering the middle of the projected range. The further increase in global hunger in 2021 reflects exacerbated inequalities across and within countries due to an unequal pattern of economic recovery among countries, and unrecovered income losses among those most affected by the COVID-19 pandemic. It is all in a context of diminishing social protection measures implemented in 2020. In 2021, hunger affected 278 million people in Africa, 425 million in Asia and 56.5 million in Latin America and the Caribbean i.e. 20.2, 9.1 and 8.6 percent of the population, respectively. While most of the world's undernourished people live in Asia, Africa is the region where prevalence of undernourishment is the highest. It is estimated that nearly 670 million people will still be undernourished in 2030 i.e. 8 percent of the world population, which is the same percentage as in 2015 (FAO *et al*., 2022),

Causes of food crisis of unprecedented proportions (WFP, 2023):

- **Conflict**: 70 percent of the world's hungry people living in areas afflicted by war and violence e.g., Ukraine (Russia's invasion of Ukraine cut off many countries from their main supply of wheat and coarse grains, disrupting global food supply chains that were already stressed by the COVID pandemic)
- **Economic shocks**: governments' response to the pandemic around the world by raising interest rates. Such financial measures added further burdens to developing countries struggling with high debt loads and currency devaluation.
- **Climate extremes**: Climate shocks destroy lives, crops and livelihoods, and undermine people's ability to feed themselves (East Africa).
- **Soaring fertilizer prices**: High fertilizer prices could turn the current food affordability crisis into a food availability crisis, with production of maize, rice, soybean and wheat all falling in 2022.
- According to GHI 2022, the situation of hunger is serious in South Asia and Africa (South of the Sahara), where hunger is second highest, the prevalence of undernourishment and the rate of child mortality are higher than in any other world region.

The fifth World Food Safety Day (WFSD) will be celebrated on 7 June 2023 to draw attention and inspire action to help prevent, detect and manage foodborne risks, contributing to food security, human health, economic prosperity, agricultural production, market access, tourism and sustainable development (WHO, 2023).

Food security status of Nepal

Nepal has been struggling hard for attaining sustainable livelihoods since past few decades; and has been rampantly facing food insecurity. The growing incidence of poverty and food insecuirty in Nepal is an outcome of the economic process of worsening income distribution pattern among the rural households. Lack of employment opportunities has been futher deteriorating the situation of poverty, food insecurity and livelihoods in Nepal (Rajbhandari, 2001).

If we look at the prevalence of food insecurity in mountain, hilly and terai regions, the mountain and hilly regions seem to be more affected (14%) by food insecurity than terai region (9%) as reported by MoALD et al., (2018). Low farm productivity, limited livelihood opportunities and weak market connectivity caused by poor infrastructure, together with geographical heterogeneity, gender and caste disparities are considered as underlying causes of food insecurity and under nutrition in Nepal (MoALD *et al.,* 2018).

Although there are still issues, Nepal has made progress in reducing poverty and food insecurity. Nepal made significant success in lowering its Multidimensional Poverty Index (MPI) from 30.1% to 17.4% between 2014 and 2019, according to the 2021 MPI. However, the Nepal Demographic and Health Survey (2016) had reported that 10% of households in Nepal had severe food insecurity, 20% of households had moderate food insecurity, and 22% of households had mild food insecurity. More rural households (61%) than urban families (46%), and the majority of these households in Karnali provinc were food insecure. High rates of undernourishment are a result of food insecurity in Nepal. In total, 27% of children under the age of five are underweight, 10% are wasted, and 36% are stunted (IFPRI, 2023).

Nepal ranks 81st out of the 121 countries in the 2022 Global Hunger Index (GHI) with a score of 19.1. Nepal has a moderate level of hunger. The stunting rates in Bagmati province is 22.8% while Karnali province has just the double to that of former i.e., 47.8% (MOALD, 2023). Also according to WFP (2023), Nepal has the following indicators:

- Human Development Index (2022): 143 out of 191 countries.
- Income Level: Least developed level

- Chronic malnutrition: 25% of children between 6-59 months.
- Thirty six percent of children under 5 are stunted.

Causes of food insecurity in Nepal

High rate of population growth, poor infrastructure development, and poor legal provision based on inheritance (patriarchal) division of property and land tenure systems are the main reasons for land fragmentation in the study area (Dhakal and Khanal, 2018). Land fragmented is considered as a major obstacle to agricultural mechanization which causes great inefficiencies in production and also requires considerable cost to alleviate its effects in Nepal (MoALD, 2023). Major causes of food insecurity include the following:

- Low soil productivity, insufficient agricultural inputs (such as improved seeds, irrigation, finance), poorly developed agricultural infrastructures.
- Vicious cycle of poverty, poor access of farmers and marginalized groups to productive resources, lack of skill development training, lack of improved technologies, lack of credit facilities and subsidies (Rajbhandari, 2001).
- Increasing population and increasing food demand:
- Stagnant yields due to lack of adequate resource allocation for agricultural research, development and extension.
- Geographical variations eg. Terai region contributes most to the agricultural production while other two ecological belts: the Hills and Mountains, have less arable land and are more difficult to transport goods through, creating a huge challenge to ensure the year-round availability of sufficient food (NPC and WFP, 2019).
- Unregulated chemical pesticides on commercial agricultural produce, antibiotics, hormones, mixing of non-edible substances with food (food quality).
- Climate change and other natural disasters that affects food supplies and decrease in production
- Pandemic related crisis
- Discriminatory gender relations.
- Discrimination in the distribution of food (concerned with the access of all people to food).

Factors such as financial constraints due to persistent poverty, inequality and lack of sufficient job opportunities play a vital role. Likewise, physical constraints due to poor governance, infrastructural inadequacies or wrong policy

framework (Rajbhandari, 2001), lack of access to commodity markets etc. are other factors responsible for poverty in Nepal.

- Due to inability to fulfill their year-round needs Nepalese (with over 20% still below poverty line) have resorted to migrant labor and their remittances in order to mitigate the food shortages and negative effects of unpredictable harvest (NPC and WFP, 2019)
- Changing food habits: Urbanization needs more processed food which consumes more food.
- Wastages: over eating, throwing away of cooked food and food getting expired in the domestic fridges/ chain stores

Status: Though the childhood malnutrition remains high, over the past 15 years the country has succeeded in reducing malnutrition due to a stronger social protection system, changes in diet and improvements in access to healthcare (NPC and WFP, 2019).

Ways forward

Here are few important suggestions for future:

- Preservation and improvement of indigenous seeds, plant/animal genetic resources and IKS (Rajbhandari, 2011).
- Optimum utilization of wetlands for alleviating poverty and attaining sustainable livelihood (Rajbhandari and Shrestha, 2014)
- Promote bio-intensive farming system which is a holistic approach addressing issues of food security (Rajbhandari, 2011)
- Proper policy, planning and strategy urgently needed
- Proper use of grants provided by global organizations (small farmer or entrepreneur focused)
- Importance to both fermented and non-fermented food for nutritional security such as; Dahi, Gundruk, Sinki etc. which solves the problem of storage and wastage.

CONCLUSION

As of 2023 several initiatives have been taken for ensuring food availability, access and stability to every household by different global organizations such as the World Bank and even in national level realizing the dire situation of food security and its importance in present day. With the increasing population and degrading land along with tremendous pressure on the limited resources that day isn't far when people won't be able to afford single ounce of grains. It is unquestionable that food security is a must for human existence along with that global food security helps reduce poverty, enhances economic growth, trade

opportunities, improved health and health care and so on. Better policies and step towards better farming systems which focuses on increasing the production as well as improving the environment (especially soil) together hand in hand is a pivotal step toward global and national food security.

REFERENCES

Dhakal, B.N. and Khanal, N.R. (2018) Causes and consequences of fragmentation of agricultural land: A case of Nawalparasi district, Nepal, *The Geographical Journal of Nepal*, 11: 95-112

FAO. (2006) *Food Security; Policy Brief*, Food and Agriculture Organization of the United Nations, Rome

FAO, IFAD, UNICEF, WFP and WHO. (2022) *The State of Food Security and Nutrition in the World Repurposing food and agricultural policies to make healthy diets more affordable*. Rome.

IFPRI, (2023) *The Ukraine War and its Food Security Implications in Nepal*. 1-9

MoALD, (2023) *Food and Nutrition security brief concept*, Hariharbhawan, Lalitpur.1-2.

MoALD, CBS, WFP, and FAO. (2018) *SDGs and food insecurity in Karnali: Results from the food insecurity experience scale*. Ministry of Agriculture and Livestock Development, Central Bureau of Statistics, World Food Programme and Food and Agriculture Organization, Kathmandu, Nepal.

NPC and WFP, (2019). *The Food Security Atlas of Nepal*. Kathmandu, Nepal. 1-56.

Rajbhandari., B.P. (2001). *Bio-intensive farming system for sustainable livelihood and food security*. *Development Journal*, SAGE Publication, Rome, 44(4): 67-72

Rajbhandari, B.P. (2011). Relationships among rotational intensity, crop diversity index, land utilization index and yield efficiency in bio-intensive and conventional farming systems. *Nepalese Journal of Agricultural Sciences*, 9:44- 52.

Rajbhandari, B.P. and Shrestha, S. (2014). *Crop production and food security in the face of climate change*. HICAST Publication, Kathmandu: 158.

Rajbhandari., B.P. (2015). *Fundamentals of sustainable agriculture and rural development*, HICAST Publication, Kathmandu, 44-51.

Shrestha, H.P. (2022) Ukraine War and risk of food insecurity in Nepal, Nepal Republic Media Pvt. Ltd., Kathmandu.

WFP. (2023*). A global food crisis*, World Food Program, Rome

WHO. (2023). *A guide to World Food Safety Day: food standards save lives*, World Health Organization

A Review on Precision Agriculture: Advancements, Challenges, and Future Prospects

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ABSTRACT

Precision agriculture, also known as precision farming or site-specific crop management, is an approach that utilizes modern technologies and data analysis techniques to optimize agricultural practices at the field level. This review article provides an in-depth analysis of the advancements made in precision agriculture, the challenges faced by its implementation, and the future prospects that lie ahead. The article explores the key components of precision agriculture, including remote sensing, Geographic Information Systems (GIS), Global Positioning Systems (GPS), and data analytics. It examines the benefits of precision agriculture in terms of increased productivity, resource efficiency, and environmental sustainability. Furthermore, the review delves into the challenges associated with adopting precision agriculture, such as high initial costs, data management complexities, and the need for farmer training. Lastly, the article discusses the future prospects of precision agriculture, including emerging technologies, policy implications, and potential areas for further research and development.

Keywords: GPS, GIS, IoT, Precision agriculture, Remote sensing

INTRODUCTION

Nepal, as a nation deeply rooted in agriculture, heavily relies on the expertise of farmers, their tireless manual labor, and the unpredictable forces of nature for production. This inherent dependence has underscored the urgent need to enhance agricultural productivity and strengthen food security in the country. The urgency to enhance agricultural productivity and ensure food security is staggering. Now is the time to delve into the intricacies of crop and soil variability within fields, harness the power of information technology and agricultural science, and develop systematic and efficient production techniques for sustainable crop yield. It is imperative to transition from environmentally costly conventional farming practices to modern, eco-friendly methods that can revolutionize agricultural productivity while preserving our natural resources (Shrestha and Khanal, 2020). In the age of agricultural innovation, a

revolutionary concept is captivating farmers and researchers alike, promising to redefine the very essence of cultivation: precision agriculture. Breaking free from traditional farming methods, this visionary approach harnesses the power of advanced technologies, big data analytics, and interconnected systems to unlock a new era of precision, efficiency, and sustainability. With its transformative potential to maximize yields, conserve resources, and cultivate a brighter future, precision agriculture stands as the innovative beacon guiding us toward a more productive and environmentally conscious world of farming.

Precision Agriculture, a relatively recent paradigm of farm management that originated in the mid-1980s, encompasses a comprehensive range of tools for effective PA management, often referred to as Precision Farming. The fundamental principle of Precision Agriculture revolves around achieving a harmonious alignment between various variables (Pierce and Nowak, 1999).Precision agriculture provides the platform for the possibility to do the right thing, in the right place, at the right time, and in the right way. Therefore, PA bases its applicability on the use of technologies to detect and decide what is "right" (Zhang *et al.*, 2002).Worldwide, investments in research and technology development on PA have considerably increased during the past decade (Schellberg*et al*., 2008).

According to the International Society of Precision Agriculture, "Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production" (ISPA, 2019). Precision agriculture, also known as precision farming or site-specific crop management, is a modern approach that combines advanced technologies, data analysis techniques, and agronomic principles to optimize agricultural practices at the field level. It represents a paradigm shift in farming, enabling farmers to make data-driven decisions and manage their resources more efficiently. By integrating various technologies such as remote sensing, geographic information systems (GIS), global positioning systems (GPS), and data analytics, precision agriculture aims to maximize crop productivity, minimize input wastage, reduce environmental impact, and improve overall farm profitability (Shisodia*et al*., 2020). Over the past decade, there has been a substantial increase in global investments directed toward research and technological advancements in the field of PA (Schellberg*et al.*, 2008 as cited in S. Liaghat*et al*., 2010).

Traditionally, agriculture has been practiced using uniform management strategies, where inputs such as water, fertilizers, and pesticides were applied uniformly across a field, regardless of spatial variations in soil conditions, crop health, or environmental factors. This blanket approach often resulted in inefficient resource utilization, over-application of inputs in some areas, under-application in others, and increased environmental risks. However, with the advent of precision agriculture, farmers can now tailor their practices to the specific needs of different areas within a field, allowing for more targeted and precise interventions.

One of the key components of precision agriculture is the use of remote sensing technologies, including satellites, aerial imagery, and drones, to collect high-resolution data about soil characteristics, crop health, and environmental parameters. This data, combined with GIS and GPS technologies, enables farmers to create detailed maps and spatially explicit models of their fields, providing valuable insights into the variability within their farming systems. By understanding these spatial variations, farmers can apply inputs such as fertilizers, water, and pesticides at the right time, in the right amounts, and in the right locations, maximizing their effectiveness while minimizing waste. The adoption of precision agriculture brings forth numerous benefits. By optimizing input management and reducing resource wastage, farmers can enhance crop yields and improve overall farm profitability. Moreover, precision agriculture promotes environmental sustainability by minimizing the use of agrochemicals, reducing nutrient runoff, and preserving water resources. It also facilitates better decision-making through real-time data analysis, allowing farmers to respond promptly to changing conditions and make informed choices regarding planting, irrigation, pest control, and harvesting.

However, the implementation of precision agriculture is not without its challenges. High initial costs, complex data management, and the need for specialized training are among the hurdles that farmers face when adopting precision agriculture technologies. Furthermore, issues such as connectivity, interoperability, and standardization pose additional barriers to the widespread adoption and integration of these technologies into existing farming systems. Looking ahead, precision agriculture holds promising prospects. Emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI) are expected to further enhance the capabilities of precision agriculture, allowing for real-time monitoring, autonomous decision-making, and improved farm automation (Jha *et al.*, 2019). Policy frameworks and regulatory guidelines will play a crucial role in supporting the growth and sustainable implementation of precision agriculture. Additionally, exploring the integration of precision

agriculture with other farming systems, such as organic farming or agroforestry, can unlock new synergies and promote holistic approaches to sustainable agriculture.

ADVANCEMENTS IN PRECISION AGRICULTURE

Remote sensing technology: Remote Sensing (RS) is a scientific discipline that involves acquiring and interpreting information from a distance by utilizing sensors that do not require physical contact with the object under observation (Jensen, 1996).Application of RS and GIS technologies in the management of natural resources is increasing rapidly due to great strides made in space-borne RS satellites in terms of spatial, temporal, spectral, and radiometric resolutions(Venkataratnam, 2001).RS technology plays a pivotal role as a key component of Precision Agriculture (PA), and its utilization is witnessing a growing trend among scientists, engineers, and large-scale crop growers.

Remote sensing techniques play a vital role in assessing crop conditions, yield forecasting, pest and disease detection, and various agricultural applications. They offer a cost-effective and efficient method for identifying pest-infested and disease-affected plants. Researchers have successfully employed remote sensing techniques to detect specific insect pests and distinguish between damage caused by insects and diseases in oat crops (Riedell *et al*., 2004).

GIS and GPS: The Navigation Satellite Timing and Range Global Positioning System, or NAVSTAR GPS, is a satellite-based radio-navigation system that is capable of providing extremely accurate worldwide, 24-hour, 3-dimensional location data (latitude, longitude, and elevation). Manufacturers of GPS equipment have introduced a range of innovative tools designed to enhance productivity and efficiency for farmers and agribusinesses engaged in precision farming activities. These advanced tools enable farmers to optimize their operations by leveraging precise location data and improving the accuracy of various farming tasks (Yousefi and Razdari, 2015).

Geographic Information Systems (GIS) in Precision Agriculture refers to the integration of spatial data and analysis techniques within the framework of precision farming practices. GIS technology involves the use of specialized software and hardware to collect, manage, and analyze data related to soil properties, crop health, topography, weather patterns, and other relevant spatial information. By incorporating GIS in Precision Agriculture, farmers can create detailed maps, identify optimal management zones, and implement site-specific

strategies for resource allocation, input application, and crop management, leading to improved efficiency, productivity, and sustainability.

Field-portable GPS and GIS receivers enable rapid mapping of insect infestations, allowing precise communication to field managers. This data facilitates targeted chemical application by custom spray operators, with GPS records documenting treatment location and timing.To map yield variations, yield monitors will be connected to GPS receivers, enabling the creation of yield maps. These maps will serve as valuable tools for identifying field areas that necessitate distinct treatment approaches, optimizing resource allocation, and improving overall farming outcomes (Smith, 2002).

Sensor Technologies: Sensor technologies play a crucial role in monitoring soil conditions and environmental parameters in precision agriculture. These technologies provide real-time and accurate data that enable farmers to make informed decisions regarding irrigation, nutrient management, and environmental stewardship (Shafi*et al*., 2019). Here are some commonly used sensor technologies in precision agriculture:

Soil Moisture Sensors: These sensors measure the moisture content in the soil, allowing farmers to optimize irrigation practices and prevent both over-watering and under-watering of crops.

Soil pH Sensors: Soil pH sensors measure the acidity or alkalinity of the soil, providing insights into soil fertility and the availability of nutrients to plants. This information helps farmers adjust pH levels to support optimal crop growth.

Soil Nutrient Sensors: These sensors detect the levels of essential nutrients such as nitrogen, phosphorus, and potassium in the soil. By monitoring nutrient concentrations, farmers can apply fertilizers precisely and avoid excessive use, reducing environmental impacts and optimizing plant nutrition. Other sensor technologies used in precision agriculture are Weather Sensors, Crop Canopy Sensors, Water Quality Sensors, and Environmental Monitoring Sensors. Integration of sensor technologies with data analytics platforms and decision support systems allows farmers to interpret and utilize the collected data effectively.

BENEFITS OF PRECISION AGRICULTURE

Precision agriculture offers a wide range of benefits that contribute to improved efficiency, productivity, sustainability, and profitability in farming practices (Pierce and Nowak, 1999). Some key benefits of precision agriculture include:

Enhanced Yield and Productivity: Precision agriculture enables farmers to optimize inputs such as water, fertilizers, and pesticides based on site-specific variability within their fields. By applying the right amount of inputs at the right time and in the right location, farmers can maximize crop yield and productivity.

Resource Efficiency: Precision agriculture allows for precise and targeted application of resources, reducing waste and minimizing environmental impacts. By utilizing sensors, GPS technology, and data analytics, farmers can optimize water usage, fertilizer application, and pesticide use, resulting in reduced costs and minimized environmental pollution.

Cost Savings: By using precision agriculture technologies, farmers can minimize input costs by precisely tailoring resource applications to match specific crop needs. This targeted approach ensures that resources are used efficiently, reducing unnecessary expenses and increasing profitability.

Improved Environmental Sustainability: Precision agriculture practices help mitigate the environmental impact of farming. By reducing the use of agrochemicals and optimizing resource management, precision agriculture minimizes soil erosion, water pollution, and greenhouse gas emissions, promoting sustainable and environmentally friendly farming practices (Roy and George, 2020).

Accurate Decision-Making: The integration of advanced technologies such as GPS, remote sensing, and data analytics provides farmers with accurate and timely information about their fields. This enables them to make informed decisions regarding crop management, resource allocation, and pest/disease control, leading to better outcomes and increased profitability.

Site-Specific Management: Precision agriculture enables farmers to adopt a site-specific approach to crop management. By understanding the variability within their fields, farmers can tailor management practices to specific areas, addressing the unique needs of each location and optimizing crop performance (Hakkim*et al*., 2016).

Real-Time Monitoring: Precision agriculture allows for real-time monitoring of various factors such as crop health, soil conditions, and weather patterns. This enables early detection of issues, such as pest infestations or nutrient deficiencies, allowing for timely intervention and minimizing potential crop losses.

Data-Driven Insights: Precision agriculture generates a wealth of data that can be analyzed and utilized to gain valuable insights into crop performance, resource utilization, and field variability. This data-driven approach empowers farmers to make data-informed decisions and continuously improve their farming practices.

Overall, precision agriculture offers numerous benefits that promote sustainable and efficient farming practices, ensuring higher crop yields, reduced costs, improved environmental stewardship, and increased profitability for farmers.

CHALLENGES IN IMPLEMENTING PRECISION AGRICULTURE

While precision agriculture offers significant advantages, there are several challenges that farmers and stakeholders may encounter when implementing precision agriculture practices. These challenges include:

High Initial Investment: Adopting precision agriculture technologies often requires a substantial upfront investment in equipment, software, and training. The cost of purchasing and maintaining GPS systems, sensors, drones, and data management systems can be a barrier for small-scale farmers or those with limited financial resources (Demirbas, 2018).

Data Management and Integration: Precision agriculture generates vast amounts of data from various sources, including sensors, drones, and satellite imagery. Managing and integrating these diverse datasets can be challenging, requiring robust data management systems and efficient analysis tools to extract meaningful insights (Schimmelpfennig, 2016).

Connectivity and Infrastructure: Precision agriculture relies on reliable and high-speed internet connectivity to transmit data between devices and platforms. However, in rural or remote areas, access to such infrastructure may be limited, hindering the seamless transfer of data and real-time monitoring.

Farmer Acceptance and Awareness: Not all farmers are aware of the benefits and potential of precision agriculture. Convincing and educating farmers about the value proposition and long-term advantages of precision agriculture practices is crucial for widespread adoption (Swinton *et al.*, 2001).

Overcoming these challenges requires collaboration among stakeholders, including farmers, researchers, technology providers, policymakers, and agricultural extension services. Continued innovation, improved affordability of technologies, and supportive policies can help address these challenges and accelerate the adoption of precision agriculture practices.

FUTURE PROSPECTS OF PRECISION AGRICULTURE

The future prospects of precision agriculture are promising, with ongoing advancements in technology and the potential for transformative changes in agricultural practices. Here are some key future prospects for precision agriculture:

Internet of Things (IoT): The IoT revolutionizes precision agriculture by creating interconnected systems for real-time data collection, remote monitoring, and automated decision-making, enhancing farming efficiency and responsiveness (Khanna and Kaur, 2019).

Big Data Analytics: Increasing data availability, including satellite imagery, weather forecasts, and farm sensors, offers opportunities for advanced data analytics in precision agriculture. Big data analytics can optimize crop management, enhance resource utilization, and predict yield variability (Bhat and Huang, 2021).

Integration of Multiple Technologies: The future of precision agriculture lies in the seamless integration of various technologies, such as GIS, remote sensing, GPS, robotics, and data analytics. The synergy between these technologies can enable comprehensive and holistic decision-making processes, leading to improved crop productivity and sustainability.

Block chain Technology: Block chain technology holds potential in enhancing transparency and traceability in the agricultural supply chain. It can provide secure and immutable records of transactions, certifications, and product origins, ensuring food safety and enhancing consumer trust (Liu et al., 2021).

Climate Smart Agriculture: Precision agriculture can play a crucial role in climate change mitigation and adaptation strategies. By optimizing resource use, reducing greenhouse gas emissions, and implementing climate-resilient practices, precision agriculture can contribute to sustainable and climate-smart agricultural systems (Roy and George, 2020).

Farm-to-Consumer Connectivity: Precision agriculture can facilitate direct communication and connectivity between farmers and consumers. Through digital platforms and mobile applications, consumers can access information about the origin, production practices, and quality of the food they consume, fostering transparency and trust in the agricultural value chain.

Sustainability and Environmental Stewardship: Future prospects for precision agriculture emphasize the importance of sustainable and

environmentally friendly practices. Precision technologies can enable precise application of inputs, reducing environmental impacts, conserving resources, and promoting biodiversity conservation (Bongiovanni et al., 2004).

Adoption in Developing Countries: As precision agriculture technologies become more affordable and accessible, there is potential for increased adoption in developing countries. Precision agriculture can help small-scale farmers improve their productivity, increase their income, and enhance their resilience to climate change (Shrestha and Khanal, 2020).

These future prospects highlight the potential for precision agriculture to transform agricultural systems, enabling more sustainable, efficient, and productive farming practices. Continued research, innovation, and collaboration among stakeholders are key to realizing these prospects and driving the widespread adoption of precision agriculture worldwide.

CONCLUSION

Precision agriculture has made significant advancements in recent years, leveraging technologies such as remote sensing, GPS, IoT, and data analytics. These advancements have enabled farmers to optimize resource allocation, enhance productivity, and reduce environmental impacts. However, challenges like high initial investment, technical complexity, and data management remain. Looking ahead, the future prospects of precision agriculture are promising. Artificial intelligence, machine learning, and the integration of various technologies offer opportunities for further optimization, automation, and sustainable farming practices. With continued innovation and collaboration, precision agriculture has the potential to revolutionize the way we farm, ensuring efficient resource use, increased profitability, and environmental stewardship.

REFERENCES

Bhat, S.A. and Huang, N.F., (2021). Big data and ai revolution in precision agriculture: Survey and challenges. *IEEE Access*. 9: 110209-110222.

Bongiovanni, R. and Lowenberg-DeBoer, J., (2004). Precision agriculture and sustainability. *Precision agriculture*. *5*: 359-387.

Demirbas, N. (2018, October 27-28). Precision Agriculture in Terms of Food Security: Need for Future. Ohrid, Macedonia: X. IBANESS Congress Series

Hakkim, A.V., Joseph, A., Gokul, A.A. and Mufeedha, K. (2016). Precision Farming: The Future of Indian Agriculture. *Journal of Applied Biology & Biotechnology*. 4(6): 68-72. https://doi.org/10.7324/JABB.2016.40609

ISPA. (2019). ISPA precision Ag definition. Retrieved 26 February 2020, from https://ispag.org/.

Jensen, J. R., (1996). Remote sensing of the environment:An Earth Resource Perspective. 3rd ed. USA: Prentice Hall, 1-28.

Jha, K., Doshi, A., Patel, P., and Shah, M., (2019). A comprehensive review on automation in agriculture using artificial intelligence. *Artificial Intelligence in Agriculture*. 2: 1-12.

Khanna, A. and Kaur, S., (2019). Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. *Computers and electronics in agriculture*. 157: 218-231.

Liaghat, S. and Balasundram, S.K., (2010). A review: The role of remote sensing in precision agriculture. *American Journal of Agricultural and biological sciences*. 5(1): 50-55.

Liu, W., Shao, X.F., Wu, C.H. and Qiao, P., (2021). A systematic literature review on applications of information and communication technologies and blockchain technologies for precision agriculture development. *Journal of Cleaner Production*. 298: 126763.

Pierce, F.J. and Nowak, P., (1999). Aspects of precision agriculture. *Advances in agronomy*. *67*: 1-85.

Riedell, W.E., S.L. Osborne and L.S. Hesler, (2004). Insect pest and disease detection using remote sensing techniques. *Proceedings of 7th International Conference on Precision Agriculture*. Minneapolis, MN USA.

Roy, T. and George K, J., (2020). Precision farming: A step towards sustainable, climate-smart agriculture. *Global climate change: Resilient and smart agriculture*. 199-220.

Schimmelpfennig, D., (2016). *Farm profits and adoption of precision agriculture* (No. 1477-2016-121190).

Shafi, U., Mumtaz, R., García-Nieto, J., Hassan, S.A., Zaidi, S.A.R. and Iqbal, N., (2019). Precision agriculture techniques and practices: From considerations to applications. *Sensors*. *19*(17): 37-96.

Shrestha, M. and Khanal, S. (2020). Future prospects of precision agriculture in Nepal. *Archives of Agriculture and Environmental Science*. 5(3): 397-405. doi: 10.26832/24566632.2020.0503023

Sishodia, R.P., Ray, R.L. and Singh, S.K., (2020). Applications of remote sensing in precision agriculture: A review. *Remote Sensing*. 12(19): 31-36.

Smith, Katherine. (2002). Does Off-Farm Work Hinder Smart Farming? *USDA Agricultural Outlook.* Sept: 28- 30.

Swinton, S.M. and Lowenberg-Deboer, J., (2001). Global adoption of precision agriculture technologies: Who, when and why. *In Proceedings of the 3rd European conference on precision agriculture*. 2: 557-562.

Yousefi, M.R. and Razdari, A.M., (2015). Application of GIS and GPS in precision agriculture (a review). *International Journal of Advanced Biological and Biomedical Research*. *3*(1): 7-9.

Zhang, N., Wang, M. and Wang, N., (2002). Precision agriculture - a worldwide overview. *Computers and electronics in agriculture*. 36(2-3): 113-132.

ARTICLES OF THE RESEARCH PROJECTS
SUPPORTED BY THE MoALD, BAGMATI PROVINCE

Assessment of Farming Practices Adopted by Organic Farmers at Harisiddhi, Lalitpur District

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ABSTRACT

A study on assessment of farming practices adopted by organic farmers at Harisiddhi, Lalitpur district was carried out in 2023 with a general objective of assessing different types of organic farming practices carried out in the study site. For the study, 30 organic farms were selected randomly; and the managers or the owners of the farms along with the workers / co-workers were interviewed with the help of a semi-structured questionnaire. From the survey, it was found that majority of respondent belonged to active age groups of 41- 50 years. Most of the respondents were from Newar community and majority of the respondents had primary level of education. The study revealed that majority of the responders had practiced organic farming on an average 2 to 3 ropani of their land. The study also revealed that most of the respondents were doing integrated crop X livestock organic farming with the use of locally available botanical pesticides, ash, FYM and micro-organisms like Trichoderma for pest management. The survey revealed that majority of the respondents had self-gained experience and traditional knowledge about organic farming. Different types of training and knowledge sharing programs were also suggested to be provided by the government and academia at the local level.

Key words: Organic agriculture, cooperatives, marketing, quality, integrated farming

INTRODUCTION

Nepal is an agricultural country. More than 52% of the people of Nepal are engaged in agriculture (CBS, 2021). In context of Nepal majority of the agricultural practices are carried out in the rural areas of Nepal due to large availability of land resources which we can rarely see in urban areas. There is also large number of people who follow agricultural practices even in the urban areas of Nepal. Agriculture sectors engage more than 66% of the total population in Nepal. Due to availability of diverse natural resources such as

water, land, temperature, climate, rainfall it creates a favorable conditions for practicing agriculture in Nepal. In context of Nepal, agriculture provides the source of food, income, livelihood, and supports the life of the different people as well as provides different types of raw materials needed by different agro-industries. There have been a lot of efforts in increasing the number of people to engage themselves in agricultural practices as well as increase in production and productivity of the agricultural sectors of Nepal. Agriculture contributes around 27.08 percent to the GDP of Nepal (MoALD, 2021).

Status of organic farming in Nepal

Nepal is an agricultural country. More than 66% of the people of Nepal are engaged in agriculture (CBS, 2017). But Nepal is also the same country which ranks 127th on the human development index. It is also a country in which 25% of the population is living below the poverty line and where the unemployment rate is 15.4% (CBS, 2011). In context of Nepal, organic sector has been growing rapidly, but in a slow and steady process. Different types of NGOs and INGOs have been playing an important role in improving the organic agriculture development in Nepal. But there is lack of proper government support to the farmers, who practice organic farming, and also to the marketers. Some of the problems such as market problems, value of the product to name a few still exist in national scenario which have not been properly managed which are one of the major setbacks in adopting organic farming in Nepal.

Programs in support of organic agricultural development in Nepal

Different types of programs are carried out in support of organic agriculture. Nepal, realizing vital role of plant protection in sustainable agriculture, Agriculture Prospective Plan (APP), as well as other succeeding periodic plants have introduced Integrated Pest Management (IPM) as a new extension approach to solve pest and pesticides problems. The IPM program introduced Farmers Field School (FFS) as one of the most effective tools of learning and teaching to address farmers' problems through community participation (BPD 2003). More than 15,000 farmers, including thousand 4500 women have been trained through 600 FFS throughout the country (BPD, 2007). As a result of which there is reduction in pesticide consumption by 55% and also there is an increase in crop production by 10% as reported (PPD, 2005). Sustainable Soil Management project (SSMP) is also launching several activities in favor of organic agriculture, particularly in the areas of soil fertility management and organic coffee production.

Policies and strategies on organic agriculture development

As the relationship between agriculture and environment has been recognized, some policy statements to reduce detrimental effects of agriculture on environment have been undertaken ever since the seventh plan. In this regard, the state has enacted Plant protection act 2048, Pesticides act 2049 and regulation 2050, Food act 2023, Consumers' Right Act 2054 and Regulation, 2056 and Environmental Protection Act 2053 and Regulation 2054 and formulated National standards of Organic Agriculture, Production and Processing 2064 and some other relevant policies and strategies though fragmented and inadequate.

Organic certification

It is the procedure for verifying that the products meet a certain standards. Organic certification is a process by which an independent third party gives a written assurance that a clearly identified process has been methodically assessed such that adequate confidence if specified products conform to specified requirements. A certificate is a written guarantee issued by an independent certification agency and it officially states that the production processes or product complies with certain standards. Organic Certification Nepal (OCN) is one of the founder members of Certification Alliance (Cert All). Being part of Cert All, OCN offers an internationally accredited inspection and certification services to local clients/operators at a reasonable cost. Certification of the organic products was for the first time introduced in 1996 in Nepal and NGOs (Vaidya, 2006). However, the national norms and standards required for production, inspection and certification of organic products has not yet been implemented in the country, though some initiatives have been taken by some private traders and NGOs. Some internationally recognized certifying agencies such as NASAA (Australia), IMO (Switzerland), ICEA (Italy), and Ecocert (Belgium) show their presence in Nepal to work on organic product certification. Recently, the government has Sanctioned Technical Standards for Organic Certification system 2064 BS, as guidelines for promoting organic farming in the country. With the implementation of National Standards of Organic Agriculture Production and Processing 2007 (2064) the organic certifiers operating in the country are to be operated (Pokharel and Pant 2009), Baskota (2006), further stated that, the major challenges for organic sector is certification of small growers worldwide.

MATERIALS AND METHODS

Site selection

The study was carried out from March to June 2023 at Harisiddhi, Lalitpur of Bagmati Province. It is situated at about 8 km South-east from Kathmandu.

Harisiddhi covers an area of 3.100 sqkm and has a population of more than 10,736 (CBS, 2021). The majority of people living in Harisiddhi are Newars; however people from different places of country have also settled here (CBS, 2021). The climate here is mild warm. The average annual temperature is 25.7 degrees Celsius with precipitation of 1128 mm. It is one of the major areas of Lalitpur district where agriculture in practiced at a large scale; and has a significant number of organic farms in the area.

Sampling technique and sample size

Simple random sampling method was followed for sampling. A total of 30 organic farms at Harisiddhi were selected for the study.

Data collection method

Primary data were collected through direct face to face interview with the respondents, with the help of a semi-structured questionnaire. Personal observation was one of the most important and reliable tools used for the survey. Many organic farms were personally observed for authentication of data. Secondary data were collected from various published sources as well as internet browser.

Data analysis

The obtained information were carefully checked, edited, processed and verified for missing and incomplete answers using computer program such as Microsoft Excel.

RESULTS AND DISCUSSION

Size of the land holding for organic farming

From the survey, 33 percent of the respondents had allocated less than 1 ropani of land. Similarly, 12 percent had allocated between 1 to 2 ropani of land, 44 percent had allocated between 2 to 3 ropani of land and only 5 percent had allocated more than 3 ropani of land for organic farming by the farmers (Figure 9).

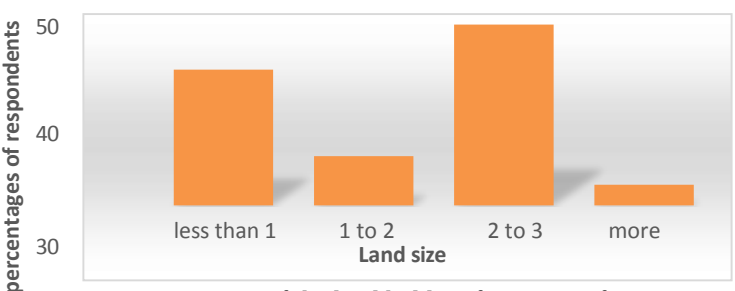

Figure 1. Size of the land holding for organic farming

Land ownership

From this survey, we found out that 18 percent of the respondent had rented or leased the land for carrying out organic farming practices. Sixty seven percent of the respondents had their own land for organic farming. Whereas, about 15 percent of the respondents had leased or rented as well as had their own land for the purpose of carrying out organic farming practices (Figure 2).

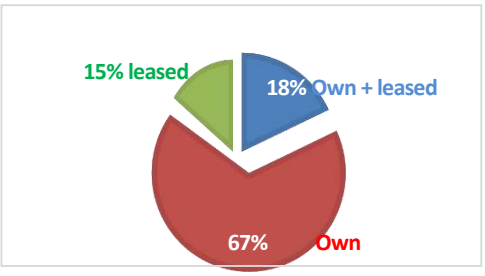

Figure 2. Land ownership of the respondents

Source of irrigation

It was found that almost all the farmers (76%) used ground water for irrigation due to access to wells. Fifteen percent of the respondents used surface water (kulo) as source of irrigation and only 9 percent of the respondents depended on rainwater (Figure 3). Availability of water for irrigation was found as a determining factor for organic farming throughout the year.

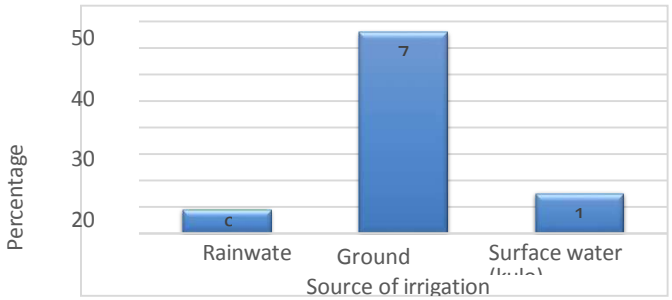

Figure 3. Source of irrigation used by theespondents

Level of trainings of the respondents

The survey revealed that 64 percent of the respondents had taken training regarding different aspects of organic farming. This was one of the factors for promotion of organic farming in the study areas. The respondents reported that the trainings were provided by NARC and I/NGOs. Still there is 36 percent of the organic growers who had never taken any kind of training (Figure 4).

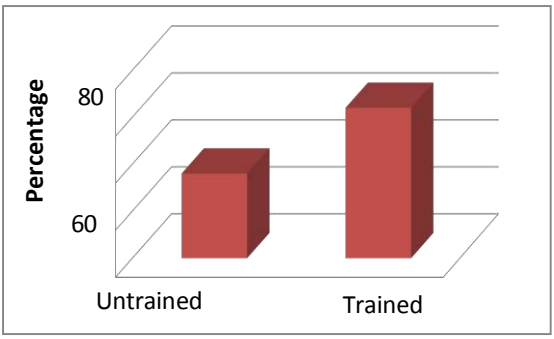

Figure 14. Level of trainings of the respondents

Organic farming practices adopted by the farmers

It was found that different methods of organic farming practices were adopted by the farmers such as use of FYM, compost, bio-pesticides, and pest-resistant varieties. Combination of various organic farming practices was also observed. Moostly the use of FYM was done in the farms in highest amount about 93 percent, followed by the sue of ash on the land about 80 percent, followed by the combination use of FYM and bio- pesticides of about 74 percent from the study area.

Table 2. Organic farming practices adopted by the farmers

S.N.	Method	Yes (%)	NO (%)	Total (%)
1	Ash	80	20	100
2	Bio pesticides	64	36	100
3	Compost	37	63	100
4	FYM	93	7	100
5	Resistant varieties	72	28	100
6	Micro-organisms	33	67	100
7	Cow urine (diluted)	45	55	100
8	FYM + BP	74	26	100
9	FYM + BP + MO	43	57	100
10	FYM + BP + Ash + Urine	8	92	100

Organic product certification

The organic certification process of organic products is a long, expensive and complicated process which cannot be done by the farmers themselves. It should be done by the government level. From the survey, we found out that almost 98 percent of famers from Harisiddhi do not get organic certificates for their products.

Farm records and documentation

The survey revealed that only one third of the respondents used to maintain farm records or document their farm activities. It means the remaining two third or 65 percent of the respondents did not care about keeping the farm records. That is why they cannot make proper planning their farm activities for increasing the income.

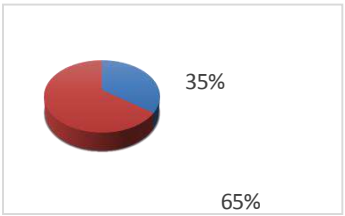

Figure 15. Farm records and documentation

Organic practices adopted by the respondents

From the survey, it was found that respondents used different types of botanical pesticides for pests and disease management. Some of the botanical pesticides used were neem, titepati, timur, garlic to name a few. Different types of organic measures were adopted by the respondents for disease/ pest management (Table 3).

Table 3. Some organic practices used by the respondents for insect / disease management

SN	Organic practices used	Percentage (N=30)	Control
1	Use of trap crops	5	To trap pest on the field
2	Use of sticky and pheromone traps	52	To control insect pests
3	Conservation of natural enemy	63	To minimize the effects of pests
4	Crop rotation	90	To avoid crop infestation by pests
5	Botanicals pesticide cum fertilizer such as jholmol	85	To control soil borne and other pests
6	Use of cow urine + 5 litre of water	100	To control aphids
7	Use of titepati mixed with 1:5 ratio of leaf and water	25	Control of fungal disease / worms
8	Use of trichoderma as bio-pesticides	68	To improve fertility of soil
9	Cultural practices such as soil treatment, solarization, etc.	72	To eradicate the insects and pest on field

It should be noted that all farmers used cattle urine (diluted with water @1:5) were using for aphid management. This was followed by crop rotation (90% of the respondents) for prevention of pest damage. The third important practice was

using Jholmol (liquid botanical pesticide) for the prevention of soil borne and other pests.

CONCLUSION

Organic agriculture is one of the most rapidly growing methods of sustainable cultivation practices in the present context of Nepal. It is one of the best ways of using the available natural productive natural resources more efficiently in a sustainable way. This study revealed that small farmers had adopted a number of useful and low cost organic measures for producing healthy products. And they were able to meet their livelihoods needs.

SUGGESTIONS

Based on the results of the study it is suggested that the MoALD Bagmati province should consider organic agriculture as one of the best alternative to promote for addressing hunger, poverty, unemployment and livelihoods of the small farmers.

More research covering more districts and locations in Bagmati and other provinces as well municipalities is suggested to be conducted in future.

REFERENCES

Bhandari, R., Acharya, R. and Rajbhadari, B.P., (2015). Indicators of Scocio-economic and technological transformation in the promising eco-village in Dang. *Nepalese Journal of Agricultural Sciences*: HICAST, Kathmandu, Nepal. Vol 13.109

CBS (2001)., *Nepal in figure*. Central Bureau of Statistics, Thapathali, Kathmandu, Nepal MOAC, (2004). *National Agriculture Policy*, 2061 (Nepali). Kathmandu: Ministry o f Agriculture and Cooperative.

CBS (2021), *Nepal in figure*. Central Bureau of Statistics, Thapathali, Kathmandu, Nepal MOALD, (2021), *Statistical information on Nepalese Agriculture*, Government of Nepal.

CBS (2017)., *Nepal in figure*. Central Bureau of Statistics, Thapathali, Kathmandu, Nepal NPC, (1998). *The Ninth Plan*. Nepal: National Planning Commission.

FAO (2002). *Oragnic agriculture, environment and food security*. Published as monograph Environment and Natural Resources Series, FAO, 2002, Rome.

Gautam, U. and Rajbhandari, B.P.,(2019). A preliminary study on the role of organic agriculture in food security at Tamankhola rural municipality, Baglung. *Nepalese Journal of Agricultural Sciences, 18*, pp.18-22.

IFOAM (1996) '*Principles of Organic Agriculture'* , IFOAM. Doi 10.1300/j064.

MOAD (2021), *Statistical information of Nepal Agriculture*, Ministry of Agriculture and Co- operattion, Government of Nepal.

NPC, (2003). *The Tenth Plan*. Nepal: National Planning Commission.

NPC, (1995). *Nepal Agriculture Perspective Plan*, Nepal: National Planning Commission and Asian Development Bank TA No. 1854-Nep

NPC, (1997). *Nepal Interim Agriculture Perspective Plan*, Nepal: National Planning Commission and Asian Development Bank, TA No.2618-Nep

Parajuli, S., Shrestha, J. and Ghimire, S., (2020). *Organic farming in Nepal: A viable option for food security and agricultural sustainability.* Archives of Agriculture and Environmental Science, 5(2), pp.223-230.

Pokhrel, D.M., Pant, K.P. (2019). Perspective of organic agriculture and policy *Journal of agriculture and environment*, pp 92-99

PPD, (2005)..*Annual progress report.* Plant Protection Directorate. Harihar Bhawan, Lalitpur, Nepal.

Rajbhandari, B.P. (2015). *Fundamentals of Sustainable Agriculture and Rural Development*. Kathmandu, HICAST Publ.

Vaidya, B., (2006). *The organic Scenario in Nepal*, Paper presented in APO seminar on organic farming for sustainable development held in Colombo, Sri Lanka, 11-15 Sept, 2006.

Investigating the effectiveness of Integrated Pest Management (IPM) strategies for non-hazardous management of crop pests in smallholder farming systems of Dhading District

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ABSTRACT

This study analyzed the effectiveness of Integrated Pest Management (IPM) strategies in non-hazardous pest management for crop pests in small-holder farming systems. Conducted in the Dhading district of Nepal from June to July 2023, the survey involved 100 farmers selected through purposive and random sampling. Findings revealed an average farm size of 0.40 ± 0.06 hectares among small-holding farmers. Farmers primarily learned about IPM approaches through NGOs/INGOs and government programs. Most farmers adopted IPM practices between one and five years ago, with the predominant use of botanicals and animal products. Additional commonly used practices included soil treatment, soil solarization, flooding, and bio-pesticides like Trichoderma. However, a concerning trend emerged, as approximately 90% of farmers applied more pesticides than recommended, with only 4% adhering to label instructions. Compliance with the recommended Pre-Harvest Interval (PHI) stood at around 15% among farmers. Comparative analysis showed that the IPM group achieved an average crop yield increase of 10% (SD = 2%), while the Non-IPM group had a yield increase of 5% (SD = 3%). The study identified a lack of awareness among farmers regarding IPM approaches and safe pesticide use as significant barriers to the widespread adoption of IPM practices.

Keywords: IPM, Pesticide, Pre-harvest Interval (PHI), Small-holders, Farming system

INTRODUCTION

The agriculture sector accounts for a significant portion of Nepal's GDP. Among numerous agricultural commodities, vegetable crops make up the majority of improved crop varieties popular in Nepal in the past few decades (Kafle et al., 2014). There is a crucial role for vegetable crops in reducing rural poverty and

unemployment in Nepal since they produce five to ten times higher economic returns than regular cereal crops (Gurung et al., 2016). But this sector is short of appropriate technologies including proper soil management strategies (Tripathi, 2019 cited by Paudel et al., 2020) and chemical pesticides' replacement to manage pests (Paudel et al., 2016 and Rasul et al., 2019 cited by Paudel et al., 2020).

Since vegetable crops are closely associated with people's health, environment, and happiness, an increase in the production and productivity of these crops can be crucial for our country's prosperity (NAST, 2021). Vegetable production is susceptible to diseases and pests (Paudel et al., 2020). The commercial vegetable industry in Nepal is largely dependent on chemicals (Rijal et al., 2006 cited by Rijal et al., 2018). In Nepal, crops requiring high input are substantially polluted because of large and frequent pesticide doses (Kafle et al., 2014). However, neither the amount of pesticides used in agriculture nor its effects on human and animal health nor the environment has been properly documented (Atreya, 2007 cited by Rijal et al., 2018). In many situations, farmers are unaware of the adverse effects of pesticides, and their modes of action (Thapa et al., 2021); as a result of that, they apply pesticides haphazardly which can lead to pesticide poisoning in humans and animals while also degrading the environment and soil quality. In a developing country like Nepal, crop protection is a must for tackling pests' deleterious effects on crop production if we aim to achieve food security (G.C., 2018). To accomplish effective pest management, farmers' understanding of pesticides and their safe use is very crucial (Rijal et al., 2018). It is not prudent to obliterate the entire insect population since some beneficial insects and pollinators are destroyed in the process. It is also not sensible to use pest control measures as soon as pests appear until they reach a certain level where the cost of controlling the pest is lesser than the financial loss the pest is causing. For pest management to be effective, farmers should be aware of the economic threshold level for various pests. Monitoring the pest population is necessary before applying any measures to minimize their numbers. IPM can be an effective tool for monitoring and managing pest populations in farmers' fields. Integrated Pest Management (IPM) is an environmentally safe approach to pest management that uses all the appropriate pest management strategies and manages pest damage through the most cost-effective route with the least possible risk to humans, animals, and the environment (EPA, 2022). IPM encourages vigorous crop growth and natural methods of pest control (FAO, 2020 cited by Deguine et al., 2021). IPM combines multiple pest management tactics including cultural, mechanical, physical, biological, and chemical methods, where chemicals are used only as a last resort. According to G.C. in 2018, IPM approaches should be promoted among Nepali farmers. This in turn

contributes to higher adoption of crop intensification and helps in increased production and income subsequently.

The study was conducted with the general objective of investigating the effectiveness of Integrated Pest Management (IPM) strategies for non-hazardous crop pest management in smallholder farming systems in Dhading District.

MATERIALS AND METHODS

The study targeted smallholder farmers in Bagmati province, Nepal, as the study population. A combination of purposive and random sampling methods was employed to select participants. Initially, villages within the province were purposively identified based on the prevalence of pest problems. Subsequently, smallholder farmers were randomly selected from the chosen villages using a list provided by agriculture extension offices. The research was conducted in Tripura Sundari Rural Municipality and Nilkantha Municipality within the Dhading district, located in central Nepal with a significant smallholder farming population. This district is known for its production of pest-susceptible crops such as rice, maize, wheat, and vegetables. Various sources and methods were utilized to gather the required information. The study involved the collection and analysis of both primary and secondary data.

A power analysis was performed considering the expected effect size, significance level, and study power to determine the sample size. Assuming a 20% difference in crop yield between the two groups, with a power of 80% and a significance level of 5%, a minimum of 100 farmers was required. To account for potential dropouts, 150 farmers were recruited. This sample size ensured statistically significant results and reduced the risk of type II errors.

Data collection involved surveys and field observations. Surveys were administered to gather information on farming practices, pest issues, and crop yields. Field observations were conducted to assess pest prevalence and natural enemy populations. The study successfully collected valuable data regarding farming dynamics, pest challenges, and crop productivity within the smallholder farming community in the Dhading district of Bagmati province, Nepal.

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

Differentials of socio-economic profiles among tomato farmers under traditional and improved technologies

Table 1 presents summary statistics of small land-holding farmers' socioeconomic profiles. The data reveal various characteristics of farmers, including their age, experience, farm size, household size, education level, and membership in cooperative/farmer group organizations. These factors have significant implications for their ability to adopt improved farm technologies, make production decisions, and access resources such as credit facilities. The average age of farmers in the study was 39.82 ± 4.78 years, aligning with previous research associating this age group with youthfulness, energy, and resourcefulness in farming activities (Jones, 2018; Brown & Johnson, 2019). However, the study did not provide information on the age range or distribution of the surveyed farmers, affecting the interpretation of the mean age (Smith et al., 2022). While youthfulness brings vitality to farming, limited experience, and financial constraints can pose challenges, hindering the adoption of improved farming practices and technologies (Thomas & Evans, 2020). Age significantly influences farmers' decision-making processes (Smith et al., 2022). As farmers age, they accumulate more farming experience, enhancing their knowledge of agricultural practices, risk management, and efficient production (Brown & Johnson, 2019).

The average farm size for small land-holding farmers in this study was 0.40 ± 0.06 hectares. This finding aligns with the classification model employed in the study, which designates farmers with less than 6.36 ± 1.07 hectares of land as small land-holder farmers. Consequently, it suggests that the farmers examined in this research were resource-poor smallholders engaged in small-scale farming on plots smaller than 0.5 hectares. The relatively limited landholding size among these small land-holding farmers can present challenges in achieving economies of scale and maximizing productivity. Smaller farms may face constraints related to mechanization, input utilization, and market access (Jones, 2018).

These farmers had relatively large household sizes, with an average of 5.49±1 individuals per household (Table 1). The presence of a large household implies the availability of more family labor for farming activities. This can have implications for labor-intensive tasks and reduce the need for hiring external labor. Additionally, greater household sizes may imply a lower financial burden in terms of hiring labor, as family members can contribute their labor without additional costs. However, the study does not elaborate on the potential challenges or benefits associated with large household sizes in farming, leaving room for further discussion.

Farmers on average had secondary education. Education plays a crucial role in farmers' decision-making processes, as it influences their awareness, perception,

reception, and adoption of cutting-edge ideas and agricultural innovations. Higher education levels can contribute to increased farm management efficiency and productivity. The data indicate that farmers had access to credit facilities, and 89 were members of cooperative organizations. A cooperative/farmers' association membership provides access to farm inputs and credit facilities. In addition, members can engage in collective bargaining to purchase or sell their produce. Farmers' economic and social standing can be enhanced by these benefits.

Table 1. Summary statistics of socio-economic and demographic profiles of tomato producers

SN.	Variables	Mean Values
1.	Age in years	39.82±4.78
2.	Experience in farming over the years	6.36±1.07
3.	Farm size in hectares	0.40±0.06
4.	The household size in the Number of people	5.49±1
5.	Access to credit	100/0
6.	Membership in cooperative/ farmer group	89/11

Sources of knowledge on IPM approaches

The table 2 presents the sources from which respondents in Tripurasundari RM and Nilkantha M learned about IPM (Integrated Pest Management) farming approaches. The number of respondents and their respective percentages are provided for each source category.

Table 2. Source of knowledge on IPM approaches to the respondents

Sources of knowledge on IPM approaches	Number of Respondents			
	Tripurasundari RM (n=50)		Nilkantha M (n=50)	
	Number	Percentage	Number	Percentage
Government programs	11	22.0	12	24.0
NGOs/ INGOs	32	64.0	34	68.0
From TV/ Radio programs	3	6.0	0	0.0
From friends/ neighbors	4	8.0	4	8.0
Total	50	100.0	50	100.0

In Tripurasundari RM, 22% of the respondents (11 individuals) learned about IPM farming approaches through government programs. The majority, 64% (32 individuals), acquired knowledge from NGOs/INGOs. A smaller proportion, 6% (3 individuals), mentioned learning from TV/Radio programs, while 8% (4 individuals) learned from friends/neighbors. In Nilkantha M, the percentages

were similar, with 24% (12 individuals) learning about IPM farming approaches from government programs and 68% (34 individuals) obtaining knowledge from NGOs/INGOs. None of the respondents mentioned learning from TV/Radio programs. Similarly, 8% (4 individuals) learned from friends/neighbors.

Understanding of the IPM approach by the respondents

The table presents the understanding of IPM (Integrated Pest Management) approaches among farmers in Tripurasundari RM and Nilkantha M. In Tripurasundari RM, 8% of the respondents (4 individuals) understood IPM as farming without the use of chemical fertilizers, while 18% (9 individuals) understood it as farming without the use of pesticides. Additionally, 34% (17 individuals) had an understanding of IPM as the integrated approach to farming. In Nilkantha M, the percentages were slightly higher, with 14% (7 individuals) understanding it as farming without the use of chemical fertilizers and 28% (14 individuals) understanding it as farming without pesticides. Moreover, 44% (22 individuals) had an understanding of IPM as the integrated approach to farming. A small proportion in both regions (6% in Tripurasundari RM and 12% in Nilkantha M) understood it as farming without the use of both chemical fertilizers and pesticides. The remaining respondents had different understandings of IPM or did not fall into any specific category.

Years of adoption of IPM approaches

The figure provides data on the duration of adopting IPM (Integrated Pest Management) approaches in Tripurasundari RM and Nilkantha M. In Tripurasundari RM, 14 individuals reported that they started growing crops using IPM approaches less than 1 year ago.

Table 3. Understanding of IPM farming by the farmers

Understanding of IPM by the farmers as:	Number of Respondents			
	Tripurasundari RM (n=50)		Nilkantha M (n=50)	
	Number	Percentage (%)	Number	Percentage (%)
Farming without the use of chemical fertilizers	4	8	7	14
Farming without the use of pesticides	9	18	14	28
Integrated approach of farming	17	34	22	44
Farming without the use of chemical fertilizers and pesticides	3	6	6	12
Others	17	34	1	2
Total	50	100	50	100

Additionally, 78 individuals had been practicing IPM for 1-5 years, and 8 individuals had been using IPM for more than 5 years. In Nilkantha M, 8 individuals reported adopting IPM approaches less than 1 year ago. The majority, comprising 86 individuals, had been practicing IPM for 1-5 years. A smaller number, 6 individuals, had been using IPM approaches for more than 5 years. The table provides insight into the duration of farmers' adoption of IPM approaches in the two regions, indicating varying levels of experience and familiarity with IPM practices.

IPM approaches under practice

According to the data presented, the use of botanicals such as Neemazin, Ultineem, and Jholmal was reported by 100% of the respondents, indicating widespread adoption of this IPM practice. Pheromones, specifically Heli-lure and cue-lure, were reported to be used by 68% of the respondents. These substances are commonly used to attract and trap pests using their natural pheromones. The utilization of yellow sticky traps and light traps, which are effective in monitoring and trapping certain insect pests, was reported by 70% of the respondents.

Animal products like cow urine and cow milk were used by 100% of the respondents. These products are known for their potential repellent or deterrent effects on pests. Bio-pesticides, specifically Trichoderma, were reported to be used by 33% of the respondents.

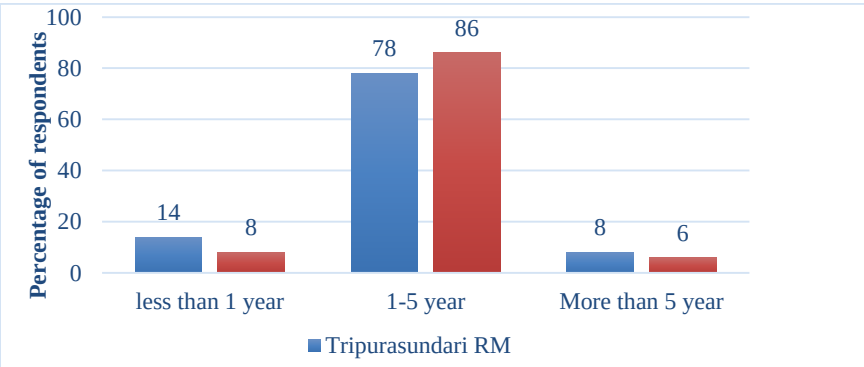

Figure 2. Number of years since the farmers adopted IPM approaches

Trichoderma is a beneficial fungus used for biological control of plant diseases. Cultural practices, including soil treatment, solarization, and flooding, were

reported by 91% of the respondents. These practices aim to manage pests through modifications in agricultural practices and environmental conditions. Trap crops, such as marigolds, chrysanthemums, and coriander, were reported to be utilized by 88% of the respondents. These crops are strategically planted to attract pests away from the main crop. Conserving natural enemies, which involves preserving beneficial organisms that can naturally control pest populations, was practiced by 47% of the respondents. Crop rotation, a technique involving the alternating planting of different crops in a specific sequence, was reported by 79% of the respondents. This practice helps disrupt pest life cycles and reduce pest pressure.

The table 4 provides an overview of the adoption and usage rates of various IPM practices among the respondents, reflecting their understanding and implementation of integrated pest management approaches in their farming systems.

Pre-harvest intervals followed by the farmers

The EPA (Environmental Protection Agency) has recommended that farmers should allow a 1-3 weeks period to reduce the residual effects of pesticides before harvesting the crop and it's depending on the type of pesticide for Nepal the pre-harvest interval (PHI) for pesticides is typically established and regulated by the Department of Agriculture (DoA) under the Ministry of Agriculture and Livestock Development.

Table 4. IPM approaches under practice

S.N.	IPM approaches under practice	Percentage (n=100)
1	Botanicals such as Neemazin, Ultineem, *Jholmal*	100.00
2	Pheromones such as Heli-lure and Cue-lure	68.00
3	Yellow Sticky Trap and Light trap	70.00
4	Animal products such as cow urine and cow milk	100.00
5	Bio-pesticides such as Trichoderma	33.00
6	Cultural practices (soil treatment, solarization, and flooding)	91.00
7	Trap crops (marigolds, chrysanthemum and coriander)	88.00
8	Conserving natural enemies	47.00
9	Crop rotation	79.00

According to the data, 10% of the respondents reported a PHI of the same day, indicating that they harvested their crops on the same day by applying any necessary treatments or interventions. A larger proportion, 18% of the respondents, reported a PHI of the following day. This suggests that they waited

until the next day after applying any required treatments before harvesting their crops. The majority of the respondents, 32%, reported a PHI of after a week, implying that they allowed a week to pass between applying treatments and harvesting their crops. A slightly lower percentage, 25% of the respondents, reported a PHI of after two weeks. This indicates that they waited for a two-week interval between treatment application and crop harvesting. A smaller proportion, 15% of the respondents, reported adhering to the recommended PHI. This implies that they followed specific guidelines or recommendations regarding the appropriate time interval between treatment application and crop harvesting.

Table 5. PHI considerations by the farmers

SN.	Pre-harvest Interval (PHI)	Percentage (%) of respondents (n=100)
1.	Same day	10
2.	Following day	18
3.	After a week	32
4.	After two weeks	25
5.	Recommended PHI	15

Awareness of pesticide dose

About 90% of the farmers use more amounts of pesticides than recommended. About 4% of the respondents follow the instruction given by the label, they dilute to the recommended level. Farmers are reluctant to follow the recommended dilution as prescribed on the label. Some respondents said that they use an excessive dosage of chemicals as their neighbor is using the same dosage. They also believe that excessive use of pesticides will give more yields. Resistance of pests to chemicals due to long-term application also made the farmers use over dosages. Farmers use over dosages of pesticides in many developing countries. The major reasons stated by the farmers for less use of pesticides were lack of funds, low pest incidence, and lack of knowledge (Ngowi et al., 2007).

Methods of applying pesticides

Farmers in the survey applied pesticides by both single and mixed methods. Few farmers (about 9%) apply one chemical at a time. However, the majority of (91%) the farmers applied the pesticides in mixtures. Farmers believe that a "cocktail" application is always more effective and reduce labor cost (Jipanin et al.,2001).\

Effectiveness of Integrated Pest Management (IPM) in Farmers

In this study, we investigated the effectiveness of Integrated Pest Management (IPM) practices in improving crop yield among farmers. The sample consisted

of 50 farmers who implemented IPM practices (IPM group) and 50 farmers who did not implement IPM practices (Non-IPM group). The data collected for each group included the sample size (n), the average crop yield increase expressed as a percentage, and the standard deviation.

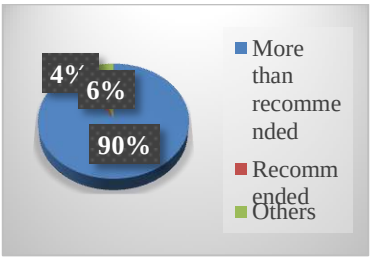

Figure 3. Awareness of pesticide dose

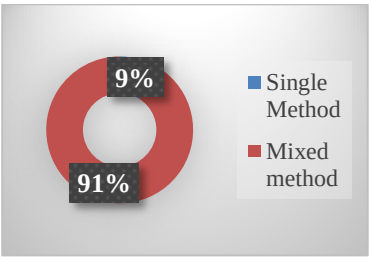

Figure 4. Awareness of pesticide mixing

Table 5. Comparison of IPM and Non-IPM practicing farmers

Group	Sample Size (n)	Average Crop Yield Increase (%)	Standard Deviation
IPM Group	50	10	2
Non-IPM Group	50	5	3

The IPM group, comprising 50 IPM-practicing farmers, exhibited an average crop yield increase of 10% with a standard deviation of 2%. On the other hand, the Non-IPM group, consisting of 50 non-practicing farmers, showed an average crop yield increase of 5% with a standard deviation of 3%. These results suggest that the implementation of IPM practices positively impacted crop yield among the farmers in the IPM group.

Figure: Field inspection (pests)

The average crop yield increase in the IPM group was higher compared to the Non-IPM group, indicating a potential benefit of IPM practices in enhancing

agricultural productivity. However, to establish the statistical significance of these findings, a two-sample t-test was performed. The t-test compared the mean crop yield increase between the IPM and Non-IPM groups, considering the respective sample sizes and standard deviations.

CONCLUSION

In conclusion, the socioeconomic profiles of small land-holding farmers in the study revealed important characteristics that impact their farming practices and access to resources. The average age of farmers indicated a relatively young and potentially resourceful group, although limited experience and financial constraints could pose challenges. Farm size was small, suggesting resource-poor smallholders facing potential constraints in achieving economies of scale. Larger household sizes implied the availability of family labor, which could reduce the need for external labor and associated costs. Education levels were generally secondary, influencing farmers' decision-making and adoption of new agricultural innovations. Membership in cooperative organizations provided access to resources and improved economic and social standing.

The study also examined farmers' knowledge and adoption of Integrated Pest Management (IPM) approaches. It revealed that government programs and NGOs/INGOs were the primary sources of learning about IPM. Farmers' understanding of IPM varied, with differing levels of comprehension regarding farming without chemical fertilizers, pesticides, or integrated approaches. Adoption of IPM varied in duration, indicating varying levels of experience and familiarity with IPM practices among the farmers.

Regarding specific IPM practices, the use of botanicals, animal products, cultural practices, and trap crops was relatively widespread among the respondents. However, the adoption rates for bio-pesticides, conserving natural enemies, and adhering to recommended pre-harvest intervals were lower. Some farmers reported using excessive dosages of pesticides, influenced by neighbor practices, beliefs about increased yields, and resistance of pests to chemicals. The majority applied pesticides in mixtures, considering it more effective and cost-efficient.

Overall, the study highlights the diverse socioeconomic profiles of small land-holding farmers and the implications of their characteristics on their farming practices, adoption of technologies, and access to resources. Understanding these factors is crucial for designing targeted interventions and support systems to promote sustainable and efficient agricultural practices among small-scale

farmers and also the implementation of IPM practices positively impacted crop yield among the farmers in the IPM group. The average crop yield increase in the IPM group was higher compared to the Non-IPM group, indicating a potential benefit of IPM practices in enhancing agricultural productivity.

REFERENCES

Atreya, K. (2007). Pesticide use knowledge and practices: Gender differences in Nepal. *Environ. Res.*, *104*, 305–311

Belay, D., Daba, T., & Admasu, B. (2018). Integrated Pest Management Practices for Teff (Eragrostis tef (Zucc.) Trotter) Production in Ethiopia. *Journal of Agricultural Science*, 10(12), 372-383.

Deguine, JP., Aubertot, JN., Flor, R.J. *et al.* (2021). Integrated pest management: good intentions, hard realities. A review. *Agron. Sustain. Dev.* **41**, 38 (2021). https://doi.org/10.1007/s13593-021-00689-w.

EPA (2022). 'Integrated Pest Management (IPM) Principles.' United States Environmental Protection Agency [Online]. Available at: Integrated Pest Management (IPM) Principles | US EPA. Accessed on 28th May 2023.

FAO (2020). NSP – Integrated Pest Management, FAO definition. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/.

G.C., Y.D. (2018). Integrated pest management efforts for eco-friendly agricultural production in Nepal: a perspective. *Journal of the Plant Protection Society*. Vol. 5

Grube, A., Donaldson, D., Kiely, T., Wu, L. (2011). Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates. *United States Environmental Protection Agency*.

Gurung, B., Thapa, R. B., Gautam, D. M., Karki, K. B. and Regmi, P. P. (2016). Commercial Vegetable Farming: An Approach for Poverty Reduction in Nepal, *Agronomy Journal of Nepal*, 4, pp. 92–106. DOI: 10.3126/ajn.v4i0.15518.

Jipanin, J., Rahman, A.A., Jaimi, J.R. and Phua, P.K. (2001). Management of pesticide use on vegetable production: Role of Department of Agriculture Sabah. *6th SITE Research Seminar*. pp. 1-21.

Kafle, L. et al. (2014). Integrated Pest Management in Nepal. *The 5th International Conference of Clinical Plant Science* [Online]. Available at: (PDF) Integrated Pest Management in Nepal (researchgate.net). Accessed on 27th May, 2023.

Kogan, M. (1998). Integrated Pest Management: Historical Perspectives and Contemporary Developments. *Annual Review of Entomology*, 43, 243-270.

NAST (2021). Comprehensive Insights in Vegetables of Nepal.' *Nepal Academy of Science and Technology (NAST)*. ISBN: 978-9937-0-9153-4 [Online]. Available at: Comprehensive-Insights-in-Vegetables-Book.pdf (nast.gov.np). Accessed on 28th May 2023.

Ngowi, A.V.F., Mbise, T.J., Ijani, A.S.M.,London, L. and Ajayi, O.C. (2007) Pesticides used by smallholder farmers in vegetable production in Northern Tanzania. *Crop Protection (Guildford, Surrey)*. 26 (11), 1617.

Paudel, S., Sah, L.P., Devkota, M., Poudyal, V., Prasad, P.V.V. and Reyes, M.R. (2020). Conservation Agriculture and Integrated Pest Management Practices Improve Yield and Income while Reducing Labor, Pests, Diseases and Chemical Pesticide Use in Smallholder Vegetable Farms in Nepal. *Sustainability*, [online] 12(16), p.6418. https://doi.org/10.3390/su12166418.

Paudel, S.; Sah, L.P.; Pradhan, K.; Colavito, L.A.; Upadhyay, B.P.; Rajotte, E.G.; Muniappan, R. Development and Dissemination of Vegetable IPM Practices and Packages in Nepal. In *Integrated Pest Management of Tropical Vegetable Crops*; Springer: Dordrecht, the Netherlands, 2016; pp. 251–269.

Pimentel, D., Acquay, H., Biltonen, M., Rice, P., Silva, M., Nelson, J., Lipner, V., Giordano, S., Horowitz, A., & D'Amore, M. (1992) 'Environmental and Economic Costs of Pesticide Use.' *BioScience*, 42(10), 750-760.

Rasul, G.; Saboor, A.; Tiwari, P.C.; Hussain, A.; Ghosh, N.; Chettri, G.B. Food and nutrition security in the Hindu Kush Himalaya: Unique challenges and niche opportunities. In *Hindu Kush Himalaya Assess*; Springer: Cham, Germany, 2019; pp. 301–338.

Rijal, J., Regmi, R., Ghimire, R., Puri, K., Gyawaly, S. and Poudel, S. (2018) 'Farmers' Knowledge on Pesticide Safety and Pest Management Practices: A Case Study of Vegetable Growers in Chitwan, Nepal.' *Agriculture*, [online] 8(1), p.16. https://doi.org/10.3390/agriculture8010016.

Rijal, J.P., Malla, R.K., Rawat, P.R., Tiwari, S., GC, Y.D. (2006) A preliminary study on the practices of insect pest management at Sukranagar VDC, Chitwan.' *In Proceedings of the National IPM Workshop of Plant Protection Society of Nepal, Lalitpur, Nepal, 25–26 August 2006*; KC, G.K., Pokhrel, S., Upadhaya, N.S., Marahatta, S.P., Bhandari, B.D., Eds.; *Plant Protection Society of Nepal*: Lalitpur, Nepal, pp. 297–307.

Singh, R., Singh, G., & Singh, D. (2014). Integrated Pest Management in Cotton: A Case Study from India. *International Journal of Agriculture and Biology*, 16(2), 415-418.

Susan Thapa, Gaetano Piras, Sudesh Thapa, Arjun Goswami, Prabas Bhandari & Bimesh Dahal, Manuel Tejada Moral (2021) Study on farmers'pPest management strategy, knowledge on pesticide safety and practice of pesticide use at Bhaktapur district, Nepal, *Cogent Food & Agriculture*,
Accesses from: 7:1, DOI: 10.1080/23311932.2021.1916168

Tripathi, B.P. (2019). Sustainable soil fertility management practices in Nepal.*Acta Scientific Agriculture*, *3*(4), pp.112-113.

Efficacy of *Trichoderma* Spp. against Fusarium Wilt: An Ecologically Secure Bio-Agent for Diseases Management of Tomato

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ABSTRACT

Tomato is one of the most widely grown vegetable crops throughout the world; however its production is decreasing due to various problems. Diseases are the most important production constraints for tomatoes and one of the most important diseases being Fusarium wilt. Trichoderma spp are considered as promising biological control agent against Fusarium wilt. Trichoderma spp. are naturally occurring organisms that have a long history of safe use in agriculture. One of the advantages of using Trichoderma spp. as a bio-agent for disease management is its ecological safety. They are non-toxic to humans, animals, and beneficial insects and do not leave harmful residues in the environment. Moreover, Trichoderma spp. can promote plant growth and provide other beneficial effects, such as increased nutrient uptake and improved tolerance to abiotic stresses. The main purpose of this study was to investigate Trichoderma harzianum isolates towards their contribution to growth of tomato in Kathmandu valley to counteract the effect caused by Fusarium wilt. Investigation of T. harzianum was performed under in vitro condition against the pathogen (Fusarium oxysporum f. sp. lycopersici). Three native Trichoderma antagonists were isolated from twenty soil samples from various ecological habitat of Kathmandu valley. Under in vitro conditions, the results revealed that Trichoderma harzianum, isolate Th-NM, was found to inhibit the mycelial growth of the pathogen effectively by (58%) followed by Th-DM (56%) and Th-CM (40%). Therefore, the antagonist T. harzianum, Th-NM is chosen to be the most promising bio-control agent for F. oxysporum f.sp. lycopersici.

Keywords: Tomato, Trichoderma, Fusarium wilt, Biological Control Agent, Management.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most consumed and widely grown vegetable crops worldwide. Its production in recent years has

been increasing throughout the world, but at the same time farmers are experiencing losses due to the incidence of diseases in the crops, which is affecting this sector economically. Tomatoes are the target of more than 200 pests and diseases (Fuentes et al., 2016). One of the most important diseases of tomato is Fusarium wilt.

Fusarium wilt caused by *Fusarium oxysporum f. sp. lycopersici* is a devastating soil-borne fungal disease of tomato throughout the Nepal and worldwide that can cause significant yield losses of tomato production in greenhouse, high tunnel, and field condition. Symptoms of fusarium wilt include yellowing of lower leaves. Yellowing then progresses up the plants and the lower leaves dry and turn brown. Plants begin to wilt at the top during the day and recover at night, but wilting becomes progressively worse until plants are permanently wilted (Srinivasan, 2010). The use of pesticides is the common method to treat diseases, which however cause several impacts, such as: very harmful to the environment contributing to the climate change; in the health of people which consume the final product; in the plant making it more vulnerable to other diseases and resistance to chemicals, which involve in stress of the plant (Fuentes et al., 2016). Use of the fungicides leads to severe environmental pollutions, and reduces beneficial microbes (Jaiswal *et al*., 2015). Non-chemical and ecofriendly botanicals and biocontrol agents as broad spectrum fungicides have been found to provide an answer to the non-discriminatory broad spectrum fungicides. Several plant extracts and essential oils are found to have antifungal and antimicrobial properties and the active constituents responsible for antifungal properties of the extracts are phytochemicals (Khatun et al., 2020). A great success for the management of soil and seed borne diseases of crop plants by using bio-control agents have been received much attention in recent years because of the vast potential of these organisms in sustainable agriculture production. Biological control offers a promising eco-friendly method to manage this disease. Use of biological agent can be an alternative to chemical control of the Fusarium wilts diseases (Mohammed and Toama, 2019). In recent years, non-chemical and ecofriendly botanicals and biocontrol agents as broad-spectrum fungicides have been found to provide an answer to the non-discriminatory broad-spectrum fungicides. Chemical treatments against soil-borne root pathogens are very dangerous; they cause technical, environmental and economic problems. These limits of chemical control and the high concern for the preservation of the environment (Alabouvette *et al* 2006) are the major reasons for the increased interest in the use of biological control through its ability to provide an effective protection in the long term and without negative impact on the environment or on human health (Demir *et al* 2015).

As a biological alternative, scientists have long considered to use fungus as the controlling agent against wilt. Biological control agents have been suggested a safe alternative of chemical method of disease control. Biocontrol agent (BCAs) can inhibit the growth of soil borne pathogens through various biocontrol. Mechanisms such as ability to grow much faster than them for space and nutrients, producing many powerful plant degrading enzymes such as lytic enzymes, proteolytic enzymes and more than 200 types of antibiotics which are highly toxic to any macro- and microorganism. The ability to produce multiple antibiotics probably helps to suppress diverse microbial competitors, some of which are likely to be plant pathogens and thus enhance biological control. *Trichoderma* species are an efficient biocontrol agent that is commercially produced to prevent development of several soil pathogenic fungi. Trichoderma is active rhizosphere colonizers and act as Biological Control Agents and Plant Growth Promotion. So, Trichoderma application for disease management is one of the cheapest, ecofriendly and reliable measure for controlling Fusarium wilt that helps in enhancing and promoting plant growth (Nakkeeran et al., 2016). The *Trichoderma* strain is successfully used as a bio-control agent because it stimulates the plant immune system against pathogen attacks. Its growth-promoting ability in soil provides an additional benefit in the agricultural application of fertilizers and antifungal activity. In addition, the fungus successfully promotes plant growth. These beneficial microbes are eco-friendly with a dual mode of action for growth promotion and diseases suppression in crops.

Trichoderma species naturally occurring soil fungi is considered as promising biological control agents against numerous phytopathogenic fungi since it can inhibit the phytopathogenic fungi either by including resistance and plant defense reaction or by direct confrontation through mycoparasitism and competition or by producing antibiotics. Trichoderma spp. is associated with root ecosystem and hence they promote growth and defense mechanism by production of several compounds (Rai et al. 2016). *Trichoderma* species is one of such fungus showing inhibition of plant pathogen. Genus *Trichoderma* has gained immense importance since last few decades due to its biological control ability against several deadly plant pathogens (De Medeiros *et al* 2017). Trichoderma spp. has multiple mechanisms by which they suppress the growth and activity of Fusarium oxysporum. These mechanisms include competition for nutrients and space, production of antifungal compounds, induction of plant defense responses, and parasitism of the pathogen's mycelium. Trichoderma spp. can colonize the root system of the plants, forming a protective barrier and preventing the entry of Fusarium oxysporum into the roots. The effectiveness of Trichoderma spp. can be enhanced by optimizing application techniques, such as

seed treatment, soil drenching, or foliar spray, depending on the specific requirements of the Trichoderma strain and the target pathogen.

Trichoderma spp. are found in almost all soil types viz. cultivated soil, garden soil, fallow and pasture land, forest soil etc. (Harman *et al* 2004). *Trichoderma harzianum* is a common soil, litter, and wood fungus. It possesses highly cellulolytic activity and is main agents of decomposition. Several strains of Trichoderma have been developed as biocontrol agents against fungal diseases of plants. Trichoderma fungi use various complex direct or indirect mechanisms against fungal pathogens, which usually interact altogether in the biocontrol phenomenon. The direct impact on pathogens includes the production of cell wall degrading enzymes (CWDEs), synthesis of antibiotics, competition for space and nutrients (mainly carbon, nitrogen, and iron), and establishment of a direct parasitic relationship with the fungal pathogen. On the other hand, *Trichoderma* indirectly induces local or systemic plant resistance through products (elicitors) released from the cell walls of the plant host (endoelicytors) and the infecting microorganism (exoelicytors) (Tyśkiewicz et al., 2022). The efficacy of Trichoderma spp. in managing Fusarium wilt depends on several factors, including the specific strain of Trichoderma used, the application method, and environmental conditions. Overall, Trichoderma-based biocontrol agents have shown promising results in controlling Fusarium wilt in tomatoes. Since last few decades, genus *Trichoderma* has gained great importance due to its biological control ability against several deadly plant pathogens (Verma et al., 2018. Most biocontrol agents are from the species *T. harzianum, T. viride* and *T. hamatum* (Wikipedia Contributors, 2019). As plant growth promoter and antagonist against plant pathogens, *Trichoderma* strains are appealing alternatives to hazardous fumigants and fungicides (Kasa et al 2015). Thereby positively impacting farmers' profits and sustaining the food safety approaches. In addition, developing sustainable crops that could be grown with little to no pesticides and/or chemical fertilizers reduces costs for farmers in developing areas. Moreover, developing novel and environmentally friendly approaches is essential to reduce the Fusarium Wilt Diseases incidence and yield loss in tomato crops. Therefore, with the view of biocontrol efficacy of Trichoderma isolates, the study was done to evaluate Trichoderma isolates against *Fusarium oxysporium F.sp. lycopersici* in in-vitro condition.

MATERIALS AND METHODS

Experiment site and design

The study was conducted from April 2023 to June 2023. This study was a laboratory based cross-sectional study. All the work concerning this research

was carried out in the Plant Pathology laboratory of Central Campus at HICAST, Kirtipur Kathmandu, Nepal.

Sample collection

In this research, soil samples (50gm) were collected from various ecological habitat of Kathmandu valley for the isolation of *Trichoderma harzianum*. The sample was collected from the top 2-5 cm depth of rhizospheric soil from Chandragiri Municipality, Dakshinkali municiaplity and Nagarjuna Municipality. The soil sample collected from a field in the polythene bag was labeled and stored at 4 °C in the laboratory. Likewise, disease samples were also collected for isolation of fusarium wilt pathogen.

Cleaning and sterilization of glass wares

The Petri plates, pipettes, conical flasks, test tubes, beakers etc. used in the experiments were thoroughly washed, dried and sterilized in a hot air oven at 160°C for 2 hours.

Preparation of Trichoderma Selective Media (TSM)

Trichoderma selective medium (TSM) is recognized for quantitative isolation of *Trichoderma* spp. from soil. It is composed of low glucose level for rapid growth and sporulation of the fungus (Shah, and Afiya, et al., 2019). In order to prepare TSM, 3 g glucose, 0.2 g magnesium sulphate, 0.9 g potassium hydrogen phosphate, 1.0 g ammonium nitrate, 0.5 g potassium chloride and 20 g agar was added in 1000 ml of distilled water, which was then autoclaved at 15 psi for 15-20 minutes. It was then allowed to cool, and 0.2 g of streptomycin was added into a solution and then finally poured into the sterilized petri plates.

Preparation of Potato Dextrose Agar (PDA) Media

For the preparation of PDA media, 39 g of commercial PDA Powder was added to 1 Litre of distilled water, the solution was boiled while mixing to dissolve. It was then autoclaved for 15 min at 121°C. Solution was then allowed to cool, and finally be poured into the sterilized petri plates.

Isolation of *Trichoderma harzianum*

About 1 g of soil sample was taken and added to 9 ml of sterilized distilled water to make dilution of 10^{-1}. Six-fold serial dilution of soil sample was prepared in sterilized distill water and 0.5 ml of each dilution i.e., 10^{-4}, 10^{-5} and 10^{-6} dilutions were poured onto TSM contained in petriplates and spread uniformly by adopting spread plate method. The petriplates were incubated at 25 ± 3℃ for 168hrs. Morphologically different colonies appearing on the plates

were purified in the Trichoderma Selective media (TSM). The purified isolates were preserved at 4°C.

Phenotype characters of the Trichoderma isolates

After the isolation of all isolates, growths observed on those plates were taken for studying colony characteristics, morphology and microscopic examination of each *Trichoderma* isolates. It was examined under a microscope for the identification and confirmatory of *Trichoderma harzianum*. Microscopic observation of specimens was done by preparing slide culture method.

Isolation and purification of *fusasrium oysporum f. sp.* lycopersici

Infected vascular tissues from root and leaf regions of tomato showing wilt symptoms were collected separately from field. The collected plant parts were washed with running tap water to remove adhering mud and soil particles and the infected parts were split open longitudinally with a sharp knife. The internal pith portion showing the typical symptoms of wilt was cut into small bits. The tissue bits were surface sterilized with 10% sodium hypochlorite for 5-10 min. and subsequently three washings with sterile distilled water. The sterilized tissue was dried in a laminar flow on sterile filter paper. Then, they were plated on potato dextrose agar (PDA) medium separately and incubated at the laboratory conditions at 25 ± 3℃ for five days and monitored on routine basis for growth of the hyphae from the tissue margins. The fungi were purified separately by transferring the tip of the mycelia to frseh PDA plates and maintained on PDA. These isolates produced abundant white mycelia on the PDA media for three days. An isolated fungus was identified according to their morphological characteristics which matched the descriptions in The *Fusarium* Laboratory Manual (Leslie and Summerell, 2006).

- **Dual plate culture**

Dual plate culture technique (Dennis and Webster, 1971a) was followed to determine the antagonistic activity of *Trichoderma harzianum* isolates against plant pathogen Fusarium oxysporum.Briefly, 4 mm discs of 6-7 days old antagonistic fungi and pathogen cultures were placed on PDA medium one cm away from the edge of the plate, separately. Three replicated plates for each treatment were maintained and incubated at 25 ± 3℃. Control plates were inoculated with phytopathogen only. Growth of each phytopathogen isolates in dual culture and in control (without antagonist) was measured after different intervals from the 5th DAI i.e., 120hrs, 144hrs, 168hrs, 192hrs and 216hrs and Percent inhibition over control was calculated as per the formulae:

PI = C − T /C × 100% Where, PI = Per cent inhibition over control, C = Growth of test pathogen with absence of *Trichoderma harzianum* (cm) T = Growth of test pathogen with *Trichoderma harzianum* (antagonist) (cm).

Data analysis

The data recorded from dual culture were documented and tabulated. The data were statistically analyzed using SPSS version 16. One way ANOVA test was used to determine the association of plant growth parameters with different treatments. The test was statistically significant if P<0.05 with 95% confidence interval.

RESULTS AND DISCUSSION

Isolation of *Fusarium oxysporum*

In this investigation, twenty samples were collected from diseases suspected tomato plants. The samples were collected from infected vascular tissues of roots and leaf regions of tomato showing wilt symptoms. Out of twenty samples, three samples gave the positive signal. Sample was identified on the basis of morphological and colonial characterization under microscope. And among three isolates, single isolate was further subjected for study.

Isolation of *Trichoderma sp.*

Phytopathogen antagonist *Trichoderma harzianum* was isolated from different soil of Kirtipur, Kathmandu. Out of twenty samples, three samples gave the positive result, and it was further subjected for microscopic confirmation. The isolates were named based on their isolated areas. These selected isolates were further subjected for dual culture assay and *in vivo* trial.

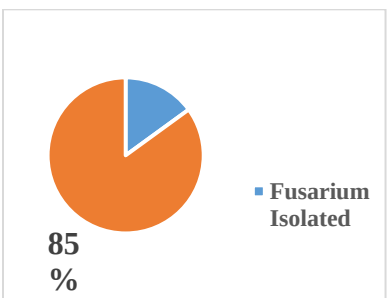

Figure 1

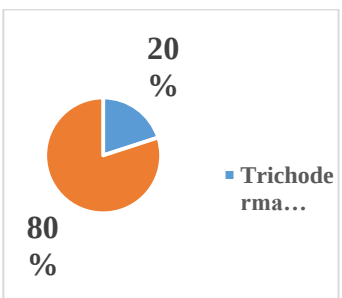

Figure 2

Figure 1.Isolation of *Fusarium* from infection suspected tomato plant
Figure 2. *Trichoderma harzianum* isolation from soil sample

Morphology of the *Fusarium oxysporum* isolate

Two distinct *Fusarium oxysporum* isolates were obtained from the leaves of infected tomato plant. The isolates exhibited a slow growth on PDA plates reaching between 5.1 and 5.3 cm in diameter after 5 days of incubation at 25°C. Out of three isolates, one isolate was used in the study. The microscopic features on PDA plates, presented by the isolates were; macroconidia which were elongate, curved, septate and slightly foot shaped, the microconidia produced were cylindrical, non-septate and abundant.

The color of colony on PDA was whitish/pinkish aerial mycelium with purple undersurface. The diameter length was 4cm on PDA (cm) after 7 days. Elongate, curved, three septate and with a slight foot shaped end cell type of macroconidia µm (PDA) was observed whereas cylindrical, non-septate type of microconidia µm (PDA) was observed. Both terminal and intercalary chlamydospores with smooth wall was found and Phialides were short and non-septate.

Morphological characteristics of *Trichoderma sp.* isolates

Out of 20 soil samples, three isolates of *T. harzianum* was obtained. Cultural characteristics comprising growth rate, color and colony appearance were examined. On PDA, *T. harzianum* formed 1-2 concentric rings with green conidial production. The conidia production was denser in center then towards the margins. Some white pustules were also found growing on the green mat of conidia. *T. harzianum* form cottony white mycelium with dark green conidiation towards the margins, while on the reverse the color was pale, tan or yellowish. The diameter length on PDA (cm) after 5 days was 7cm. Flask shaped phialides was formed. Chlamydospore was subglobose, short hyphae. Ellipsoidal, smooth and dry conidia µm (PDA) was observed.

Effect on dual plate culture

Growth inhibition of the pathogen by all the *Trichoderma sp.* isolates was evident from the fifth day of incubation. The mycelial growth of the pathogen was daily evaluated by measuring the diameter of the petri dish in which the radius of the pathogen was found next to the antagonist. This evaluation was done every 24 hours for 5 days. The reduction of the mycelial growth of pathogen (*Fusarium oxysporum*) was significantly higher in the dual culture compared to the pathogen control. *Trichoderma harzianum*-NM showed significantly higher inhibition of the mycelial growth of the pathogen (58%) than *Trichoderma harzianum* - DM (56%) and *Trichoderma harzianum*- CM (40%) (Table 1). The differences in the mycelial inhibition may be due to the diversity in the *Trichoderma* isolates. In this test, after a maximum of 8 days, it

was observed that the colonies of *Trichoderma* isolates recovered those of the fungi thus, revealing their inhibitory power.

Photograph 1. Trichoderma isolates against *Fusarium oxysporum F.sp. lycopersici*

Table 1. Effect of *Trichoderma harzianum* isolates on mycelium Per cent (%) inhibition on growth of *Fusarium oxysporum*

S.N	Treatments	Day 5	Day 6	Day 7	Day 8	Day 9	Average
1.	Th-CM	15%	29%	38%	51%	67%	40%
2.	Th-DM	27%	39%	63%	72%	79%	56%
3.	Th-NM	26%	41%	62%	78%	83%	58%

DISCUSSION

This *Trichoderma harzianum* isolates showed potential in controlling of *Fusarium oxysporum* f.sp. *lycopersicon* in in-vitro condition with varying degrees of inhibition amongst the isolates. Competition, mycoparasitism and antibiosis resulting from production of secondary metabolites were the main mechanisms observed in the effect of *Trichoderma harzianum* against the pathogen.

Three *Trichoderma harzianum* species were obtained from the area of study. This result is in concurrence to earlier research that have reported that *Trichoderma* species are cosmopolitan fungi, that occur widely worldwide and are frequently present in all types of soil, manure and decaying plant tissues (Rahman et al 2009). *Trichoderma* species is one of such fungus showing inhibition of plant pathogen. Genus *Trichoderma* has gained immense importance since last few decades due to its biological control ability against several deadly plant pathogens (De Medeiros *et al* 2017). It was revealed from the results, *Trichoderma* isolates varied in their effect on tomato plants and ability to reduce the effect of *F. oxysporum.* The results from the dual cultures showed that different isolates of *Trichoderma harzianum* have differing abilities in the bio-control of *Fusarium oxysporum* f.sp. *lycopersicon*.

In this study the results from the dual plate cultures showed that among the 3 *Trichoderma* isolates collected from Kathmandu valley, Chandragiri Municipality (Th-CM), Dakshinkali municiaplity (Th-DM) and Nagarjuna Municipality (Th-NM), Th - NM showed the highest inhibition (58%) at day 9 in comparison to Th - CM (40%) and Th-DM (56%). This outcome is similar to earlier experiments that have demonstrated that *Trichoderma spp*. mycoparasitize the hyphae and resting structures of plant pathogens in vitro and also in natural soil (Papavizas 1985). This finding is similar to other research that has reported that *Trichoderma* uses several mechanisms in controlling soil pathogens (Vinale et al 2008). This study also agrees with reports that have suggested that different strains of *Trichoderma* control every pathogenic fungus. However, most *Trichoderma* strains are more efficient for control of some pathogens than others and may be largely ineffective against some fungi (Shelton 2012).

Forcelini *et al.*(2001) and Deising *et al.* (2008) focused on increasing use of chemicals has become an issue on alarming increase in fungicide resistance of plant pathogens in number of crops in modern agricultural practices in several countries. A great success for the management of soil and seed borne diseases of crop plants by using bio-control agents have been received much attention in recent years because of the vast potential of these organisms in sustainable agriculture production. These beneficial microbes are eco-friendly with a dual mode of action for growth promotion and diseases suppression in crops. In this context, the project is proposed to identify potential of microorganisms for diseases management as well as growth promoting capacity. Popularization of safe, soil inhabitants having antagonistic potential will change the farmer's habit which is already using synthetic pesticides indiscriminately. Microbes use as bio-control agents have not only diseases management capacity but also growth promoting and yield increasing capability. It will create healthy and pollution free environment for mankind. The chemical free biologically managed organic produce will increase the export potential and also attract foreign currency which will ultimately strengthen our economic status of state. Regarding this, development of microbial product from resident micro-organisms is a need of the day, which should be eco-friendly and cost effective and can be afforded by small and marginal farmers.

CONCLUSION

Our current research revealed that the *Trichoderma* harzianum isolates are antagonistic to the *F. oysporum f. sp. lycopersici* pathogen. The antagonism mechanisms include competition for nutrients and space, mycoparasitism, and

antibiosis. This study supported the potential of *Trichoderma* as suppressor of pathogen growth in in-vitro condition. Effect of *Trichoderma harzianum* isolates (Th-NM) on mycelium is 58% inhibition on growth of *Fusarium oxysporum.* Th-NM exhibited better inhibition against *Fusarium* culture. Thus, the finding of present investigation holds a good promise in tomato wilt management. However, further studies on the effect of these treatments in field conditions need to be undertaken so that *Trichoderma* could be recommended as a biocontrol agent. Therefore, the antagonist *T. harzianum* is chosen to be the most promising bio-control agent for *F. oxysporum* f.sp. *lycopersici*. On the base of this study, the biocontrol agents of plant diseases might be exploited for sustainable disease management programs to save environmental risk.

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REFERENCES

Alabouvette C.C., Olivain and Steinberg C., (2006). Biological control of plant diseases: the European situation. *European Journal of Plant Pathology*, 114(3): 329-341.

Deising, H.B., Helmann, S., and Pascholati,S.F. (2008) Mechnisms and significance of fungicide resistance. *Braz. Jour. Microbiol*. 39(2): 386-285

Demir S., Sensoy S., Ocak E., Tüfenkçi S., Durake D., Erdinç C. and Ünsal H., (2015). Effects of arbuscular mycorrhizal fungus, humic acid and whey on wilt disease caused by *Verticilliumdahliae* Kleb in three solanaceous crops. *Turk. J. Agric. For*., 39: 300-309

Forcelini, C.A.,Goellner,C.I. and May-De Mio L.L.(2001). Resistancia de fungos a fungicidas. *Rev. Annu. Pathol. Planstas*. 9:339-381

Fuentes, A., Lee, Y., Hong, Y., Yoon, S., and Park, D., (2016). *Characteristics of Tomato Plant Diseases - A study for tomato plant disease identification*

Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. (2004). *Trichoderma* species-opportunistic, a virulent plant symbiont. *Nat Rev Microbiol*.; 2:43–56. doi: 10.1038/nrmicro797.

Jaiswal K, Tiwari S, Faisal M and Shukla HO (2015). Biological control of tomato wilt through soil application of bio-agent and organic amendments. *J. Eco-friendly Agri*. 10(2): 189-190

Kasa, P., Modugapalem, H. and Battini, K., (2015). Isolation, screening, and molecular characterization of plant growth promoting rhizobacteria isolates of Azotobacter and Trichoderma and their beneficial activities. *Journal of natural science, biology, and medicine*, *6*(2), p.360

Khatun, M.J., Khalequzzaman, K.M., Naher, M.S. and Neela, F.A., (2020). Management of fusarium wilt of tomato by botanicals and biocontrol agents and their effect on yield. *Bangladesh Journal of Botany*, *49*(1), pp.71-74

Mohammed, B.L. and Toama, F.N., (2019). Biological control of Fusarium wilt in tomato by endophytic rhizobactria. *Energy Procedia*, *157*, pp.171-179

Nakkeeran, S., Renukadevi, P. and Aiyanathan, K.E.A., (2016). Exploring the potential of Trichoderma for the management of seed and soil-borne diseases of crops. *Integrated pest management of tropical vegetable crops*, pp.77-130

Papavizas G. C. (1985). *Trichoderma* and *Gliocladium*: biology, ecology, and potential for biocontrol. *Ann. Rev. Phytopathol*. 23:23-54

Rahman, M.A., Begum, M.F. and Alam, M.F. (2009). Screening of *Trichoderma* isolates as a biological control agent against *Ceratocystis paradoxa* using pineapple disease of Sugarcane. *Journal of Microbiologyl* 37(4): 277–285

Rai Shalini, Kashyap LP, Kumar, Sudheer, Srivastava KA, Pramod RV et al. (2016). Identification, characterization and phylogenetic analysis of antifungal Trichoderma from tomato rhizosphere. *Springer Plus*, 2016, 5:1939

Shah, M.M. and Afiya, H., (2019). Introductory chapter: identification and isolation of Trichoderma spp.-Their significance in agriculture, human health, industrial and environmental application. In: *Trichoderma-The Most Widely Used Fungicide*. IntechOpen

Shelton, Anthony (2012). Biological Control: A Guide to Natural Enemies in North America. *http://www.nysaes.cornell.edu/ent/biocontrol*

Srinivasan, R., (2010). Safer tomato production techniques. *A field guide for soil fertility and pest management. AVRDC Publication. Taiwan*.

Tyśkiewicz, R., Nowak, A., Ozimek, E. and Jaroszuk-Ściseł, J., (2022). Trichoderma: The current status of its application in agriculture for the biocontrol of fungal phytopathogens and stimulation of plant growth. *International Journal of Molecular Sciences*, *23*(4), p.2329

Verma, N.P., Kuldeep, Y.K. and Sinha, B.K., (2018). Efficacy of indigenous Trichoderma strain bio-control against of Fusarium sp. tomato plant causal agent of (Solanum lycopersicon L.) in vitro condition. *Int J Curr Microbiol App Sci*, *7*(3), pp.1578-1584

Vinale F., Krishnapillai S., Emilio L., Ghisalberti R. M., Sheridan L. and Woo M. L. (2008). *Trichoderma* plant-pathogen interractions. *Soil Boil. & Biochem*. 40:1-10

Wikipedia Contributors (2023). *Trichoderma.* https://en.wikipedia.org/wiki/Trichoderma [Accessed on: June 5, 2023]

Exploring the Feasibility and Impact of Hydroponic Farming in Urban Areas of Bagmati Province: A Case Study of Kathmandu Valley

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ABSTRACT

Recently, the use of hydroponic production mostly in urban areas has become an increasingly practiced alternative, since it implies a production with less use of labor, and still in a differentiated product of better quality. A study was carried out to analyze the economic viability of hydroponic production in all the hydroponic farms inside Kathmandu valley; and an interview was conducted among all the growers using pre-tested questionnaire to gather information on various aspects of hydroponics farming. The techniques used to verify viability were mainly Payback period (PBP) and Benefit Cost (BC) ratio. The results showed that the benefit cost ratio of hydroponics farming per ropani (0.05 ha) was found 2.32. The results also pointed to a quick recovery of invested capital, being approximately 2.85 year on an average of all the farms. Hydroponic products were mostly green leafy vegetables and marketed via two different channels mainly, also online orders were taken. Despite several socio-economic and commercial benefits of hydroponic farming the farmers were facing various problems like leakages of pipes, nutrient toxicity and deficiency along with marketing problems. Therefore, for more economic return and sustainable development of hydroponic farming, the government and all concerned agencies should have to play a vital role on overcoming these weakness, problems and possible threats.

Keywords: Benefit cost ratio, hydroponic, payback period, market,sustainability

INTRODUCTION

In today's world with the increasing population (world's population expected to exceed 9.8 billion, with more than two-third living in urban areas (FAO, 2011; NSF, 2015), the demand for food, housing, clothes *i.e.*, demand for every basic requirement of a human being have also risen with far greater rates. Likewise, technological advancements have made it possible to grow more food within

limited land but the same advancements have also resulted into intensive systems of agriculture causing land degradation, forest encroachment and climatic changes. With unmanaged urbanization, fewer lands are available for cultivation and that too most have lostthe potential and fertility due to excessive use of pesticides and chemicals.Such excessive use of agricultural inputs and intensive cultivation in the same region results in severe soil degradation (Liu *et al*., 2019). Therefore, a new trend of growing food has been popularized in recent days *i.e.,* "Soilless farming" where nutrients required by plants are delivered through other media or forms instead of soil along with high levels of oxygen, efficiently to the plant roots.It isn't a new invention rather has been used and perfected throughout the human history (e.g., Floating gardens of China and The Hanging Garden of Babylon). According to USDA: "Growing plants in water culture or sand culture without soil are procedures that have been used by physiologists studying plant nutrition and by other plant scientists for more than a century" (*Growing Crops Without Soil*. Beltsville, MD: USDA, rev 1965).

Hydroponics is one of the soilless farming techniques where plants are grown in nutritional solution with or without mechanical support. Hydroponics plantation is an advanced form of agriculture which enables the option of exclusive supervision over the distribution and delivery of nutrition among the plants (Calpas, 2001). Proper supply of sufficient oxygen to the roots is crucial with proper aeration of solution for which pumps or perforated pipes can be used. Control of the composition of the nutrient solution is alsosomewhatmore exacting than in the other systems. Factors such as climatic factors (temperature and intensity of sunlight), part of the plant the grower want (leaf, root, fruit or flower) also determines the composition of nutrient solution for the optimum growth. Several naturally occurring aggregates can be used such as gravel free of sand and clay, coral limestone, vermiculite,,etc. The size of the particles of aggregates should be between 1/16- and one-half inch in diameter. The size of the particles and porosity determines the frequency of irrigation; other media such as perlite, peat, rock wool, sand, sawdust are also commonly used as aggregates in hydroponics (Stuart, 1947).

Despite the need for aeration, the difficulty of supporting the plants, the need for adequate expertise and relatively high investment being some of its disadvantages, this water mediated agricultural system has following benefits over soil- based plantation:

- High performance
- Simplicity of works
- Low labor force required

- Easy to control weeds
- Uniform plant growth
- Minimal water dissipation
- No competition between plants for water and nutrients
- Control over nutrients absorbed by plants
- Healthier agricultural product
- Free of need of following the plants plantation cycle
- Lower or no exploitation of chemicals (Jaenaksorn and Ikeda, 2004).

Beside these, in hydroponics system the crop pests and diseases can be checked precisely reducing the time and cost required to sterilize soil (Cantliffe *et al.*, 2007). Less space with lack of irrigation water combined has become the biggest challenge for people in urban areas to grow their own food. Especially after covid-19 the importance if growing ones' own food has been realized by all city dwellers and hence the growing trend of urban farming. There is a huge scope and possibility of hydroponics in urban areas, where land, labor and water getting scarce day by day (Butler & Oebker, 2012). It has attracted attention both as an alternative to food security and home businesses to achieve community economic resilience. It provides an increased productivity using few natural resources, making it a viable option for global food production (Chen *et al.*, 2020).

Scenario of hydroponic farming in Nepal

Due to effective resource management and high-quality food production, hydroponic farming growth is currently gaining popularity across the nation, mostly in metropolitan areas. Urbanization, catastrophic events, environmental change, and the indiscriminate use of chemicals and pesticides that are reducing the fertility of the ground are some of the challenges that soil-based farming is currently facing. People in urban areas today must work alone to grow vegetables because they are sick of eating crops that have been treated with pesticides and because they have limited space. With a little work and commitment, they can succeed. In fact, by using this method, we can deliver or cultivate over time in any season or climate (Acharya, 2017). People are already growing leafy greens, tiny herbs, and spices on their balconies and roofs for fresh consumption in a variety of large towns, including Kathmandu. Today more than ever before, hydroponics appears to have a bright future. Although the initial costs to set up a hydroponic farm might differ greatly, they are often higher than those for soil-based farming. Therefore, it is crucial to deploy technologies that decrease reliance on human labor and lower overall startup costs in order to promote the expansion of the hydroponics business. Numerous

academics are also working to find ways to make it more affordable (Kumar, 2018).

There are now just 10–15 commercial hydroponic farmers in the Kathmandu Valley, with many more spread out across the rest of the nation. The major farms include Urban Farm Nepal (Kathmandu), Muttha (Lalitpur), Aeroroots (Kathmandu), NFT Hydroponics (Lalitpur), True farms (Lalitpur), Hydroponics Nepal (Kathmandu), Hope Nepal Bioponics (Lalitpur) which produces a large amount of leafy greens and other veggies. The rapid installation of so many modest setups of hydroponic technology on rooftops is also due to the growing popularity of hydroponic farming and the growing interest of people in farming, particularly in urban areas. In summary, this sort of farming has a lot of potential and opportunity in urban locations like Kathmandu, where land and water are becoming increasingly rare. Although hydroponics may be a relatively new concept for Nepal and many potential farmers may be unsure of its benefits over traditional farming, many industrialized nations have had experience growing a wide range of crops using hydroponics, and gradually, people are coming to understand its significance, and the hydroponics market is growing.

MATERIALS AND METHODS

Kathmandu valley is a highly urbanized area with a population of approximately 2.5 million people. In recent years, there has been a growing interest in hydroponic farming in the region, with several commercial hydroponic farms and home-based systems already in operation. Three of Nepal's main towns' *viz*., Kathmandu, Bhaktapur, and Lalitpur are located in the Bagmati province, where the study was carried out. The Kathmandu valley is the most developed and populated place in Nepal. The majority of offices and headquarters are located in the valley, making it the economic hub of Nepal. The valley was chosen as the study location because the majority of hydroponic farming pioneers practice this sort of growing method in Kathmandu Valley's metropolitan areas, where the majority of farms are situated. Only a small portion of the 15 growers were using hydroponics. In order to choose all 15 of those farms as the sample size for study, a census survey was conducted. Personal interviews with hydroponics growers at the research site were used to obtain primary data on the basis of pre-tested semi-structural questionnaires. Total sample size used in this quick study was 15.

Economic analysis

Gross income, net income, B/C ratio, payback period, internal rate of return (IRR) and net present value (NPV) were taken as economic variables. However,

B/C ratio and payback period were taken as prime economic variables. It measures the worth of project.

Tools and technique of data analysis

The collected data were tabulated and analyzed by using Microsoft Excel. Both quantitative and qualitative analyses were done.

RESULTS AND DISCUSSION

Occupation of the respondents

As shown in Figure 2, among all the respondents hydroponic farming was found as the main occupation of majority of individuals in the study site. Above 45 percent of the respondents was primarily engaged in farming while 22 percent were engaged in government services. And 34% were working in private sectors and only 4% were engaged in other services.

Types of hydroponic system

The Figure 3 shows that, according to survey it was found that most of the respondents 74.83% were practicing NFT (Nutrient Film Technique) system as this system is most common and popular. 7 percent of the total respondents were practicing only NFT and aeroponics system; again the 18.17% of total respondents were practicing both NFT system and DWC (deep-water culture) system.

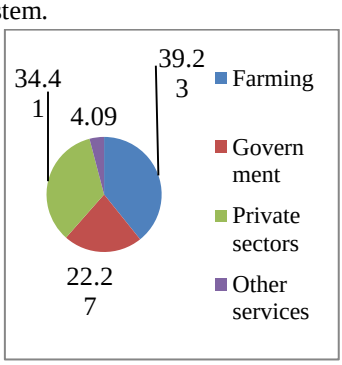

Figure 1. Occupation of respondents

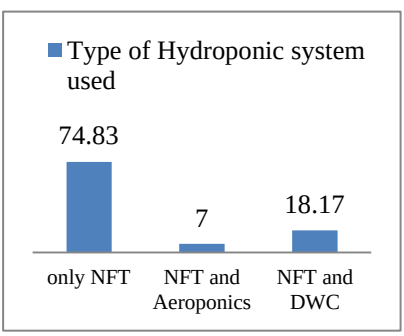

Figure 2. Type of Hydroponic system used

Source of water

As water is the most important component of hydroponic farming. Regarding the source of water used in farming was asked to each individual farm. It was found that most of farms *i.e.* 78% were using ground water, 13% were collecting rain water to use for farming, 7% were depending on the river source and again the 2% were using both ground water and rain water.

Training taken by respondents

From the study it was found that most of the individuals 72.72% had taken training regarding hydroponic farming, which had helped respondents to be more familiar with this technique for better yield. While 27.27% of the respondents had not taken any training before and doing this farming in their own by researching and gathering knowledge from various places, which is shown in Figure 5.

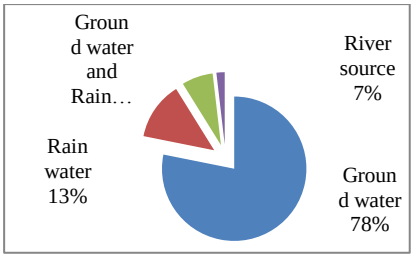

Figure 3. Source of water

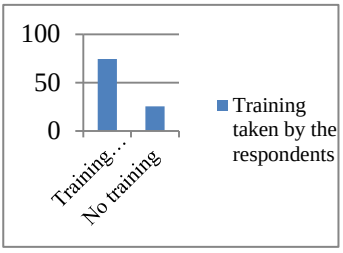

Figure 4. Trainings taken by the respondents

Crops grown at the farm

The study reveal that majority of the farm were engaged on leafy green vegetables (Lettuce, Coriander, Celery, Swiss chard, Pak-choi). Few farm where engaged in tomato; also, herbs as well particularly, basil. Research work and study were also going on simultaneously with some of the berries *viz.*, strawberry,

Benefit Cost ratio

The study revealed that the average total variable cost (seedlings production, electricity cost, water cost, nutrient solution cost, maintenance cost, labor cost, land rent, list of pesticides and fungicides) and total fixed cost (green house setup cost and other internal setups of farm which include PVC pipes, water reservoir, planting net cups, electronic meters such as pH meter and EC meter, pumping motors, air control system and growing systems) per ropani were NRs 16,201,390 per year and NRs 6,745,500 per year respectively. And the average cost of production per ropani was NRs 22,946,890 per year (Figure 6).

Gross income from hydroponic farming per ropani

Gross return from the hydroponic farming was calculated. The gross income is the monetary value of the entire product from hydroponics farming. The study revealed that gross return from the hydroponics farming per ropani was NRs. 57,365,225/year.

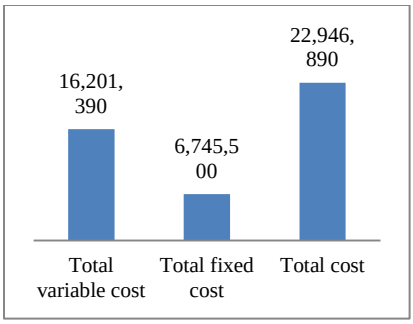

Figure 5. Cost of hydroponic farm

Table 1. Benefit cost ratio of hydroponic farming

S.N.	Gross return	Benefit cost ratio
1	57,365,225	2.49

Benefit cost ratio of hydroponic farming

As shown in Table 1, the study reveals that the benefit cost ratio of hydroponic farming per ropani was found 2.49. This indicates that hydroponics farming is a worthy business. In other word the hydroponic farming returns 2.49 times than the investment on it. Thus, among all the farming system, hydroponic is profitable business. Production costs of a hydroponic farm in Mato Grosso do Sul (Brazil) were searched between July and October, 2017 and similar result of benefit cost ratio of 2.13 was obtained (Gimenes & Souza, 2019).

Net present value (NPV), internal rate of return (IRR) and payback period (PBP)

The study revealed that the average payback period among all the farms was 2.85 years. 26.67% of the farms had PBP between 0-2 years, 53.64% of the farms had PBP between 2-4 years and remaining 19.69 % had PBP more than 4 years. This variation is also due to the difference in initial cost for the farm set up, variation in net annual income due to the types of crops, number of plants and cost difference in various inputs for the farms. During a research on economic feasibility study of hydroponic system in Brazil found the similar result as return on the investment was 4 years (Milk *et al.*, 2016). A quick payback period of 2.1 years was found in the study of economic analysis of an urban vertical hydroponic farm (Sace and Nativad, 2015). As shown in table 2, it was seen that the average IRR of all the hydroponics farms was 27%. NPV of all the farms after 10 years was also analyzed and NPV of all the farms found to be positive, which indicates that all the farms are in profit. There was drastic

variation in NPV between all the farms. This is due to their drastic variation in initial investment for the farm setup and variation in annual income.

Table 2. Net present value (NPV), internal rate of return (IRR) and payback period (PBP) of different farms

Farm	Total Investment	Net Income per annum	Payback Period	Modified NPV	IRR
Ltp01	18,800,000	5,010,400	3.75	6,306,526.61	21.57%
Ltp02	23,400,500	9,090,450	2.57	13,614,641.64	33.47%
Ktm01	8,555,000	5,977,500	1.43	7,134,774.89	52.90%
Ltp03	3,562,500	2,655,230	1.34	3,288,741.73	49.86%
Ktm02	6,870,020	1,921,000	3.58	3,192,931.55	19.92%
Bkt01	1,130,000	465,500	2.43	1,554,331.21	19.49%
Ktm03	56,061	12,174	4.6	38,116.09	83.41%
Ktm04	20,331	8,305	2.45	18,596.56	81.79%
Ktm05	18,911	7,215	2.62	16,214.77	80.20%
Ktm06	31,632	7,937	3.99	21,442.52	64.59%
Ltp04	15,700,000	4,010,420	3.91	3,336,694.08	13.49%
Ltp05	13,560,091	3,010,420	4.5	1,855,896.37	9.48%
Ktm07	967,005	2,011,400	0.48	714,015.06	172.90%
Bkt02	577,865	1,050,490	0.55	262,432.94	186.32%
Bkt03	1,695,600	474,940	4.645	41,692.71	28.41%
Average	5,733,950.27	2,332,152.20	2.85	-	

SWOT Analysis

Based on the field survey and interacting with different hydroponic growers some strength, weakness, opportunity and threats regarding the hydroponics farming is analyzed.

Marketing system and marketing channel

Marketing of hydroponic products involves all the activities in moving the products from hydroponic growers to the ultimate consumers. Generally marketing system includes producers, traders, transporters, wholesalers, retailers and consumers as the main actors to carryout different activities. The study was conducted in study site to know about the marketing system of hydroponic products. Most of the producers were selling their hydroponic products such as various leafy vegetables like lettuce, mint, basil, spinach, pakchoi, coriander, etc directly to the various hotels, restaurants and super markets like Bhatbhateni. Some of them were selling their produced vegetables to the wholesale markets and then from wholesale market to retailers and finally to the consumers. And some of them were selling via online as well (order from website, facebook, instagram).

Strength	Weakness
➢ Needs less ground to grow more. ➢ Conserves water by using less of it. ➢ Produces high yields from smaller spaces. ➢ Require a lot less labor than soil farming, which lowers the cost. ➢ Utilize any unusable or unused area that has a water source and convert it into a hydroponics farm. ➢ Due to the efficient utilization of nutrients, plants produced in hydroponic systems often develop 30% to 50% quicker than those grown in soil. ➢ The controls for nutrients and pH are exceedingly precise and efficient. ➢ Unwanted weeds will be eliminated, and plants will be healthier.	➢ Expense of installing a hydroponic system is higher initially. ➢ Power interruptions have an impact on hydroponic systems. ➢ Waterborne illnesses have a high rate of spread. ➢ Farm needs frequent oversight and more care and attention. ➢ Plants are affected more quickly by errors and system failures. ➢ Needs really effective branding and marketing to succeed. ➢ Highly technical and demands much training and experience.
Opportunity	**Threats**
➢ Can be used for indoor farming and is simpler to set up in cities without harming the environment. ➢ Produce may command high prices. ➢ Can be built up to sell specialized products with substantial returns. ➢ Identify, market, and sell produce as fresh, nutritious, and distinctive. ➢ Chance to transform conventional farming practice into cutting-edge, sustainable agriculture technology. ➢ Chance to create and certify hydroponics as organic.	➢ Challenging to persuade rural farmers of the benefits of hydroponic farming over soil-based farming because not enough study has been done on the subject and it is not widely known. As a result, hydroponic farming is perceived as being unnatural. ➢ The hydroponic cultivation inputs were untimely unavailable. ➢ Poor market knowledge.

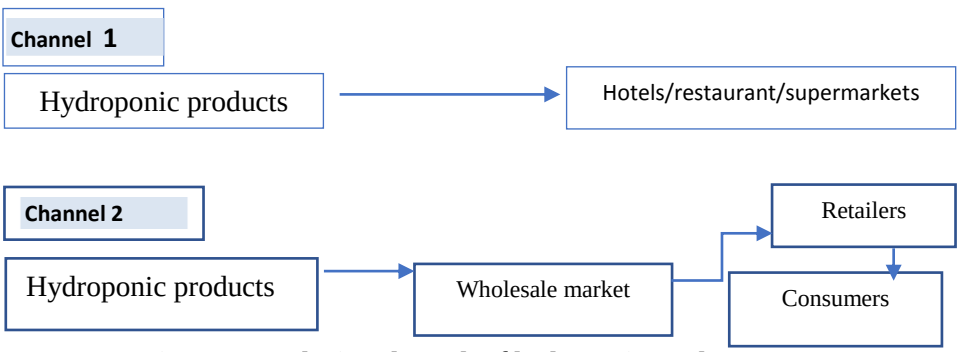

Figure 7. Marketing channels of hydroponic products

Problems regarding hydroponic farming

Since, hydroponic farming is quite new concept in context of Nepal. Many growers are facing various problems regarding this farming technique. Opinion survey was conducted to know the problem faced by hydroponics growers inside study area. From the study it was revealed that among all the problems, leakages and blockages of pipes, nutrient deficiency and toxicity and marketing problem were major 1st, 2nd and 3rd problems respectively among all the hydroponic growers (Table 3).

Table 3. Problems regarding hydroponics farming

Problems	Index	Rank
Leakages and blockages of pipes	0.836	I
Nutrient deficiency and toxicity	0.82	II
Marketing problems	0.72	III
Plant diseases and pests	0.30	IV
Other problems	0.29	V

Source: Field survey, 2023 **Note:** Ranking was done by indexing/scaling technique

CONCLUSION

The study area's hydroponic production of green and spicy vegetables exhibited strong economic viability and offers local farmers an appealing alternative to conventional food production system. However, it is important to mention that the farmer should exercise extreme caution before beginning an investment in hydroponics because this system demands a large initial investment. The farmer has to know the number of units to be produced and the return on investment before deciding whether to proceed with the project or not. The type of structure has an impact on the payback period. Therefore, the modest returns may make the project less alluring when the opportunity cost of forgoing other investment opportunities with comparable risk is taken into account.

The outcome demonstrated that hydroponic farming is both a lucrative and promising agricultural practice within the research area. We may draw the conclusion that hydroponic farming offers tremendous potential and opportunities throughout the research area due to market accessibility, easy access to inputs, social and environmental benefits, and employment opportunities. With these scopes, certain significant issues and dangers were noted, including the lack of timely input availability, greater beginning costs, power interruptions, and a lack of technical understanding.

It should be taken into consideration that hydroponics has agronomic and expert supervision requirements. So, before implementing the investment project, the farmer should find out if there are any specialized professionals in the area. To address numerous issues and challenges to the long-term sustainability of hydroponic farming in research sites, the relevant agencies should coordinate their policies.

REFERENCES

Acharya, H., (2017). Hydroponics: New and scientific methods of farming and its scope in Nepal. *Namaste times*.

Butler, J. and Oebker, N. (2012). Hydroponics as a hobby : growing plants without soil., University of Illinois; College of Agriculture; Extension Service in Agriculture and Home Economics.

Calpas, J. (2001). Management of the greenhouse environment. Government of Alberta, Agriculture and rural development

Cantliffe, D.J., Funes, J., Jovicich, E.,Parajpe, A., Rodriguez, J. and Shaw, N. (2007). Media and containers for greenhouse soilless grown cucumbers, melons, peppers, and strawberries *Acta Hort.*, 614, 199-203

Chen, P., Zhu, G., Kim, H-J., Brown, P. B., and Huang, J-Y. (2020). Comparative life cycle assessment of aquaponics and hydroponics in the Midwestern United States. *J Clean Prod* 275:122888

FAO (2011). *FAO in the 21st century: ensuring food security in a changing world.* Food and Agriculture Organization of the United Nations

Guraya, G., (2021). S*cenario of hydroponics in Nepal* [Interview] (18 February 2021).

Jaenaksorn, T. and Ikeda, H. (2004) Possibility of substituting soilless fertilizer with soil fertilizer for growing leafy vegetables in hydroponics, *Acta Hort.*, 644, 351-357.

Liu, Z., Wang, Y., Geng, Y., Li. R., Dong, H., Xue, B., Yang, T. and Wang, S. (2019). Toward sustainable crop production in China an energy-based evaluation. *J Cleaner Production.* 206: **1126**.

Milk, D., Migliavacca, R. A., Moreira, L. A. and Fausto, D. A. (2016) Economic feasibility of implementing the hydroponic system for lettuce with PRONAF resources in Matao-SP= Economic feasibility of implementing the system for hydroponic lettuce with PRONAF resources in Matao-SP. *Revista iPecege*, 01,. 57-65.

NSF (2015). America's future: environmental research and education for a thriving century. NSF *Advis. Comm. Environ. Res. Educ.* Washington. 48.

Sace, C. and Nativad, P. E. (2015). Economic analysis of an urban vertical garden for hydroponic production of lettuce (Lactuca sativa). *International Journal of Contemporary Applied Sciences*, July. 2.

Stuart, N., W. (1947). About Hydroponics. *The yearbook of Agriculture*, U.S. Dept. of Agriculture, Washington D.C., USA. 289-291

Assessment of Maize Varieties for Drought Tolerance through Polyethylene Glycol Induced Drought Stress at Seedling Stage

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ABSTRACT

Drought stress is a significant challenge to agricultural productivity in the current context of changing climate and global warming, necessitating the identification and adoption of drought-tolerant crop varieties for sustainable and resilient agricultural systems. The purpose of this study was to look into the effects of osmotic stress caused by PEG 6000 on the germination characteristics and seedling growth of maize varieties, as well as to compare the performance of each variety under such induced drought. This study used a two factorial totally randomized design with three replications to assess the germination characteristics of six maize varieties: Arun-2, Arun-4, Poshilo Makai-1, Manakamana-4, Manakamana-3, and Khumal hybrid-2 under five levels of PEG 6000 (0, 5%, 10%, 15%, and 20%). This was discovered that raising the concentration of PEG 6000 had a substantial effect on major maize parameters such as germination percentage, germination energy, root and shoot biomass, vigor index, and yield stability index. Except for the ratio of root biomass to shoot biomass, these metrics decreased dramatically as the PEG 6000 level increased due to decreased osmotic potential. The value grew as water stress increased. PEG levels of 15% and 20% caused considerable water stress in the studied seeds when compared to controls of 5% and 10%. Similarly, variation in the number of seminal roots, root length, shoot length, and yield stability index was shown to be considerable across the variety. Arun-2 outperformed in terms of root and shoot characteristics, allowing it to grow in water-stressed environments. It had high seedling vigor, indicating that it could resist drought. Furthermore, when compared to other examined cultivars, Poshilo Makai-1 demonstrated a positive drought resistant index, particularly in terms of yield stability. Field-level experiments focused on growth and yield characteristics are recommended to expand our understanding and make educated judgments. This will allow farmers and researchers to identify and select the most effective drought-tolerant cultivar, resulting in successful deployment in agricultural practices.

Key words: Maize, variety, PEG 6000, drought, osmotic potential, germination

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important crops of the world agricultural economy, and ranks third next to rice and wheat in production. Globally, maize is known as the 'Queen of Cereals' because of its highest genetic yield potential among cereals. Maize is one of the three leading global cereals that feed the world. Globally maize is cultivated over an area of 187.95 million hectares with a production of 1060 million metric tons and productivity of 5.5 tons per hectare (Islam *et.al*. 2019).

In the Nepalese context, maize is the second most important staple food grain crop after rice and plays a crucial role in the hilly region, where it is the principal staple cereal diet for most Nepalese people. It contributes to approximately 24.93% of the total edible cereal grain production in Nepal. Per capita, maize consumption in Nepal was 98 g/person/day. Maize demand has been constantly growing by about 5% annually in the last decades (KC, G, *et al*., 2015). However, the national average yield of maize in Nepal is 3.062 MT/ha which is significantly lower than that of neighboring countries (MoAD, 2022). The feed demand is also increasing at the rate of 11% per annum. There is a need for about 6.46 million mt. feed to run smoothly the existing poultry industries in Nepal, and about 0.5 million mt. of feed has been produced annually by the feed industries in Nepal. Thus, the demand for maize is also shifting from food to feed for livestock and poultry (KC, *et.al*., 2015). The current Nepalese maize yield level is far below its potential yield, with a substantial gap between the potential yield of maize varieties (6.7 t/ha), attainable yield with improved practices (5.7 t/ha), and the national average yield (2.4 t/ha) (MoAD, 2016).

Drought stress poses a significant threat to agricultural productivity in the present context of changing climate and global warming, requiring the identification and adoption of drought-tolerant crop varieties for sustainable and resilient agricultural systems. Drought stress is one of the most important environmental factors in the reduction of growth, development, and production of plants. It can be said that it is one of the most devastating environmental stresses (Aslam *et al*., 2011). Various biotic and abiotic factors limit maize yield, with drought being a significant one. Maize crop produces maximum yield when grown in fertile soil with an ample supply of water, but it is least tolerant to drought stress. The very limited area under winter and spring maize in Terai is irrigated (KC *et al*., 2015). Among the stages of the plant life cycle, seed germination and seedling emergence and establishment are key processes

in the survival and growth of plants (Hadas, 2004). Germination is one of the main growth stages and success in this stage is dependent on the moisture content of the soil at the time of planting. Germination is regulated by the duration of wetting and the amount of moisture in the growth medium (Schutz and Milberg, 1997). Water stress acts by decreasing the percentage and rate of germination and seedling growth (Delachiave and De Pinho, 2003). Water stress not only affects seed germination but also increases mean germination time in crop plants (Willenborb *et al*., 2004).

Germinating the seeds in solutions of different water potentials is a convenient method to study the responses of seeds at germination against water stress or drought. Polyethylene glycol (PEG) compounds have been used to simulate osmotic stress effects in vitro to maintain uniform water potentials. Exposure to polyethylene glycol (PEG-6000) solutions has been effectively used to mimic drought stress.PEG 6000 was found to be a convenient solute to create osmotic stress without causing any toxicity to the plant cells (Verslues *et al*., 2006; Van den Berg and Zeng 2006 Datta *et al*., 2011). This s study aimed to investigate the effects of osmotic stress generated by PEG 6000 on germination characteristics and seedling growth of maize genotypes as well as to analyze the performance of each variety under such induced drought. Comprehensively, the primary objective of the present study was to compare six maize varieties to withstand the water stress during the germination period.

MATERIALS AND METHODS

An experiment was conducted from 22nd May, 2023 to 5th June, 2023 in Seed and Seed Technology Laboratory at HICAST to study the effect of different concentrations (i.e., 0, 5, 10, 15 and 20%, respectively) of polyethylene glycol (PEG) on germination and early growth stages of 6 varieties of maize. The different concentrations of PEG 6000 impose the varied osmotic potential for the tested seed and henceforth were represented as the level of drought. The experiments were set up in two factorial completely randomized designs with three replications. Six maize varieties viz. Arun -2, Arun -4, Poshilo Makai -1, Manakamana -4, Manakamana -3, and Khumal hybrid -2 were used in this study as one factor, and PEG levels of 0 (control), 5, 10, 15, and 20%, respectively as another factor. There were a total of 30 treatments, and these treatments were replicated 3 times, resulting in a total of 90 observations.Seeds were collected from certified sources for this test. The different concentration of PEG 6000 was prepared by adding the respective amount of PEG concentration in 100 ml distilled water, for instance, 5 % PEG 6000 was prepared by adding 5 gram PEG

6000 granules in 100ml volumetric flask to make a final volume of 100ml. Healthy and uniform seeds were surface sterilized with 0.5 % Sodium hypochlorite for 1 minute and then washed thoroughly with distilled water. Sterilized seeds were sown in P Petri dishes containing two layers of moistened germination paper with different PEG 6000 levels viz., 0.0 (control), 5%, 10%, 15 %, and 20%, respectively. Each Petri Petri dish contained 10 seeds The 2 mm radicle length was set as the criterion for germination (Kaur *et al*., 2017). The number of seeds that germinated was counted at 4 days after sowing (DAS), 6 DAS, 8 DAS, 10 DAS, and 12 DAS, respectively to determine the germination percentage and germination energy. Germination enegy was calculated as germination percentage on 4^{th} day. Seedling growths parameters such as the number of seminal roots, plumule length and radicle length, fresh weight and dry weight of root and shoot biomass, and root and shoot biomass ratio were recorded. The shoot dry matter and root dry matter of 10 seeds (each Petri dish) were recorded after oven drying at 65 ºC for 72 h. To determine the root: shoot ratio (RSR), the root dry matter obtained was divided by the shoot dry matter. Seedling vigor index (VI) and yield stability index (YSI) were measured using the below-mentioned formula. The variation among maize varieties for these traits was found to be a reliable indicator to screen the drought-tolerant genotypes at the primary growth stage. The data collected were subjected to analysis of variance using SPSS and also mean comparison between maize lines and various levels of PEG was performed by SPSS.

Germination percentage (%) = (Number of seeds germinated / Total number of seeds tested) × 100

VI = Seedling length (cm) × Germination percentage

The drought tolerance index was measured by calculating the Yield stability index as below:

YSI = (Ys/Yn), where YSI is Yield Stability Index, Ys is the total biomass yield under water stress conditions and Yp is the total biomass yield under nonstress conditions (Wasae, 2021).

Data collection and analysis

The data collected were entered in the form of completely randomized design using Microsoft Excel 2013 in which data preparation, data editing, data validation, outlier's detection and normality assumptions were examined. These edited data were imported to Statistical Packages for Social Science (SPSS)

version 23.00.Descriptive and inferential statistical tools were used to analyze and interpret data.

RESULTS AND DISCUSSIONS

Analysis of variance showed that there were significant differences ($p < 0.05$) between PEG 6000 levels. The results of various concentrations of PEG had a significant effect ($p < 0.05$) on most of the measured traits. The analysis of variance showed that the main effect and interaction effects were significant ($p < 0.05$) for different traits (Table 1).

Table 1. Analysis of variance for traits scored under different levels of PEG 6000 in maize (*Zea mays* L.)

S.O.V	Df	Germination energy	Germination percentage	No. of Seminal roots	Root length (cm)	Shoot length (cm)	Shoot dry weight (gm)	Root dry weight (gm)	Root shoot ratio	VI	YSI
Variety	4	60.362	26.181	1.494*	22.641*	55.67*	12.461	9.02	5.931	38.383	4.39*
PEG level	5	1.423*	1.111*	2.554	2.292	2.449	1.524	1.441	0.642*	1.679*	6.99*
Variety x PEG level	20	1.179	1.014	0.877	0.745	1.279	2.062*	1.964*	1.835*	0.884	0.97
Error	60	104.444	40	38.963	12.253	2.317	0.118	0.066	0.485	232409	0.419

* Significant at $P < 0.05$, SoV=source of variation, Df= degree of freedom, VI= vigor index, YSI=Yield stability index, Root and shoot dry weight of 10 seeds

Germination percentage and germination energy

According to the result of the mean comparison between different varieties and different drought levels, the germination percentage and germination energy lowered with the increase in the concentration of PEG 6000 for all varieties. PEG 6000 was found to ascertain water stress and increasing its concentration resulted in a lowering of the plant's water potential that eventually resulted in a decrease in germination energy and germination percentage of the seeds (Muscolo *et al*., 2014). The germination percentage and germination energy were found to be at par among the different varieties (Table 3) but there was significant differences ($p < 0.05$) between the different level of PEG 6000 (Table 2), while the interaction effect between varieties and PEG level was also found to be insignificant (Table 1). The germination energy was 56.67 and the germination percentage was 82.22 at 20% PEG 6000 concentration. More than 80% of seeds were germinated by 10 days. The decline in germination

percentage and germination energy due to lower water potential due to high PEG concentration have been reported earlier by Shobanadevi *et.al*., 2022, and Khodarahmpo, 2011 in black gram and maize, respectively.

Number of seminal roots, root, and shoot length

The mean value of the number of seminal roots at 12 days was recorded as the highest 5.71 for variety Manakamana -4 which was at par with Arun-2 followed by Khumal Hybrid -2 and Manakamana -3. The mean differences were significant at 5% for varieties and non-significant for the concentration of PEG 6000 and the interaction effect (Tables 1, 2 and 3). The root length and shoot length were found to be decreased as the concentration of PEG 6000 increased. In terms of varieties, Manakamana -3 showed the highest root length of 13.728 cm followed by Arun -2, Manakamana -4, and Arun -4 which were at par and least for Khumal hybrid -2. The shoot length was recorded highest for Arun -2 which was 6.01 cm, followed by Khumal hybrid -2 at 5.10 cm. The effect of root length and shoot length was non-significant for the different concentrations of PEG 6000 while it was significantly different for varieties. The interaction of varieties and PEG 6000 concentration was also non-significant. In contrast to this result, Ul Islam *et.al*. (2019), **and** Khodarahmpo (2011) found significant differences ($p < 0.05$) in the primary root length of maize at different concentrations of PEG 6000.

Root, shoot biomass, and ratio

In the experiment, the root and shoot biomass decreased with the increase in the concentration of PEG 6000 and it was lowest for 20% PEG concentration as 0.1283 gm dry root weight and 0.093 gm dry shoot weight. They both were recorded highest for control. The root shoot biomass ratio was recorded lowest for control as 0.9011 in ingcomparison to the highest value at 20%PEG of 1.8844. The effect of all these parameters was significant ($p < 0.05$) across the different concentrations of PEG, but non-significant across the varieties selected. The interaction effect of varieties and PEG level was significant ($p < 0.05$) for root and shoot biomass and their ratio.

Vigor index

It was revealed that with the increase in the concentration of PEG level the vigor index decreased significantly ($p < 0.05$) and the highest value was found for control as 2392.78 which was at par with the 5% PEG concentration. It was lowest at 20% PEG 6000 as 729.89. The mean differences of control over 10%, 15%, and 20%, respectively PEG 6000 were significant ($p < 0.05$). In terms of

varieties, Arun -2 had the highest vigor index of 1825.67 followed by Manakamana -3 and lowest for Khumal hybrid -2. However, the values were non-significantly different for these tested varieties.

Table 2. Effect of osmotic pressure created by PEG 6000 in different maize varieties

Level of PEG	Germn energy	Germn %	No. of seminal roots	Root length (cm)	Shoot length (cm)	Shoot dry wt (g)	Root dry wt (g)	Root Shoot ratio	Vigor index (VI)	Yield Stability Index (YSI)
Control	100^{a}	100^{a}	5.32	15.46	8.47	0.805^{a}	0.575^{a}	0.90^{d}	2392.77^{a}	1.106^{a}
5%	93.89^{a}	99.44^{a}	5.14	14.85	6.22	0.318^{b}	0.353^{b}	1.25^{cd}	2101.01^{a}	0.752^{ab}
10%	94.44^{a}	100^{a}	5.58	12.42	5.17	0.230^{b}	0.376^{b}	1.71^{ab}	1759.25^{b}	0.675^{bc}
15%	70^{b}	96.11^{a}	5.04	7.78	2.90	0.137^{b}	0.157^{c}	1.66^{ab}	1033.92^{c}	0.355^{c}
20%	56.67^{c}	82.22^{b}	5.04	7.02	1.72	0.093^{b}	0.128^{c}	1.88^{ab}	729.88^{c}	0.326^{c}
Mean	83.00	95.56	5.22	11.51	4.90	0.32	0.32	1.48^{a}	1603.37	0.643
N	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
SEm (±)	2.08	0.98	0.09	0.52	0.30	0.05	0.03	0.09	83.38	0.171

Small alphabetical letters a–d with mean values representing the difference among applied PEG concentration within the columns according to Duncan's multiple range test at a significance level of 5%.

Table 3: Mean comparison of the main effects of maize varieties on water stress levels

Varieties	**Germn energy**	**Germn %**	**No. of Seminal roots**	**Root length (cm)**	**Shoot length (cm)**	**Shoot dry wt (g)**	**Root dry wt (g)**	**Root Shoot ratio**	**Vigour index (VI)**	**Yield Stability Index (YSI)**
Arun-2	84.67	98.67	5.3747^{a}	12.3827^{ab}	6.01^{a}	0.46	0.40	1.52	1825.67	0.285^{b}
Arun-4	84.67	94.00	4.7333^{b}	11.114^{ab}	4.7627^{b}	0.26	0.24	1.32	1542.51	0.751^{ab}
Poshilo Makai-1	84.00	94.00	5^{b}	10.858^{b}	4.5207^{b}	0.21	0.23	1.47	1497.22	1.089^{a}
Manakamana-4	84.67	95.33	5.7107^{a}	11.1667^{ab}	4.2527^{b}	0.21	0.27	1.60	1501.35	0.440^{b}
Manakamana-3	76.67	95.33	5.2453^{ab}	13.7287^{a}	4.7153^{b}	0.34	0.35	1.68	1791.40	0.588^{b}
Khumal hybrid-2	83.33	96.00	5.2673^{ab}	9.7847^{b}	5.1087^{ab}	0.43	0.42	1.32	1462.09	0.706^{ab}
Mean	83.00	95.56	5.22	11.51	4.90	0.32	0.32	1.48	1603.37	0.643
SEm (±)	5.10	2.33	0.20	1.26	0.74	0.08	0.10	0.21	205.82	0.2127

Small alphabetical letters a–d with mean values representing the difference among applied PEG concentration within the columns according to Duncan's multiple range test at the significance level of 5%., SEm (±) is the standard error of the mean.

Yield Stability Index

The yield stability index declined significantly ($p < 0.05$) with the increase in PEG 6000 level for all the varieties. It was recorded highest under control as 1.1060 value and least as 0.3265 at 20% PEG 6000. Similarly, the YSI of

Poshilo Makai -1 was highest with a value of 1.089 followed by Khumal hybrid -2 and Arun -4. Arun -2 showed the least YSI of 0.285. The treatment was significant in terms of both PEG 6000 level and varieties, but the interaction effect was found non-significant (Table 1).

DISCUSSION

Drought is the most pervasive limitation to the realization of yield potential in maize (Edmeades *et al*., 2001). Water stress affects almost every developmental stage of the plant. However, the damaging effects of this stress were more noted when it coincided with various growth stages such as germination; seedling shoot length, root length, and flowering (Rauf *et al.*, 2006; Khayatnezhad *et al*., 2010). Germination is a useful criterion in screening for water stress tolerance. This experiment was designed to identify the responses of popular maize varieties against different levels of drought for different germination and seedling growth parameters.

The experiment revealed that the increasing level of drought by increasing the osmotic potential due to PEG 6000 concentration has a significant effect ($p < 0.05$) on parameters like germination percentage, germination energy, root shoot biomass and its ratio, and vigor index of seedlings. The result was similar to the findings of Khodarahmpo (2011), Islam *et al*. (2019), and Shobanadevi, *et al*. (2022). The effect of 15 % and 20% PEG 6000 concentration was significantly ($p < 0.05$) able to create osmotic pressure on the seeds under test. The germination percentage and germination energy decreased with the increase in PEG 6000 resulting in reduced osmotic potential. The reduced osmotic potential of dehydrated seeds restricts their metabolism and water is considered the primary germination regulator, as germination begins with seed imbibition (Bhatt, *et.al*., 2022). In the mean comparison of germination percentage and germination energy, it was revealed that the Arun -2 was superior over Arun -4 and Poshilo Makai -1 while at par with Mankamana -4, Manakamana -3, and Khumal hybrid -2. However, the overall effect among all the varieties was non-significant (Table 1). The findings of Magar *et al*., (2019) yielded comparable results that the Arun -2 variety showed high performance against induced drought stress by PEG 6000. Furthermore, this is supported by the results of Tripathi (2012) in which Arun -2 performed well with a higher number of cobs per plant and the highest grain yield under natural water stress conditions.

The root and shoot parameters like the number of seminal roots root length, shoot length, and root and shoot biomass were influenced by the water stress and

the values lowered significantly with increasing PEG level. Islam, *et al*. (2019) also finds a significant reduction ($p < 0.05$in the number of seminal roots and length of primary root on the increasing water stress to the maize. However, the ratio of root and shoot biomass increased with decreased osmotic potential. Domesticated maize generally forms between two and six seminal roots. Increased seminal root number improved plant nitrogen acquisition under low-nitrogen environments (Perkins and Lynch, 2021). Water stress induced a decrease in root dry weight and root length by 26.5% and 3.4%, respectively. Similar to the fibrous root system, in most cases water stress decreased the dry weight in both shoot and root with a greater reduction in the root system, leading to an enhanced root-to-shoot ratio (Kou *et al*., 2022). The number of seminal roots varies significantly among 10%, 15%, and 20%, respectively PEG levels. The extreme sensitivity of seminal roots to water deficit was probably caused by the absence of a cuticle that could protect against water evaporation. Due to the death of existing apices and no initiation of new lateral roots under severe water stress, seminal roots cease to grow (Sahnou ne *et.al*., 2004). The ratio of root weight to shoot weight has been used as an index for drought resistance because large deep-rooted systems can extract more water while relatively smaller shoots transpire less (Srividya *et al*., 2011). Arun -2 variety manifested good root and shoot parameters like several s seminal roots, length of primary roots, and shoot length to thrive against the induced drought. The results of Magar *et al*. (2019) align with this study, as they observed that the Arun-2 variety exhibited favorable characteristics in terms of seedling growth traits.

The vigor index was influenced by the osmotic potential and was lowered with the decrease in osmotic potential which mimics the drought in the plant tissues. The finding was in line with the finding of Magar *et al*. (2019) where the vigor index of maize was reduced by 99% over control at -15 bar osmotic potential. This is supported by reports of Spielmeyer *et al*. (2007) in wheat where highly vigorous seeds covered the soil surface quickly reducing the loss of water from the soil, emphasizing the early seedling establishment as the major character to sustain drought stress. The vigor index of Arun -2 was found superior to other varieties and the mean differences were significant ($p < 0.05$) to the Khumal hybrid. It was followed by Manakamana -3, Arun -4, and Manakamana -4. However, the main effect of varieties and its interaction effect with PEG level in terms of VI was insignificant. In contrast to this finding, the effect of VI was significant (p level) for different genotypes under test in the findings of Khodarahmpo *et al.* (2011) in different maize genotypes and in the fiundings of Shobanadevi et al. (2022) in different black gram genotypes. All the tested

varieties in this experiment showed good seedling vigor under induced drought, which means all these varieties can perform well under drought in the germination and initial seedling stages.

The yield stability index (YSI) is one of the effective approaches to assessing drought tolerant index. The YSI reduced up to 70% over the control when the level of drought or osmotic potential decreased to the maximum level. Poshilo Makai-1 had a high YSI as compared to Arun-2, Manakamana-3, and Manakamana-4 significantly. Poshilo Makai -1 is one of the genotypes of Quality Protein Maize (QPM). The QPM was identified as promising genotype for lower hills and river-basin agro-ecosystem of the far western hills (Kushwaha, 2015).

CONCLUSION

This study demonstrated that increasing osmotic stress through PEG 6000 concentrations had a significant impact ($p < 0.05$) on germination percentage, germination energy, root-shoot ratio, seedling vigor, and drought tolerant index. The different varieties showed variations in their responses to drought stress, highlighting the importance of selecting drought-tolerant genotypes in drought-prone areas. Arun -2 demonstrated superior performance in terms of root and shoot parameters, enabling it to thrive better in water stress conditions. It exhibited strong seedling vigor, indicating its ability to withstand drought. Additionally, Poshilo Makai -1 displayed a favorable drought tolerant index, particularly yield stability when compared to other tested varieties.

RECOMMENDATION

Field-level experiments focused on growth and yield characteristics are recommended to expand our understanding and make educated judgments. This will allow farmers and researchers to identify and select the most effective drought-tolerant cultivar, resulting in successful deployment in agricultural practices.

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REFERENCES

Aslam, M., Zamir, M.S.I., Afzal, I., Yaseen, M., Mubeen, M., & Shoaib, A. (2013). Drought stress, its effect on maize production, and development of drought tolerance through potassium application. *Cercetări Agronomice în Moldova*, XLVI (2), 154.

Bhatt, A., Daibes, L. F., Gallacher, D. J., Jarma-Orozco, A., & Pompelli, M. F. (2022). Water Stress Inhibits Germination While Maintaining Embryo Viability of Subtropical Wetland Seeds: A Functional Approach With Phylogenetic Contrasts. *Frontiers in Plant Science*, 13, Article 824.

Datta, J.K., Mondal, T., Banerjee, A. and Mondal, N.K. (2011). Assessment of drought tolerance of selected wheat cultivars under laboratory conditions. *ISOR Journal of Pharmacy and Biological Sciences*, 7(2): 383-393.

Delachiave MEA, De Pinho SZ (2003). Germination of Senna occidentalis link: seed at different osmotic potential levels. *Brazilian Archives of Biology and Technology*, 46: 163-166.

Hadas A (2004). Seedbed Preparation: The Soil Physical Environment of Germinating Seeds. In: Handbook of Seed Physiology: *Applications to Agriculture, Benech-Arnold RL and Sanchez RA (Eds.)*. Food Product Press, New York, ISBN: 1560229292, p. 480.

KC, G., Karki, T.B., Shrestha, J. and Achhami, B. B.(2015). Status and prospects of maize research in Nepal. *Journal of Maize Research and Development*, Vol.1(1).1-9.

Khodarahmpo, Z. (2011). Effect of drought stress induced by polyethylene glycol (PEG) on germination indices in corn (Zea mays L.) Hybrids. *African Journal of Biotechnology Vol*. 10(79), pp. 18222-18227.

Kou, X., Han, W., & Kang, J. (2022). Responses of root system architecture to water stress at multiple levels: A meta-analysis of trials under controlled conditions. *Frontiers in Plant Science*, 13, 1085409.

Kushwaha, U. (2015). Evaluation of Quality Protein Maize and Drought Tolerant Maize in Far Western Hills of Nepal. *International Journal of Applied Science and Biotechnology*, 3, 387-391.

Muscolo A., Sidari M., Anastasi U., Santonoceto C., Maggio A.(2014) Effect of PEG-induced drought stress on seed germination of four lentil genotypes. *Journal of Plant Interactions*, 9:354–363.

Magar, M. M. , Parajuli, A. , Sah, B. P. , Shrestha, J. , Sakh, B. M. , Koirala, K. B. & Dhital, S. P. (2019). Effect of PEG-Induced Drought Stress on Germination and Seedling Traits of Maize (Zea mays L*.) Lines. Türk Tarım ve Doğa Bilimleri Dergisi* , 6 (2) , 196-205

MOAD, (2016). *Statistical information on Nepalese agriculture*. Government of Nepal, Ministry of agricultural development monitoring, evaluation and statistics division, agri Statistics section. (Retrieved from http://moad.gov.np/public/uploads/1142453195-statistic agriculture book_2016.pdf)

Perkins, A.C. and Lynch, J.P. (2021). Increased seminal root number associated with domestication improves nitrogen and phosphorus acquisition in maize seedlings. *Annals of Botany*, 128 (4), 453–468.

Sahnoune, M., Adda, A., Soualem, S., Harch, M. K., & Merah, O. (2004). Early water-deficit effects on seminal root morphology in barley. *Comptes Rendus Biologies*, 327(4), 389-398.

Shobanadevi, C., Elangaimannan, R.and Vadivel, K. (2022). Screening of Blackgram Genotypes for Drought Tolerance using PEG (Polyethylene Glycol) Induced Drought Stress at Seedling Stage. *Legume Research*. 45(8), 968- 973.

Schutz W, Milberg P (1997). Seed germination in Launaea arborescent: a continuously flowering semi-desert shrub. *Journal of Arid Environments*, 36, 113- 122.

Spielmeyer, W., Hyles, J., Joaquim, P., Azanza, F., Bonnet, D., Ellis, M.E., Moore, C., Richards, R.A. (2007). A QTL on chromosome 6A in bread wheat is associated with longer coleoptiles, greater seedling vigor, and final plant height. *Theoretical and Applied Genetics*, 115: 59-66.

Srividhya, A., Vemireddy, L.R., Ramanarao, P.V., Sridhar, S., Jayaprada, M., Anuradha, G., Srilakshmi, B., Reddy, H.K., Hariprasad, A.S. and Siddiq, E.A. (2011) Molecular mapping of QTLs for drought-related traits at seedling stage under PEG induced stress conditions in rice. *American Journal of Plant Science*, 2, 190–201.

Tripathi, M.P., 2012. Development of Drought and Low N Stress Tolerant Maize Cultivars for Terai and Mid Hills of Nepal. Annual Report of National Maize Research Program 2011/12, Rampur, Chitwan, Nepal, 103-107.

Ul Islam, N., Ali, G., Dar, Z. A., Maqbool, S., Khulbe, R. K., & Bhatt, A. (2019). Effect of PEG-induced drought stress on maize (Zea mays L.) inbreds. *Plant Archives*, 19(Supplement 2), 1677-1681.

Van den Berg, L. and Zeng, Y.J. (2006). Response of South African indigenous grass species to drought stress induced by polyethylene glycol (PEG) 6000. *African Journal of Botany*. 72: 284-286.

Verslues, P.E., Agarwal, M., Katiyar-Agarwal, S., Zhu, J. and Zhu, J.K. (2006). Methods and concepts in quantifying resistance to drought, salt, and freezing, abiotic stresses that affect plant water status. *Plant Journal*, 45(4), 523-39.

Wasae, A. (2021). Evaluation of Drought Stress Tolerance Based on Selection Indices in Haricot Bean Varieties Exposed to Stress at Different Growth Stages. *International Journal of Agronomy*, Volume 2021, Article ID 6617874.

Willenborb CJ, Gulden RH, Jhonson EN, Shirtliffe SJ (2004). Germination characteristics of polymer-coated canola (Brassica napus L.) seeds subjected to moisture stress at different temperatures. *Agronomy Journal*. 96, 786-791.

A Study on Chicken Meat Production and its Consumption Pattern in Bagmati Province, Nepal

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ABSTRACT

With the proliferation of poultry industry, chicken meat production has been rapidly increasing. The study was conducted to know about the status of chicken meat production and its consumption pattern as well as to assess the thoughts, behaviour and knowledge about the consumption of chicken meat among the consumers of Bagmati province. A total of 200 meat shops and 200 consumers (25 meat shops and 25 consumers from Kathmandu, Bhaktapur, Lalitpur, Chitwan, Makwanpur, Kavrepalanchowk, Dhading and Nuwakot) were randomly selected and interviewed by using a self-prepared semi-structured questionnaire. 94.5% of the meat sellers and 98.5% of the consumers were unaware of the Slaughterhouse Meat and Inspection Act, 51.5% of the meat shops personnel never used aprons, 8.5% of meat shops had a lairage facility and 17.5% of meat shops had evisceration facility. 36% of meat shops only sold meat to hotels and restaurants. Among the consumers, 66% preferred breast meat, 30% preferred thigh meat whereas 4% preferred both as well. 62% of the consumers preferred sausage as the most popular meat product, and 26% of them preferred other products such as drumstick, minced meat etc. while the remaining 12% of the consumers preferred meat more than the meat products and 94% of the consumers were satisfied with the meat shop. General hygiene practices in most of the meat shop of Bagmati province have not been satisfactory. Slaughterhouse and Meat Inspection Act should be implemented more promptly.

Keywords: *Meat hygiene, sanitation, survey, consumption pattern, production*

INTRODUCTION

Agriculture is the main profession in the context of Nepal and major sector of Nepalese economy. Nepal has two- third of population directly engaged in agriculture contributing almost 25% of National GDP (Gross Domestic product) and 4% from poultry sector. Among livestock, poultry sector contribute 8 % to AGDP (2021, Ministry of Agriculture and Livestock Development, Government of Nepal). In most of the developing countries, livestock farming plays important roles in human food and nutritional security, livelihood, regional

balance, gender mainstreaming, and rural poverty alleviation (ILO, 2004). Nepal has biodiversity of topography of land and climates where livestock farming exists in all the regions including poultry farming however most of the farmers raise small numbers of livestock in small land holdings (Pradhanang et al., 2015).

The number of birds and productivity is increasing, but poultry sector in Nepal faces many challenges. First and foremost, the cost of per unit production of chicken poultry is high due to costly raw feed materials and inefficient marketing structure (Dhakal, Joshi, Kam, Bhusal & Acharya, 2019). More than 75% cost of production is attributed to feed and treatments. Nepal is heavily reliant on maize as the energy source and soybean, sunflower, and meat and bone meals (MBM) as protein sources. Around 0.55 million tonnes of maize are utilized for poultry feed per annum of which only 35% is domestic production. About 95% of protein sources are imported and on average Rs 1.8 billion per year is invested to import chicken feed supplement (Singh, 2018). Several appearance defects, such as pinking of raw and cooked meat, bone darkening, red/bloody discolouration, white striping, wooden breast, spaghetti meat and pale, soft, exudative appearance of breast meat are the major issues observed in chicken meat production. Unsanitary meat production has also been major issue in quality and wholesome meat production.

Consumer behaviour is about how consumer makes their decisions on personal or household products with the use of their available resources such as time, money and effort as mentioned by Schiffman and Kanuk (2000). Further, a holistic view that defines consumer behaviour as the activities and the processes in which individuals or groups choose, buy, use or dispose the products, services, ideas or experiences as provided by Gabbott and Hogg (1998) and Blackwell et al. (2006). Consumer behaviour is an important factor that determines consumption pattern.

Very limited scientific study and monitoring has been done in the Bagmati province. Chicken meat colour is affected by the factors such as bird age, sex, strain, diet, intramuscular fat, meat moisture content, pre-slaughter conditions and processing variables. Colour of meat depends upon the presence of the muscle pigments myoglobin and haemoglobin. Many places have not adapted to the standards provided by Animal Slaughterhouse and Meat Inspection Act, 2055. Quality of water, feed provided may not be in standard level and people involved in poultry farming may not fulfil the appropriate bio security measures. Clean slaughterhouse with better storage of chicken products is needed for wholesome meat production. Through in- person interview with the farmers,

major challenges faced by them during production, marketing can be identified, assessed and solutions may be formulated. The findings of this study will help us to understand the status of the chicken meat production and thoughts, behaviour and knowledge about the consumption of chicken meat among the consumer of Bagmati province.

MATERIALS AND METHODS

No ethical approval was required as it is a survey based study. However, individual consent was taken from the respondents who participated in the study. A Quantitative Descriptive method was employed to determine the chicken meat production and consumption pattern among the people of Bagmati province.

Study area

Survey was conducted in Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchowk, Dhading, Chitwan, Makwanpur and Nuwakot districts of Bagmati province since these districts have the highest amount of chicken meat production according to the data provided by *Livestock Statistics of Nepal, 2077/78*.

Sample size, sampling method, questionnaire design

25 meat sellers and 25 consumers were selected from eight districts of Bagmati province using random sampling methods.

A cross sectional simple random sampling method was employed to select the respondents. Evaluation method including a well-designed interview and pre-tested questionnaire containing both open and closed ended questions on different aspects of chicken meat production and consumption pattern i.e., status of the chicken meat production and thoughts, behaviour and knowledge about the consumption of chicken meat among the consumers of Bagmati province.

Data collection and analysis

Data was collected by using a questionnaire, interviews as well as publications and statistical documents. The data generated were entered into a MS-Excel-2010 program and were analysed for descriptive statistics and possible associations between the variables.

RESULTS AND DISCUSSION

A summary of the socio-economic characteristics of the respondents is presented in Table 1. The average age of meat sellers was 33 years. Tthis shows that the sampled meat sellers were relatively young and within the active working age

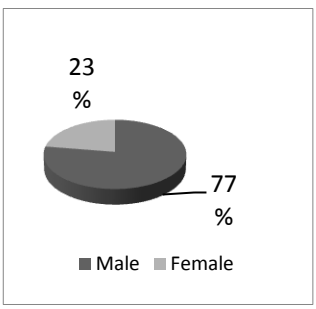
group. Majority of the respondents (77.5%) were male and about 22% were female (Figure 1).

Table 1. Information about the characteristics of the respondents (Meat Sellers-200)

Parameters	Frequency	Percentage	Mean
Age			
10-20	30	15	32.3
20-30	46	23	
30-40	72	36	
40-50	52	26	
Sex			
Male	155	77.5	
Female	45	22.5	

Status of chicken meat production

Two hundred respondents (meat sellers), 25 from eight districts were interviewed for the volume of chicken meat selling per day. It was found that the volume of chicken meat sold in each district ranged from 600 to 1200 kg daily (Figure 2). Only 36% of meat shops sold meat to hotels and restaurants (Figure 4).



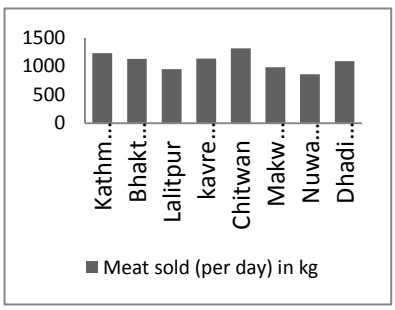


Figure 1. Proportion of meat sellers interviewed; Figure 2. Amount of meat sold per day in meat shops in each district

The volume of average meat sold in each district was found to range from 30 to 50 kg per day (Figure 3). The highest figure was in Chitwan followed by Kathmandu, and the lowest was in Nuwakot district.

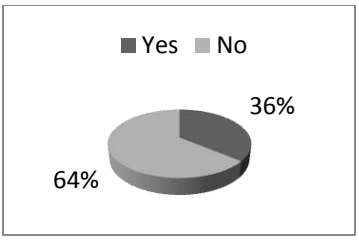


Figure 3. Meat sold to hotels and restaurants

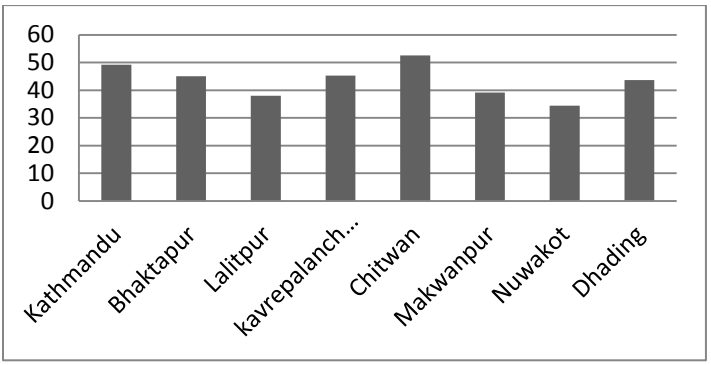


Figure 4. Average meat sold per day (in kg) in each district of Bagmati province

Practice regarding the hygienic status of the meat shop workers

On the survey of hygienic practice, 51.5% of the meat shops personnel never used protective clothes whereas 48.5% of meat handlers were using apron. But all of them handled meat with bare hands wearing jewellery materials, handling money and without covering their hair with hair nets (Table 3). Obviously the meat hygieninc practice of the shop workers was under standard.

Table 3. Practice regarding hygienic status of the meat shop workers

Characteristics	Responses	Percentage
Wearing Protective cloths	Yes	48.5
	No	51.5
Cutting instrument	Stainless steel	0.5
	Iron	99.5
Jewellery materials	Not worn	13.5
	Worn	86.5
Handling money	Self (with bare hands)	94
	Cashier	6

Practice regarding slaughtering facility and meat storage in meat shops

According to the survey, 92% of meat shops sold meat of broiler species only whereas, 8% of the shop sold broiler meat along with locals and other breeds. Also, 8.5% of meat shops had a lairage facility and 17.5% of meat shops had evisceration facility. It was found 93.5 % of meat shop had hot or cold water as required, 82% of meat shops had a refrigerator for the storage of all leftover meat but the rest 18% had no such provision (Table 4).

Table 4. Practice regarding slaughtering facility and meat storage in meat shops

Characteristics	Responses	Percentage
Species available	Broiler only	92
	Broiler and others	8
Lairage facility	Yes	8.5
	No	91.5
Evisceration facility	Yes	17.5
	No	82.5
Hot and cold water available	Yes	93.5
	No	6.5
Leftover meat	Store in refrigerator	82
	Not store	18

Practices regarding cleaning and disinfection process

In the study, 84.5% of the meat shops were found to be clean (Table 5). Upon questioning the meat handlers regarding the procedures of cleaning and disinfection, 34.5% of them indicated that water and detergent were used to clean and disinfect the surfaces while 65.5% of meat handlers indicated that they use only water to disinfect the surfaces.

Table 5. Practices regarding cleaning and disinfection process

Characteristics	Practices	Percentage
Sanitation of the meat shop	Clean	84.5
	Unclean	15.5
Means of Disinfection	Only with water	65.5
	Water with detergent	34.5

Knowledge about Sslaughter House and Meat Inspection Act, 2055

Out of 200 meat sellers interviewed, 94.5% of respondents were unaware of *Slaughterhouse and Meat Inspection Act, 2055*. Among the aware respondents 5.5% also were not fully acquainted with the act (Figure 5). That indicated a

need of making all of them ware of the act so that their negligence would not possess risk to public health.

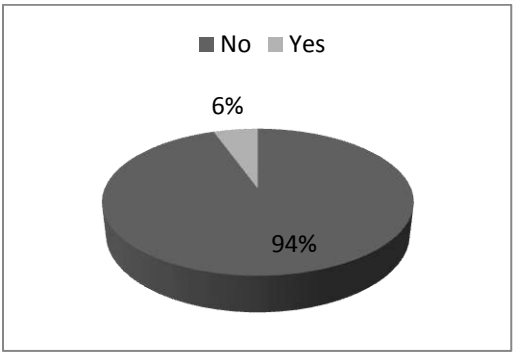


Figure 5. Knowledge about slaughterhouse and Meat Inspection Act, 2055 among meat sellers

Meat consumption pattern

From the meat sellers interviewed, it was found that 66% of the consumers preferred breast meat, 30% of the consumers preferred thigh meat whereas 4% preferred both (Figure 6). About 96% of the consumers' favoured broiler breeds than the locals. Out of 200 consumers interviewed, 62% of them preferred sausage as the most popular meat product whereas, 26% of them preferred other products such as drumstick, minced meat etc. Remaining 12% of the consumers preferred meat more than the meat products. Visceral organs were found to be least popular among the consumers.

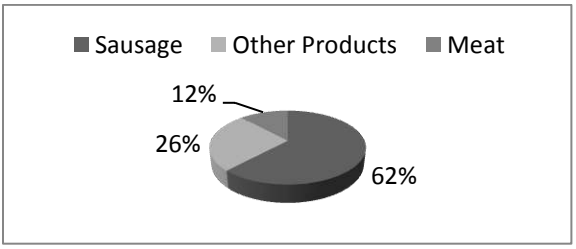
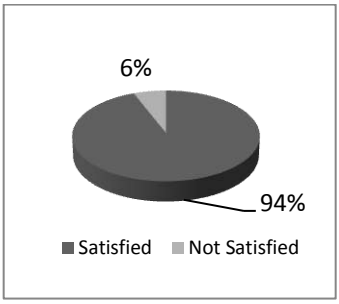


Figure 6. Most popular meat product with the consumers

Thoughts, knowledge and behaviours of consumers

Two hundred consumers were interviewed from the meat shop to gain their thoughts, behaviour and knowledge on various aspects of chicken meat production and consumption. Most consumers (73%) claimed sale of clean and

hygienic meat as a reason they buy meat from that shop while 22% of the consumers stated meat shop being nearest as the reason they buy meat from the same meat shop and 5% of the consumers routinely bought meat from meat shop ran by friends or family. 94% of the consumers were satisfied with the meat shop (Figure 7).



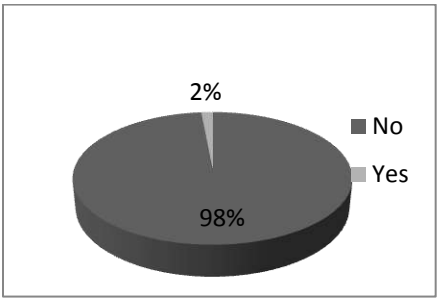


Figure 7. Consumer Satisfaction Figure 8. Knowledge of consumers about *Slaughterhouse and Meat Inspection Act, 2055*

About 98.5% of the consumers interviewed had no knowledge about *Slaughterhouse and Meat Inspection Act, 2055.* Only 1.5% of the consumers were acquainted with the act as well as roles of local and state government to implement this act (Figure 8).

DISCUSSION

From the information provided by the Livestock Statistics of Nepal, 2077/78 published by Department of Livestock Service, eight most chicken meats producing districts of Bagmati province was selected for the study. The study reveals that largest amount of meat is sold in Chitwan and Kathmandu with the least amount in Nuwakot which correlates with the production data of these districts. Chitwan and Kathmandu where the production of chicken meat is high, according to Livestock Statistics of Nepal, 2077/78, the sale of meat is also higher.

The average age of meat sellers in the study was 32.3 with 77.5% being male and 22.5% being female which was similar to Paudel, *et al* (2018), where 79.41% of the butcher/meat sellers interviewed were male and 20.58% of them were female. Similarly, Subedi *et al* (2022) also revealed that 75.2% of the shops were run by males and handled most of the meat shop activities. This showed the major involvement of adult males in chicken meat production and sale which may be due to it, being a labour intensive job. The study also reveals

that only 36% of meat shops sold meat to hotels and restaurants. According to Paudel, *et al* (2018), the primary customers of meat producers are the general public (73.52 %) and hotels and restaurants (7.84 %). This shows that proportion of meat being sold to hotels/restaurants is increasing.

On the survey of hygienic practice, 51.5% of the meat shops personnel never used protective clothes whereas 48.5% of meat handlers were using apron and all of them handled meat with bare hands without covering their hair with hair nets. The result is similar to Subedi *et al* (2022), where only 47.9% of the butchers were found wearing an apron (a protective cloth), but in most cases, it was not properly washed and cleaned. 85.5% of butchers had not covered their hair during meat handling. Even those who had covered their hair were wearing normal winter cap, not the hair net. Also, Upadhayaya *et al* (2018), concluded that in the survey on hygienic practice, 38.42% of meat shops personnel never used protective clothes whereas 61.58% of meat handlers were using personal protecting equipment (PPE) in the form of apron.

According to the survey, 92% of meat shops sold meat of broiler species only whereas, 8% of the shop sold broiler meat along with locals and other breeds. Also, 8.5% of meat shops had a lairage facility and 17.5% of meat shops had evisceration facility. It was found 93.5 % of meat shop had hot or cold water as required, 82% of meat shops had a refrigerator for the storage of all leftover meat but the rest 18% had no such provision. Ante mortem and Postmortem examination was completely absent. This is similar to Upadhayaya *et al* (2018), where 92.63% of meat shops sold meat of single species, 3.16% of meat shops had a lairage facility, 4.74% of meat shops had evisceration facility, 94.74 % of meat shop had hot or cold water as required and 78.95% of meat shops had a refrigerator for the storage of all leftover meat.

In the study, 84.5% of the meat shops were found to be clean and disinfected whereas Upadhayaya *et al* (2018), revealed that 97.37% of meat handlers indicated that they never cleaned or disinfected the wall surfaces, ceilings, ventilation. Subedi *et al* (2022),also revealed that 49 out of 117 (i.e., 41.88%) meat shop had poor sanitation and hygienic meat handling practices (score <45%), and the remaining 58.12 % had a fair level score. The variation may be due to the rules and regulations being stricter as well as the consumers being aware.

Study also revealed that 94.5% of the meat sellers and 98.5% of the consumers lack understanding of Slaughterhouse and Meat Inspection Act, 2055. It is unfortunate that till today, the "Slaughterhouse and Meat Inspection Act 1999"

has been a failure in terms of implementation. In Nepal, the Act and Regulation have not been enforced to date (Upadhayaya *et al* (2018)).

About 66% of the consumer preferred breast meat, 30% of the consumers preferred thigh meat whereas 4% preferred both and 96% favoured broiler meat than the others were found in this study. Hemin, *et al* (2019), conducted survey and identified that chicken breast (31.0%) was the most preferred, followed by thigh (21.2%) than other parts, while chicken feet were less preferred (8.7%). Chicken breast being more popular may be due to the breast part having more meat than the thighs.

As per this survey conducted on 200 consumers present in the meat shop, most consumers (73%) claimed sale of clean and hygienic meat as a reason they buy meat from that shop while 22% of the consumers stated meat shop being nearest as the reason they buy meat from the same meat shop and 5% of the consumers routinely bought meat from meat shop ran by friends or family. 94% of the consumers were satisfied with the meat shop.

No, previous study on consumption pattern has been done in Nepal. Consumption pattern is essential to understand the specific expectations of producer, processor, retailer and thoughts of consumers for meat consumption. Training given in sanitation and hygiene should be able to change personnel behavior and attitude as well as impart knowledge (Egan et al., 2007). However, training alone is not sufficient for long-lasting improvement in personnel hygiene. Several studies indicate that more than training is required to convince food industry workers to wash their hands (Michaels et al., 2002).According to Adams and Moss (2008) , training of food handlers regarding the basic concepts and requirements of personal hygiene plays an integral part in ensuring safe products to consumers. Food safety knowledge among food handlers is significantly related to better food handling practices (Nigusse and Kumie, 2012). The consumption pattern provides information on the chicken products most favoured by the people from the region and programmes can be formulated to produce those products in quality and large number.

CONCLUSION

From the result, it can be concluded that the present sanitation and hygienic practices followed by the retail meat shapes of Bagmati province are not satisfactory and adequate to avoid the possible cross-contamination and ensuring safer meat for the consumer. There is still a large gap on knowledge about

Slaughterhouse and Meat Inspection Act, 2055. Although, chicken meat production is increasing rapidly with the proliferation of poultry industry, wholesome meat production is still lacking.

SUGGESTIONS

Government and the concerned authorities have to take initiative to the implementation of existing Slaughterhouse and Meat Inspection Act 1999 and training courses must be conducted for butchers and meat sellers to promote hygiene practices and animal welfare thereby improving the quality standard of meat shops and finally the quality of meat and hygiene practices in meat shops. Further, study on consumption pattern should be done to gain valuable information into how meat producers perceive and respond to chicken meat production and its issues. Strategy to improve standards on quality meat production should be generated and introduced to the less producing areas.

REFERENCES

Abbott, M. & Hogg, G., (1998*). Consumers and services.* Chic ester: John Wiley & Sons.

Adams, M., & Moss, M., (2008). Factors affecting the growth and survival of micro-organisms in foods. In: *Food Microbiology* (3rd ed.), pp. 46-48. Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge CB4 0WF, UK.

Bajagai, Y. S., (2019). *Major issues about the safety of meat in Nepal*.

Blackwell, R. D., Mansard, P. W. & Engel, J. F., (2006). *Consumer behavior*. Mason: Thomson

Dhakal, R., Joshi, B., Karn, R., Bhusal, S., Acharya, B., 2019. A Review on Scenario, Challenges and Prospects Of Poultry Production In Nepal. *Malaysian Journal of Sustainable Agriculture*, 3 (2), 60-63.

Egan, M.B., Raats, M.M., Grubb, S.M., Eves, A., Lumbers, M.L., Dean, M.S., & Adams, M. R. (2007). A review offood safety and food hygiene training studies in thecommercial sector. *Food control*, 18(10), 1180-1190.

MoALD (2021). *Statistical Information*, Ministry of Agriculture and Livestock Development. Government of Nepal.

Neima, H.A., Sirwan, K., Hameed, K., (2019). Consumers Choice and Preference for Chicken Meat in Sulaymaniyah.

Nepali Times, (2021). Meat, money, and the middle class.

Nigusse, D., & Kumie, A., (2012). Food hygiene practices and prevalence of intestinal parasites among food handlers working in Mekelle university student's cafeteria, Mekelle. *Global Advanced Research Journal of Social Science*, 1(4), 65-71.

Poudel, B. *et al*., (2018). *National Livestock Welfare Survey*. MoALD

Poudel, U., Dahal, U., Dhakal, S., (2021). *Review of Poultry Production and Poultry Vaccine Manufacture in Nepal*. MoALD

Pradhanang, U.B., Pradhanang, S.M., Sthapit, A., Krakauer, N.Y., Jha., A., Lakhankar, T. (2015) *National Livestock Policy of Nepal: Needs and Opportunities*, 5, 103-131

Schiffman, L. G. & Kanuk, L., (2000). *Consumer behavior*. Upper Saddle River, 76 NJ: Prentice Hall.

Subedi, D., Bhattarai, T., Acharya, D.R., (2022). *Meat Handling Practices Among Retail Meat Shops in Dharan Sub-Metropolitan City*.

The Kathmandu Post, (2016). *Nepal´s Poultry Industry* Worth Nrs.33.72 Billion.

The Kathmandu Post, (2021). *Nepal becomes self-sufficient in egg and meat production*.

Upadhayaya, M., Ghimire, B., (2018). Survey on Good Hygiene Practices in Retail Meat Shops in Butwal Municipality, *Nepalese Veterinary Journal*, 35, 110-121.

Yadav, R.K.., Yadav, R. (2021). *A Review on Poultry Population, Production (Egg and Meat) And Distribution In Nepal.*

Comparative Research on Effectiveness of Methylene Blue and Autohemotherapy in Treatment of Lumpy Skin Disease

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ABSTRACT

Lumpy Skin Disease (LSD) is a highly contagious viral disease of cattle and buffalo that has caused significant economic loss in many countries. LSD is characterized by the development of nodular lesions on the skin which can lead to severe inflammation, fever, and reduced milk and meat production in diseased animals. Methylene Blue, Autohemotherapy and Supportive therapy are treatment protocols used in this research for treatment of LSD. The purpose of the study was to compare effectiveness of Methylene Blue, Autohemotherapy and Supportive therapy in treatment of Lumpy Skin Disease. The study was conducted from March 2023 to June2023 at Makawanpur and Chitwan District on 90 cattle and buffalo of various breed, irrespective of age, sex and divided into three groups consisting 30 animals in each group. Treatment group 1 (n=30), was treated with 0.1% Methylene Blue Solution in 3 doses per day for five consecutive days. Treatment group 2 (n=30), was treated with combination of Autohemotherapy and Supportive therapy. Control group (n=30), was treated with Supportive therapy only. Comparing the three groups, Treatment group 1 has the highest recovery rate (73.33%) and low mortality rate (3.33%) compared to other groups. Methylene Blue demonstrates its efficacy in reducing lesion count, improving general health status and restoring appetite. In Treatment group 2, the recovery rate (70%) is slight lower than the treatment group 1 but not significantly lower than the control group (53.33%). In the majority of cases, the size of the skin nodules is markedly reducing while in some instances the nodules ruptures and subsequently decreases in size. The number of active cases is lower in both Treatment group 1(23.33%) and Treatment group 2 (23.33%) compared to Control group (30%). Furthermore, Treatment group 1 has the best results in terms of lowering mortality, with a mortality rate of 3.33%. Treatment group 2 has a marginal mortality rate of 6.67% compared to Treatment group 3, which has the highest mortality rate of 16.67%. This suggests that Treatment Group 1 is more effective in preventing LSD-related fatalities, followed by Treatment Group 2. The result of this study suggests that both Methylene Blue and Autohemotherapy have potential benefits in the management of Lumpy Skin Disease compared to Supportive therapy alone.

Keywords: Lumpy Skin Disease, Autohemotherapy, Methylene Blue, Recovery rate, Mortality rate

INTRODUCTION

Lumpy Skin Disease (LSD) is a highly contagious viral disease of cattle and buffalo that has caused significant economic loss in many countries. In Nepal, the first case of LSD was reported on 24th June, 2020 in Morang district of Koshi Province and since then there has been sporadic outbreak throughout the country (Regmi, 2020).

LSD is characterized by the development of nodular lesions on the skin, which can lead to severe inflammation, fever, and reduced milk and meat production in diseased animals. (Tuppurainen et al., 2017) The economic impact of LSD is enormous; as it affects both dairy and meat production and can lead to trade restrictions and loss of markets for affected countries (OIE, 2021).

There is no any specific treatment applicable till date for treatment of Lumpy Skin Disease, prevention by the means of vaccination is a method to control Lumpy Skin Disease epidemics. Various treatment protocols used in the treatment of Lumpy Skin Disease are Supportive therapy, Autohemotherapy, and Methylene Blue. (Tuppurainen, E.S.M. and Oura, C.A.L., 2012) There is no direct antiviral drug available for treatment of LSD. Supportive therapy involves the use of antibiotics, pain killer, wound spray, vitamins, and anti-allergic medication to treat symptoms (Vis, 2023).

Autohemotherapy procedure involves drawing blood from the jugular vein of an infected animal and infusing it back into the muscle that would result in more macrophages production in the body. They continuously circulate through all organs with the sole purpose of locating and eliminating foreign substances. (Singh, 2022) Autohemotherapy also restore the health status of sick animals by suppressing suppurative biodegradation of soft tissue; enhance the immune system, improving cell metabolism as well as improving blood and lymphatic circulation. According to Borges et al., (2014), Autohemotherapy can be used in treatment of Papillomatosis, Parvo, Acute Interdigital Phlegmon, TVT, Inflammatory diseases, Dermatitis etc. In other hand, autohemotherapy can be used as treatment and control of Lumpy Skin Disease (Singh, 2022).

Methylene blue (MB) is a broad-spectrum antiviral drug known for its antiviral properties against many diseases. Methylene blue has also recently been shown to be effective in reducing the spread of SARS-CoV2. Methylene Blue will prevent damage to the immune system through various anti-inflammatory mechanisms until the body activates the immune system, reducing infectious virus in cattle and helping to treat various skin diseases along with protecting the body's immune system and preventing multiple organ damage. This promotes

faster and reduces mortality. (Swarnakar, 2022) According to Purohit (2022), Methylene blue can be used for both topical and systemic administration and the result in various states of India is quite favorable. He also suggested more research is needed to find out efficacy of methylene blue in the treatment of Lumpy Skin Disease.

According to some literature, researches and trails in the use of methylene blue and autohemotherapy for the treatment of LSD in cattle has been an alternative therapy in many countries including India. But in the context of Nepal, there is a lack of research on the use of both Methylene Blue and Autohemotherapy in treatment of LSD, which should be addressed as soon as possible because LSD is initially present as sporadic case but it has the potential to turn into an epidemic under certain conditions.

Although there is limited study on this topic, this research aim is to compare the effectiveness of various treatment protocol used in the treatment of LSD which will be beneficial for both animal and farmers and also play crucial role in lowering the incident of Lumpy Skin Disease in Nepal.

MATERIALS AND METHODS

Site and Animal selection

The study was carried out at Bagmati Province from March 2023 to June 2023, which covered areas Manahari and Hetauda of Makwanpur District and Bharatpur of Chitwan District. 90 cattle showing signs and symptoms of Lumpy Skin Disease were included in this study.

Study Design

A randomized control trail module was followed to evaluate the effectiveness of the treatment protocol. In an RCT, 90 animals showing clinical signs of Lumpy Skin Disease were randomly assigned to three groups. The Treatment group 1 (n=30), the Treatment group 2 (n=30) and Control group (n=30).

Treatment Protocol

- Treatment group 1(n=30) was treated with 0.1% Methylene Blue solution in 3 doses per day for five consecutive days.
- Treatment group 2 (n=30) was treated with a combination of Autohemotherapy and Supportive therapy.
- Control group (n=30), was treated with Supportive therapy only.

- **Methylene Blue (MB)**

0.1% MB solutions (1gram MB in a liter of water) PO is given in 3 doses per day for a period of 4-5days. In case of adult cattle (approx. 350 kg body weight):

300 ml at 8 hourly intervals (thrice in a day) for 4-5 days. In the case of calves, half dosage of Methylene Blue should be given.

- **Autohemotherapy**

  30 ml of blood was drawn from the jugular vein of a diseased animal and then 15 ml blood was injected subcutaneously in the neck region and 15 ml blood was injected deep intramuscularly in the gluteal region. The treatment was repeated once.

- **Supportive therapy**

➢ Antibiotics: Oxytetracycline at a dosage rate of 10mg/kg I/M SID and Penicillin at a dosage rate of 2.5gm/kg I/M q48hr for pregnant animals were using for 5-7 days continuously to prevent secondary bacterial infections.

➢ Antihistamine: Chlorpheniramine at a dosage rate of 0.5 mg/kg SID was used to prevent allergic conditions.

➢ NSAID: Meloxicam at a dosage rate of 0.5 mg/kg SID I/M was given for three consecutive days for management of pain, fever as well as inflammation.

➢ Ivermectin at a dosage rate of 0.2 mg/kg S/C was used once because Ivermectin inhibits invitro replicating stage of Lumpy skin disease virus.

➢ Himax or Charmil ointment can be administered topically to erupted lesions to speed up recovery. (Pooja. Et al, 2023)

- **Clinical evaluation**

The efficacy of the treatment protocol for Lumpy Skin Disease was evaluated based on the observation of the presence or absence of clinical signs and mortality among the three treatment protocols on Day 5th, 7th, and 14th.

Data collection

Primary data of experiment was collected from the research site, while the Secondary data were collected by contacting farmers, Doctors, technicians, or by reviewing various published Literatures, articles and documents and other available materials in the internet related to the topic of the study.

Data analysis

The collected data were compiled systematically and chronologically and analyzed using Microsoft Excel and SPSS (Statistical Package for the Social Sciences). The result will be presented in the form of a table, graph, bar diagram, pie chart etc.

RESULTS AND DISCUSSION

The study aimed to compare the effectiveness of Methylene Blue and Autohemotherapy in the treatment of Lumpy Skin Disease. A randomized controlled trial was conducted to compare the effectiveness of various treatment

protocols. A total of 90 cattle were divided into three groups, each containing 30 animals showing signs and symptoms of Lumpy Skin Disease.

The most observed clinical symptoms among the selected animals were skin lesions, enlargement of lymph nodes, swelling in brisket and leg regions. The less frequent symptoms observed were lameness, respiratory distress, nasolacrimal discharge, (Figure 1A). In the majority of cases of skin lesions were distributed throughout the entire body (81.11.%) or found to be restricted to particular areas of the body such as the only head (3.33%), only legs (6.67%), only neck (1.11 %) or combination of legs and neck (7.78%), (Figure 1B). Throughout the study, clinical parameters such as skin lesions, healing time, fever duration, appetite, swelling and edema and pruritus were monitored.

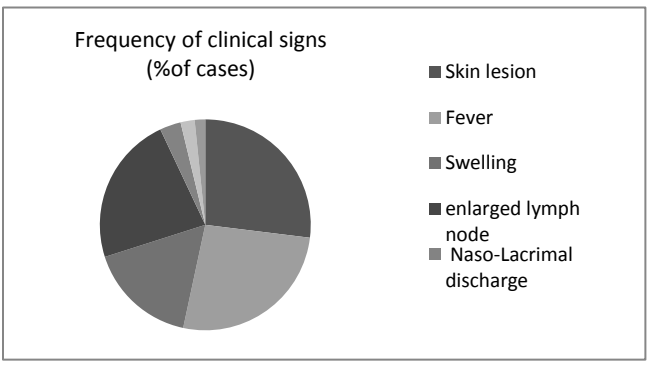

Figure 1A. Pie chart showing distribution of skin lesions in different part of body

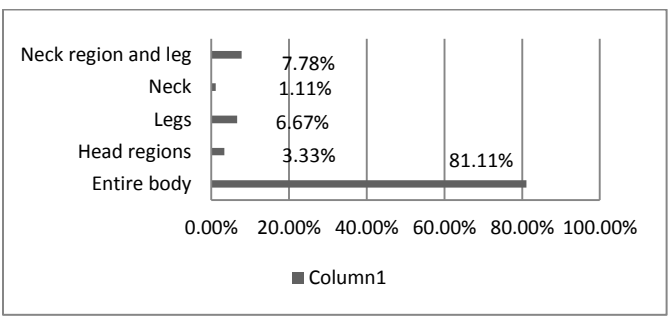

Figure 1B: **Frequency of clinical signs shown by affected cattle**

Figure 1. Clinical observation and distribution of lesion in affected cattle population

Treatment group 1: In this group, out of total patients Twenty-two patients showed a significant reduction in signs and symptoms of Lumpy Skin Disease with a recovery rate of 73.33%. After 5 days of treatment, a notable reduction in the size of skin nodules, lacrimation, salivation, and swelling in the brisket and legs was observed. Most of the animals regained their appetite within 24-48 hours after receiving oral medication of methylene blue. Furthermore, eight patients showed mild to moderate recovery from the disease even after receiving oral medication of methylene blue, representing 23.33% of the active cases in this group. The mortality rate in this group was 3.33%. In terms of fever, it was observed that the maximum duration of fever was 2-3 days, while in severe cases, it persisted for 4 days. There was a sudden drop in milk production, which was restored after the full course of treatment.

Treatment group 2: In this group, out of total patients twenty-one patients showed a gradual decrease in the sign and symptoms of LSD after a complete course of treatment representing 70% recovery rate in this group. Animal appetite was restored within the timeframe of 3-5 days. Additionally, in a majority of cases, the size of the skin nodules reduced while in some instances the nodules ruptured and subsequently decreased in size. There was a sudden drop in milk production, which was gradually restored after a period of time. Furthermore, seven patients showed moderate recovery from disease, the skin nodules along with swelling on brisket and leg region reduced in size only after 20-25 days of treatment representing 23.33% of the active cases in this group. The average duration of fever was reduced from 8 days at baseline to 4 days after treatment. The mortality rate observed in this group was 6.67% which is low compared to supportive therapy group.

Control group: In this group, out of total patients observed 16 patients showed a reduction in sign and symptoms after 7-8 days of treatment indicating a positive response of treatment representing 53.33% recovery rate. Furthermore, it was found that nine of the patients were in a serious state indicating the severity of disease. Despite receiving treatment, these patients showed slight improvement and the swelling in legs were filled with pus which makes animal reluctance to move. In some cases, young animals were showing signs of nasal and ocular discharge followed by respiration distress and dyspnea representing 30% of the active cases in this group. In terms of fever, the fever was observed for a maximum period of 9 days in severe cases while in moderate cases it remained for a period of 4-5 days. The variation of fever varied among individual patients on the basis of severity of disease. Additionally, there was a gradual drop in milk production in the case of dairy cattle which restored after

15-20 days ago. It was noted that animals regained their appetite within a timeframe of 3-5 days after treatment. However, in this group of animals the mortality rate was 16.67% which is comparatively higher than the mortality rate observed in the other group.

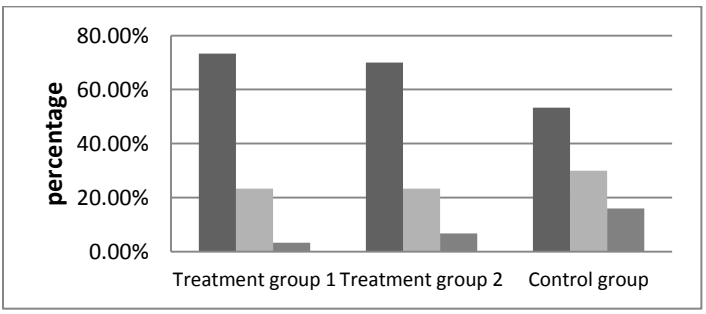

Figure 2. Comparative Analysis of Treatment Protocols in treatment and control groups

DISCUSSION

This research was based on comparative effectiveness of Methylene Blue and Autohemotherapy for treatment and control of Lumpy Skin Disease. Comparing the three groups, Treatment group 1 had the highest recovery rate and low mortality compared to other groups. Methylene Blue demonstrated its efficacy in reducing lesion count, improving general health status and restoring appetite. In Treatment group 2, the recovery rate is slight lower than the treatment group 1 but not significantly lower. In the majority of cases, the size of the skin nodules is markedly decreasing while in some instances the nodules ruptures and subsequently decreases in size. The number of active cases is same in both Treatment group 1 and Treatment group 2 (23.33%) compared to Control group (30%). When comparing severity of cases between three groups after the full course of treatment, patients in the Treatment group 1 exhibits mild symptoms, followed by moderate symptoms in Treatment group 2, and in the case of a control group, they exhibit severe symptoms despite receiving a full course of treatment. The swelling in legs is full of pus which makes animal reluctance to move. In some cases, young animals are showing signs of nasal and ocular discharge followed by respiration distress and dyspnea.

Regarding fever duration, the Treatment group 1 has the shortest duration of fever followed by Treatment group 2 and the Control group. In all three groups, milk production initially decreased but then gradually increased. In contrast to the other groups, Control group required a longer period of time (15–20 days)

for milk production to return to normal. This suggests that the control group effect on milk production is more significant, which could have an impact on overall productivity and financial loss.

Table 1. Different treatment protocols along with changes in symptoms seen during course of treatment following each treatment protocol

Treatment	Skin Nodules	Fever	Swelling in brisket and legs	Respiratory distress	Naso-lacrimal Discharge	Enlarged lymph node
Group 1	Reduction in size of skin nodules was seen between 4-5 days	Subside within 2-3 days	Reduced in 80% animals	Not present after full course of treatment	Not present after full course of treatment	Not present after full course of treatment
Group 2	Skin nodules reduced in size after full course of treatment but in some cases, nodules ruptured and subsequently decreased in size	Fever persisted for 4-5 days then gradually decreased	Reduced 10-15 days after treatment	Not present after full course of treatment	Present in young calves	Not present after full course of treatment
Control	Took 20-25 days for nodules to reduce their size	Fever persisted for 9 days even after providing antipyretics.	Took longer time to heal	Present in young calves	Present in young calves	Not present after full course of treatment

Furthermore, Treatment group 1 has the best results in terms of lowering mortality, with a mortality rate of 3.33%. Treatment group 2 has a marginal mortality rate of 6.67% compared to Treatment group 3, which has the highest mortality rate at 16.67%. This suggests that Treatment Group 1 is more effective in preventing LSD-related fatalities, followed by Treatment Group 2.

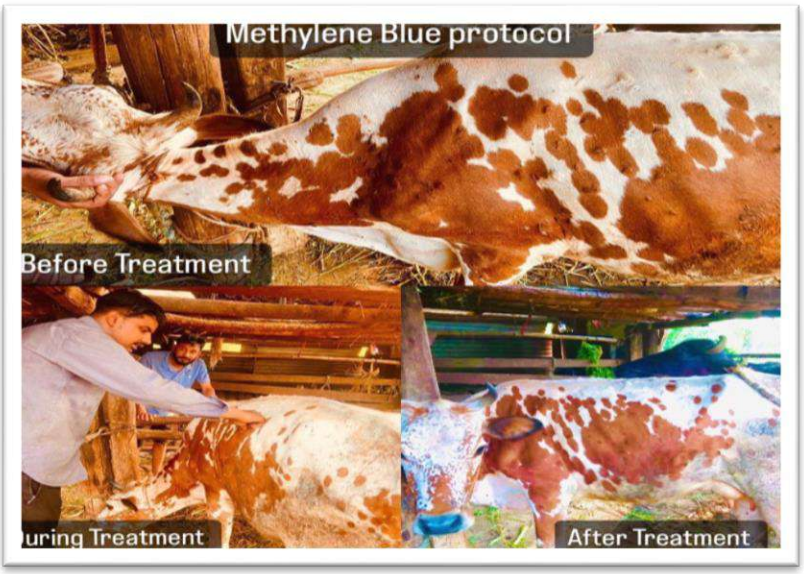

Figure 3. Methylene Blue treatment protocol used in LSD along with result

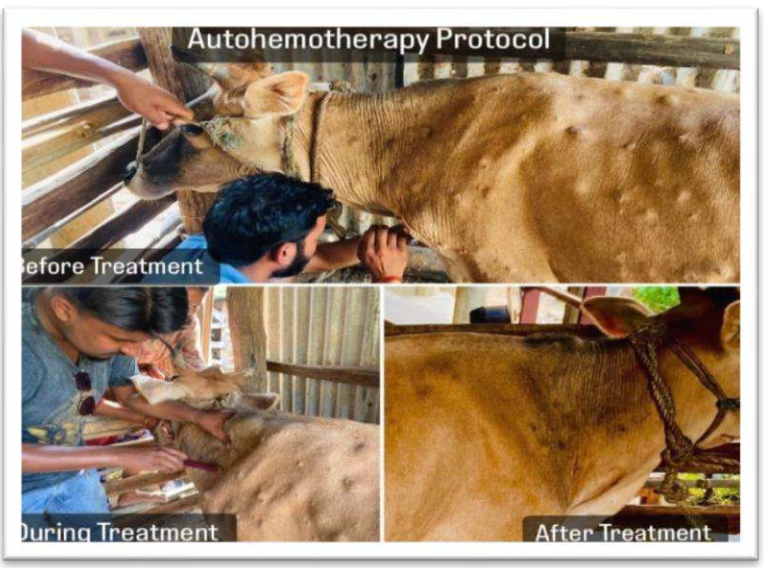

Figure 4. Autohemotherapy treatment protocol used in LSD along with result

CONCLUSION

The study highlights the comparative effectiveness of Methylene Blue, Autohemotherapy and Supportive therapy in treatment of LSD in cattle. The result demonstrates that Methylene blue is the most effective treatment option with significant higher recovery rate (73.33%), compared to Autohemotherapy (70%) and Supportive therapy (53.33%). Methylene blue not only showed significant higher recovery rate but also demonstrated improvement in reduction of lesion, healing time and overall health status. In case of autohemotherapy, it showed better efficacy when used in combination with supportive therapy. This suggests that combination of autotherapy and supportive therapy can yield positive outcome in management of Lumpy Skin Disease.

On the other hand, the study revealed that Supportive therapy alone was found to be less effective and offer low benefit to diseased animals. The mortality rate and rate of active case after a full course of treatment were higher in supportive therapy group compared to other groups indicating low efficacy of this treatment protocol in managing LSD.

In conclusion, the findings of this study suggest that both Methylene Blue and Autohemotherapy together with supportive therapy have potential benefits in the management of Lumpy Skin Disease compared to Supportive therapy alone.

REFERENCES

Acharya, K.P. and Subedi, D. (2020). First outbreak of lumpy skin disease in Nepal, *Preventive Veterinary Medicine*, 102(4), pp. 274-283.

Borges, O.M., Silva, R.M., Mendes, R.D., and Souza, A.P. (2014). Autohemoterapia, uma nova ou antiga alternativa terapêutica? Revisão de literatura, Medvep-Revista Científica de Medicina Veterinária-Pequenos Animais e Animais de Estimação, 12(39), pp. 32-40.

OIE (2021). *Lumpy skin disease*, [Online]. Available at: *https://www.oie.int/en/animal-health-in-the-world/animal-diseases/Lumpy-skin-disease/* (Accessed: June 18, 2023).

Pooja, Singh, S., Kumar, S., & Singh, S. (2023). Lumpy Skin Disease: An Emerging Disease and its Treatment Strategy, *Acta Scientific Veterinary Sciences*, 5(2), pp. 71-73.

Purohit, G.N. (2022). *How effective is Methylene blue in the treatment of lumpy skin disease cattle*, [Online video], Youtube. Available at: https://www.youtube.com/watch?v=W2cxVgOlEJI (Accessed: April 26, 2023).

Regmi, S. (2020). *Lumpy skin disease (LSD) outbreak in Nepal*, Doi: 10.22541/au.159986266.62442803.

Shakman, S.H. (2010) 'Autohemotherapy Reference Manual. Definitive Guide and Historical Review from Bloodletting to Stemcells', Institute of Science www. InstituteOfScience.com, pp. 177-179.

Swarnkar, A. (2022) 'Treatment of Lumpy Skin disease in cattle with methylene Blue', Macsen Labs. Available at: https://www.macsenlab.com/blog/methylene-blue-treatment-for-lumpy-skin-disease-in-cattle/

Tuppurainen, E.S., Venter, E.H., Coetzer, J.A.W., and Bell-Sakyi, L. (2017) 'Lumpy skin disease: A review of the disease and aspects of control', Journal of the South African Veterinary Association, 88(0), a1452.

Tuppurainen, E.S.M. and Oura, C.A.L. (2012) 'Lumpy skin disease: An emerging threat to Europe, the Middle East and Asia', Transboundary and Emerging Diseases, 59(1), pp. 40-48. doi:10.1111/j.1865-1682.2011.01242.x.

Vis, K. (2023) 'Lumpy cow skin disease treatment explained', Diamond Hoof Care. Diamond Hoof Care Ltd. Available at: https://diamondhoofcare.com/lumpy-cow-skin-disease-treatment-explained/ (Accessed: 17th June 2023).

High Corn Silage Diets in Plastic Packaging: A Way-Out Solution in Fodder Scarcity

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ABSTRACT

The study aimed to identify the practices of silage production in plastic packaging and utilization of whole crop high corn silage diet in dairy animals. This case study was conducted in one of the leading dairy cooperatives; Annapurna Milk Producers' Cooperative Ltd. located at Gitanagar of Chitwan district of Bagmati Province of Nepal. The silage production unit was established with the support from province government Ministry of Agriculture and Livestock Development towards the aim of assuring availability of nutritious green fodder source in the fodder scarcity season ultimately increasing the milk productivity from dairy animals. Data on production input and output, technological levels taking into account the parameters of milk production on the farms, productivity of the cows, and breed; as well as their prices, was gathered from a survey conducted in the surround location. Finally, technical indicators were used to define each qualitative variables constructed. The result of data analysis was examined

through a focus group discussion (FGD) attended by the cooperatives management staff. The project used hybrid corn that could be planted and harvested twice in a year and yields corn silage on an average 1700 ton/ year. The harvested whole-plant high corn crop was processed to produce packaged silage, further distributed to meet the needs of the member of the cooperative. Approximately 75-80% of households in study sites raised at least 2-3 cross-bred milking cows and 20% keep 1-2 buffalo. A wide variety of crops were grown throughout the year in different seasons. Different green fodders, crop residues, mainly rice straw and commercial feed available throughout the year, contributed to the diet of the dairy animals. Management system adopted was complete stall fed. Herd recorded mastitis as a major disease (63.16%) followed by infertility (13.16%), milk fever (10.53%), helminths (7.89%) and remaining (5.26%). The result showed that per day milk production of cattle and buffalo was highest in medium farm category followed by small farm category whereas that of buffalo was vice-versa, whereas the lactation period of cattle was highest (9.73) in medium (semi-commercial) category followed by small (9) and that of buffalo was highest (8.65) in small category followed by medium (8.46) farm category. This study indicated a high potential of dairy farming in Chitwan district and can be considered as a leading milk producing districts in Bagmati Province of Nepal.

Key Words: Animal nutrition, dairy animals, feeds and fodder, high-corn diet, silage

INTRODUCTION

Agriculture is still the largest economic sector that solely contributes more than 24.1% of national GDP. The restructuring of the state provided opportunities to improve agriculture governance as well. Nepalese agriculture is characterized by higher level of diversification in terms of climatic and geographic variations. Due to the high range of altitudes and temperature throughout the country, agriculture in Nepal has peculiar characteristics. Within almost 200 Km in north-south, we find all kinds of temperature and crop types as well. This provides both opportunities and challenges for agriculture development in Nepal. After introduction of the new constitution, the unitary country has been restructured into 7 provinces. These provinces have been divided mostly on the geographic basis. With perspective of agriculture development, all provinces have particular strengths and some weaknesses. Provinces 1, 3, 5 and 7 have both temperate and tropical climates and more diverse in terms of agriculture crop production potentialities. While province 2 has mostly tropical climate, province 4 and 6 have largely temperate climate and are less diverse. These provinces will be interdependent to each other in terms of economic production. Further, some provinces will be surplus in certain commodities and deficit in other commodities. Not only production, there will be an interdependency for inputs and product markets.

Livestock is an integral part of farming system in Nepal and plays significant role in food security and overall economic empowerment of the country. It contributes 6.23% in the National Gross Domestic Product; and 27.83% in the National Agriculture Gross Domestic Product (MoALD, 2020/21). There are total 7,466,841 cattle, 5,159,931buffalo, 13,442,614 goat, and 793,725 sheep, directly dependant on the forages (MoALD, 2020/21). Most of these animals are local and only 3.4 % of the cattle and 4.3 % of the buffaloes are of improved breeds, and their population is gradually increasing. The increasing trend of livestock in past ten years is presented in Table 1.

The annual milk production is 2480 (‘000 MT), 520 (‘000 MT) of meat production, and 1,493,550 (‘000 pieces) of egg production; contributing 85 liters, 18 kg and 52 pieces per capita consumption of milk, meat and egg respectively in Nepal MoALD, 2020/21). The population of small ruminants (sheep and goats) is 11.9 million, of which goat population comprises 95 percent and remaining is sheep. There are only 2.7 percent of the goats and only 0.5 percent of the sheepof improved breeds.The remaining are local across the country. There are non-ruminant animals also, sharing the available feed resources, and mainly the concentrate feeds. These are pigs, poultry and equines (horse/mules/asses/donkeys). There are 1.5 million pigs out of which only 7.3% of the improved breeds, that produce 31,450 MT meat annually. Another animal species to share the feed resources (concentrate feeds) is chicken,their population is 73.4 million, out of which about 10 million (14 %) are layers (MoALD, 2020/21). The data on livestock products in past ten years is illustrated in Table 2.

Table 1. Livestock population for last ten years

Unit: Number

CATEGORY	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Cattle	7,244,944	7,274,022	7,243,916	7,241,743	7,302,808	7,347,487	7376306	7,385,035	7,458,885	7,466,841
Buffaloes	5,133,139	5,241,873	5,178,612	5,167,737	5,168,809	5,177,998	5,277,819	5,308,664	5,257,591	5,159,931
Sheep	807,267	809,536	789,216	789,292	800,658	801,975	800,749	798,889	806,079	793,725
Goat	9,512,958	9,786,354	10,177,531	10,251,569	10,986,114	11,165,099	11,647,319	12,283,752	12,811,953	13,442,614
Pigs	1,137,489	1,160,035	1,190,138	1,203,230	1,291,308	1,328,036	1,435,369	1,488,338	1,519,593	1,588,838
Fowl	45,171,185	47,959,239	48,079,406	50,195,285	68,630,638	70,007,151	72,245,732	75,709,330	82,598,879	73,418,077
Duck	376,916	375,975	390,209	390,287	392,255	394,775	404,670	416,400	427,226	432,226
Milking cow	998,963	1,025,591	1,024,513	1,025,947	1,026,135	1,029,529	1,039,538	1,078,775	1,166,156	1,209,041
Milking buffaloes	1,331,037	1,369,796	1,345,837	1,345,164	1,355,384	1,509,512	1,535,948	1,560,584	1,635,492	1,630,642
Laying hen	7,907,468	8,233,616	8,350,237	8,412,247	12,353,515	12,388,889	12,517,558	12,526,979	12,927,842	11,374,011
Laying duck	174,978	174,714	179,447	179,480	180,927	183,940	186,912	190,747	191,701	220,532

Source: MoALD, 2020/21

Table 2. Livestock products for last ten years (MoALD, 2020/21)

Products	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Milk Production (Mt.)	**1,622,751**	**1,680,812**	**1,700,073**	**1,755,725**	**1,854,247**	**1,911,239**	**2,092,403**	**2,168,434**	**2,301,000**	**2,479,899**
- Cow Milk	468,913	492,379	532,300	587,719	643,806	665,285	754,126	795,530	920,400	1,060,487
- Buff. Milk	1,153,838	1,188,433	1,167,773	1,168,006	1,210,441	1,245,954	1,338,277	1,372,905	1,380,600	1,419,412
Meat (Net) Production (Mt.)	**287,930**	**295,167**	**298,244**	**303,401**	**322,059**	**332,544**	**346,179**	**357,082**	**552,156**	**520,742**
- Buff	172,414	175,132	173,906	174,012	175,005	180,080	185,180	188,574	189,517	188,172
- Mutton (Sheep)	2,720	2,721	2,656	2,658	2,684	2,714	2,754	2,763	2,735	2,964
- Chevon	53,956	55,578	59,053	60,906	65,583	67,706	70,802	73,914	75,023	70,755
- Pork	18,277	18,709	19,269	20,135	23,509	24,535	28,214	28,579	29,493	31,450
- Chicken	40,346	42,810	43,133	45,458	55,041	57,268	60,122	62,899	255,001	226,959
- Duck	217	217	227	232	237	241	280	353	387	442
Egg Production ('000 Number)	**801,370**	**887,240**	**872,918**	**879,501**	**1,308,072**	**1,352,296**	**1,512,265**	**1,549,689**	**1,620,000**	**1,493,550**
- Hen Egg	788,310	874,194	859,515	865,947	1,294,166	1,338,312	1,498,024	1,534,680	1,604,526	1,475,620
- Duck Egg	13,060	13,046	13,403	13,554	13,906	13,984	14,241	15,009	15,474	17,930
Wool Production(Kg.)	**587,017**	**587,834**	**586,848**	**586,731**	**588,348**	**594,312**	**594,639**	**589,738**	**592,687**	**584,000**

There is potential to improve the fodder production in the country. There have been a significant change in land use pattern in Nepal for two decades from 1990 to 2010 (ICIMOD). The significant changes can be observed in terms of increased build up area and reduction in barren land, over the years. The land distribution pattern is illustrated in Table 3.

Table 3. Land distribution pattern

Category	Area ('000 Hectares)	Percentage(%)
Agricultural land cultivated	3,091	21.00
Agricultural land uncultivated	1,030	7.00
Forest	4,268	29.00
Shrubland	1,560	10.60
Grass land and pasture	1,766	12.00
Water	383	2.60
Others	2,620	17.80
Total	**14,718**	**100.00**

Source: MoALD, 2020/21

The grassland area has reduced by 26.8 % and forest area by 7 percent, indicating the need to increase green fodder production to meet the TDN need. On the other hand, existing livestock feed is highly imbalanced, as straws constitute over 65% of total TDN supply, and makes up the major diet (>80%) during the winter, spring, and the dry summer. While considering paddy and maize, their TDN contribution from straw reaches about 80% of total TDN supply, but these feedstuffs are low in nutrient with poor digestibility due to the high content of silica in the fiber (Upreti and Shrestha, 2006, Banerjee1998 and Mc Donald 2010). Nepalese agriculture is dominated by cereal crops. Rice, maize and wheat constitute more than 80% of cereal area and production. Rice solely contributes to 20.8% of AGDP and is the major cereal crop. Maize is the second most important crop after rice in terms of area and production in Nepal. It is a way of life for the hill farmers of Nepal. It is a traditional crop grown for food, feed and fodder. Maize demand has been constantly growing by about 5% annually in the last decades (Sapkota and Pokhrel, 2010). The feed demand is also increasing at the rate of 11% per annum. There is a need of about 6.46 million mt. feed to run smoothly the existing poultry industries in Nepal, and about 0.5 million mt. of feed has been produced annually by the feed industries in Nepal (114, registered in NFIA). Thus, the demand for maize is also shifting from food to feed for livestock and poultry. Winter maize under rice-wheat system has been emerging as a new intervention and it can be an option to increase the maize production in Nepal. The recent data on production of cereal crops is illustrated in Table 4.

Table 4. Production of cereal crops

Area in Hectare, Production in Metric Tonnes

Cereal crop	2075/76 (2018/19)		2076/77 (2019/20)		2077/78 (2020/21)	
	Area	Production	Area	Production	Area	Production
Paddy	1,491,744	5,610,011	1,458,915	5,550,878	1,473,474	5,621,710
Maize	956,447	2,713,635	957,650	2,835,674	979,776	2,997,733
Wheat	703,992	2,005,665	707,505	2,185,289	711,067	2,127,276
Millet	263,261	314,225	262,547	320,953	265,401	326,443
Buckwheat	10,311	11,464	10,369	11,724	13,875	15,917
Barley	24,409	30,550	24,404	31,147	21,862	29,433
Total	**3,450,163**	**10,685,550**	**3,421,389**	**10,935,664**	**3,465,455**	**11,118,512**

Source: MoALD, 2020/2021

Ruminants and equines are mostly dependent on fodder from private and community lands. Non- ruminant animals depend on concentrate feeds, of which more than 90 percent of raw materials (maize, soyabean, feed supplements) imported. The animals in Nepal are under fed as there is 36 percent deficiency of feed, mainly during the winter season. In the context of available Total Digestible Nutrient (TDN), about 29 percent is deficient (NAFLQML, 2019). The shortage of feed during 1980s in terms of TDN was about 36 percent (Rajbhandari and Sah, 1980).

In Nepal, the scarcity and low quality of feed resource are the main constraint against the increase in animal production during the fodder-shortage period (Hayashi et. al., 2007) and feed resources and their efficient utilization are therefore considered as the first limiting fact in improving animal productivity. There is shortage of green and dry fodder to the extent twice a year, and the problem gets very acute due to shortage of green fodder for cattle. This is because availability of fodder has a huge dependence on monsoon performance. There is abundant fodder available for cattle during the monsoon season but during lean periods or drought conditions, the fodder availability decreases remarkably. This periodic unavailability poses a great challenge to not only sustain milk production but also the health of the animal population, hence it is very necessary to provide abundant fodder to the cattle during lean periods as well.

Commercial dairy farming is increasing in Nepal, especially in Terai, which required more fodder to replace the higher amount of concentrate feed. A recent prediction by the MoALD showed that the national Total Digestible Nutrient (TDN) demand is 15,597,950 t (2021/22) and that will be increased by 1.54 times more compared to the demand of 2016/17 (MoALD, 2019; Singh and Singh, 2019) to meet the need of an increased number of dairy animals. In spite of these challenges and scenario, feeding management of the ruminants including productive dairy animals are not done well as most of the feeding materials are crop residues and crop stover that are poor in digestibility and low in nutrient content, especially in terms of crude protein (Singh, 2019). Thus, it is necessary to work towards developing technologies that would address the need of more green fodder (with high nutrition and digestibility), especially for winter and spring seasons (Garg and Upreti, 2019).

Whole-plant corn silage has become the predominant forage to provide fibre and energy in dairy cattle diets, and it is generally conserved worldwide through ensiling (Ferraretto, 2018). The success and efficiency of silage depend on the acidification that occurs when, in an anaerobic environment, a sufficient amount of lactic acid is produced by the population of lactic acid bacteria present in the forage at harvesting (Pahlow et. al., 2003). The degree of anaerobiosis reached in the filled silo and its maintenance over the entire conservation period is key factors in obtaining a high quality silage (Woolford, 1990 and Borreani et. al., 2007). If the air-tight sealing of the silo is not ensured, air penetrates the silage, and aerobic microorganisms multiply, thereby triggering aerobic deterioration and causing dry matter (DM) losses which, in the peripheral area of the silo, can exceed 35% (Borreani et. al., 2018).

The new oxygen barrier plastic films (OB) have shown benefits pertaining to improvements in the quality of peripheral areas in silos as a result of the increased uniformity of the whole profile of the silo during the feed-out phase (Borreani and Tabacco 2014). The main benefits are a better prevention of the growth of pathogenic and mycotoxigenic molds during conservation, a delay in their growth after the exposure of the silage to air, and a reduction in the DM losses of the overall ensiling system, compared to film made of PE alone (Wilkinson and Fenlon, 2014). On the other hand, the disposal of PE and OB films can represent a potential environmental concern, because they can only be used once, and they are non-biodegradable, difficult to recycle and are rarely disposed of correctly (Bhatti, 2010). The current disposal methods include transferring silage plastics to a solid waste station or plowing them into the ground, and it often happens that silage plastic covers are burned directly in an open fire on the farms, causing the release of toxic volatile compounds, which are dangerous for human and environmental health.

Hence, the aim of this case study was to identify the practices of silage production in plastic packaging (that is able to improve oxygen impermeability, on fermentation quality, DM losses, yeast and mold counts at opening, aerobic stability); and utilization of whole crop high corn silage diet in dairy animals.

MATERIALS AND METHODS

A case study was carried out in a corn silage production unit managed by the Annapurna Milk Producers' Cooperative Ltd., Gitanagar, Chitwan; aimed to identify the practices of silage production and utilization in dairy animals. Harvested corn is processed and stored to produce silage in plastic packaging, further distributed to meet the needs of the member of cooperatives themselves.

Data on production input and output, technological levels taking into account the parameters of milk production on the farms, productivity of the cows, and breed; as well as their prices, was gathered from a survey conducted in the surround location. Finally, technical indicators were used to define each qualitative variables constructed. The result of data analysis was examined through a focus group discussion (FGD) attended by the cooperatives management staff.

Supply Chain of Corn Silage Based feeding system

The corn silage was produced by the Feed Silage Production Unit (UPS) of the dairy cooperative. Their tasks involved three main production activities which consist of (1) corn planting, (2) harvesting and storage and (3) corn silage distribution to cooperative members. The corn is planted to produce nutritious feed forage, hence the whole part of the crop or all the edible part is harvested and processed (leaf, stalk, and ear of corn which contains grain).

RESULTS AND DISCUSSION

Producing corn silage for a commercial purpose was a new business branch for the Cooperative (AMPC). It is a result of the searching and learning process by doing business to find out the best scheme in the development of a forage production system. Interest in the feeding of corn silage for lactating cows increased, many studies showed that processing whole-plant corn silage improves total tract-starch digestion and milk production by dairy cows (Bal et.al., 2000). Recently many dairy farmers using corn silage for their cattle feed, some have tried to make silage, however, it was only for trial and discontinues. The high price of raw materials and the unavailability of storage facilities caused farmers to return to traditional practices, except those who have a large number of dairy cows. The purpose of this paper is to review supplementation strategies for high corn silage diets.

Crop suitable for silage making

Quality silage can be prepared from cereal green fodder i.e., Maize, Hybrid Napier, Oat, etc. Cereal green fodder is preferred as these are rich in soluble carbohydrates and hence are more suitable for fodder ensiling. Sugar is utilized in fermentation process to make lactic acid by microorganism. Lactic acid act as preservative also helps in improving digestion of fodder and proper utilization by ruminants. Silage based on maize crop is mostly used in the study site as it is very nutritious with 8-9% crude protein.

Fibrous carbohydrate

Fiber is required in dairy cattle diets to maintain normal chewing activity, rumen function, and milk fat test. Diets are formulated to meet or exceed minimum allowances for chemical fiber. The physical form of fiber influences its effectiveness and should also be considered in diet formulation.

Chemical fiber

Feed analysis and diet formulation for fiber involve neutral detergent fiber (NDF; hemicellulose, cellulose, and lignin) and acid detergent fiber (ADF; cellulose and lignin). These measures of fiber vary widely in corn silage making routine and accurate analysis critical for formulation of high corn silage diets. Recommended minimum allowances for NDF and ADF are 27%-30% and 18%-21% (DM basis), respectively.

Effective fiber

The minimum recommended dietary NDF from forage allowance for high corn silage diets is about 20% (DM basis). Many studies observed increased DM intake and milk yield in response to feeding high corn silage diets containing 19%-21% NDF from forage compared to 24% NDF from forage. An exception to the 20% minimum NDF from forage guideline is with diets containing brown midrib corn silage where because of its increased NDF digestibility a minimum dietary NDF from forage allowance of 23%-24% may be more appropriate. This is especially important for early lactation cows, and may necessitate feeding 25%-30% of the forage DM as long or coarsely processed hay.

Non-fiber carbohydrate (NFC)

Percent NFC usually is calculated by subtracting %NDF+%CP+%Fat+%Ash from 100%. NFC contains starch primarily, but also sugars, pectin, and organic acids. The concentrations of starch and organic acids in corn silage are highly variable normally ranging from 20%-30% and 5%-10% (DM basis), respectively. Sugar concentrations usually are low (2%-3% of DM) in well-fermented corn silage. There is negligible pectin in corn silage.

Recommended dietary allowances for NFC and starch are 35%-40% and 25%-30% (DM basis), respectively. Ruminal starch degradability should be evaluated and in cases where it is low (i.e. coarse-processed dry corn or unprocessed dry corn silage) diet formulation should be to the high end of these ranges. On the other hand, in cases where ruminal starch degradability is high (i.e. immature, wet corn silage or fine- processed high-moisture corn) diet formulation should be to the low end of these ranges. Feeding corn silage with a high grain (starch) content in high corn silage diets usually necessitates the use of high-fiber

byproducts in the concentrate so that the upper limits on dietary NFC and starch are not exceeded. Soy hulls, beet pulp, and citrus pulp are good corn substitutes in high corn silage diets to limit dietary starch concentration. When high-fiber byproducts replace forage and low NDF from forage diets are fed, dietary NFC should not exceed 35% (DM basis).

Fat

Rations for high producing cows usually are formulated to 5%-7% total fat (DM basis). The basal ration without supplemental fat usually contains 3% fat (DM basis). Supplemental fat usually is provided from a combination of oilseeds, animal fat, and(or) rumen-inert fat. With high corn silage diets, high dietary fat concentrations especially from supplementation of non rumen-inert sources may cause milk fat test depression through effects on trans fatty acids. Milk fat test should be monitored closely with changes made in dietary fat concentrations and (or) supplemental fat sources when necessary.

Protein

Diets for dairy cattle are formulated for crude protein (CP), degraded intake protein (DIP), and undegraded intake protein (UIP). Sufficient dietary DIP is needed to support the nitrogen requirements of ruminal microbes for high ruminal digestion of carbohydrates to volatile fatty acids (VFA) and for high ruminal microbial protein production. Sufficient dietary UIP is needed to supplement ruminal microbial protein output for meeting the amino acid requirements of high producing cows. Dietary CP guidelines for early to mid-lactation dairy cows are 16.5%-18.0% (DM basis).

DIP

Degraded intake protein (DIP) should comprise 60%-65% of dietary CP. With high corn silage diets, these guidelines may necessitate the use of urea (50-100 grams) or raw soybeans (1.0-1.5 kg).

UIP and Amino Acids

Dietary UIP should be formulated for 35%-40% of CP or about 6.5% of DM. Close attention should be paid to the amino acid profile of UIP supplements. Corn by- products, corn gluten meal, distillers dried grains, and brewers' grains, should not be emphasized in the formulation of protein supplements for high corn silage diets because of their low lysine content. Heat-processed soybeans, heat-processed soybean meal, fish meal, blood meal, and meat meal are better UIP sources in protein supplements for high corn silage diets. Among these UIP sources, quality control and cost are important considerations.

Macro-Minerals

Corn silage is inherently low in its concentrations of calcium, magnesium, potassium, and sulfur. The recommended dietary calcium allowance is 0.80%-1.0% (DM basis) with calcium carbonate as the primary calcium supplement. The recommended dietary magnesium allowance is 0.30%-0.35% (DM basis) with magnesium oxide as the primary magnesium supplement. Dynamite (11% Mg - 18% K - 22% S) is a source of magnesium, potassium, and sulfur making it a popular ingredient in high corn silage diets. Other commonly used sources of potassium and sulfur are potassium chloride and potassium carbonate and calcium sulfate (gypsum), respectively. Recommended dietary allowances for potassium and sulfur are 1.0%- 1.2% and 0.20%-0.25% (DM basis), respectively. In heat stress situations like Chitwan district, the recommended dietary allowance for potassium increases to 1.2%-1.5% (DM basis). Salt should be supplemented at the rate of 0.50% of lactation TMR DM. Use of sodium bicarbonate as a buffer may necessitate the use of potassium chloride rather than sodium chloride to balance dietary sodium, potassium, and chloride concentrations. The recommended dietary allowance for phosphorus is 0.40% (DM basis).

Buffers

With high corn silage diets, sodium bicarbonate is recommended at the rate of 1% of lactation TMR DM to buffer acidity in the corn silage and acid production in the rumen. A mixture of sodium bicarbonate and magnesium oxide (3:1 ratio) elicits a better response than either fed alone. Potassium carbonate can substitute for sodium bicarbonate as a ruminal buffer in the lactation TMR, and also supplements needed potassium in high corn silage diets. Calcium carbonate works as a post- ruminal buffer to improve starch digestion and supplements needed calcium in high corn silage diets. Free-choice sodium bicarbonate may benefit early lactation or high producing cows and cows under heat stress, but may need to be mixed with salt (3:1 ratio of sodium bicarbonate to NaCl) to limit its intake and should not replace what is provided in the TMR. Sodium or potassium buffers should not be fed to dry cows, because of effects of elevated dietary-cation difference on hypocalcemia.

Feed additives

Yeast products have been shown to increase DM intake and lactation performance when fed in high corn silage diets, particularly when supplemented during the transition period through the first trimester of lactation. There are a number of commercially-available propionic-acid based products that reduce the growth of yeast and molds when added to the TMR and thereby may improve

bunk stability. These products often contain some acetic acid or benzoic acid to make them more effective against yeast. Since these are buffered-acid products, corrosion of TMR mixer is not a concern. These products are usually added at the rate of 1 to 2 kg per ton of as-fed TMR. Bunk stability can be an issue with high corn silage diets, especially during hot, humid feeding conditions. There are a number of fine-ground bentonite products that are marketed as mycotoxin binding agents. It appears that they are most effective against aflatoxin—their effectiveness against Fusarium mycotoxins (DON, T2-toxin, Zaeralenone) is not well established. These bentonite products are normally fed at the rate of 150 grams per cow per day with mycotoxin suspicious or contaminated feeds.

Bunk management

With high corn silage diets, sorting in the feed bunk should be monitored closely. This can be evaluated by using the Penn State-Nasco shaker box on TMR samples collected just after mixing/feeding, 12 hours post feeding, and when the refusal is pushed away the next day. The degree of variation in percentages of as fed mix on the three screens with time post mixing/feeding provides an indication of the degree of sorting. In situations of excessive sorting in the feed bunk, the following practices should be considered: feeding smaller amounts of TMR more frequently, pushing TMR up more frequently, finer or more uniform processing of coarse particles, addition of water to dry TMR, and(or) addition of a liquid-molasses product to TMR to tie up the fines. It is recommended that corn silage be limited to less than 50% of forage DM in the TMR for transition cows. In situations where corn silage is fed separately from other forages, limit its overall feeding rate and manage the feed bunk to prevent slug feeding.

Ensiling procedure

The silage production unit was established by the leading dairy cooperative (AMPC) at Gitanagar, Chitwan with the support from province government Ministry of Agriculture and Livestock Development towards the aim of assuring availability of nutritious green fodder source in the fodder scarcity season ultimately increasing productivity from dairy animals. In the study site, corn hybrid whole plant was harvested at around the 75% milk-line stage and with a theoretical DM content of 400 g DM/kg of fresh forage. The forage was chopped by using a self propelled forage harvester, to a theoretical 10-mm length of cut, and ensiled and packaged within 2 hours in an air tight sealing with white polyethylene plastic films. The harvested whole-plant high corn crop was processed to produce packaged silage, further distributed to meet the needs of the member of the cooperative. The project used hybrid corn that could be

planted and harvested twice in a year and yields corn silage on average 1700 ton/ year as per current data.

Anaerobiosis is critical for successful ensilage, and it can be difficult to achieve adequate anaerobic conditions in farm silos. Corn silage is particularly susceptible to aerobic deterioration when it is exposed to oxygen. If airtight sealing of the silo is not achieved, air penetrates the silage and aerobic microorganisms multiply, resulting in aerobic deterioration. Polyethylene films have been used since the 1950s to seal silos and drive-over piles because of their suitable mechanical characteristics and low costs. Because the oxygen impermeability of the plastic films used to seal silage has a great effect on reducing the top spoilage losses, it is crucial to optimize the mechanical characteristics and the level of oxygen impermeability of the plastic films.

Land holding and its utilization pattern

Land holding in the study site was broadly divided into two categories namely; irrigated and un-irrigated. The proportion of irrigated land was highest (73.71%) in the medium sized farm category followed by small (58.87%) category. But in case of un-irrigated land, the proportion was highest (41.13%) in small category followed by medium (26.29%) category (Figure 1).

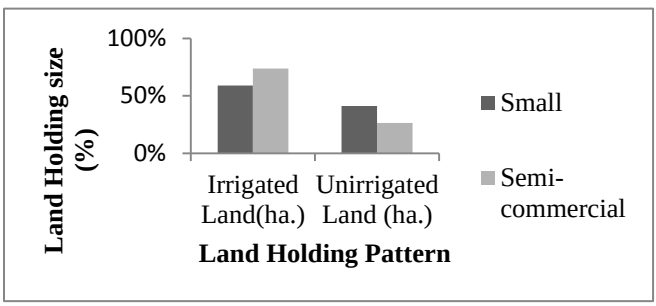

Figure 1. Land holding and its pattern by farm category

Livestock production system

Livestock in the study sites were integrated into this system primarily as a means of income generation through the sale of milk. Cross-bred Holstein Friesian and Jersey cows, were the main livestock species kept by households for the purpose of milk production. Approximately 75-80% of households in the area own minimum of 2-3 cross-bred milking cows. Twenty percent of households kept 1-2 buffalo, predominately Murrah buffalo for milking. When the milk production capabilities of the buffalo cows begin to decline, they were

sold for slaughter after a short period of fattening. Goats and poultry were also kept by most households for household consumption. About 80% of all households raised at least 3 goats and 50% of households had at least 10 poultry birds (chickens and/or ducks). Only 10% and 3 % households kept sheep and pigs respectively (Figure 2). The study indicated that large ruminants were major source of income in the study site.

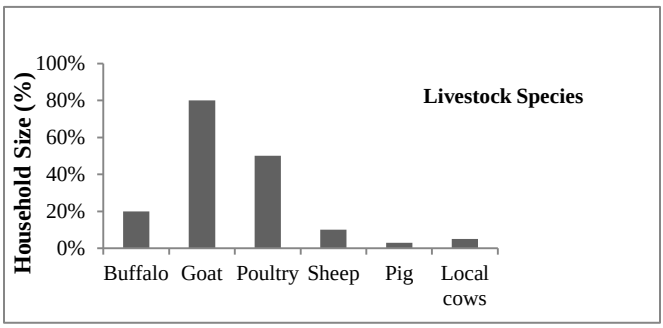

Figure 2. Livestock distribution by household size

Overview of the feeds and fodder production system

The study area experienced 3 seasons; Barkhe (rainy) which usually occurs from July to October, Hiunde (winter) which occurs from November to March and Chaite (Spring) which occurs from April to July. The main rainfall usually occured from the early May to mid August. Irrigation was available to over 80% of all households in the area. A wide variety of crops were grown throughout the seasons. The main crops grown by households are shown in Figure 3. During Rainy and Spring, rice (*Oryza sativa*) and maize (*Zea mays*) were grown. During winter; wheat (*Trictium aestivum*), oil crops such as Mustard *(Brassica rapa*), and vegetables such as Lentils (*Lens culinaris*) and potatoes (*Solanum tuberosum*) were grown. A range of fodder crops such as Napier grass (*Pennisetum purpureum*) and fodder oats (*Avena sativa*) were also grown.

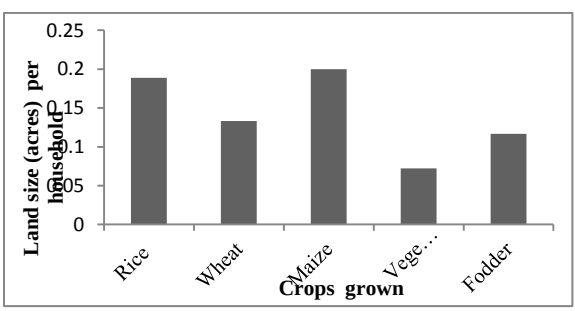

Figure 3. The average area of land per household

Feed availability throughout the year

Green fodder is the main component of the diet comprising approximately 4784kg (46%) of the diet as shown in Figure 4. Crop residue, mainly rice straw, is also a key component in the diet of dairy animals in this area. On average each household produces approximately 832kg (8%) of rice straw, 312 kg (3%) of wheat straw and 416kg (4%) of maize stover for livestock feeding. Additional rice straw is purchased during October and November (directly after the main rice harvest) and stored until required. On average, each household in the area purchases approximately 2600kg (25%) of rice straw annually. Purchased concentrate feeds (1456 kg) compose 14% of the diet (as fed). Wheat bran, rice bran and a commercially formulated mixed ration are the main concentrate feeds purchased. There is no price differential between the commercially formulated mixed ration and wheat bran.

Feeding and Management

Dairy cattle feeding are affected by season, cropping pattern, availability of labor for feed collection, availability of grazing land, animal numbers, and breeds of cattle and physiological stages of the animals. The diet of dairy animals in this area was composed of a number of key elements. Rice straw was the main component of the diet. Green fodder was also a key element but during the winter season, green fodder was a minor component of the diet. During winter and early dry summer, animals had to heavily depend on crop residues. Green maize was the primary contributor to green fodder material fed to dairy animals. Most households were involved in the cropping of maize for the sole purpose of feeding. Other green fodder materials were also obtained and often include; Napier grass (*Pennisetum purpureum*), Berseem (*Trifolium alexandrinum*), Oat (*Avena sativa*), and naturally occurring grasses. Concentrate feeds were also a key feature of this diet throughout the year, and particularly in winter. The main concentrate feeds purchased by farmers in the area were wheat bran, rice bran, a locally available commercially mixed ration and rice polish.

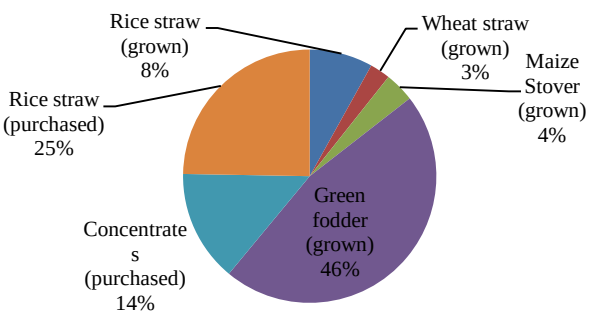

Figure 4. Dietary overview of the dairy animals in the study site

Complete stall-feeding management system with cut and carry systems were prevalent in the study sites. Dairy animals in this area were housed in a separate shed alongside the owner's house. Most of the shed were scientifically constructed and specialized housing system was common in most of the dairy farms. The keen interest of the Co-operative in the production and utilization of silage to dairy animals with capital infusions, the acceptance of packed silage among dairy farmers and the readiness of farmers to take up fodder crops as a remunerative production option plus the province governments supporting the process with subsidies for machineries are all setting into motion a cycle of hope which in the future would grow into a great revolution.

Dairy animal health status

The survey result revealed that the most prevailing disease in the study site were mastitis (63.16%) followed by infertility (13.16%), milk fever (10.53%), helminths (7.89%) and others (abortion, poisoning, diarrhea, viral like lumpy skin disease etc.) (5.26%) (Figure 5).

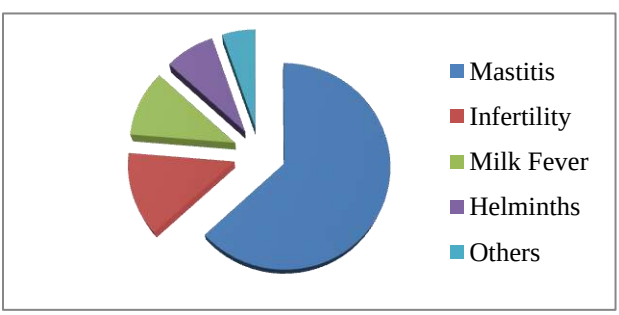

Figure 5. Health situation in the study site

Milk yield and lactation period

The result showed that per day milk production of cattle and buffalo was highest in medium farm category followed by small farm category whereas that of buffalo was vice-versa, whereas the lactation period of cattle was highest (9.73) in semi-commercial category followed by small (9) and that of buffalo was highest (8.65) in small category followed by medium (8.46) (Table 5).

Table 5. Daily milk yield and lactation period of animals by farm categories

Farm category	Milk Yield (liter per day)		Lactation Period (Months)	
	Cattle	Buffalo	Cattle	Buffalo
Small	7.27	4.13	9	8.65
Semi-commercial	8.97	3.41	9.73	8.46
Total	7.74	4.28	9.46	8.37

CONCLUSION

The availability of cropland was an essential resource for a dairy cooperative in developing a sustainable feeding system. But due to the unavailability of green grasses and due to the shortage of feed resources throughout the year, the dairy animals were dependent upon locally available feed resources and on crop residue, mainly rice straw. These feedstuffs were not adequately balanced in nutrient which might cause lower production and increasing feeding costs. Mastitis, milk fever, infertility which is the major diseases of dairy animals were most prevalent that could be due to the poor veterinary services. The differences in milk production might be due to the better care and management in semi-commercial dairy model. It is the strategic policy for a dairy cooperative develops long term cooperation with members for land utilization in growing different types of crops and fodder assuring all year availability of quality silage for better productivity; and minimizing feed costs for sustainability. Selling price, cropland productivity, and cost of silage distribution were the key factors that might financially cause a sensitive effect on the project feasibility. Dairy business is one of the potential agri-business in Chitwan district, with an establishment of dairy processing plant, the business has been declared as commercial farming in the district. Further, it could create employment and income generation for the rural households.

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REFERENCES

Bal, M.A., Shaver, R.D.; Jirovec, A.G., Shinners, K.J. and Coors, J.G. (2000) Crop Processing and Chop Length of Corn Silage; Effects of Intake, Digestion, and Milk Production by Dairy Cows. *J Dairy Sci*, 83:1264-1273

Bhatti, J.A. (2010) *Current State and Potential for Increasing Plastics Recycling in the U.S.* Master's Thesis, Columbia University, Sponsored by Earth Engineering Center, New York City, NY, USA

Borreani, G. and Tabacco, E. (2014) Improving corn silage quality in the top layer of farm bunker silos through the use of a next-generation barrier film with high impermeability to oxygen. *J. Dairy Sci.*, 97, 2415–2426. [CrossRef]

Borreani, G., Tabacco, E. and Cavallarin, L. (2007) A new oxygen barrier film reduces aerobic deterioration in farm-scale corn silage. *J. Dairy Sci*., 90, 4701–4706. [CrossRef] [PubMed]

Borreani, G., Tabacco, E., Schmidt, R.J., Holmes, B.J. and Muck, R.E. (2018) Silage review: Factors affecting dry matter and quality losses in silages. *J. Dairy Sci*. 2018, 101, 3952–3979. [CrossRef]

Economic Survey (2018/19) https://www.mof.gov.np/uploads/document/file/compiled%20economic%20Survey%20english%207-25_20191111101758.pdf. Ministry of Finance; Nepal Government. Singhadurbar; Kathmandu

Ferraretto, L., Shaver, R. and Luck, B. (2018) Silage review: Recent advances and future technologies for whole-plant and fractionated corn silage harvesting. *J. Dairy Sci*., 101, 3937–3951. [CrossRef] [PubMed]

Hayashi, Y., Devkota, N.R. and Kumagai, H. (2007). Effects of field pea (Pisum sativum L.) hay feeding on DM intake and milk production of Murrah buffaloes (Bubalus bubalis) fed rice straw ad libitum. Animal Science Journal 78, 151–158.

NAFLQML (2019). Balance Sheet of Animal Feed and Forage Seed of Nepal and Impact Study of Forage Mission Program. *http://naflqml.gov.np/downloadfiles/Report_Feed-balance-study_1619598795-1629451338.pdf* Hariharbhawan, Lalitpur, Nepal

Pahlow, G., Muck, R.E., Driehuis, F., Oude Elferink, S.J.W.H. and Spoelstra, S.F. (2003) Microbiology of ensiling, In: *Silage Science and Technology (Agronomy Series No. 42);* Buxton, D.R., Muck, R.E., Harrison, H.J., Eds.; American Society of Agronomy: Madison, WI, USA; pp. 31–93

Paudel, P. and Matsuoka, A. (2008) Factors Influencing Adoption of Improved Maize Varieties in Nepal: A Case Study of Chitwan District Archived 31 October 2012 at the Wayback Machine. *Australian Journal of Basic and Applied Sciences* 2(4): 823–834

Rajbhandary, H.B. and Sah, S.G. (1981) *Trends Projection of Livestock Production the Hills of Nepal*. Seminar on Nepali experience in Hill Agriculture Development HMG/Nepal

Sapkota, D., and Pokhrel, S. (2010) Community-based maize seed production in the hills and mountains of Nepal: A review. *Agronomy Journal of Nepal*, 1, 107

Wilkinson, J.M. and Fenlon, J. S. (2014) A meta-analysis comparing standard polyethylene and oxygen barrier film in terms of losses during storage and aerobic stability of silage. *Grass Forage Sci*., 69, 385–392. [CrossRef]

Woolford, M.K. (1990) The detrimental effect of air on silage. *J. Appl. Bacteriol*. 1990, 68, 101–116. [CrossRef] [PubMed]

Livestock Diseases and their Distribution Patern in Bagmati Province, Nepal

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ABSTRACT

Nation wise, several bacterial, viral, and parasitic illnesses in livestock result in significant financial loss. Numerous animal illnesses, infections, and infestations have been identified by the World Organization for Animal Health (OIE) as being serious and notifiable diseases worldwide. In both rural and urban parts of Nepal, there was an elevated incidence and distribution of diseases that must be reported to the OIE, endangering the welfare of livestock and generating tremendous financial loss for the livestock industry.The study aimed to assess the prevalence and distribution of endemic animal diseases in Bagmati Province by analyzing past data reported to formal government authorities in the region.

For this purpose we had visited various veterinary hospital and livestock service expert centers, ministry of agriculture and livestock service, Bagmati province and related offices to collect the data. This paper explored the limitations encountered during data collection and highlights the implications for understanding and managing endemic animal diseases in Bagmati province. Despite the limitations, the available data on LSD in Bagmati Province were analyzed to gain insights into the disease's prevalence and distribution. The data provided valuable information on reported cases, affected regions, and affected cattle populations. Descriptive analysis revealed variations in disease incidence over time and spatial differences within the province.

Key words: Lumpy Skin Disease (LSD), Epidemic, endemic diseases, Bagmati Province

INTRODUCTION

Nepal is an agricultural country where the livestock sector alone contributes around 11.5% of gross domestic product (GDP). There are about 7.3 million cattle, 5.2 million buffalos, 0.8 million sheep, 11 million goats, and 1.4 million pigs in Nepal (Poudel *et al*., 2020). Bagmati Province is the second-most populated and fifth-largest province in terms of area in Nepal. China's Tibet Autonomous Region, the Gandaki Province, Koshi Pradesh, the Madhesh Province, and the Indian state of Bihar has bordered Bagmati province to the north, west, east, and south, respectively.

Status of major livestock diseases

Worldwide, several bacterial, viral, and parasitic illnesses in livestock result in significant financial loss. Numerous animal illnesses, infections, and infestations have been identified by the World Organization for Animal Health (OIE) as being serious and notifiable diseases worldwide (OIE-Listed Diseases, Infections and Infestations, 2020). In both rural and urban parts of Nepal, there is an elevated incidence and distribution of diseases (Table 1) that must be reported to the OIE, endangering the welfare of livestock and generating tremendous financial loss for the livestock industry (VEC, 2018). The Veterinary Epidemiology Center (VEC) of Nepal noted larger outbreaks of Foot and Mouth Disease (FMD), black quarter (BQ), hemorrhagic septicemia (HS), actinomycosis, babesiosis, and theileriosis during the year 2018 (Table 1), along with sporadic outbreaks of diseases like anthrax, brucellosis, and tuberculosis (data not shown) (VEC, 2018).

Table 1. Status of the world organization of animal health (OIE)-listed major disease outbreaks of livestock in the year 2018 (January–December)

Diseases	Species Affected	No. of Outbreaks	Number of Animals		
			Susceptible	Affected	Dead
Foot and Mouth Disease	Cattle and Buffalo	271	150,669	18,556	311
Black Quarter (BQ)	Cattle and Buffalo	58	41,275	968	42
Hemorrhagic Septicemia (HS)	Cattle and Buffalo	57	6182	2864	92
Actinomycosis/ Lumpy Jaw	Cattle and Buffalo	52	122	493	12
Babesiosis	Cattle and Buffalo	28	503	148	11
Theileriosis	Cattle and Buffalo	23	65	255	0
Peste des Petits Ruminants (PPR)	Sheep and Goat	75	232,096	3305	1139
Enterotoxaemia	Sheep and Goat	46	600	1065	25
Classical swine fever	Swine	6	1783	142	39

Source: Veterinary Epidemiology Center, Department of Livestock Services; Hariharbhawan: Lalitpur, Nepal, 2018

According to the Disease profile of Livestock Statistics of Nepal 2077/78, Disease Profile (CVL, VLs) fiscal years are listed in table 2.

Introduction of some Major Livestock Diseases

Foot and Mouth Disease (FMD)

All animals with cloven hooves are susceptible to FMD, which is caused by the single-stranded RNA virus, i.e., FMD virus (Genus: Aphthovirus, Family: Picornaviridae). There are seven FMD virus serotypes that are now recognized: A, O, C, SAT1, SAT2, SAT3, and Asia 1(Grubman and Baxt, 2004) Serotypes O, A, and Asia-1 of the FMD virus predominate in Nepal out of the seven known serotypes. The most common serotypes are O, A, and Asia-1. (Brito et al., 2017) Serotype C however was present in Nepal in ancient time (Ferris et al., 1992), but it has not been detected since 1996 (Jha, 2012; Adhikari et al., 2018). There is no particular course of treatment. Symptomatic therapy is administered in accordance with the clinical signs. Applying antiseptic solutions, potassium permanganate, and glycerine to oral lesions is possible. In cases where a cow is seriously affected, fluid treatment is suggested. Meloxicam-paracetamol combination, 0.5 mg/kg body wt., I/M, can be used to treat pyrexia (Kandel et al., 2018).

Table 2. Disease Profile (CVL, VLs)

S.N	Species	Disease	Fiscal Year BS			
			2074/75	2075/76	2076/77	2077/78
1	Cattle / Buffalo	FMD	89	83	52	-
2	Cattle / Buffalo	Mastitis	1057	1269	1140	228
3	Cattle / Buffalo	Babesiosis	115	193	225	307
4	Cattle / Buffalo	Anaplasmosis	51	24	60	61

5	Cattle / Buffalo	Anthrax	-	2	3	-
6	Cattle / Buffalo	Rabies	43	11	6	8
7	Cattle / Buffalo	Trypanosomiasis	140	401	135	107
8	Cattle / Buffalo	Hemorrhagic Septicemia	14	43	49	-
9	Cattle / Buffalo	Theileriosis	45	84	91	83
10	Cattle / Buffalo	LSD	-	-	-	191
11	Sheep / Goat	PPR	143	153	176	139
12	Sheep / Goat	Rabies	3	5	7	4
13	Sheep / Goat	Toxoplasmosis	-	156	22	2
14	Pig	Classical Swine Fever	10	25	13	4
15	Pig	Anthrax	2	1	3	-
16	Pig	Rabies	-	-	1	2
17	Pig	PPRS	0	0	0	19

(Source: Livestock Statistics of Nepal, 2077/78)

In Nepal, the biggest percentage of FMD outbreaks among different species occurred in cattle (42%), followed by buffaloes (32%), goats (19%), sheep (4%), and pigs (3%) (Jha, 2016). FMD is endemic in Nepal causing substantial economic losses to livestock sector (Adhikari et al., 2018) Nepal as being a member of the World Trade Organization (WTO) where the endemic presence of FMD in the country constitutes a barrier to international trade of livestock and animal products (Thakuri, 2012).

Peste Des Petits Ruminants (PPR)

PPR is a trans-boundary viral disease of sheep and goats that is notifiable, economically significant, and linked with substantial morbidity and death, according to the World Organization for Animal Health. (Venkataramanan R *et.al*, 2005) The Peste des Petits Ruminants virus (PPRV) mostly affects small ruminants, such sheep and goats, and causes a significant viral illness of livestock. It belongs to the family Paramyxoviridae, subfamily Paramyxovirinae, and genus Morbillivirus in the order Mononegavirales (Barrett *et al.*, 1993).

Available research indicates that **Nepal** is PPR epidemic country. In 1994, Nepal released its first PPR report. (Pandey SK *et al*., 2019) In Nepal, the disease has spread to 71 districts of the country out of 77 districts (Veterinary Epidemiology Section, 2018).

Lumpy Skin Disease (LSD)

A trans-boundary viral illness that affects cattle and buffaloes, lumpy skin disease (LSD), has a considerable negative economic impact on the livestock sector, including financial losses (Davies, 1991). It is a resurgent, non-zoonotic disease caused by a single strain of capripoxvirus from the Poxviridae family.

Except for dogs, the majority of domestic animals can contract sickness from the biggest virus family, Poxviridae (Mulatu & Feyisa, 2018). The younger animals are found to be more susceptible to the virus (Tageldin et al., 2014). The OIE has identified the disease because of its possibility for rapid trans-boundary transmission. (Tuppurainen et al., 2018 and Swiswa et al., 2017) In Asia, Europe, and the Middle East currently, the disease has become a deadly concern for large domesticated ruminants (Calistri et al., 2020). Although there are no particular antiviral medications available, affected animals can get supportive care, such as the treatment of skin lesions, antibiotics to prevent subsequent skin infections and pneumonia, and some anti-inflammatory medications (Babiuk, 2018; Thomas, 2002; Vinothraj et al., 2020). In Nepal, Morang district (a district close to Indian border) was the first to report Lumpy Skin Disease (LSD) in 2020 June, which was afterwards found in numerous other locations. The OIE-WAHIS report from 2021 states that LSD was seen in the Morang district in June 2020, in Chitwan, Rautahat, Makawanpur, Kaski, Tanahu, Kathmandu, and Kavrepalanchowk in July 2020, and in the Kailali district in August 2021(OIE-WAHIS, 2021).

The study conducted by (Bhusal et al., 2020), Lumpy Skin Disease outbreak were reported in six provinces of Nepal. He reported a higher prevalence in the Bagmati province. The study reported that the overall prevalence was 17.31% and the mortality rate was 2.2%. He suggested that the early disease detection, appropriate treatment and effective control measures is required to prevent the spread of LSD throughout the country.

MATERIALS AND METHODS

The study was carried out in Bagmati province of Nepal. Directorate of Livestock and Fishery Development (DOLFD), Veterinary Hospital and Livestock Service Expert Center (VHLEC) located in Bagmati province, Hetauda were the main sites visited during the study period. Available data of the past 6 months or above about animal diseases in Bagmati province were collected and further study was done by personal interviews with technical personnel related to animal health.

Secondary data were collected from DOLFD and VHLEC or by reviewing various published Literature, Articles and Documents and other available materials in the internet related to the topic of the study.

The collected information was compiled systematically and chronologically. The data was analyzed by using Microsoft excel. The results were presented in the form of table; graph, bar diagram, pie chart etc.

RESULTS AND DISCUSSION

This study sheds light on analyzing available data on Lumpy Skin Disease (LSD) and the challenges faced in reporting system in Bagmati Province. Despite these challenges, the analysis of the available data provided valuable insights into LSD's prevalence and distribution. Addressing the identified challenges through improved reporting protocols, enhanced awareness and training, and strengthened coordination mechanisms will contribute to more effective disease control and management strategies in Bagmati Province.

Analyzing the information, figure 2, it is evident that the Bagmati province is facing a challenge of LSD infections. Among the districts mentioned, Chitwan and Makwanpur stand out with significantly higher numbers of infected animals, indicating a potential hotspot for the spread of infections. Chitwan reported a staggering 3,873 infected cattle and 252 infected buffalo, while Makwanpur has 7,275 infected cattle and 16 infected buffalo.

Other districts also exhibit varying degrees of infection. Dhadhing, with 782 infected cattle and 151 infected buffalo, seems to be experiencing a significant impact as well. On the other hand, some districts have relatively lower numbers of infected animals, such as Bhaktapur and Rasuwa, with only one infected animal each.

The data raises concerns about the health and well-being of the affected animals, as well as the potential economic implications for the region, especially if the infections spread further. It suggests the need for concerted efforts in disease control, prevention, and veterinary care to mitigate the spread of infections and protect the livestock population.

Further analysis, such as identifying the causes of the infections and assessing the effectiveness of existing control measures, could provide valuable insights for devising targeted strategies to address the issue. Additionally, raising awareness among livestock owners and implementing measures to improve animal health practices may help prevent the further spread of infections and ensure the overall welfare of the animals in the region.

Figure 3 shows the number of dead animals due to LSD in various districts. It is apparent that the region is facing the challenge of LSD outbreaks, resulting in the unfortunate death of animals.

Among the districts listed, Chitwan and Makwanpur had higher numbers of dead animals due to LSD. Chitwan reports 112 dead cattle, while Makwanpur records 274 dead animals.

Other districts also report cases of LSD-related deaths, although with comparatively lower numbers. Lalitpur has the next highest number of dead animals, with 13 reported cases. Nuwakot follows with 17 deaths, and Sindhuli and Dhadhing report 9 and 10 dead animals, respectively.

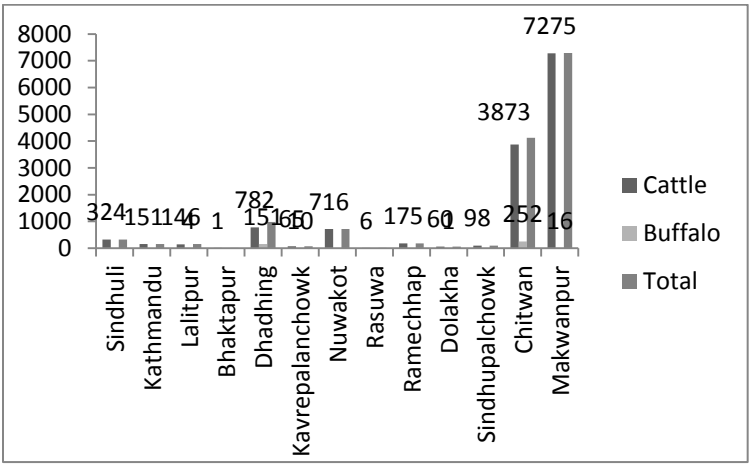

Figure 2. Status of LSD infected in Bagmati province in 2080/81
(Source: Livestock development division, MoALD Bagmati Province)

Some districts, such as Bhaktapur, Rasuwa, Dolakha, and Kathmandu, do not report any deaths due to LSD according to the table. However, it is important to note that even a lack of reported deaths does not necessarily indicate an absence of the disease, as it could be due to underreporting or other factors.

The total number of dead animals across all districts in the table is 444, highlighting the severity of the situation. These figures emphasize the need for urgent measures to control the spread of LSD, prevent further deaths, and protect the livestock population.

Efforts should be directed towards implementing effective vaccination programs, raising awareness among livestock owners about the disease and its prevention, and ensuring prompt veterinary care for infected animals. Collaboration between authorities, veterinary professionals, and the local community is crucial to address the LSD outbreaks and mitigate their impact on the region's livestock industry and economy.

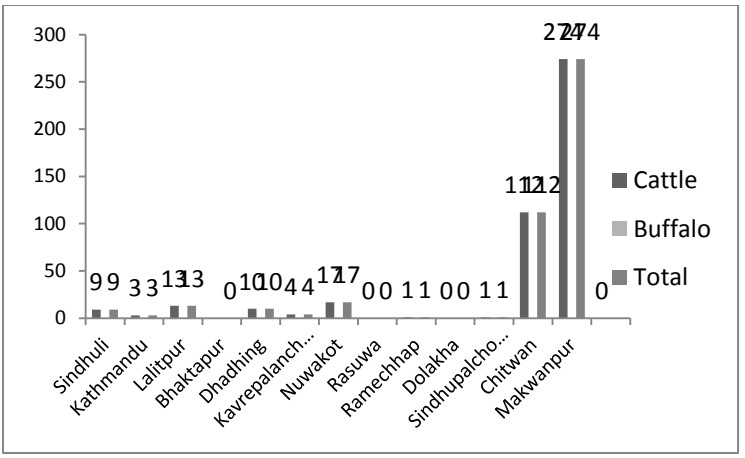

Figure 3. Death of livestock due to LSD Bagmati province during 2080/81

(Source: Livestock development division, MoALD Bagmati Province)

Suspected skin scrapings and nodular lesions examine for LSDV at the Central Veterinary Laboratory using the polymerase chain reaction (PCR). The overall sero-prevalence of lumpy skin disease in Western Chitwan was 53.2% (57/107) (Pandey *et al*, 2021). This research shows there was signification spread of disease among the region but there was lacking of reporting in national data base.

The implementation of a federal system in Nepal has brought about several changes in governance and administration. However, one critical issue that has emerged is the inadequate reporting of animal diseases to relevant government authorities. This deficiency in animal disease reporting has resulted in a significant deficit in animal health management and planning across the country. In this study, we had faced challenges to collect current data of many endemic animal diseases which were used to publish formally before implementation of federal system.

Fragmented Reporting Structure with the introduction of a federal system, the responsibility for animal health management has been divided among multiple tiers of government, including the federal, provincial, and local levels. This fragmentation has led to confusion and lack of coordination in reporting animal diseases, making it challenging to track and manage outbreaks effectively.

CONCLUSION

In conclusion, the study focused on the prevalence of Lumpy Skin Disease (LSD) in Bagmati Province and shed light on the challenges within the animal

disease reporting system. The analysis of available data on LSD highlighted the significance of the disease in the region, emphasizing the need for effective control and management strategies. However, it is important to note that the absence of data on other animal diseases in Bagmati Province indicates a broader problem within the animal disease reporting system.

The lack of data on diseases other than LSD underscores the challenges and limitations faced in accurately assessing and addressing the overall animal health situation in the province. The problems within the reporting system have hindered the collection, analysis, and dissemination of comprehensive disease data, resulting in an incomplete understanding of the disease landscape and impeding evidence-based decision-making.

The findings of this study call for urgent attention to rectify the reporting system's deficiencies in Bagmati Province. It is crucial to establish standardized protocols, enhance coordination among government authorities and stakeholders, and improve communication channels to ensure timely and accurate reporting of all animal diseases. Efforts should also be made to raise awareness among livestock owners and veterinary professionals about the importance of disease reporting, and training programs should be implemented to enhance their reporting skills.

Addressing the reporting system's challenges will enable a more comprehensive understanding of the animal health situation in Bagmati Province, allowing for the implementation of targeted interventions and improved disease control measures. By strengthening the reporting system and promoting transparency, Bagmati Province can enhance its ability to effectively monitor, manage, and prevent not only Lumpy Skin Disease but also other prevalent animal diseases, leading to improved animal health outcomes and safeguarding the livelihoods of farmers and stakeholders in the region.

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REFERENCES

Adhikari G, Acharya KP, Upadhyay M, Raut R, Kaphle K, Khanal T & Arzt J (2018). Outbreak investigations of foot and mouth disease virus in Nepal between 2010 and 2015 in the context of historical serotype occurrence.*Veterinary medicine and science*

Babiuk, S., (2018) Treatment of lumpy skin disease. In: *Lumpy skin disease 8*1. Springer International Publishing

Barrett, T., Romero, C. H., Baron, M. D., Yamanouchi, K., Diallo, A., Bostock, C. J. & Black, D**. (**1993**).** The molecular-biology of rinderpest and peste-des-petits ruminants. *Ann Med Vet* 137

Bhusal, D. P., Joshi, H. D., Jha, P. K., & Singh, B. K. (2020). Lumpy skin disease outbreak in Nepal: epidemiological and clinical aspects, *Veterinary World*, 13(11)

Brito BP, Rodriguez LL, Hammond JM, Pinto J & Perez AM (2017) *Review of the global distribution of foot-and-mouth disease virus from 2007 to 2014*.Transboundary and emerging diseases

Calistri P, De Clercq K, Gubbins S, Klement E, Stegeman A, Cortiñas Abrahantes J, et al. (2020) Lumpy skin disease epidemiological report IV: data collection and analysis. *EFSA Journal*. 2020

Davies, F.G. (1991) Lumpy skin disease, an African capripox virus disease of cattle, *Br. Vet. J.* 1991

Ferris NP, Donaldson AI, Shrestha RM, & Kitching RP (1992). *A review of foot and mouth disease in Nepal.* Revue Scientifique ET Technique-Office International Des Epizooties

Grubman MJ & Baxt B (2004) Foot-and-mouth disease.*Clinical microbiology reviews*

Jha, VC (2012). Situation of foot and mouth disease and its progressive control initiatives in Nepal Retrieved Sep, from: http://www.fao.org/docs/eims/upload/299831/an359e00.

Kandel, M, Regmi S, Thakur B, Acharya R & Kaphle K (2018) Foot-and-Mouth Disease Outbreak at Bageshwori Gaushala, Chitwan, *Nepalese.Journal of Agricultural Science and Technology*,

MoALD (2020/2021) *Statistical Information in Nepalese Agriculture*, Ministry of Agriculture and Livestock Development, Kathmandu Nepal

Mulatu E, Feyisa A (2018) Review: Lumpy Skin Disease. J. Vet. Sci. Technol.

OIE-Listed Diseases (2020). Infections and Infestations in Force in 2020. Available online: https://www.oie.int/animal-health-in-the-world/oie-listed-diseases/ (accessed on 21 April 2020).

OIE-WAHIS, (2021). Lumpy Skin disease follow up report. https://wahis.oie.int/#/reportinfo?reportId=37253

Poudel, U.; Dahal, U.; Upadhyaya, N.; Chaudhari, S.; Dhakal, S. Livestock and poultry production in Nepal and current status of vaccine development. *Vaccines* 2020, *8*, 322.

Tageldin, M.H., Wallace, D.B., Gerdes, G.H., Putterill, J.F., Greyling, R.R., Phosiwa, M.N., Al Busaidy, R.M., Al-Ismaaily, S.I., 2014. Lumpy skin disease of cattle: An emerging problem in the Sultanate of Oman. *Trop. Anim. Health Prod*., 46(1)

Thakuri K. (2012). *Status of animal disease outbreak and identification of provisional disease-free zone/area*. Veterinary Epidemiology Center, Directorate of Animal Health, Kathmandu, Nepal.

Tuppurainen ESM, Babiuk S, Klement E. (2018) *Lumpy skin disease*. Springer international Publishing, USA, 2018

VEC. (2018) *Annual Epidemiological Bulletin* (January–December, 2018) of Veterinary Epidemiology Center, Department of Livestock Services; Hariharbhawan: Lalitpur, Nepal, 2018; p. 38.

Venkataramanan R, Bandyopadhyay SK, Oberoi MS. (2005) Present status and strategies for the control of transboundary and other economically important animal diseases in India: a review. *Indian J Anim Sci*. 2005

Veterinary Epidemiology Section (2018). *Six-monthly Epidemiological Bulletin January-June*. Tripureshor, Kathmandu: Veterinary Epidemiology Section, Animal Disease Investigation and Control Division

Vinothraj, S., Preethi, J., Alagesan, P., Siva, M., Srinivasan, R.D., Kumar, S., and Thirumoorthi, M., (2020) A case study on lumpy skin disease and its management. *Pharma Innov.*

Presence of *E. coli* in Raw and Pasteurized Milk in Bagmati Province, Nepal

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ABSTRACT

A study was conducted on milk samples (Raw and Pasteurized) at HICAST Microbiological laboratory, Kirtipur, during April 14 to Jun 14, 2023. The study was aimed to find the occurrence of E. coli in milk samples collected from various dairy shops around Kathmandu, Bhaktapur, Lalitpur and Kavrepalanchowk. A total of 30 samples were collected (i.e Raw milk=15 and Pasteurized milk= 15) in which five (33.33%) E. coli were isolated from raw milk and one (6.67%) from pasteurized milk. Total viable count from five E. coli isolated raw milk were $36X10^9$cells/ml, $31x10^9$cells/ml, 35 $X10^9$cells/ml, $66X10^9$ cells/ml and $41x10^9$ cells/ml whereas Total Viable count from one E. coli

isolated pasteurized milk sample were found to be 28 X 10^9cells/ml. Raw milks were more contaminated with E. coli compared to pasteurized milk.
Key words: *E. coli, Raw & Pasteurized Milk*

INTRODUCTION

Milk is a complex colloidal solution (emulsion) containing fat globules, casein micelle and whey protein in aqueous solution of lactose, minerals and few other minor compounds. It is considered as an the 'ideal food' (D. Maheswara Reddy et al., 2017).Buffalo milk is known to contains 7.6% fat, 3.8% protein, 4.9% lactose, 0.78% ash and 17% total solids and Cow milk contains 4.5% fat, 3.8% protein, 4.9% lactose, 0.72% ash 13.9% total solids. This is the reason why it has been an important part of diet to all age group (Wijesihha-Bettoni and Burligame , 2013).

Naturally milk contains beneficial lactic acid bacteria such as *Streptococcus, Lactococcus, Lactobacilli, Bifidobacteria, Enterococcus, and Pediococci* that produce several secondary metabolites which are advantageous to human. In addition to these useful bacteria, milk serves as a rich source of nutrients for growth of pathogenic bacteria, which is influenced by several other factors such as temperature, pH, humidity, etc. (Hickey et al., 2015). Microbes may gain entry into raw milk directly from dairy animals, from the farm environment particularly the water source (Eberhart et al., 1977) and utensils used for the storage of milk on farm or during transportation.

Among various microorganism Coliforms, especially *E. coli* are often used as marker organisms for contamination of milk. Coliforms are Gram-negative and non-spore forming bacteria that ferment lactose with the production of acid and gas at 35 °C within 48 hours. These belong to the family Enterobacteriaceae (Corry et al., 1996; Dehghan Banadkouki et al., 2017; Hajimohammadi et al., 2017; Jasemizad et al., 2016; Zandi et al., 2017). *E. coli* is one of the main inhabitants of the intestinal tract of most mammalian species, including humans and birds. Most *E. coli* are harmless, but some are known to be pathogenic bacteria, causing severe intestinal and extra intestinal diseases in man (Kaper et al., 2004). Recovery and counting of *E. coli* is used as reliable indicator of fecal contamination and indicates a possible presence of enteropathogenic and/or toxigenic microorganisms which constitute a public health hazard. Its presence in milk directly questions the suitability of milk for drinking (Standard Method Committee, 1981).

Assurance of the quality of dairy products begins at the farm and ends in the hands of the consumers (Murphy et al., 2000). In developing countries, most of the milk is produced by mall holder farmers dominated by local herds of cattle (Pandey and Voskuil, 2011). Their milking units are widely distributed throughout in rural areas with a poor infrastructure, while most of the markets and customers are in urban areas. Therefore, the need for good hygienic practices and a streamlined collection, handling and transport system is important but has been always a challenge (Pandey and Voskuil, 2011). Dairy sector in Nepal contributes around 9% in national GDP and 63% in livestock GDP of Nepal (MoALD, 2019). Animal census data showed that the population of cattle and buffalo in Nepal are 7,385,035 and 5,308,664, respectively (Krishi Diary, 2020). The total milk production was found to be 2,168,434 t on 2020 (Krishi Diary, 2020). According to survey of the Food and Agriculture Organization of the United Nations in 2020/21, annually 75 liters of milk is consumed by a single person in Nepal (Peters, et al., 2012).

Milk has also been well documented as a vehicle for the transmission of a variety of bacterial diseases agents for a very long time (Bhat et al., 2007). If it is produced unhygienically and handled carelessly, it gets contaminated very easily leading to its early spoilage (Prajapati, 1995, Schmidt, Van Vleck, 1982). The presence of organisms in the milk is indicative of unhygienic for consumption. It has been shown that contamination of milk to *E. coli* in the milk distributing centers is increasing, which is indicative of the unhygienic conditions in preparing, distribution and transportation (M Vahedi et al.,2013).

The most important source of *E. coli* contamination of milk is probably humans. The contaminants reached the products either during cooking or handling after cooking (Kumar & Prasad, 2010). Similarly, Poor sanitation and hygiene, lack of advance facilities in farming industry, and inadequate training are responsible for the microbiological contamination of milk (Amatya et al., 2023).

Amatya et al., 2023 studied the microbial contaminants present in milk samples collected from different sites in Kathmandu from January to July 2019. Out of total 90 milk samples (30 farm milk, 30 dairy milk and 30 pasteurized packaged milk) from local farms and outlets, 41.1% showed bacterial contamination and 46.6% showed fungal growth. The study revealed overall prevalence of 14.4% for *E. coli*. The study also showed mean bacterial (279.13 x10 cfu/ml) and coliform count (175.53x10 cfu/ml) in dairy milk and found that dairy milk samples were highly contaminated than farm and pasteurized packaged milk. It

concluded that microbiological quality of milk samples does not meet the requirements of the standard guidelines by Food and Drug Administration.

An cross sectional study done by Chaulagain, 2022 to assess and compare microbial quality of raw and pasteurized milk along with antimicrobial susceptibility pattern of coliforms from milk sample revealed that out of 30 milk samples collected from Kathmandu, the prevalence rate of *E. coli* was 41.94%. The study concluded that milk produced from small-scale farm from the study area were not of good quality. He further recommends more study to be done to monitor the microbial quality of milk as it can be a potential source of milk born infection and may be hazardous to the consumers.

Research conducted by Bhandari et al., 2021 in 243 dairy animals in western Chitwan region of Nepal found the overall prevalence of 16.5% (n=40/243) of *E. coli* in milk samples. This study reported the occurrence of multi-drug resistance E. coli in sub clinical mastitis and recommended the task of creating awareness of milk pasteurization, and food safety practices to the farmers.

The study done by Limbu et al., 2020 from September 2019 to January 2020 with an aim to evaluate the quality of raw and pasteurized milk marketed in Dharan showed the total 55% prevalence of *E. coli*. The study also showed the average total Viable Count, total Coliform Count, and thermoduric Count of raw milk to be, 59×105 CFU/ml, 14×104 CFU/ml and 5×103 CFU/ml respectively. Again, the average total Viable Count, total Coliform Count and thermoduric Count of pasteurized milk to be 15×104 CFU/ml, 14×103CFU/ml and 4×103 CFU/ml respectively.

Hasan et al., 2015 studied the microbial analysis of raw and pasteurized milk from selected areas of Dinajpur, Bangladesh from May to December 2012. A total of 32 milk samples (12 from raw milk and 20 from pasteurized milk) were subjected to total viable count (TVC), total coliform count (TCC), Total *Staphylococcus* count (TSC) and Gram's staining to determine the loads of microbes in raw and pasteurized milk. Total viable counts (TVC) range of 12 raw milk samples (R, R2 and R3) were found to be 1.3 x106 to 7.4 x105 cfu/ml and the presence of *Escherichia coli* in the raw milk samples were from 2.3 x102 to 9.4 x102cfu/ml. Similarly, the range of TVC for five brands of pasteurized milk (P1, P2, P3, P4, and P5) were from 1.8 x104 to 9.8 x104 cfu/ml and total coliform count (TCC) from 1.01 x102 to 9.1 x10 cfu/ml. The study concluded that high counts of bacteria were found in raw milk and pasteurized milk.

To estimate the incidence of opportunistic pathogen, *Escherichia coli (E. coli)*, in raw cow's milk from different localities of Sfax governorate in Tunisia Kumar & Prasad, 2010; Samet Bali et al., 2013 randomly collected 40 raw milk samples and inoculated on the relevant bacteriological media. The results revealed that 32.5% of the samples were *E. coli* positive. The highest mean value of coliform was found in milk from El Amra farms with 3.34 ± 0.31 log10 cfu/ml, while the lowest mean count of 2.61 ± 0.40 log10 cfu/ml was detected in milk obtained from Nakta farms. Ali & Abdelgadir, 2011 studied the incidence of *E. coli* in Raw cow's milk in Khartoum state, Sudan. Out of 100 raw milk samples 63% samples were positive for *E. coli*. Another studied conducted by (Kumar & Prasad, 2010) to isolate *Staphylococcus* and *E.coli* from milk (dairy farm, vendors and house) and milk products (viz; Dahi, Ice cream, Gulabjamun, Burfi, Khoa and Butter) revealed that out of 135 samples, 25 samples were found contaminated with Staphylococcus (14 , 10.34%) and E.coli (11, 8.15%). The study concluded that contamination of bacteria was due to improper handling and processing of milk and milk products.

MATERIALS AND METHODS

Study areaA study was conducted on Bagmati province of Nepal. Out of 13 districts a total of 4 districts were selected for the study namely Kathmandu, Bhaktapur, Lalitpur and Kavrepalanchok to find the presence rate of *E. coli* in milk samples. Raw and Pasteurized milk samples from different local dairy shops of these districts were collected and transported to HICAST microbiology laboratory for the laboratory identification.

Study design

A cross sectional study was conducted from Baisakh to Ashad 2080. Milk from various local dairy shops was collected aseptically for the study.

Sample and sampling method

A total of 30 milk samples (i.e., Pasteurized packet milk n=15 and Raw milk n=15) from various local dairy shops of selected districts of Bagmati province were included in this study. All pasteurized milks were from different brands. For unpasteurized raw milk, samples were placed separately in a sterile plastic bag and transported to the laboratory in an ice box as fast as possible and promptly processed.

Collection of milk samples

Table 1. Sample collection site along with number of samples

Area (In Districts)	Total Sample Number
Kathmandu	8
Bhaktapur	8
Lalitpur	8
Kavrepalanchok	6
Total	30

Table 2. Type of milk collected with number of samples collected

Districts	No. of raw milk samples collected	No. of pasteurized milk samples collected
Kathmandu	4	4
Bhaktapur	4	4
Lalitpur	4	4
Kavreplanchok	3	3
Total	15	15

Material and reagents

The material and reagent used for this study were ice box, petri dishes, distilled water, Sterile swabs, inoculating loop, Nutrient agar (NA), MacConkey Agar, Eosin Methylene Blue, test tubes , incubator, peptone water broth, indole reagent, MR-VP broth, Methyl red, Barritte reagents, Simmon's citrate slant, TSI Slant, colony counter, crystal violet reagent, grams iodine, safranine, ethanol , beaker, conical flask, measuring cylinder, microscope etc.

Media preparation

All the media preparation and sterilization were done according to the standard protocol of Bergey's Manual of Systemic Bacteriology. MacConkey agar was used as selective media for the culture of E. coli for the collected samples. 15.45g of dehydrated MacConkey was added in 300 ml distilled water and sterilized by autoclaving at 15 lbs at 121 for 20 minutes. The molted media was cooled to about 50^0C temperature and poured in petri plates.

Selective plating for culture media

For E. coli all the samples were streaked on MacConkey agar medium and incubated for 24 hours at 37^0C. The plates were observed for the growth of E. coli (pink colony; lactose fermenter). Biochemical tests were performed to confirm the presence of E. coli using MR-VP medium, Indole medium, TSI, and Simmon citrate agar respectively.

Citrate test

Simmons citrate slant were prepared in the test tubes by autoclaving at 15 lbs at 121^0C and were streaked with loopful of young culture. The presence of growth and blue discoloration in the agar was considered as positive whereas a green slant with no growth of bacteria was considered negative.

Triple sugar iron agar test

The triple sugar iron test was done to differentiate among the different groups or genera of the Enterobacteriaceae based on the ability to reduce sulfur and ferment carbohydrates. Triple sugar iron slants were prepared in the test tubes by autoclaving at 15 lbs 121^0C. Using sterile technique; small amount of the experimental bacteria from 24-hour old pure culture was inoculated into the tubes by means of stab and streak inoculation method with an inoculating needle. The screw caps were not fully tightened, and the tubes were incubated for 24 hours at 37^0C (Cappuccino and Sheman 2005).

Methyl red test

A loopful of culture was inoculated into a test tube containing MR-VP broth and incubated for 48 hours at 37^0C. 3-4 drops of methyl red was then added to the broth. The presence of a distinct red layer at the top of the broth was considered positive and a yellow red at the top of the broth was considered negative result.

Voges-Proskauer (VP) test

A loopful of bacteria was inoculated into MRVP broth and was incubated for 48 hours at 37^0C. 15 drops of Barritt's Reagent A and 5 drops of Barritt's reagent B was then added to 1ml of MR-VP broth and was shaken well. A change in color to pink was considered positive indicating acetoin is present and no change in color was considered negative result.

Indole test

A peptone broth was prepared and 2ml of broth was dispensed in each testtube and autoclaved at 15 lbs pressure (121^0 C) for 15 min. A loopful of bacteria was then inoculated into it for 24 to 48 hours at 37^0C. The red layer at the top was considered positive result and a yellow or brown layer was considered negative result.

Gram staining Procedure

Gram-positive bacteria have cell walls that contain thick layers of peptidoglycan (90% of cell wall). These stain purples. Gram-negative bacteria have walls with thin layers of peptidoglycan (10% of wall), and high lipid content. These stain pinks. A Loopful of bacteria was taken in a glass slide and a drop od distilled

water was added on it. The slide was then air dried. Primary stain (crystal violet) was added to a heat-fixed smear, followed by the addition of a mordant (Gram's Iodine), then rapid decolorization with alcohol was done and lastly, the bacteria on the slide was counterstaining with safranin.

Total viable count (TVC)

TVC was performed according to Laboratory Handbook for Dairy Industry published by National Dairy Development Board (NDDB), Nepal, 2001 (NDDB, 2001). A, serial nine-fold dilutions of the milk sample was done and TVC was determined by the pour plate method on nutrient agar and incubated at 37°C for 24 hours.

Identification of E. coli

One loopful each of the samples was inoculated on to MacConkey Agar (MA). The plates were incubated at 37° C for 24 hours. Lactose fermenting colonies on MacConkey agar were sub-cultured to obtain pure culture. Pure cultures were tested biochemically (Indole test, methyl red test, Voges Proskauer test, citrate utilization test, triple sugar iron agar test, as described by Isenberg (2007) and Cheesbrough (2006).

Data analysis

Primary data was collected for the study. The results obtained from the study were recorded in MS Excel. Descriptive analysis was done using bar graph, pie-chart, and tabular forms.

RESULTS AND DISCUSSION

Overall presence of *E. coli* in milk

Out of 30 milk samples collected from 4 different districts of Bagmati province, 6 (20%) samples were found positive for presence of E. coli whereas 24 (80%) milk samples were negative for the presence *of E. coli.*

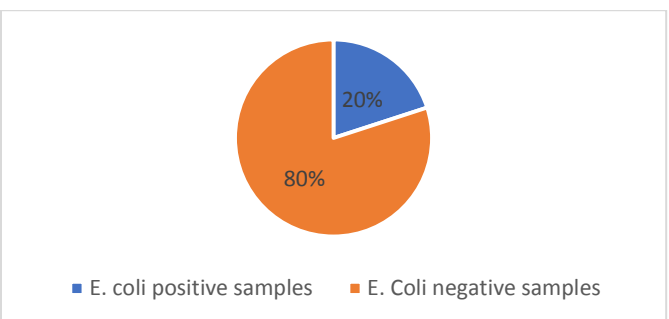

Figure 1. Results of the presence of *E. coli* in milk samples

The graph shows the presence of *E.coli* in milk samples from various selected district of Bagmati province, Nepal.

Comparison for the presence of *E. coli* based on the type of milk used for sample collection

The milk samples were divided into two groups i.e Raw milk sample and Pasteurized milk sample. Highest presence of *E. coli* was found to be in Raw milk samples of 5(33.33%) out of 25 samples followed by Pasteurized milk samples of 1(6.67%) out of 15 samples.

Table 3. Distribution of samples

Type of samples used	Total number of sample	No. of positive sample for *E. coli*
Raw milk sample	15	5 (33.33%)
Pasteurized milk sample	15	1 (6.67%)

Comparison for the presence of E. *coli* in different districts of Bagmati province

Out of 4 selected districts of Bagmati province for the study, the overall *E. coli* presence of 10% was found in Kathmandu district and 3.33% each was found from Bhaktapur, Lalitpur and Kavrepalanchowk district respectively. Whereas, the presence of *E. coli* on raw milk sample taken from Kathmandu, Bhaktapur, Lalitpur and Kavrepalanchok was found to be 2 (13.33%), 1 (6.67%), 1 (6.67%) and 1 (6.67%), respectively. Similarly among Pasteurized milk sample collected *E. coli* was only found on milk sample collected from Kathmandu district with the presence rate of 1(6.67%).

Number

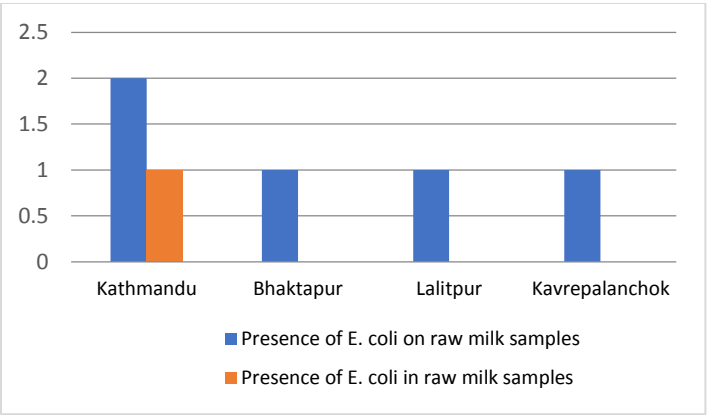

Figure 2. Presence of *E. coli* in raw and pasteurized milk samples collected from different districts of Bagmati province

Total viable count for the presence of E. coli in raw and pasteurized milk

Out of total 6 *E. coli* isolated milk samples, the total viable count from 5 raw milk samples was found to be $36X10^9$ cell/ml, $31x10^9$ cells/ml, 35 $X10^9$ cells/ml, $66X10^9$ cells/ml and $41x10^9$ cells/ml. Therefore the average TVC In raw milk was found to be $41.8X10^9$ cells/ml whereas Total Viable count from one *E. coli* isolated pasteurized milk sample were found to be 28 X 10^9 cells/ml.

Table 4. Average total viable count in milk samples

Average TVC count In *E. coli* positive Raw milk samples	Average TVC count In *E. coli* positive Pasteurized milk samples
$41.8x10^9$ cells/ml	$28x10^9$ cells/ml

DISCUSSION

The overall presence of *E. coli* in milk including both raw and pasteurized milk samples was found to be 20% (6 samples). The presence of *E. coli* on the milk samples according to different types of milk used for sampling was found to be highest in raw milk 33.33% (5/15) followed by in pasteurized milk 6.67% (1/15). District-wise, *E. coli* was isolated as follows: 10% from Kathmandu district and 3.33% from Bhaktapur, Lalitpur and Kavrepalanchowk districts each. The presence of E. *coli* in milk indicates that milk was contaminated with microorganisms during handling, processing, transportation, and storage (M Vahedi et al., 2013). The presence of bacteria in pasteurized milk may be due to inadequate pasteurization and post pasteurization contamination (Anderson et al., 2011). Along with this poor hygienic condition of dairy farms might have

contributed to this condition in raw milk (Prajapati, 1995; Schmidt, Van Vleck, 1982).

This study showed slight similarity in result with the study carried by Amatya et al., (2023) for the prevalence of Microbiological contamination in Milk sample in Kathmandu and shows the prevalence of 14.4% for *E. coli*. The similarity in results may be due to both studies being carried out on same study area having same geography, ecology, climatic condition, due to similar sample size, hygienic condition and same period of study.

A study by (Limbu et al., 2020) at Dharan, Nepal detected there was 30% prevalence of *E. coli* in pasteurized milk and 55% prevalence of *E. coli* in raw milk respectively which is higher than our study. The difference in the study may be due to difference on the time and place of study. Similarly unhygienic milking and handling practices may be another reason contributing to higher prevalence (Vahedi et al., 2013).

A higher prevalence rate of (41.94%) *Escherichia coli* was detected by Chaulagain, 2022 on raw milk samples. Similarly, much higher prevalence of 90% of *E. coli* in pasteurized milk was detected by Author et al., 2006. A 60% occurence of *E. coli* in raw milk was found in a study by Ali & Abdelgadir, 2011. All these results are higher than our study. These variations in the no of *E coli* in different studies may be due to difference in sample size, hygienic conditions of dairy shops and dairy farm, difference in milking equipment and milking technique used etc. (Amatya et al., 2023, Chaulagain, 2022).

Mean TVC in our study from raw milk was found to be $41.8X10^9$cells/ml whereas $28X10^9$cells/ml was found in Pasteurized milk. Average TVC from raw and pasteurized was found to be 39.5 X 10^9cells/ml. This is not accepted as quality milk. As *E. coli* is proof of the contamination from excreta (Vahedi et. al., 2013).

CONCLUSION

All these findings conclude that raw and pasteurized milk from various districts of Bagmati province are still contaminated with *E. coli* to some extent. The presence of *E. coli* in milk clearly indicates that there has been an unhygienic handling of milk. It also means that Microbiological quality of milk does not meet the requirements of the standard guidelines by Food and Drug Administration and may ultimately pose a threat to public health. Hence proper handing, cleaning and sanitization of equipment is necessary. Also, the

implementation of Hazard Analysis Critical Control Point (HACCP) must be done as far as possible to ensure the production of safe and high-quality milk.

SUGGESTIONS

Based on study following suggestions can be made:

- Regular monitoring of milk for the quality and presence of microorganisms must be done to prevent future health hazards.
- Strict hygienic practices, regular sterilization of dairy equipment, washing of utensils, milkers' hands, udders should be strictly practiced.
- The diseased milking animal should be treated promptly and only disease-free animal use be used for milking
- Care should be taken to eliminate the post pasteurization contamination and to ensure that milk is free of microorganism.

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REFERENCES

Ali, A. A., & Abdelgadir, W. S. (2011). Incidence of Escherichia coli in Raw Cow's Milk in Khartoum State. *British Journal of Dairy Sciences*, *2*(1), 23–26.

Amatya, S., Dhungana, N., Saud, G., & Chand, B. (2023). Prevalence of Microbiological Contaminants in Milk Samples in Kathmandu. In: *Nepal. Archives Clin Med Microbiol.* 2(1)

Anderson, M., Hinds, P., Hurditt, S., Miller, P., McGrowder, D., & Alexander-Lindo, R. (2011). The microbial content of unexpired pasteurized milk from selected supermarkets in a developing country. *Asian Pacific journal of tropical biomedicine*, *1*(3), 205-211.

Arain, M., Khaskheli, M., & Bhutto, B. (2002). Isolation of Escherichia Coli from Raw Milk and Milk Products in Relation to Public Health Sold under Market Conditions at Tandojam. In *Pakistan Journal of Nutrition*, 1(3)

Bhandari, S., Subedi, D., Tiwari, B. B., Shrestha, P., Shah, S., & Al-Mustapha, A. I. (2021). Prevalence and risk factors for multidrug-resistant Escherichia coli isolated from subclinical mastitis in the western Chitwan region of Nepal. *Journal of Dairy Science*, *104*(12), 12765–12772. https://doi.org/10.3168/jds.2020-19480

Bhat M., Macdonald K., Denny J., Lynch M.F. (2007) Escherichia coli O157:H7 infection associated with drinking raw milk- Washington and Oregon, November–December 2005. *The Journal of the American Medical Association*. 297: 1426-1428.

Suraj, C. (2022). *Enumeration and detection of antibiotic susceptibility pattern of coliform bacteria from milk samples in Kathmandu*. Doctoral dissertation, Amrit Campus, Tribhuvan University.

Eberhart, R.J., (1977). Coliform Mastitis. *J. Am. Vet. Assoc*., 170, 1160-1163.

Gruetmacher, T.J., Bradely, R.L. Jr, (1999) Identification and control of processing variables that affect the quality and safety of fluid milk J.of Food Prot. 62(6), 625-631

Hasan, M. A., Islam, M. A., Mahmud, M. S., Uddin, A. A., & Ahmed, S. (2015). Microbial analysis of raw and pasteurized milk from selected areas of Dinajpur, Bangladesh. *Asian Journal of Medical and Biological Research*, *1*(2), 292–296. https://doi.org/10.3329/ajmbr.v1i2.25624

Hayes, M. C., & Boor, K. (2001). Raw milk and fluid milk products. *Food science and technology-new york-marcel dekker*, 59-76

Hickey, C.D., Sheehan, J. J., Wilkininson, M.G., & Aunty, M.A. (2015). Growth and location of bacterial colonies within dairy foods using microscopy techniques: a review. *Frontiers in microbiology*, 6, 99

Krishi Diary, (2020). *Agriculture information and training center.* Ministry of Agriculture and Livestock Development, Accessed Jun. 25, 2020, http://aitc.gov.np/english/downloadsdetail/2/2019/ 19794382

Kumar, R., & Prasad, A. (2010) Detection of E.coli and staphylococcus in milk and milk products in and around Pantnagar 1 2. In: *Veterinary World* (Vol. 3, Issue 11). www.veterinaryworld.org

Limbu, D. S., Bantawa, K., Limbu, D. K., Devkota, M., & Ghimire, M. (2020) Microbiological Quality and Adulteration of Pasteurized and Raw Milk Marketed in Dharan, Nepal. *Himalayan Journal of Science and Technology*, 37–44. https://doi.org/10.3126/hijost.v4i0.33864

MoALD (2019). *Nepal portfolio performance review* (NPPR). Ministry of agriculture and livestock development

Murphy, S.C., K.J. Boor, (2000). Trouble-shooting and causes of high bacteria counts in raw milk. *Dairy, Food and Environmental Sanitation* 20 (8), 606-611

Pandey GS and Voskuil, GCS (2011). Manual on Milk safety, quality and hygiene Golden Valley agricultural Research Trust, Zambia, p. 52

Peters, B.M., Jabra-Rizk, m.a., o'May, G.A.., Costerton, J.W., & Shirtliff, M.E. (2012). Polymicrobial interactions: impact on pathogenesis and human disease. Clinical microbiology reviews, 25(1), 193-213

Prajapati JB (1995) *Fundamentals of Dairy Microbiology* Akta Prakashal Nadiad, Gujarat, India, 4-45

Reddy, D. Maheswara, K. Venkatesh, C. and Reddy, V.S. (2017). Adulteration of milk and its detection: a review, *International Journal of Chemical Studies*, 5(4): 613-617

Schmidt GH, Van Vleck, LD (1982). Principles of Dairy Science. *Surjeet publications*, New Delhi, 3-5

Vahedi, M., Nasrolahei, M., Sharif, M., & Mirabi, A. M. (2013). Bacteriological study of raw and unexpired pasteurized cow's milk collected at the dairy farms and super markets in Sari city in 2011, *Journal of preventive medicine and hygiene*, *54*(2), 120.

Wijesinha-Bettoni R and Burlingame B (2013). *Milk and dairy product composition, In Milk and dairy products in human nutrition, Muehlhoff E, Bennett A and McMahon D (eds)*. Food and Agriculture Organization of the United Nations (FAO)

Effect of Diet and Feeding System on the On-Farm Performance of Sakini and Ghantikhuile Local Chicken Breeds during Early Growth Phase

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ABSTRACT

The study on effect of diet and feeding system on the on-farm performance of Sakini and Ghantikhuile during the early growth phase was conducted at the Instructional Livestock Farm Complex, Himalayan College of Agricultural Sciences and Technology (ILFC, HICAST), Kirtipur, Kathmandu. The growth evaluation and survivability were performed on the Sakini and Ghantikhuile based on the effect of feeding system and diet containing 18% Crude Protein (CP) and 2900 Metabolizable Energy (ME) Kcal/kg. The mash feed was formulated at local feed factory with specific CP and energy content; and other essential supplements. There was no significant difference (P>0.05) on the feed conversion ratio (FCR) and average body weight gain (AWG) between Sakini and Ghantikhuile. The FCR of the Sakini and Ghantikhuile at the 8th weeks were 3.9 and 4.0 respectively as well as the average body weight gain at 8th week were 102g and 90g respectively. The Sakini had better performance than Ghantikhuile on the basis of the average body weight. The average body weights of the Sakini and Ghantikhuile at the 8th week were 870g and 835g, respectively. On the basis of average feed intake Sakini had better performance than Ghantikhuile; and similarly, Sakini (92.30%) had higher survival rate than Ghantikhuile (72.30%). This study showed that Sakini chicken performed better in terms of average feed intake and survivability than Ghantikhuile and similar performance in terms of feed conversion ratio (FCR) and average body weight gain with respect to feeding system and diet containing 18% CP and 2900 ME kcal/kg in an intensive management system.

Keywords: Feeding system, growth performance, local breeds, poultry, nutrition

INTRODUCTION

Livestock production accounts for twenty to twenty-four percent of agricultural gross domestic product (AGDP) in both developed and developing countries, as

per the Food and Agriculture Organization (FAO). The poultry sector, which has an extremely important place in terms of food safety and nutrition, is the fastest growing agricultural sub-sector, especially in developing countries. A figure for the global poultry market indicates 4.1% growth between 2021 and 2025, reaching a production of 100.9 million metric tons (Anon, 2022). The annual growth rate of poultry production is 17-18% contributing 3.5% of total GDP of Nepal (FAO, 2014). This expansion may be due to a combination of factors - growth in per capita income, a growing urban population and falling real poultry prices. Nepal has a diverse terrain topography and climate where poultry farming exists in all the regions Viz. Mountain (5.14%), Hill (50.25%) and Terai (44.61%). The highest concentration of commercial poultry farming is found in Chitwan (46%) and backyard holding in Biratnagar (68.30%). About 90% of the household keeping poultry have local chicken in the scavenging systems (Sah and Yadav, 2020).

In Nepal, rural poultry represents a significant part of the rural economy in particular and of the national economy as a whole; contributing 55% of the total poultry population in Nepal (Bhattarai, 2014). Chitwan, Kathmandu and Dang are the major districts with higher number of commercial poultry farms in Nepal. Chitwan, located in Bagmati province has the highest poultry population and production distribution. Chitwan produces 56720 metric tons of meat out of a total of 113348 subtotal of Bagmati Province and 540590 eggs (MoALD, 2020/21). Most of the Nepalese communities place a great cultural and social significance on poultry. In various sections of the nation, three indigenous poultry breeds discovered. Sakini, Ghanti Khuile (Naked Neck –NN), and Pwankh Ulte (Frizzled Feather –FF) are well-known among the local fowl. Their meat is well-liked and often devoured on highways. They are hardy and ideal for scavenging circumstances, and come in all sorts of colors ranging from white to dark (black, brown) with mixed patterns. On a phenotypic level, they've been characterized (Sapkota *et al*., 2013).

Sakini is a Nepalese native breed that accounts for nearly half of the country's entire chicken population. They are well adapted from temperate high hills to tropical terai. They can survive without structured feeding and have strong foraging abilities. Their body size is small and feathers color varies from black to red, spotted black and white, red and white, red and black (Uddhav *et al.*, 2016).

Ghantikhuile (naked neck) is hardy and dual purpose suitable for meat and eggs and good for scavenging condition. They may be found all across the

nation. Their population is critically low, and rapid conservation action is required. They are a characteristic bird with few feathers on the neck and feathers of various colors; they are known for the quality of their meats (Sah and Yadav, 2020).

In Nepal, indigenous chickens have nearly equal proportion of the market as commercial breeds, and also play an important role in providing protein requirements through meat and eggs. However, commercial farmers are increasingly turning to alternative dual-purpose transboundary and exotic breeds due to low productivity in terms of growth, egg output, and egg size of indigenous chicken. Chicken productivity and reproduction are influenced by two elements: genetics and non-genetic/environmental variables such as nutrition, health care, shed, and environmental conditions. Indigenous breeds are adaptable to a variety of environments and provide delicious eggs. As a result, they are more adaptable to their surroundings than exotic breeds (Sah and Yadav, 2020).

The most practical and cost-effective approach of converting feed grains to animal protein still seems to be poultry meat and eggs. The demand for animal protein tends to be income-elastic and to follow the gross domestic product (Soriano-Santos, 2010). Poultry meat is a valuable food because of its variable but moderate energy content, highly digestible proteins of good nutritional quality (with low collagen levels), unsaturated lipids (primarily found in the skin and easily removed), B-group vitamins (primarily thiamin, vitamin B6, and pantothenic acid), and minerals (like iron, zinc, and copper). Consumption of poultry meat also contributes to the overall quality of the diet at specific ages and conditions (prior to conception, during pregnancy up to the end of breastfeeding, during growth, and in the geriatric age) and is appropriate for individuals who have higher calorie and protein requirement than the general population (Marangoni *et al*., 2015).

The term nutrient denotes any single type of food, or set of similar feeds, that assists in the sustenance of life and makes it possible for birds to produce meat and eggs. The primary nutrients for poultry include water, proteins, carbohydrates, fats and oils, minerals and vitamins. In layer rations, the proteins quantities vary from 16-22 percentages. The amino acids required for the growing chickens and laying hens are satisfied in practice by proteins of plant and animal sources. The major role of carbohydrates in the diets is to supply energy to chickens. The metabolizable energy requirement for poultry ranges from 2700ME (kcal/kg) to 3200ME (kcal/kg); cereal grains and their byproducts

are great source of energy; and they normally comprise 60-70 % in their rations (Banerjee, 1986).

The location and geographical regions has significant effect on the growth performance from the first week to 22nd week with a mean weight of 1264.36 g. The mean weights recorded for 22nd week of Sakini from different AEZ (Agro-Ecological Zones) are 1149.43, 1186.10 and 1457.55 g for Terai, mid hills and high-hills, respectively. The weight of chicks from high hills was observed to be higher for all the observations taken from 1st week to 22nd week except for one day old chicks. Similarly, sex has also significant effect for all weeks expect during the hatching (0 day). The overall mean weight for the males and females during 22nd weeks of age were 1460 and 1130 g, respectively. The result showed that among three lines studied, Sakini lines from high hills showed better performance on-station (Sapkota *et al.,* 2013).

A study reveals that the highest body weight of chicks at eight weeks age was observed in the case of F1 progenies of LIR crossed with New Hampshire (1388.33±44.57 g.). On female lines, Sakini (1211.50±48.82 g.) and Black Australorp (1404.50±48.82 g) were found the best compatible with Cobb 500 (Tamang, Sharma and Barsila, 2018). The addition of probiotic to the feed significantly improved feed intake, weight gain, egg production and egg quality on Sakini and Giriraja breeds of chickens. The general trend revealed increasing level of egg production from five to eight months with significant difference. Nutrient analysis of eggs by proximate analysis in terms of CP, CF, fat and energy showed significant increase. This study reveals that Giriraja and Sakini breeds have potential effect on supplementation of Probiotic on feed (Neupane *et al.,* 2019).

A study illustrated growth performance (live weight at different weeks) and reproductive traits such as age at first laying, weight at first laying, egg number, egg weight and egg production per hen per year, fertility, and hatchability of Sakini birds was increased in progressive generations of selection under intensive management system. This study suggested that there is great scope of selective breeding within the indigenous population for bringing significant improvement on these economically important traits under intensive management as indigenous Sakini chicken performed better with respect to growth, survivability, fertility and hatchability in later generations (Sapkota *et al*., 2020).

A study revealed that, the crossed progenies of Sakini (1831 g) appeared the best performer with respect to ghati khuile 0r naked neck (1530 g) on the basis of body weight gained at tenth week. On the basis of average FCR value, the progenies of Sakini crossed with Giriraja (2.69) were observed good performer then the progenies of naked neck with Giriraja (Tamang, 2020). Another study revealed that, the egg production per year of Sakini and Ghanti Khuile was higher than that of Puwakh Ulte. Also, the hatchability of Sakini was significantly higher than that of Naked Neck. Sakini matures earlier than others and start laying eggs earlier. The clutch per year and of Sakini and Ghanti Khuile was also not significantly different and there was not much difference in the body weight of the indigenous breeds at 8 weeks (Giri, 2021).

The growth performance was significantly ($p \leq 0.05$) higher in naked neck chicken in the summer season. The dressing percentage was significantly ($p \leq 0.05$) higher in naked neck birds in both winter and summer season because of reduced plumage. The total cholesterol levels in plasma were significantly ($p \leq 0.05$) lower in naked neck birds in both the seasons. Basophil and eosinophil concentration and lipid peroxidation was significantly ($p \leq 0.05$) higher in normal chicken in summer. The enzyme glutathione reductase (GR) levels were significantly higher during the summer and varied significantly ($p \leq 0.05$) between the normal and naked neck chicken in both seasons. The results indicated that the naked neck birds performed significantly better at high ambient temperatures with respect to growth, carcass and biochemical parameters (Rajkumar *et al.,* 2011).

The other exotic dual purpose breeds, Australorp breed had improved body weight, feed conversion and carcass traits while Naked Neck had low mortality. Australorp breed gives better performance as compared to other breeds. The results of body weight showed significantly ($P<0.05$) high in Australorp and Rhode Island Red, intermediate in Fayoumi and lowest in Naked Neck. Results showed non-significant ($P>0.05$) difference in feed conversion ratio among all breeds. (Jan *et al*., 2021). The light brown and dark brown naked neck phenotypes exhibited better growth performance, superior morphometric traits and lower cholesterol content, signifying that there should be a conscious effort to develop and commercialize the light and dark brown birds as dual-purpose slow growing chicken especially in developing countries, helping the farmers in reviving a prestigious agro-based rural poultry activity, producing quality chickens; having livelihoods for their households (Shafiq *et al.,* 2022).

Our country's native poultry is becoming less popular. The non-genetic factors like feed and management can determine the performance of the poultry. Very little research findings are available on these breeds and its potential for use in the poultry industry. In addition to this, information on effect of diet and feeding system on the performance of indigenous breed of Nepal is very limited. The objective of this study was to assess the overall effect of diets and feeding system on the on-farm performance of the Sakini and Ghanti khuile during the early growth Phase (8 weeks period). This study estimates effect of nutritional plane (energy and protein) on average feed intake, average body weights, feed conversation ratio (FCR) of the birds at weekly intervals and the mortality and survivability rate of the birds.

MATERIALS AND METHODS

Study site

This study was carried out on the Instructional Livestock Farm Complex, Himalayan College of Agricultural Sciences and Technology (ILFC/ HICAST), Kirtipur, Kathmandu.

Experimental design

A total of 390-day old chicks of Sakini and Ghanti Khuile was placed and divided into two groups; where one group consisted of 195 Sakini and another group consisted of 195 Ghanti khuile. They were kept in deep litter system. The starter experimental ration was formulated from locally available resources containing 18% CP and 2900kcal ME/kg were fed to the birds.

Chicks and feeds

A day old Sakini and Ghanti khuile chicks (dual purpose local breeds) were brought from one of the commercial hatcheries of Kathmandu and kept on the ILFC, HICAST. The mash feed was formulated and manufactured from locally available resources in one of the feed mills located at Balaju, Kathmandu. The formulated feed was provided as per schedule ad libitum. The composition of the experimental diets is as illustrated in Table 1.

General management

The floors, interior of the walls and roof was cleaned and properly disinfected before the arrival of chicks. Finally lime dusting was done thoroughly inside the poultry house. Rice husk was used as litter material by maintaining 5-7.5 cm thick on the floor. The litter was stirred as pre required to prevent caking. Feed was provided ad libitum. The commercially prepared pellet pre starter feed was provided from day old to day seven for better growth and survivability. Finally,

the trial starter feed was provided from second week up to the end of the experimental period (8 weeks). The floor space for each bird was 1.9 square feet.

Table 1. Composition of the experimental diets

Ingredients	**Starter ration**	**Specifications**	**Percentage**
Maize	573	Protein %	18.25
DORB	154	ME Mcal/kg	2.819
Soya	201	Dig Lysine	0.82
Rapeseed DOC	30	Dig Methionine+Cystine	0.52
Marble powder	21	Calcium	1.05
Grit	0	Total Phosphorus	0.78
DCP	7.5	Available Phosphorus	0.47
Methionine	1.580	Chloride %	0.26
Lysine	0.500	Sodium %	0.17
Crabomults	0.500		
Soda bicarbonate	1.300		
Salt	3.200		
Threonine	0.500		
Total	**1000**		
Additives			
Crabovit/Poutvit	400		
Choline chloride	1200		
Gabamax 1000	500		
Agrimos	750		
Liver tonic	250		
Organic Mineral	250		
Diclazuril	250		
Globaflex Plus	1000		
Crebomin B	1000		
Total	**5600**		

The vaccines against major diseases were routinely administered to all birds. The infectious bronchitis vaccine (IBH120) was vaccinated to the day-old chicks. The day-old chicks were raised on an intensive care and housing system and strict biosecurity measures was taken in account to minimize mortality due to various diseases. Hence, the chickens were vaccinated against infectious body hepatitis disease at 5^{th} days. After that, ND clone 30 vaccine against new castle disease was vaccinated at the schedule. After that, these chicks were vaccinated against Gumboro at days 14 and 21. Additionally, these chicks were boostered against Gumboro and New castle disease at 28^{th} days using IB(MAS)+ND (Clone 30). At 35^{th} days, Reo-1133 vaccine was vaccinated against reoviral arthritis disease and deworming was done. On 45 days, chicks were vaccinated

against Salmonellosis (*Salmonella gallinarum)*. Before 8 weeks, the last vaccine administered was given against fowl pox on 56th days.

Data Collection

Feed Intake

Every week the quantity of the feed provided to the birds was recorded. The quantity of the feed consumption was calculated by subtracting and tallying the total feed (sacks) consumed from the remaining feeds(sacks).

Body weight

Birds were weighted from day old age up to eight weeks at weekly interval. Body weight gain was obtained by differences of body weight (g) between each week.

Mortality

Mortality number was recorded in each compartment at weekly interval. The mortality rate was calculated as:

$$\text{Mortality rate of birds} = \frac{\text{Total number of deaths of birds recorded within particular time} \times 100}{\text{Total number of birds in the population at beginning of this period}}$$

Feed analysis

The feed was analyzed for its nutritional content. The proximate analysis was performed for feed analysis. The diets were formulated from locally available resources containing 18% CP and 2900kcal ME/kg and it was analyzed according to AOAC (1990) for the proximate principles.

Feed conversion ratio (FCR)

The feed intake and live body weight of the two-compartment from day old till eight weeks of age were recorded. These feed intake and live body weight data were analyzed to calculate the FCR. The feed conversion ratio of the birds was calculated by dividing the total live body weight gain from the total feed consumption.

Data analysis

The collected data was further assessed by using simple statistic tool such as MS Excel.

RESULTS AND DISCUSSION

Feed consumption and Body weight

Feed was allotted in equal amount but the feed consumption was different in every week. The feed consumption was higher in Sakini than Ghanti khuile. The performance of Sakini and Ghanti khuile is shown in Table 1.

Comparative evaluation of feed consumption

This study showed that the feed consumption of the Sakini was greater than the Ghantikhuile in 3rd, 5th, 7th and 8th weeks and it was lower in the 1st ,2nd,4th and 6th weeks. The feed consumption of Sakini and Ghantikhuile was recorded 406g and 364g per bird respectively at eight weeks of age (Figure 1).

Table 1. Feed consumption and average body weight of Sakini and Ghanti khuile

Weeks	Feed/bird/day(g)		Feed/bird/week (g)		Average body weight/bird/week (g)		FCR	
	Sakini	Ghanti khuile	Sakini	Ghanti khuile	Sakini	Ghanti khuile	Sakini	Ghanti khuile
Day old	0	0	0	0	42	40	0	0
1	17	20	119	140	111	120	1.7	1.7
2	26	30	182	210	206	235	1.9	1.8
3	35	32	245	224	330	340	1.9	2.1
4	40	42	280	294	445	449	2.4	2.7
5	44	40	308	280	556	540	2.7	3.0
6	48	50	336	350	661	641	3.2	3.4
7	55	54	385	378	768	745	3.5	3.6
8	58	52	406	364	870	835	3.9	4.0

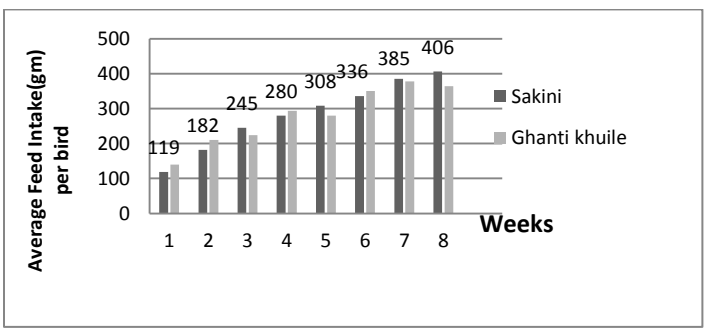

Figure 1. Feed consumption of Sakini and Ghantikhuile

The overall average hatching weight of day-old chicks of Sakini and Ghantikhuile was observed 42g and 40g respectively. The average body weight of the Sakini were lower from 1st weeks to 4th weeks and recorded as 111g, 206g, 330g and 445g respectively whereas of Ghantikhuile 120g, 235g, 340g and 449g respectively. The average body weight of Sakini were observed higher from 5th weeks to 8th weeks and observed as 556g,661g,768g and 870g

respectively whereas of Ghantikhuile 540g,641g,745gand 835g respectively (Figure 2). The average body weight gains of Sakini were recorded lower in 1st and 2nd weeks and recorded as 69 and 95 respectively whereas of Ghanti khuile 80 and 115 respectively. The average body weight gains of Sakini were observed higher from 3rd weeks to 8th weeks and observed as 124g,115g,111g,105g,107gand 102g respectively whereas of Ghantikhuile 105g,109g,91g,101g,104g and 90g respectively. There was no significant difference (P>0.05) between Sakini and Ghantikhuile on term of average body weight gain (Figure 3).

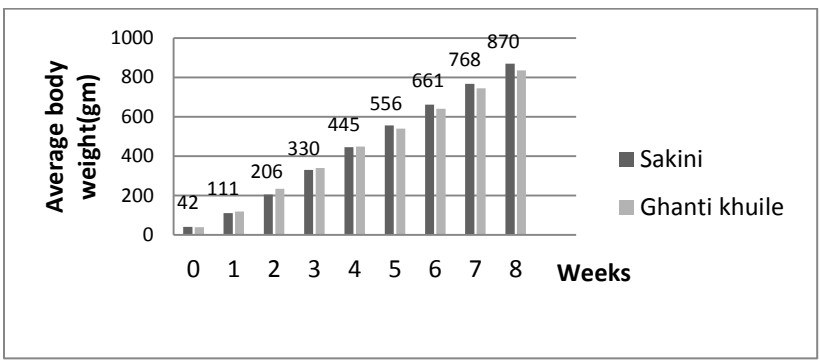

Figure 2. Average body weight and average weight gains up to eight weeks

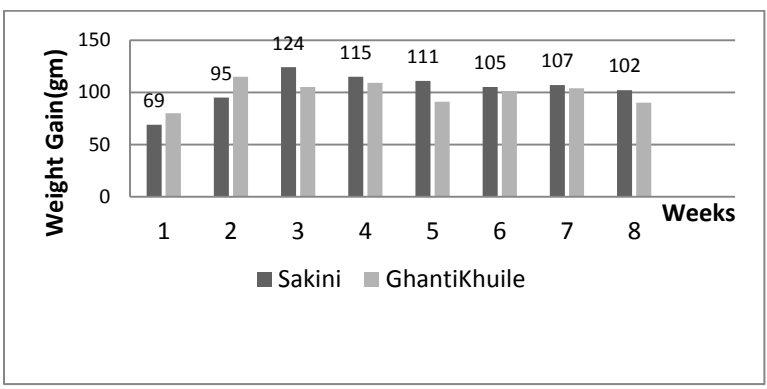

Figure 3. Average body weight gain of the Sakini and Ghantikhuile

Assessments of feed conversion ratio (FCR) of the Sakini and Ghantikhuile

Within the comparison of the two local breeds, Sakini and Ghantikhuile, we found no significant difference on the basis of average feed conservation ratio (p>0.05). The average feed conversion ratio of Sakini and Ghantikhuile was observed (1.7) equal on the 1st week. The average feed conversion ratio of

Sakini was observed higher in week 2nd week and observed as 1.9, whereas of Ghantikhuile 1.8. The average feed conversion ratio of Sakini were observed lower from the 3rd weeks up to 8th weeks, observed as 1.9, 2.4, 2.7, 3.2, 3.5 and 3.9 respectively whereas 2.1, 2.7, 3.0, 3.4, 3.6 and 4.0 respective weeks FCR of the Ghantikhuile. The FCR of the Sakini and Ghantikhuile at the 8th week was 3.9 and 4.0, respectively (Figure 4).

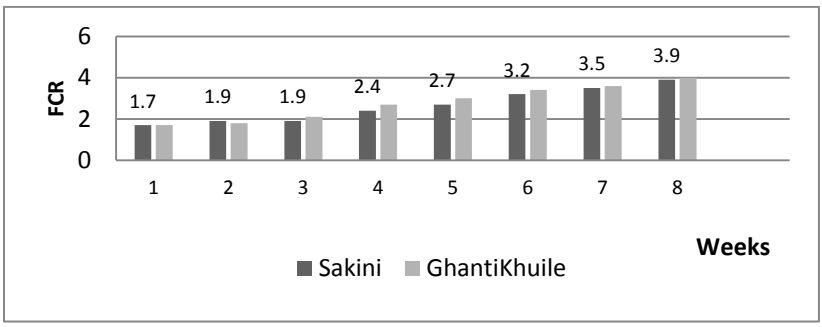

Figure 4. FCR of Sakini and Ghantikhuile

Mortality and survivability

Mortality was observed significantly higher (27.7%) in Ghantikhuile while 7.7 % mortality was observed in Sakini. The most of the Ghantikhuile chicks' mortality was observed during the 2nd week of age i.e., the mortality being 27 while the highest mortality of Sakini chicks being 4 at 1st and 8th Weeks of age. Within the comparation between two breed Sakini and Ghantikhuile, this study showed the Sakini chicks had better performance then Ghantikhuile in terms of survivability (Figure 5).

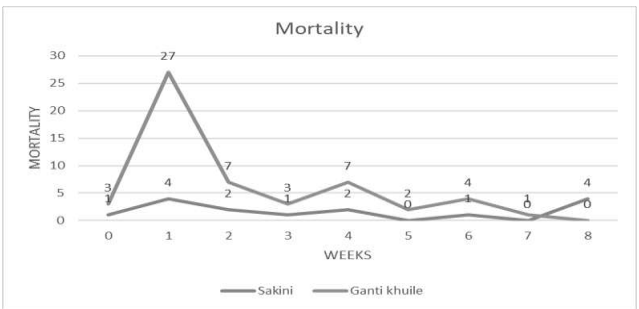

Figure 5. Mortality of Sakini and Ghantikhuile

The average feed consumption of Sakini and Ghantikhuile were recorded 58g and 52g per birds respectively at eight weeks of age which is lower (75g, Sakini

and 88g, Ghantikhuile) than the study done by (Tamang, 2020); that might be due to difference in the nutritional composition of diet (protein contain 23% and 21% and energy content 2900 kcal/kg and 3000 kcal/kg) and genetic improvement (cross progeny of Sakini and Ghantikhuile with Giriraj).

Discussion

Shafiq *et al.,* (2022) observed the higher result 71.76g for four different Ghantikhuile phenotypes at 8 weeks of age; that might be due to difference in the nutritional composition of diets (protein contains 17% and energy content 2850 Kcal/kg) and genetic makeup. (Tamang, Sharma and Barsila, 2018) observed higher result 146g for Sakini at the 8^{th} weeks; that might be due to difference in the nutritional composition of diet (protein contain 23% and 21% and energy content 2900kcal/kg and 3000kcal/kg) and genetic improvement (cross progeny of Sakini X cobb 500). The average feed conversion of Sakini and Ghantikhuile were observed higher on the other literatures, this might be the effect of higher protein and energy content of diets as well as genetic improvement of Sakini and Ghantikhuile with another breed. Within the comparison of the two local breeds, Sakini and Ghantikhuile, with respect to average feed conversion we found Sakini had better performance.

The average body weight for the 8th weeks Sakini and Ghantikhuile was observed 870g and 835g respectively which is higher (400-600g in Sakini and 400-600g in Ghantikhuile) than the study review by (Giri, 2021); that might be due to difference in feeding system (Scavenging system). (Sapkota *et al.*, 2013) observed lower result of Sakini at 8th week 469.35g, 461.79g and 769.33g for Rautahat, Kavre and Rasuwa districts respectively; that might be due to difference in the nutritional composition of diet. Based on average body weight evaluation Sakini and Ghantikhuile chicken shows higher body weight comparing with the literatures; that might be due to difference in feeding system (intensive system) and nutritional composition (18% CP and 2900kcal/kg ME). During the 8th weeks of age, the mean weight gain was observed as 498.62g for Sakini and 488.12g for Ghanti khuile which was slightly lower (516.13±12.58g, Sakini) than study done by (Sapkota *et al*., 2013). (Shafiq *et al.,* 2022) observed different result (409.29 ± 5.24g, Ghantikhuile); that might be due to difference in the nutritional composition of diet (protein contain 17% and energy content 2850 kcal).

The FCR of Sakini and Ghantikhuile at the 8th week were 3.9 and 4.0 respectively which is higher (2.4, Sakini) than the study done by (Neupane *et al.,* 2019); that might be due to use of probiotic. (Jan *et al*., 2021) observed

lower result 2.63 ± 0.21 for Ghantikhuile; that might be difference in the nutritional composition of the diet (protein contain 19% and energy content 3023.9 kcal/kg) as well as duration of study (10^{th} week). (Tamang, 2020) observed lower result 2.17 of Sakini and 2.74 of Ghantikhuile; that might be difference in the nutritional composition of diet (protein contain 23% and 21% and energy content 2900kcal/kg and 3000kcal/kg) and genetic improvement (F1 cross progeny of Sakini and Ghantikhuile with Giriraj). (Tamang, Sharma and Barsila,2018) observed slightly lower result 3.46 for Sakini at the 8th weeks; that might be due to difference in the nutritional composition of diet (protein contain 23% and 21% and energy content 2900kcal/kg and 3000kcal/kg) and genetic improvement (F1 cross progeny of Sakini X cobb 500). (Rajkumar *et al.*, 2011) observed lower results of Ghantikhuile in winter (1.95) and summer season (1.88) at 6^{th} weeks of age; that might be deference in the nutritional composition of diet (B1- 2,900 cal: ME, 22%: CP and B2- 3,000 cal: ME, 20%: CP) as well as genetic improvement (phenotypically Ghantikhuile: Ghantikhuile X synthetic boiler). Within the comparison of the two local breeds, Sakini and Ghantikhuile, we found no significant difference between Sakini and Ghantikhuile on the basis of average feed conservation ratio ($p>0.05$).

The survivability of the Sakini and Ghantikhuile at the 8th weeks was observed 92.30% and 72.30% respectively which is similar (90.2%, Sakini) with the study done by (Sapkota *et al.*, 2020) and (Shafiq *et al.*, 2022) observed almost similar result for Ghantikhuile 71.56 ± 5.43 %; that might be due to similar feeding system (deep litter system) as well as disease resistance nature of local breeds. Within the comparation between two breeds on the base of the survivability Sakini have higher survival rate than Ghantikhuile local breeds of Nepal.

CONCLUSION

This research was conducted at ILFC HICAST, Kirtipur to observe the overall effect of diets (18% CP and 2900 kcal/kg energy) and feeding system on the on-farm performance of the local chickens (Sakini and Ghantikhuile) during the early growth Phase (8 weeks period). The findings of this study focus on the on-farm performance such as live weight at different weeks, feed intake, feed conversion ratio (FCR), mortality and survivability of Sakini and Ghantikhuile. From this study we can conclude that there was no significant difference ($P>0.05$) on the feed conversion ratio (FCR) and average body weight gain between Sakini and Ghantikhuile and Sakini had better performance then Ghantikhuile on the basis of the average feed intake and survivability.

SUGGESTIONS

From this study following suggestions can be made:

- In order to uplift the present status of Sakini and Ghantikhuile, strategy should be focused on improving performance of these chickens through better feeding systems and management systems.
- Emphasis should be given on quality feeds to upgrade the level of income of the chicken raring farmer.
- Increase in the protein level in the feed can increase performance level of the chickens to certain extent.

REFERENCES

Anon (2022). Livestock and Poultry: World Markets and Trade. [online] Available at: <https://apps.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf> [Accessed 22 August 2022].

Banerjee, G (1986). *A textbook of animal husbandry*. 8th ed. *New Delhi: Oxford and IBH*, pp.895-897.

Bhattarai, T. C (2014). Poultry production scenario of Nepal. *Paper presented in AGM of Nepal Feed Industries Association.* Kathmandu, Nepal.

CBS (2014/15) *Nepal Commercial Poultry Survey 2014/15*. Central Bureau of Statistics. Kathmandu, Nepal.

FAO (2014). Poultry Sector Nepal. In FAO Animal Production and Health Livestock Country Reviews. No. 8. pp. 4-16.

Giri, D (2021). Comparative Evaluation of Nepalese Indigenous Breeds of Chicken in relation to Egg Production performance. *Malaysian Animal Husbandry Journal*, 1(1), pp.40-42.

Jan, Muhammad & Rajput, Nasir & Naeem, Muhammad & Irfan, Waja & Abbas, Rahat (2021). Comparative Study on Growth Performance of Naked Neck, Rhode Island Red, Fayoumi and Australorp Breeds in Local Conditions. *Indo American Journal of Pharmaceutical Sciences*, pp103-110. 10.5281/zenodo.5778326

Krishi and Pashupanchi Diary (2020/21). Agriculture Information and communication Center. Kathmandu, Nepal.

Marangoni, F., Corsello, G., Cricelli, C., Ferrara, N., Ghiselli, A., Lucchin, L. and Poli, A (2015). Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document. *Food & Nutrition Research*, 59(1), pp.27606.

MOALD (2020/21). Satistical information on Nepalese agriculture. Ministry of Agriculture and Livestock Development. Singhadurbar, Kathmandu.

Neupane, D., Nepali, D., Devkota, N., Sharma, M. and Kadaria, I (2019). Effect of Probiotics on production and egg quality of dual-purpose chicken at Kathmandu in Nepal. *Bangladesh Journal of Animal Science,* 48(1), pp.29-35.

Poudel, U., Dahal, U., Upadhyaya, N., Chaudhari, S. and Dhakal, S (2020). Livestock and Poultry Production in Nepal and Current Status of Vaccine Development. *Vaccines*, 8(2), p.322

Rajkumar, U., Reddy, M., Rao, S., Radhika, K. and Shanmugam, M (2011). Evaluation of Growth, Carcass, Immune Response and Stress Parameters in Naked Neck Chicken and Their Normal Siblings under Tropical Winter and Summer Temperatures. *Asian-Australasian Journal of Animal Sciences*, 24(4), pp.509-516.

Sah, R. and Yadav, R (2020). Non-Genetic Factors Affecting Growth Performance of Indigenous Chicken Breeds in Nepal. *Sustainability in Food and Agriculture*, 2(1), pp.21-24

Sapkota, S., Gorkhali, N., Bhusal, R., Dhakal, R. and Shrestha, B (2013). On-Station Growth Performance Evaluation of Sakini (*GALLUS GALLUS DOMESTICUS*) Poultry Breeds. *National Workshop on Livestock and Fisheries Research in Nepal*, 9, pp 198-205

Sapkota, S., Kolakshyapati, M., Devkota, N., Bhattarai, N. and Gorkhali, N (2020). Selective Breeding to Improve Productive and Reproductive Performances and Survivability of Indigenous Sakini Chicken. *Journal of Nepal Agricultural Research Council*, 6, pp.62-69.

Shafiq, M., Khan, M., Rehman, M., Raziq, F., Bughio, E., Farooq, Z., Gondal, M., Rauf, M., Liaqat, S., Sarwar, F., Azad, A., Asad, T., Arslan, M., Azhar, M., Kamal, R. and Shakir, M (2022). Assessing growth performance, morphometric traits, meat chemical composition and cholesterol content in four phenotypes of naked neck chicken. *Poultry Science*, 101(3), pp.101667.

Soriano-Santos, J (2010). Chemical Composition and Nutritional Content of Raw Poultry Meat. Handbook of Poultry Science and Technology, pp.467-489.

Tamang, D (2020). The Meat Production Performance of F1 Cross Between Indigenous and Giriraja Chicken Breeds reared under Intensive management system. *The Blue Cross (2020)*, 16, pp.1-13.

Tamang, D., Sharma, M. and Barsila, S (2018). Performance of meat purpose hybrid chicken under intensive system. *Journal of the Institute of Agriculture and Animal Science*, pp.187-194.

Uddhav, P., Kolachhapati, M.R., Bhattrai, N. and khanal,T.,June (2016). Economic of rearing, Productive and Reproductive Performance of Indigenous chicken Raised as Backyard Farming in Nepal. *Wayambu journal of animal sciences*, pp.1336

Comparative Study on Chemical Methods of Pregnancy Diagnosis at Various Dairy Cattle in Bagmati Province, Nepal

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ABSTRACT

A comparative study was conducted on chemical test method of pregnancy diagnosis from 1st May and 16th June. A total 100 urine samples each group were collected from per-rectal palpation positive (two month onward pregnant) and per-rectal palpation negative (non-pregnant of any stage) cows at different dairy farms, located in the Kathmandu and Kavre districts of Bagmati Province Nepal. Aseptic measures were strictly followed during the sample collection process. The Barium Chloride Test, a chemical method of pregnancy diagnosis, was performed on the collected urine samples from cows. Urine samples were collected in the morning using collection bags/vials. The results obtained from the diagnosis revealed that $BaCl_2$ demonstrated an accuracy rate of 69.5% in correctly classifying pregnant and non-pregnant cows. Furthermore, sensitivity and specificity was found 54%, and 85% respectively. This study confirms the potential of $BaCl_2$ test for pregnancy diagnosis in cow showed as a non-invasive method for pregnancy diagnosis in the study area.

Keywords: Barium Chloride Test, $BaCl_2$ Test, Pregnancy Diagnosis

INTRODUCTION

Livestock production is an integral part of the most Nepalese livelihoods where 65% of Nepalese are involved in agriculture and more than 80% of them rear one or more types of livestock. Livestock played a significant role in the income generation of rural poor people thereby contributing significant role in the poverty reduction. One of the major components of Nepalese mixed farming system; forest supplies fodder, fuel wood, grazing land, and balances hydrology; livestock convert fodder, grasses and agricultural by-products to milk, meat, manure, and household income. Dairy is considered an important sector of national economy as well as AGDP, and said to be contributing to 9 % in national GDP as well as 33% of AGDP. (AITC, 2022) It is expected that more than Rs. 3 karod (Nepalese currency) in daily basis is transferred from urban to

rural areas because of the dairy industry, average 50 lakh litres milk per day is produced in Nepal among them half of milk is consumed by self-producer and other half (17% is take on in formal sector and 33% is supply informal sector (Dairy Association, 2021). Total cow milk production in the country is 6,65,285 MT, average milk production of a lactating cow is 646 liter per year per cow and a total buffalo milk production in country is 15,09,512 MT, average milk production of a lactating buffalo is 825 liter per year per buffalo which is much below than Indian buffaloes, furthermore two-third of milk comes from buffaloes and one-third from cattle. Lactating percentage of cows and buffaloes are 14.01% and 29.15% respectively (AITC, 2019).

Pregnancy diagnosis is an invaluable tool to the cattle producer who is trying to maintain maximum profitability. Cows that are open (not pregnant) will add to the cost of maintaining the herd while not providing income in support of the producer. A cow that fails to become pregnant in a timely fashion will ultimately produce less milk, thus adding cost but not enhancing income. A pregnancy test that would identify pregnant and open cows before they return to estrus, thus allowing intervention and rebreeding by the subsequent estrus, would help minimize the calving interval and thereby maximize profit especially in a program utilizing artificial insemination (AI). In addition, the ideal pregnancy test would be minimally invasive, simple to perform requiring little investment in equipment, supplies and time, yield quick results allowing cowside decisions to be made by the producer, and have high sensitivity and specificity. This comparative study of chemical test and methods will give a common idea which could be suggestive for other similar management system.

Nepal, is a land lock country, it has a population about 28.8 million (CBS, 2012). The country is predominantly an agricultural country where 65.66% people depend in agriculture for their livelihood. Nepalese livestock sector, contributing 27.66% in agricultural gross domestic production (AGDP), has been considered as a major contributor as poverty elevation in remote rural areas. At national level, the annual population growth rate is 1.12 ٪in cattle, 1.93% in buffalo, 2.03% in goat, 4.7% in poultry and 4.55% in pigs between years 1992-2002.

Mainly subtropical region elevation range from 1000-2000 Mt (88.2% Area and rest of part is 2000-3000 Mt (11.8%) In the urban center, the temperature fluctuates between 32 °C in summer (June–July) to -2 °C in winter (December–January). Except for the high hills including Chandragiri which has a temperate

climate, Kathmandu district has a subtropical climate. The annual rainfall of the district is 176.4 ml.

Cost-effective husbandry practice is critically important on every cattle farm, if a farm is not lucrative it is difficult to justify continuing to raise cattle. It is critical that cows become pregnant in order to succeed the desired production. Only the cattle raise in city areas in country are checked for pregnancy each year due to lack of technical personal and technology. As a result, days open in cows is increasing in herd. If the calving interval increasing obviously it costlier to maintain each cow, furthermore there no provision of official sale of unproductive cattle due to religious causes.

Pregnancy diagnosis is a commonly performed diagnostic procedure in cattle, aimed at determining the pregnancy status of individual cows. Timely identification of pregnant cows is crucial for maximizing their productivity and increasing farm profitability. Therefore, it is recommended that each mated female animal undergo a pregnancy test at least once per year to ensure effective fertility management, including the maintenance of pregnancy. The results obtained from a comparative study on the chemical method of pregnancy diagnosis using the Barium Chloride Test can provide valuable insights applicable to a broader population.

MATERIALS AND METHODS

Study area

The studies were carried out from small to medium scale dairy farms at different farms in Kathmandu and Panchkhal district.

Sample size

A total of 100 early morning urine samples were collected from pregnant cows starting from the 2^{nd} month of pregnancy as well as 100 urine samples were collected from non-pregnant cows. The samples were obtained from various farms, and strict aseptic measures were employed during the collection process.

Sampling techniques

A combination of purposive and random sampling methods was employed to select cattle.

- **Working procedure**
- **Barium chloride test**

This test is used for pregnancy diagnosis in cattle and buffalo, End-products of progesterone (after metabolisation in liver) present in the urine and this prevents precipitation of barium chloride while oestrogens favour precipitation (Singh, 2021).

Procedure:

- 5 ml of pregnant cow's urine was poured in to test tube (10 Ml)
- By adding 5-6 drops of 1 % $BaCl_2$ solution and mixed well.

Interpretation:

- Clear white precipitation: Non-pregnant
- No precipitation – Pregnant

To evaluate the accuracy of the result of the pregnancy diagnosis, following classification was adopted.

Table 1. Classification of test rsults

True Positive (TP)	These are cases in which the cattle is known to be pregnant by per-rectally, and pregnancy is confirmed true during the pregnancy diagnosis using the 1% $BaCl_2$.
True Negative (TN)	These are cases in which the cattle is known to be dry (non-pregnant) and the status was confirmed using the 1% $BaCl_2$.
False Positive (FP)	These are cases in which it was known that the cattle was dry, but the test result confirms that the cattle is pregnant.
False Negative (FN)	These are cases in which it was known that the cattle is pregnant, but the test result confirmed that the cattle is dry or non-pregnant.

RESULTS AND DISCUSSION

Using 1% barium chloride ($BaCl_2$), the result revealed that from 200 samples, 54 were regarded as true positive while 85 were classified as true negative. There were 46 false positive data and 15 were regarded as false negative.

Table 2. Per-rectal palpation (PRP) positive and PRP Negative animal's urine sample on 1% $BaCl_2$ test

	$BaCl_2$ test on PRP +ve samples										$BaCl_2$ test on PRP -ve samples			
			TP				FN							
SN	Farm Code	Total Sample	Total	1st Tri	2nd Tri	3rd Tri	Total	1st Tri	2nd Tri	3rd Tri	Farm Code	Total sample	FP	TN
1	K1	14	14	2	9	3	0	0	0	0	PB1	8	0	8
2	KA2	21	4	0	1	3	17	14	3	0	PB2	28	6	22
3	KA3	10	10	1	9	0	0	0	0	0	PB3	0	0	0
4	KA4	13	2	0	0	2	11	8	3	0	PB4	22	4	18
5	KA5	10	3	0	1	2	7	2	4	1	PB5	12	0	12

6	KA6	10	10	0	8	2	0	0	0	0	PB6	0	0	0
7	BA7	10	1	0	0	1	9	5	3	1	PB7	14	4	10
8	KA8	10	8	0	5	3	2	1	1	0	KB8	5	0	5
9	KA9	2	2	0	2	0	0	0	0	0	PB9	11	1	10
Sum		100	54	3	35	16	46	30	14	2	Sum	100	15	85
Percentage			54	5.6	64.8	29	46	65	30	4	Percentage		15	85

Table No. 3, True positive, true negative, false positive and false negative results barium chloride tests ($BaCl_2$) for detection of pregnancy

	Barium Chloride Test ($BaCl_2$) (Number (%))	
	Predicted Yes	Predicted NO
Actual (YES)	TP= 54 (54%)	FN = 46 (46%)
Actual (NO)	FP=15 (15%)	TN= 85 (85%)
Total	69	131

The accuracy, specificity, and sensitivity of barium chloride test was derived. The results were categorized as True Negative (TN), True Positive (TP), False Negative (FN), and False-Positive (FP). From these values, the accuracy, specificity, and sensitivity of $BaCl_2$ was calculated. Accuracy was calculated as 100 × ((TP + TN) ÷ (TN + TP + FP + FN)), sensitivity as 100 × (TP ÷ (TP + FN)), and specificity as 100 × (TN ÷ (TN+ FP)).

Table 4. Performance of $BaCl_2$

Parameters	$BaCl_2$
Sensitivity (%)	54
Specificity (%)	85
Accuracy (%)	69.5

Figure 1. Result of pregnancy detection using barium chloride method. 1 = no reaction in the test, resulting pregnancy and 2 = cloudiness, resulting no pregnancy

The accuracy of $BaCl_2$ test is found to be 69.5% with the sensitivity of 54% and specificity of 85%. The True Positive (TP) in 1st, 2nd and 3nd trimester were found 5.6%, 64.8% and 29.6% respectively. The highest TP was found in 2nd trimester. The False Positive (FP) in 1st, 2nd and 3nd trimester were found 65.2 %, 30.4 % and 4.3 % respectively. The highest FP was found in 1st trimester. This result is in contrast with the Febrianingtyas *et al.* (2018) study which reported the $BaCl_2$ methods have sensitivity and specificity of 40.54% and

100% respectively. A study by Azmi Z. *et al.* (2020), using $BaCl_2$ and urine in 1:1 ratio also found, mostly false negative results having a sensitivity of 100% and a specificity of 13.21% with the accuracy of 28.13% the difference result may due to geographical condition.

Lalrinluanga and Dutta (2009) also reported that $BaCl_2$ method had an inadequate sensitivity and specificity i.e. 64% and 84% respectively from 50 samples tested between pregnant and non-pregnant cows. This study has similar sepecificity as Lalrinluanga and Dutta (2009), however the sensitivity is lower may be due to the alternation in breed.

Different findings were obtained by Skálová *et al.* (2014), that the sensitivity and specificity of this method were 79.70% and 50% respectively from the 40 sample tested a 1: 1 proportion between pregnant and non-pregnant cows which are different result with this study due to the feeding practices.

Based on the report of Skálová *et al.* (2014) it is estimated that the accuracy of the $BaCl_2$ method is around 63.89% which is found to be slightly lower than the accuracy obtained in this study. Meanwhile, based on Lalrintluanga and Dutta (2009), the accuracy of the $BaCl_2$ method is estimated at 72.91% which is found to be slightly higher than the accuracy obtained in this study, which might be due to the mild uterine disease.

CONCUSION

Pregnancy detection by chemical ($BaCl_2$) method showed inconsistent results. Our study showed that based on CUI values, $BaCl_2$ method gave average good performance in determining of pregnancy diagnosis. Therefore, this study confirms the potential of $BaCl_2$ test for pregnancy diagnosis in cow showed as a non-invasive method for pregnancy diagnosis in the study area.

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REFERENCES

AITC (2019). Agricultural and Information Training Centre, Retrieved from http://aitc.gov.np//english/downloadsdetail/2/2019/19794382/

AITC (2022). Agricultural and Information Training Centre. Retrieved from http://aitc.gov.np/downloadfile/agriculture diary 2079_1651480914.pdf

CBS, (2012). Central Bureau of statistics, National population and housing census, Government of Nepal; National planning commission secretariat, *National report*, Pp (88),Volume 1

Dilrukshi HNN, Perera ANF (2012). Evaluation of an ancient technique to diagnose the pregnancy in cattle using urine. Wayamba *J. Anim. Sci.* 1252245657. 6–8.

Febrianingtyas, L.F., M. F. Ulum and A. Winarto, (2018), Perangkat Mikrofuida Berbasis Penyeka Kapas dan Benang Katun sebagai Alat Deteksi Dini Kebuntingan pada Sapi. http://repository.ipb.ac.id/handle/123456789/94700.

Fricke, P. M., Ricci, A., Giordano, J. O., and Carvalho, P. D. (2016). Methods for andImplementation of Pregnancy Diagnosis in Dairy Cows. Veterinary Clinics of North America - *Food Animal Practice*, 32 (1), 165–180. https://doi.org/10.1016/j.cvfa.2015.09.006

Kubátová A, Fedorova T, Skálová I, Hyniová L (2016). NonInvasive pregnancy diagnosis from urine by the cuboni reaction and the barium chloride test in donkeys (Equus asinus) and alpacas (Vicugna pacos). *Polish J. Vet. Sci.* 19(3):477–84. https://doi.org/10.1515/pjvs2016-0060

Lalrintluanga, K. and M. Dutta. (2009). Pregnancy diagnosis in swine from urine using barium chloride test. *Indian J. Anim. Res.* 43(2):114-116.

MoALD (2019). Ministry of Agriculture and Livestock Development.Statistical Information on Nepalese Agriculture 2073/74 (2016/17).and NepaleseAgriculture 2075, 76 (2018, 19).pdf *http://moad.gov.np/public/uploads/639899230-Statistica*l Information on:

Ndu, A., L. Bratte, and S.U. Eyoufe. (2000). A preliminary trial on the use of barium chloride for pregnancy diagnosis in sows. *Tropicultura.* 18(4):161-163.

Nebel R., Whittier W., Cassell B., Britt J. (2020). Comparison of on-farm and laboratory milk progesterone assays for identifying errors in detection of estrus and diagnosis of pregnancy. *J Dairy Sci.* 1987:70:1471–1476.

Nepal Dairy Association. (2021). Website content. NDA – Nepal Dairy Association, Casa Nepal Country Team. Retrieved from *dairyassociation.org*

Nepali Times. (2017, May 31). *High and dry*. Retrieved from: https://www.nepalitimes.com

Rao S., Veena T. (2009). Comparison of seed germination test with urine barium chloride test and milk copper sulphate test for efficacy to detect pregnancy in cows. *Indian J Anim Res.* 2009; 43:124–126

Skálová, I., A. Kubátová, and T. Fedorova. (2014). Non-invasive urine sampling and pregnancy diagnosis in domestic cattle and alpacas. *Proceedings of the Annual Conference on Tropical and Subtropical Agricultural and Natural Resource Management* (Tropentag).Prague. pp: 218

Theriogenology (2020). *Diagnosis, Treatment, and Prevention of Reproductive Diseases in Animals* (2nd edition).

Zemjanis, R. (1980). Repeat breeding or conception failure in cattle. In: *D.A. Morrow (Ed.),Current Therapy*

Zul Azmi, Muhammad I. Desem, Hastuti Handayani S. Purba, Dwi Endrawati, FaidahRachmawati, Eni Kusumaningtyas, and Didik T. Subekti. (2020). *Evaluation of sulfuric acid, barium chloride, and seed germination assay method as early pregnancy detection instruments in cattle.* https://doi.org/10.21157/j.ked.hewan.v14i2.15271

Study of Livestock Production System and Management Practices Adopted by Small Ruminants Farmers in Bagmati Province, Nepal

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ABSTRACT

Small ruminants, such as sheep and goats, have long been integral to the livelihoods of rural farmers in the country, providing a sustainable source of income, food security, and employment opportunities. However, the sustainability of the small animal farming heavily relies on the production and management practices adopted by the famers. Thus to get a better understanding a door to door survey with pre-tested questionnaire including both open and closed end questions was implemented including 25 farmers each from four districts (Kathamndu, Makwanpur, Dolakha and Kavrepalnchowk) of Bagmati Province of Nepal. Study revealed that majority of farmers in the region is subsistence farmers (86%) with average goat holding of 12±1.38. Semi-intensive system is popular among farmer. Though health management practices such as deworming, vaccination were practiced by majority of farmers there were inconsistency in the practices adopted making it contributor for parasitic infestation and disease outbreak. Much gender disparities were not found in terms of division of labor in farm. In context of technical and logistic inputs goat farmers were found to be struggling. Availability of fodder in lean season is still a problem. Additionally, farmers have minimal understanding on good housing for goats, insurances policies, inbreeding. Quarantine of new (16%) and isolations of sick animals (26%) are practiced by only few farmers. A need was felt for capacity-building initiatives to enhance farmers' knowledge and skills in small ruminant's farm operation and managements.

Keywords: Goat, Production system, Management, Health, Bagmati Province

INTRODUCTION

The agricultural sector plays a crucial role in the economy of Nepal, with livestock production being a significant contributor (CBS, 2019). Small ruminants, such as sheep and goats, have long been integral to the livelihoods of small scale rural farmers in the developing countries (McDermott et al., 2010). In Nepal they have contributed for providing a sustainable source of income,

food security, and employment opportunities to marginalized farmers of Nepal (Poudel,, 2018 and Aryal, Upadhaya and Pandey., 2018), which has led to the recognition of goats as poor man cows. However, the efficiency and productivity of small ruminant farming systems heavily rely on the adoption of appropriate management practices.

Understanding the livestock production systems and management practices adopted by small ruminant farmers is of paramount importance for sustainable agricultural development and rural poverty alleviation in Nepal (Thapa and Baltenweck., 2013 and Regmi and Ghimire 2019). It allows for the identification of strengths, weaknesses, and potential areas of improvement, paving the way for targeted interventions, policy formulation, and capacity building initiatives to enhance small ruminant production and its associated socio-economic benefits, while some research has been conducted in this area, a significant research gap remains, necessitating further investigation and analysis. Existing studies have often focused on broader aspects of livestock production or concentrated on specific regions, overlooking the diverse farming systems and management practices employed by small ruminant farmers across Nepal (Dhakal et al., 2021, Redding et al., 2012, and Nepali et al., 2014). This gap inhibits the development of comprehensive and context-specific strategies that can address the unique challenges faced by these farmers. The present study aims to bridge this gap by conducting an in-depth examination of livestock production systems and management practices among small ruminant farmers in four districts of Bagmati province of Nepal to get broader view of the production system by encompassing socio-economic, and managemental aspect of small ruminant rearing to unravel the complexities, opportunities, and constraints associated with small ruminant farming. Moreover, this study intends to shed light on factor influencing sustainable management practices by exploring the role of knowledge, access to resources, socio-cultural factors, market dynamics, and policy frameworks in shaping farmers' decision-making processes. Such insights are crucial for designing targeted extension programs, capacity building initiatives, and policy interventions that can effectively promote sustainable livestock production systems in Nepal.

MATERIALS AND METHODS

Study area

Bagmati is province located in central Nepal encompassing 13 districts. The province is known for its diverse geography, consisting of varying landscapes including mountains, hills and terai making it suitable of crop farming and livestock earing. Our study was conducted in four districts of Bagmati Provinces

namely Kathmandu, Makwanpur, Kavrepalanchowk, and Dolakha as they represents the diversity of small ruminant production system in the region, encompassing urban, periurban, rural and mountainous context to get a broder picture of the challenges and opportunities faced for a better production system. Additionally, these districts also have high number of goat heads.

Data source and sampling procedure

A quantitative descriptive study was done by purposive sampling method (25 farmers from each districts) to study the livestock production system and management practices adopted by small ruminant farmers in the study area. For that data collection door to door survey was conducted with pre tested questionnaire consisting of both open and closed end questions to gather information on farming practices- housing, feeding, breeding, health managements and marketing system of goats and sheep. Before starting the survey informal key informant interview was done to generate preliminary information regarding the demographic, socio-cultural, and topographical settings of the site and to know the various information about goats and sheep farming in the region, its adaptability, production and management aspects in the community. During the administration of questionnaire one member of the households who is willing to participate in the survey was taken as a sampling unit. The first section of the questionnaire covered the demographic information-including respondent's name, location, gender, age and profession. The second section consisted of questions that can evaluate the livestock production system and managemental conditions.

Data Analysis

Data collected from the survey was entered in MS-Excel, 2013 version and afterward analyzed by using SPSS 16.0 version. Supporting tables and diagrams were formulated for the interpretation of the obtained results.

RESULTS AND DISCUSSION

Demographic

Among the sampled farmers, 54.0% were male and 46.0% were female, indicating a relatively balanced representation of both genders within the study population. On average, the respondent age was 46.06 ± 1.20 year which ranged from 21 to 77. Adhibashi and Janajati (47.0%) were found to be dominant over Brahmin (40.0%), Chhetri (9.0%) and Dalit (4.0%). The literacy rate was found to be 90.0% and 10.0% were found to be illiterate. Primary source of income for the families was agriculture (85.0%) followed by remittance (6.0%), business (4.0%), government service (2.0%) and 3.0% of people were involved in other

types of work like labor, driving and so on. From the survey it was found that the average family size was 4.65 ± 0.14, ranging from 1 to 9 among the respondent. The details of demographic information of the respondents are shown in Table 1.

Table 1. Demographic of respondents from the study area

Descriptions		Percentage
Gender	Male	54.0
	Female	46.0
Ethnicity	Brahmin	40.0
	Chhetri	9.0
	Dalit	4.0
	Adibashi and Janajati	47.0
Education	Illiterate	10.0
	Primary	57.0
	Secondary	24.0
	High School	8.0
	University	1.0
Primary Occupation	Agriculture	85.0
	Business	4.0
	Government Service	2.0
	Remittance	6.0
	Others	3.0
Age	Mean ± SE	46.06 ± 1.20
Family size	Mean ± SE	4.65 ± 0.14

Farming status

The majority of farm was subsistence type (86.0%) with only 14.0% of the respondents being involved in commercial farming. This suggests that the small ruminants are popular among the marginalized farmers. Shah et al., 2023, also reported similar findings with few commercial and majority subsistence farmers in his study done at hills of Nepal. Majority of the farmers were found to adopting semi-intensive system of rearing (79.0%) followed by intensive system (21.0%). No farmers were found to rear the small ruminants by extensive system, which is mainly due to predation and other threats to the small ruminants. Most of the farmers had more than 20 years of experience on rearing small ruminants (40.0%), 27.0% of farmers had experience of 10 to 20 years, 18.0% of the farmers had less than 5 years of experience and remaining 15.0% of the farmers had less than 10 years of experience. This shows the popularity of small ruminants among the experienced farmers.

Division of work was distributed among both genders in majority (81%) of respondent houses in our study area (Table 2). In contrast to that, 19 % of

female respondents were found to be solely doing the farm activities whereas for male no such observations were made. This is indicative of importance of small ruminants in rural economy where there is less number of working males, which is similar to the findings of (Sapkota et al., 2017). Average number of laborer in the studied farms was found to be 3.0 ± 0.14.The study revealed that there has not been enough interventions on training the farmers for better farming and productivity from small ruminants. Only 30.0% of the farmers had livestock related training whereas remaining 70.0% of the farmers got no any training. This is slightly higher than the findings of Thapaliya (2020), where only 20.0% of the farmers were involved in tours and training. Furthermore only 23% of the respondents has adopted insurance practice. It helps protect farmers against unforeseen circumstances and ensures their economic stability (Nnadi et al., 2013). However, lack of awareness, affordability and limited coverage by insurance companies in remote villages might have delimitated the participation of famers in insuring their goats.

Table 2. Farming practices adopted by farmers

Description		Percentages
Farm type	Subsistence	86.0
	Commercial	14.0
Rearing System	Extensive	0.0
	Semi-intensive	79.0
	Intensive	21.0
Years of Farming	Less than 5 years	18.0
	Less than 10 years	15.0
	10-20 years	27.0
	More than 20 years	40.0
Work division	Male	0.0
	Female	19.0
	Both	81.0
Laborer	Mean ± SE	3.0 ± 0.14
Livestock Related Training	Yes	30.0
	No	70.0
Insurance of goats	Yes	23.0
	No	77.0

Livestock distribution

Averages of 2.32 ±0.05 species of livestock are raised by the respondents. Goats, cattle, buffalo and poultry are among the popular species reared. A household has an average of 12 ±1.38 goat head in a household with maximum of 71 and minimum of 2 goat heads. This is more when compared with findings by Dhakal et al., 2021 in Chitwan, Redding et al., 2012 in Kaski District and

Nepali et al., (2010) in Syangja district. This suggest increment in herd average compared to the past years and other parts of the country. There herd averages for goats per household above 1 year, between 6 and 1 year and below six months were respectively 6.02±0.75, 3.77±0.53 and 3.35±0.40 heads. Majority farmers were raising indigenous Khari breeds crossed with Jamunapari, The main purpose of rearing goats was for sale and manure purpose. Handful of farmers was keeping goats for use as breeding stock. No farmer kept goat for milk production. Furthermore, majority of farmers don't used goat raised in home for meat consumption.

Table 3. Livestock distribution in study area

Descriptions	**Mean ±SE**
Species reared	2.32 ±0.05
Herd average goat in a farm	12 ±1.38
Average goat above 1 years in herd	6.02±0.75
Average goat between 6 months to 1 year in herd	3.77±0.53
Average goat less than 6 months in a herd	3.35±0.40

Housing system

Our study found that majority of the farmers are raising goats in ground level houses (75%) and only 25.0% had stilted housing system. Majority of flooring was done with mud (63.0%), followed by wood (36.0%) and stone (1.0%). Farmers don't seem to give much attention towards housing construction. More than half of the respondent shed had poor ventilation (55%) and absence of drainage system (59%). Only 38.0% of farmers were found to clean the shed on daily basis. Provision of separate housing for adults and kids and male and female were adopted by only 23 % and 14% of the respondents. Goat houses were found to construct attached with houses of farmers in 41% respondent houses. Those who have separate housing from the settlement buildings were also not far away with average differences of 70.93 ± 15.56 meters distance. This indicate the lack of adequate knowledge about housing management of small ruminant farmers which is similar to the findings of Thapaliya (2020).

Feeding system

Stall feeding with a combination of grazing was found popular among the respondent with 68% of them adopting the practice whereas 32.0% practiced stall feeding only, which is very different from the findings of Panta et. al., (2020) in Gulmi district, where only 21.67% of farmers were involved in grazing the animals, other farmers stall fed. Almost all farmers (92%) reported sufficient availability of fodder through the year except in the lean period lasting for about 2.82±0.8 in winter months. This might be because 83% of them rely on their own land for fodder supply along with other sources like nearby forest

for grass and fodders. Furthermore, 17.0% of farmers also buys it from the market in addition to the fodder produced in their own land, which is similar to the findings in mid-hills of Nepal in research by Shah., et al.,2023. Majority (92%) of farmers reported no issues in water supply with most of them using the tap water for feeding animals. Few of them also rely on river and well for water supply. On the contrary, 8 respondents reported insuffiency in water supply for animals, which can cause significant loss in the productivity of animals. Treatment of water and feed for its safety and better utilization is important.

Table 4. Housing practices in the study area

Description		Percentage
Housing	Stilted	25.0
	Ground level	75.0
	No house	0.0
Ventilations	Well ventilated	45.0
	Poor ventilated	55.0
Flooring	Wooden	36.0
	Mud	63.0
	Stone	1.0
Drainage	Absent	59.0
	Present	41.0
Shed Cleaning	Once a week	32.0
	Twice a week	30.0
	Daily	38.0
Separate shed for adults and kids	Yes	23.0
	No	77.0
Separate shed for male and female	Yes	14.0
	No	86.0
Animal Shed location	Attached to house	41.0
	Separate from house	59.0

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Out of total farmers only 24% treated feed and water in some ways but remaining farmers did not treat feed and water before providing it to the animals. According to Growel (2015) goats do not depend on intensive feeding systems except some supplemental feeding during growth, lactation, pregnancy and winter. Feed supplementation was practiced by more than half of the respondents but supply was limited only in gestation periods. Supplementation is highly important during pregnancy and lactation, no feed supplementation during this phase can severely decrease the performance of both kid and the dam.

Table 5. Feeding practices adopted in the study area

Descriptive	Types	Percentages
Method of feeding	Stall fed	32.0
	Combination of grazing and stall feed	68.0
Availability of fodder	Sufficient	92
	Insufficient	6
	More than sufficient	2
Source of food	Own farm	83
	Buy + Own Farm	17
Availability of water	Sufficient	92
	Insufficient	8
Treatment of feed or water	Yes	24
	No	76
Food supplement	Yes	66
	No	34

Breeding practices

Natural insemination is the primary choice of almost all respondents. Only 1% practiced artificial insemination. It might be because of technical difficulties for successful conception in goats. Bhattarai et al. 2019 have also reported that AI practice not being so convincing to small livestock owner due to lack of skilled technicians, timely unavailability of liquid nitrogen in remote areas, and improper husbandry practices followed by farmers. According to NLBO (2020) out of total goat AI performed in the country, only 15.69% was performed in Bagmati province. Dhakal et al., 2021 also reported concept of AI not being known to 93.19% of respondents in his study. Hand mating (65.0%) followed by flock mating (14.0%) was preferred by farmers whereas 21% adopt a combination of both. Cross breeding was seemed to the preferred choice of mating by 71.0% of respondents. This suggests that the availability of high-quality breeding bucks is crucial for the overall improvement and productivity of the goat population. Breeders should focus on acquiring superior genetics to enhance the traits desired in the offspring, such as increased milk production or disease resistance (Robinshon and Buhr, 2005). Only 7.0% of the farmers use breeding buck from their flock whereas 88.0% of the farmers use neighborhood buck and 5.0% use buck from market for mating their goat. The findings are similar to the finding of Dhakal et al.,2021, where about 81% of farmers used neighbors breeding buck. It is said that crossbreeding Hill goats with Jamunapari goats has stopped. Non-governmental Organizations (local and international) have been encouraging Hill goats (Neupane and Pokharel, 2005) but based on this study it is found that the farmers are again attracted towards cross breeding with introduction of some new breeds.

Table 6. Breeding practices adopted in study area

Descriptive	Practices	Percentage
Mating	Natural Service	99.0
	Artificial Insemination	1.0
Mating strategy	Hand mating	65.0
	Flock mating	14.0
	Hand and flock mating	21.0
Breeding preferences	Cross breeding	71.0
	Pure breeding	29.0
Source of breeding buck	Market	5.0
	Neighborhood	88.0
	Same flock	7.0
Selection criteria for buck selection	Body morphometry	55.0
	Twinning percentage	3.0
	Breed	10.0
	No selection	30.0
	Body morphometry + breed	2.0
Preferred breeding buck availability	Always	14.0
	Never	7.0
	Often	43.0
	Rarely	36.0
Castration of male	Yes	31.0
	No	69.0
Knowledge on inbreeding	Yes	40.0
	No	60.0
Pregnancy diagnosis	Abdominal distension	29.0
	Absence of estrous	55.0
	Others	16.0

Body morphology (55.0%) and breed (10.0%) were frequently used characters for selecting the breeding bucks, whereas twinning percentage was considered by only handful of respondents. About 30.0% of the farmers did not have any selection criteria, they would use any buck available for mating. When asked about the availability of breeding buck of their choice only 14 % responded they always found buck of their choice whereas 7.0% reported never finding it when required. Additionally, 43.0% of them reported that they often find their preferred breeding buck. Inbreeding in goats was unknown to 60.0% of respondents. Farmers generally face the problem of poor performance of the goat in small scale production. Inbreeding and negative selection is causing poor performance of goat (Devkota et al. 2000). Those who are aware about inbreeding reported different practices such as castration of male at young age, separation of male and female in same flock at time of heat, use neighboring herd for breeding. Castration was performed by only 31.0% of the respondents

which was in contradiction with the finding of Dhakal et al., 2021. Most common method of pregnancy diagnosis was found to be absence of next estrous with 55.0% of farmers implementing this method. 29.0% farmers know about pregnancy by distended abdomen, remaining farmers use other methods.

Health management

Table 6 provides information on various practices related to animal health and disease management practices adopted by small ruminant farmers in the context of Bagmati province. We can find variation in different health management practices adopted by farmers. They seem to be actively engage in disease and parasite control by deworming (99%), vaccination (81%) and spraying (96%) for external parasites control. However, the respondents reported inconsistencies in the practices adopted. Though majority of farmers 63% and 59% respectively practice regular vaccination and deworming; rest of the respondent seems to do so only after disease outbreaks or parasitic infestations. Similarly spraying is done only after infestation not as precautions which indicated that farmers adopt health management practice based on disease risks and available resources. These inconsistencies could have likely lead to reinfections in the herd where safety measure are adopted due to common pastures and grazing area. Not only that it could threatens the spread on infections in wild population and environment due to the farming system adopted by farmers like grazing in forests, nearby water sources and road sideways. It was found that only few respondents adopt quarantine (16%) of newly bought animal and isolation of sick from healthy herd (26%). This could explain the cause of disease occurrence and spread in farms. Gyawali et al., 2020 have also mentioned about these practices being crucial for preventing the spread of diseases within the herd and minimizing the risk of transmission to healthy animals. The low percentage suggests the need for increased awareness and education on the importance of quarantine practices of new herds and isolation of sick animals among farmers in Nepal. Regarding disinfection of the farm post-infection, 48% of the respondents reported practicing this method. Disinfection is an important step in preventing the spread of infectious agents within the farm environment. Effective disinfection helps in eliminating pathogens and reducing the risk of recurring infections (Lambertini et al., 2016).When it comes to the disposal of dead animals, the majority of respondents (89%) reported disposing of dead animals in fields. Proper disposal of dead animals is crucial to prevent the spread of diseases and avoid contamination of the environment. However, the small percentages (5% and 6%) reporting disposal in rivers or a combination of fields and rivers suggest the need for improved practices and awareness regarding proper disposal methods.

Table 7. Health management system adopted by respondents in study area

Descriptive	Responses	Percentages
Separation of healthy and unhealthy animals	Yes	26
	No	74
Quarantine of newly bought	Yes	16
	No	84
Vaccination	Yes	81
	Sometimes	17
	Yearly	63
	Outbreaks	1
	No	19
Deworming	Yes	99
	Regular	59
	deworming	38
	During	2
	infestations	1
	Yearly	
	No	
External parasite control	Dipping	2
	Spraying	96
	Manual picking	1
	None	2
Disinfection of farm post infection	Yes	48
	No	52
Disposal of dead animals	In fields	89
	River	5
	In fields +Rivers	6

Veterinary services

Figure 2 provides insights into the current state of veterinary service sector for small livestock farmer accessibility and shed light on the strength and weakness of the government and private sectors. Majority of the farmers seems to be approaching both the government run facilities and private sector 50% (n = 50/100) seeking veterinary services. However, 22% and 28% of the respondents solely confide in government and private sector respectively. Economic condition of the farmer and geographic location of the farm could have influence in the decision making. Though majority of the respondent (89 %) are satisfied with the service provided, 59% mentioned the service is only fair enough. Only 38 % participants responded the availability of service as good. Dissatisfaction of the 11 % respondents were likely due to delay in services, lack of effective communications and prompt diagnosis. Gyawali et al., 2020 also mentioned about farmer satisfaction with the service includes effective communication,

timely and accurate diagnosis, and availability of medicines and overall professionalisms of the service providers. OIE (2019) in their PVS pathway have mentioned the need for the government to invest in strengthening and expanding veterinary services, particularly in rural areas where access to veterinary care is often limited.

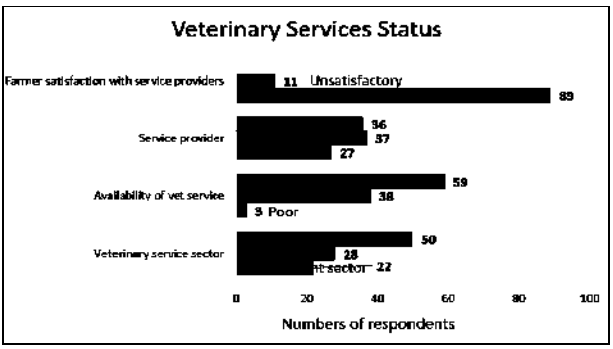

Figure 1. Veterinary service status and farmer satisfaction in study area

Regarding the service providers, 36 % of the respondent reported that both veterinary doctors and technicians are involved in delivering services. This finding suggest that there is a mix of professional involved in delivering veterinary care for small ruminants farmers in Nepal. Cheneau, El Idrissi and Ward (2004) has also mentioned about the participation of veterinary technician, who can provide basic veterinary services and support veterinary doctors being valuable for efficient service delivery, especially in areas with shortage of veterinary doctors in Asia and Africa..

Marketing system

Marketing of goats seems to be well established with farmers being able to sale their animals from home (88%) with buyers approaching them. Farmers responded they sale their goat usually to butchers (20%) followed by farmers (15%) and middleman (12%). Additionally, 31% responded selling it to both farmer and middleman and remaining 22% have experience of selling to both butchers and farmers. This suggests that a significant portion of goat sales in Nepal occurs through direct transactions between farmers and buyers, commonly referred to as home sales like in the study of Adhikari et al., 2019. Only 18 % goes to market to sell their goats. However, the low percentage of market sales highlights the need to develop and strengthen market infrastructure and marketing channels to provide farmers with better opportunities for selling their goats and reduce the monopoly in pricing of goats by buyers. Goats are usually sold by majority of respondents (70%) by the time they are above 6

months and below 1 years. Around 29% farmers sell their goats when they are above 1 years and only few (12%) when they are below 6 months. This suggests that most farmers prefer to sell goats at a relatively young age. Early marketing of goats can be attributed to the high demand for young goats for meat consumption and religious festivals in Nepal (Gyawali et al., 2020). Collaboration between farmers, butchers, and middlemen is crucial for ensuring fair prices, efficient market operations, and optimal returns for farmers (Ghafoor, Badar and Maqbool., 2017).Main reason for sale of kids as mentioned by respondents was for reduction in flock size due to limited space for housing. On the other hand some reported selling it for money too. Additionally, farmers mentioned selling of adult goats because they have reached marketable age (37%), unproductive (40%), old age (19%) and difficulty in recovery of illness (4%). In terms of weight at marketing, 66% of respondents sold goats in the weight range of 20-30 kg, followed by 19% in the range of 30-40 kg and 15% in the range of 10-20 kg. This indicates that farmers generally sell goats when they reach an optimal weight for meat production and market demand. Only 25% respondents waited for sale in special occasion while the rest (75%) made the sale throughout the year. Reason for the farmers waiting for special occasion could be because of high demand for goats during festivals and celebrations, such as Dashain and Tihar. Majority (95%) of the farmers uses money earned from goat farming to meet their familial needs and only small percentage reported using it for investment purposes, and 3% for loan repayment. This highlights the importance of goat farming as a source of income and livelihood support for rural households in Nepal (Aryal et al., 2019 and Neupane, Neupane and Dhital 2018). However, we found that only 44 % respondents are making a profitable production, while 56% did not. This suggest a mixed perception of profitability among goat farmers in Bagmati Province. Factors such as feed costs, market prices, production efficiency, and input cost might have affected the profitability.

Constrains

Our finding indicates that there are several challenges faced by goat farmers which is broadly categorized and depicted in pie chart in figure 3. Nepali et al., 2014 and Dhakal et al., 2021 has also reported similar setbacks in their studies done in western part of Nepal and Chitwan respectively. There was lack of quality forages and grazing (21%) in the study area. That indicated that the government needs to work on developing and strengthening launched strategies for improved pasture management, rotational grazing, and the cultivation of high-quality forage crops to ensure a consistent supply of nutritious feed for animals. Inadequate forage availability may reduce the productivity and hamper

the overall health of goat herds and the production system. Another hurdle at the farmers are facing are parasitic re-infestation and disease and lack of timely veterinary services. What is shows is that the current manpower involved in animal health and wellness programmes is not sufficient to ensure prompt diagnosis, treatment and preventive care. Thus, there is a need of strategy for production and dispersal of qualified personnel in every nooks and corners of the country. Additionally, trainings related to animal disease and prevention needs to be increased at farmer's level for better animal health and check the spread of disease. Lack of improved breeding buck could be a limiting factor for commercial herd development in the country. In our study also 9% farmer shares their concerns in availability of improved bucks for breeding purpose. Similarly, lack of training on improved goat farming (10%), manpower shortage (9%), and minimal goat prices (5%) were the other concern of farmers. Interestingly, 19% of the respondents reported no problems. While this may indicate a relatively favorable situation for a portion of the surveyed population, it is important to note that challenges and problems can vary depending on geographical location, farm size, and other factors. Also the government launched programmes might have contributed to some extent for achieving the success. However, it seems that still there are many small scale farmers who were not able to reap the benefits. Thus, continuous monitoring and evaluation are essential to identify emerging issues and ensure the sustainability and growth.

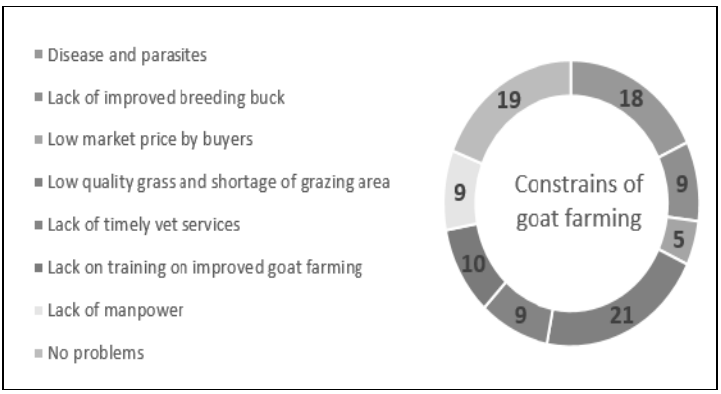

Figure 2. Pie chart showing constrains of goat farming in study area

CONCLUSION

The findings of the survey present a mixed picture of small ruminant farming among the sampled farmers. On the positive note, there is a relatively balanced

representation of both genders within the study population, indicating inclusiveness in the agricultural sector. The high literacy rate among the farmers also supports for likelihood of better dissemination of knowledge and the potential adoption of improved farming practices. However, in terms of technical and logistic inputs goat farmers were found to be struggling. There is a need for capacity-building initiatives to enhance farmers' knowledge and skills in goat farming. Training programs and workshops can provide valuable information on modern goat husbandry practices, including nutrition, breeding, and disease management. Governments need to improvise their existing strategies and develop new strategic plans and policies, coupled with incentives, to encourage subsistence farmers for expanding their goat rearing activities and contribute to sustainable development goals. Additionally, the housing system adopted for goat farming raises concerns about the overall welfare and health of the animals. Addressing these issues through strengthening knowledge and awareness among farmers, as well as providing access to resources and support can contribute to the adoption of better practices and improved animal health outcomes in the region. To decrease market monopoly by small ruminant buyers, need for market research and understanding of market dynamics to ensure that goat farmers receive fair prices for their products is necessary. Furthermore, developing market linkages and exploring value-added opportunities, such as processed goat products, could help improve profitability for farmers.

RECOMMENDATION

Collaboration between the government, academia / researchers, and the farmers is crucial to enhance the traditional production system of small ruminants for development and implementation of strategic plans and programmes to ensure the overall growth and success of small ruminant farming in the Bagmati province.

ACKNOWLEDGEMENT

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REFERENCES

Adhikari, A., Joshi, D. D., Bhandari, D. P., & Acharya, K. P. (2019). Roles of public and private veterinary service providers in rural livestock sector development in Nepal. *Journal of Agriculture and Environment*

Aryal, K. P., Paudel, G. S., Karki, S., & Lama, R. (2019). Smallholder livestock production system and its contribution to household income in Nepal. *Agriculture & Food Security*, 8(1), 12. doi:10.1186/s40066-019-0221-6

Aryal, K. P., Upadhaya, T. N., & Pandey, K. R. (2018). Small Ruminant Production in Nepal: Prospects and Challenges. *International Journal of Livestock Research*, 8(11), 71-81

Bhattarai, N., Gorkhali, N.A., Kolakshyapati, M. and Sapkota, S. (2019). Breeds and breeding system of indigenous and crossbred goats in Nepal. *Goats (Capra)-from ancient to modern*

Central Bureau of Statistics, Nepal. (2019). Agriculture Statistics of Nepal 2018/19. Retrieved from *http://cbs.gov.np/image/data/Statistics/Agriculture/Agriculture%20Monograph%202018-19.pdf*

Cheneau, Y., El Idrissi, A.H. and Ward, D., (2004). An assessment of the strengths and weaknesses of current veterinary systems in the developing world. *Revue scientifique et technique-Office international des épizooties*, *23*(1), 351-360

Devkota, N.R., Ravniyar, G.E., Kolachhapati, M.R. and Timsina, J., (2000). Production problems and potentials of livestock sub-system in the Makalu Barun conservation area of eastern Nepal: A system Analysis. In *16 Th Symposium of the International L. Fanning Systems Association and 4 Latm American Farming Systems Research and Extension Symposia* . 27-29

Dhakal, A., Regmi, S., Pandey, M., Chapagain, T. and Kaphle, K., (2021). Features of small holder goat farming from Chitwan district of Bagmati province in Nepal. *Archives of Agriculture and Environmental Science*, *6*(2), 186-193.

Ghafoor, A., Badar, H. and Maqbool, A., (2017). Marketing of Agricultural Products. *University of Agricultural-Faisalabad*, *1*(5), 114

Growel Agrovet Private Limited. (2015). *Goat Feed Supplements*, Retrieved from *https://growelagrovet.com/goat-feed-supplements/*

Gyawali, M., Bajracharya, R., Shrestha, S., & Karki, S. (2020). *Knowledge, attitudes, and practices of livestock farmers on livestock diseases and their control measures in Nepal*, Heliyon, 6-hills of Nepal

Lambertini, E., Buchanan, R.L., Narrod, C. and Pradhan, A.K., (2016). Transmission of bacterial zoonotic pathogens between pets and humans: The role of pet food. *Critical reviews in food science and nutrition*, *56*(3), .364-418

McDermott, J. J., Staal, S. J., Freeman, H. A., Herrero, M., & Van de Steeg, J. A. (2010) Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science*, 130: 95 –109

National Livestock Breeding Office (NLBO). (2020). Annual Technical Report National Livestock Breeding Office, Pokhara Fiscal Year (2075/76). Retrieved September 24, 2020,

http://nlbo.gov.np/downloadsdetail/4/2020/97666717/

Neopane, S.P. and Pokharel, P.K., 2005. Genetic gain in selected herds of Khari goats over generations in Nepal. AGTR Case Study

Nepali, Megh B, Sapkota, S., Upreti, S., Pokhrel, B. R., Sharma, B., Devkota, H. P., & Amatya, S. M. (2010). Adoption of Goat Production Technology at the Farm Level: A Case of Krishnagandaki VDC, Shyangja District. *Nepal Journal of Science and Technology*, 11: 79–82

Nepali, Megh B., Tiwari, M. R., Sapkota, S., Poudel, H. P., Acharya, B. R., & Gautam, S. (2014). Marketing Constraints to Goats in the Western Hill of Nepal. *Nepal Agriculture Research Journal*: 8: 95–102.

https://doi.org/10.3126/narj.v8i0.11601

Neupane, N., Neupane, H. and Dhital, B., (2018). A socioeconomic view of status and prospects of goat farming in rural areas of Nepal. *Journal of the Institute of Agriculture and Animal Science*, *35*(1), .1-8.

Nnadi, F.N., Chikaire, J., Echetama, J.A., Ihenacho, R.A., Umunnakwe, P.C. and Utazi, C.O., (2013). Agricultural insurance: A strategic tool for climate change adaptation in the agricultural sector. *Net Journal of Agricultural Science*, *1*(1), 1-9.

Panth, B.P., Bhattarai, N., Baral, P., Karki, M., Bhattarai, A. and Sapkota, S., (2021). Factors affecting the profitability from goat farming in Gulmi, Nepal. *Cogent Food & Agriculture*, *7*(1), 1963928.

Poudel, D. (2018). Goat Meat Industry in Nepal: Opportunities and Challenges. Biruwa. *http://biruwa.net/2018/03/goat-meat-industry-nepal-opportunities-challenges*

Redding, L., Chetri, D. K., Lamichhane, D. K., Chay, Y., Aldinger, L., & Ferguson, J. (2012). Animal production systems of small farms in the Kaski district of Nepal. *Tropical Animal Health and Production*, 44(7): 1605–1613

Regmi, P. R., & Ghimire, B. (2019). Small Ruminant Production in Nepal: Status, Opportunities, and Challenges. *Journal of Agriculture and Natural Resources*, 2(1), 1-16.

Robinson, J.A.B. and Buhr, M.M., (2005). Impact of genetic selection on management of boar replacement. *Theriogenology*, *63*(2), 668-678.

Sapkota, S., Gairhe, S., Kolakshyapati, M., Upadhaya, N., Acharya, Y., & Ghimire, Y. (2017). Role of women in goat farming in mid hills of Nepal. *10th National Workshop on Livestock and Fisheries Research in Nepal*, 351–354

Shah, M. K., Pandey, L. N., Bastola, R., Shah, B., Shah, S. (2023). Goat feed resources and feeding management in Mid-Hill of Nepal, 11(1), 1.

Thapa, B., & Baltenweck, I. (2013). Small Ruminant Value Chains in Nepal: Challenges and Opportunities. In: *Small Ruminant Research and Development in Asia* .231-248. Springer

Thapaliya, A. (2020). A comparative study of management practices of commercial and subsistence goat farming of Dhading, Nepal, Department of Animal Science and Aquaculture.the International L. Fanning Systems Association and 4th Latin American Farming Systems Research and Extension Symposia. Santiago

Knowledge, Attitude and Practices (KAP) Related to Zoonotic Disease (Rabies) among Various Stakeholders in Bagmati Province, Nepal

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ABSTRACT

Rabies is a preventable viral zoonoses having huge public health significance. In Nepal, dogs are the principle vector for the transmission of this disease in urban areas, with vaccination and community awareness being the most important preventive measures. This cross sectional study was designed to determine the level of knowledge, attitude and practices (KAP) of various stakeholders regarding the zoonotic disease rabies. It was carried out during the period between April to June 2023 in Kathmandu, Bhaktapur and Lalitpur districts of Kathmandu Valley. 148 respondents from various sectors viz. farmers, students, teachers, meat shop owners, human and animal health workers were interviewed face to face using a pre tested structured questionnaire. Our study found that 99.3 % of the respondents were aware of rabies and 88.5% believed that it is preventable. However, there was a lack of knowledge regarding the clinical signs and clinical manifestation of rabies in the community. Approximately half of the respondents were unaware of rabies being a problem in the community with one third of them denying its existence. One third of the community lacked knowledge about PEP, which highlighted a significance lack in awareness regarding its importance in the disease prevention. The study has recommended for more effective awareness programs to increase the KAP of concerned stakeholders in regards to rabies disease.

Keywords: Zoonoses, OIE, Rabies, KAP, clinical signs

INTRODUCTION

Living organisms that coexist in close proximity are in constant interaction with each other, and when the delicate balance between these entities is disrupted, it puts both their lives at risk, leading to the emergence of various hazards, including zoonotic diseases. The World Health Organization (WHO) defined zoonoses as diseases and infections that naturally spread between vertebrate animals and humans in 1959. Approximately 61% of known human disease-causing pathogens are zoonoses, and among livestock pathogens, 39.4% (243 out of 616) also infect humans (Cleaveland et al., 2001).

In Nepal there six zoonoses; Taeniasis/cysticercosis /Neurocysticercosis, Leptospirosis, Hydatidosis, Brucellosis; Toxoplasmosis and Avian Influenza are identified as priorities zoonotic diseases as they are found to have epidemic potential (Adhikari & Bagale, 2019).

Rabies, caused by a negative-stranded RNA virus belonging to the Lyssavirus genus of the Rhabdoviridae family, has been recognized as one of the oldest diseases, contributing to substantial public health challenges (WHO, 2018). Over 99% of rabies deaths in human result from virus transmission through the bites of infectd dogs however transmission can also occur when infectious materials usually saliva comes into direct contact with human mucosa or fresh skin wounds (GARC, 2013). But bats, raccons and foxes can also transmit the disease (Rupprecht, 2016). Human-to-human transmission through bites is theoretically possible but has never been confirmed (GARC, 2013). The rabies virus attacks the nervous system and show symptom of anxiety, confusion, agitation, hallucinations, excess salivation, problems swallowing and fear of water in case of furious form whereas in paralytic form slow paralyzation, will eventually slip into coma and die (WHO, 2018). Rabies in Nepal occurs in two interrelated epidemiological cycles: an urban cycle involving domesticated dogs and sylvatic cycle involving wildlife (Devleesschauwer et al., 2016).

Every ten minutes, someone in the world loses their life to rabies, making it a continuous global threat. Rabies claims nearly 70,000 human lives annually across more than 150 countries, with Africa and Asia accounting for 95% of the cases (Yousaf et al., 2012). Asia bears a significant burden of rabies, with an estimated 35,172 human deaths each year. India alone contributes to 59.9% of rabies deaths in Asia and 35% globally. In Africa, dog-mediated rabies leads to approximately 21,476 human deaths annually (Hampson et al., 2015). Nepal has reported a range of 20,000 to 40,000 animal bites each year between 2014 and 2018. The highest number of bites, 39,744, was reported in the year 2016/17, whiles the lowest, 20,610, and was reported in 2014/15 (Pantha et al., 2020). Dogs account for over 90% of reported animal bites in Nepal each year (Pantha et al., 2020). In Nepal, rabies causes the death of approximately 100 livestock and 10 to 100 humans annually. Moreover, 1,000 livestock and 35,000 humans require post-exposure treatment (Pantha et al., 2020). Stray and community dogs are responsible for 96% of human rabies cases in Nepal (Devleesschauwer et al., 2016). In terms of animal cases, 230 rabies cases were reported in 2017, and 159 cases were reported in 2018 (Pantha et al., 2020).

The objective of this study was to gain a deeper understanding of the knowledge, attitudes, and practices of the community regarding rabies in

Kathmandu valley. The findings of this study can provide valuable insights for relevant agencies, particularly the Government of Nepal (GoN), to develop and implement effective rabies control plans.

MATERIALS AND METHODS

Ethical approval

No ethical approval was required as it is a survey based study. However, individul consent was taken from the respondents who participated in the study.

Study Area

The study area is located in the Bagmati Province in Nepal. The study will be carried out in Kathmandu valley (Kathmandu, Bhaktapur and Lalitpur) whose total population is 2,996,341 and total area is 933.73 square kilometres (360.52 sq mi) according to 2021 Nepal Census.

Sample size

A survey was targeted to 148 people from students, teachers, farmers, meat shop owners, human and animal health worker's categories in Kathmandu valley using random sampling methods.

Questionnaire design and sampling method

A cross sectional simple random sampling method was employed to select the respondents. Evaluation method including a well designed interview and pre-tested questionnaire containing both open and closed ended questions on different aspects of zoonotic diseases, i.e., awareness, knowledge, risks, etc. Respondents were selected based on profession during questionnaire administration. Accordingly, semi structured questionnaire supplemented with person-person interview was administered.

The first section of questionnaire covered demographic information- including respondent's name, location, gender, age and profession. The second section consisted of questions that can evaluate the knowledge of rabies, its transmission, clinical signs in human and animals , their attitudes and practices toward rabies.

Data collection and analysis

Data was collected by using a questionnaire and interviews to evaluate the level of awareness about the zoonotic diseases among the respondents. The data generated were entered into a MS-Excel-2007 program and were analyzed with the help of SPSS v25for descriptive statistics and possible associations between

the variables.

RESULTS AND DISCUSSION

Socio-demographic status of respondents

A total of 148 respondents were included in this survey study. The study included majority of the male respondents (52 %) and 5.4 % had received informal education. About 54 % were between 14-25 years of age. The majority of the respondents were students (39.9 %) and 18.9 % farmers. 35.1 % of respondents did not have income followed by 21.6 % in between Rs 41,000-80,000.

Table 1. Socio-demographic characteristics of respondents in Kathmandu

Category	Variables	Frequency	Percentage
Address	Kathmandu	86	58.1
	Bhaktapur	26	17.6
	Lalitpur	36	24.3
Gender	Male	77	52
	Female	71	48
Age	14-25	80	54
	26-35	35	23.6
	36-45	21	14.2
	46-55	7	4.7
	56 & above	5	3.4
Education	No formal education	8	5.4
	Primary school	18	12.2
	Secondary school	20	13.5
	College	102	68.9
Occupation	Farmer	28	18.9
	Teacher	15	10.1
	Student	59	39.9
	Meat shop owner	22	14.9
	Human health worker	11	7.4
	Animal health worker	13	8.8
Income level	Rs 10,000-40,000	1	7
	Rs 41,000-80,000	32	21.6
	Rs 81,000-1,50,000	4	2.7
	Did not have	52	35.1

Knowledge of the respondents on rabies

Out of the 148 respondents, 147 individuals (99.3%) reported being aware of rabies. The results indicated that 131 individuals (88.5%) believed that rabies is preventable. A concerning 89.9% of the respondents believed that rabies can be transmitted to humans only through the bite of an infected animal. The study revealed a lack of knowledge regarding the clinical signs of rabies among all the

respondents. It confirmed that the community had limited awareness concerning the clinical manifestations of rabies. Additionally, 41.9% of the respondents were not aware of responsible dog ownership.

Table 2. Knowledge of rabies in the respondents

Category	Variables	Frequency	Percentage
Heard about rabies	Yes	147	99.3
	No	1	0.7
Is rabies preventable	Yes	131	88.5
	No	17	11.5
Transmission	Do not know	2	1.4
	Through contact with infected animal's saliva, urine or feces	13	8.8
	Through the bite of an infected animal	133	89.9
Are animals infected with rabies	Yes	130	87.8
	No	2	1.4
	Do not know	16	10.8
Vaccine available for rabies	Yes	120	81.1
	No	1	0.7
	Do not know	27	18.2
Treatment after symptoms appear	Yes	22	14.9
	No	73	49.3
	Do not know	53	35.8
Common signs and symptoms in animals	Behavioral changes (aggression or withdrawal), Excessive drooling or difficult in swallowing, Changes in vocalization or inability to bark, Sensitive to light or sound, Seizures or convulsion	127	85.8
	Bellowing, aggressive, salivation drooling	1	0.7
	Excessive drooling or difficult in swallowing, Restlessness, Sensitive to light or sound	17	11.5
	Muscular weakness or paralysis	3	2
Signs and symptoms in human	Difficulty swallowing, Excessive salivation, Difficulty in breathing, Paralysis, Hydrophobia	11	7.4
	Excessive salivation, Difficulty in breathing, Hydrophobia	12	8.1
	Fever, headache and fatigue, Restlessness, Difficulty swallowing, Excessive salivation, Difficulty in breathing, Paralysis, Convulsion, Hydrophobia	86	58.1
	Restlessness, Difficulty swallowing, Excessive salivation, Difficulty in breathing, Paralysis, Convulsion, Hydrophobia	16	10.8
	Hydrophobia	22	14.9
	Photophobia	1	0.7
Government program for rabies in community	Yes	45	30.4
	No	38	25.7
	Do not know	65	43.9

Reporting of community rabid animals to authority	Yes	106	71.6
	No	42	28.4
Awareness about responsible dog ownership	Yes	86	58.1
	No	62	41.9

Attitudes of respondents to rabies

The study revealed that 122 individuals (82.4%) acknowledged that rabies is a fatal disease, while 37 individuals (25%) were unaware of its existence as a problem within the community, and 34 individuals (23%) outright denied its presence.

Table 3. Attitudes of respondents to rabies

Category	Variables	Frequency	Percentage
Agree rabies is fatal	Yes	122	82.4
	No	4	2.7
	Do not know	22	14.9
Rabies a problem in community	Yes	77	52
	No	34	23
	Do not know	37	25
Importance to vaccinate pets against rabies	Yes	131	88.5
	No	1	0.7
	Do not know	16	10.8
Willingness to receive PEP	Yes	99	66.9
	No	3	2
	Do not know about PEP	46	31.1
Important to report rabid animals to authority	Yes	126	85.1
	No	1	0.7
	Do not know	21	14.2
Responsible pet ownership good for community	Yes	98	66.2
	No	2	1.4
	Do not know about RPO	48	32.4
Agree self and family at risk of rabies	Yes	39	26.4
	No	71	48
	Do not know	38	25.7
Agree rabies elimination is necessary	Yes	134	90.5
	No	1	0.7
	Do not know	13	8.8
Willingness to vaccinate dogs and take to vets regularly	Yes	122	82.4
	No	3	2.1
	Do not know	23	15.5

The results indicated that 46 respondents (36.1%) lacked knowledge about post-exposure prophylaxis (PEP), highlighting a significant lack of awareness in the community regarding PEP. The study substantiated that there was a substantial deficit in understanding PEP among the community members. Among the 148

respondents, 71 individuals (48%) denied any risk of rabies to themselves or their families, indicating a concerning level of denial. Our findings suggest the presence of a gap in the implementation of dog population control practices

Practices of respondents to rabies

The study revealed that 81 respondents (54.7%) had vaccinated their pets against rabies, indicating a positive step towards prevention. A significant proportion of respondents, 68.9%, were aware of the importance of cleaning wounds thoroughly with soap and water after an animal bite or scratch. However, the results showed that only 43.9% actively participated in community-based initiatives or campaigns related to rabies prevention and control, while 33.1% of respondents were unaware of such initiatives altogether.

Table 4. Practices done by respondents in regards to rabies

Category	Variables	Frequency	Percentage
Vaccinated pet against rabies	Yes	81	54.7
	No	18	12.2
	Do not have a pet	49	33.1
Ensure up to date pet vaccination	Yes	103	69.6
	No	45	30.4
Confine or put pets on lease to minimize contact with stray animal	Yes	101	68.2
	No	47	31.8
Report aggressive or unusual behavior in stray animal to authority	Yes	80	54.1
	No	68	45.9
Take immediate action if self or someone in family is bitten or scratched by an animal	Yes	130	87.8
	No	18	12.2
Clean wound with soap and water after being bitten	Yes	102	68.9
	No	9	6.1
	Not applicable as never bitten	37	25
Promptly seek medical help post bite	Yes	120	81.1
	No	28	18.9
Report animal bite to respective authority in the area	Yes	73	49.3
	No	75	50.7
Active participation in community based initiatives or campaigns related to rabies prevention and control	Yes	65	43.9
	No	34	23
	Do not know	49	33.1
Share information and educate other family members about the importance of rabies prevention measures	Yes	122	82.4
	No	26	17.6
Provide any kind of birth control for your dog	Yes	51	34.5
	No	45	30.4
	Do not own a pet	52	35.1
Raising public awareness about rabies is crucial in controlling disease	Yes	144	97.3
	No	4	2.7

This finding highlighted a gap in active participation in rabies-related programs within the community. Encouragingly, 82.4% of the respondents shared information about the importance of rabies prevention measures with other family members, indicating positive practices in the community. However, the study also found that 30.4% of respondents did not provide any form of birth control for their dogs, which could be considered a potential risk factor for rabies elimination programs.

Discussion

Rabies is a public health concern in Kathmandu Valley, where dog bite is the principle cause of transmission of this disease (G.N and J.N, 2001). Our findings draw attention to the main factor that the lack of knowledge about clinical signs could be considered a potential risk factor for rabies elimination programs. The study further confirmed that the community had limited awareness concerning the clinical manifestations of rabies and the concerned stakeholders can be targeted for further improving the behavioral and rabies control practices. We observed a high level of awareness in respondents regarding rabies being a fatal disease, however a concerning percentage did not know about its existence as a public health problem within the community. It was also observed that more than one-third of the respondents lacked knowledge about post-exposure prophylaxis (PEP), highlighting a significant lack of awareness in the community regarding PEP. The study highlighted that there was a substantial deficit in understanding PEP among the community members. More than half of the respondents denied any risk of rabies to themselves or their families, indicating a concerning level of denial. Our findings suggest the presence of a gap in the implementation of dog population control practices and rabies awareness programs/ campaigns.

Most of the respondents expressed that they vaccinated their pets regularly and confined/ put their pets on the lease to minimize contact with stray animals. This suggests that the owners are aware about the public health concern of the rabies and that vaccination is the most effective preventive and control measure. Majority of the people felt that stray dogs are a major problem in the community and that their population needs to be controlled for elimination of rabies. This might be due to different awareness campaigns that are organized regularly in and around the capital city by different government agencies, private institutes and the kennel clubs (Devleesschauwer et al., 2016; DoAH, 2013).

CONCLUSION AND SUGGESTIONS

This study provided an understanding on the variability of knowledge, attitudes and practices related to rabies disease among different stakeholders in Kathmandu valley. City area is at high risk for rabies due to higher

concentration of street dogs. Activities such as integration of zoonotic disease risk education should be done in primary and secondary school curriculum. Regular awareness campaigns on zoonotic disease should be done in community level in Kathmandu valley. Follow up studies need to be done to identify the gaps in the implementation of dog population control practices and rabies awareness programs/ campaigns in order to stop future spillovers of rabies in the community. The findings of this study can be used by concerned government bodies and authorities to further develop intervention strategies and policies related to rabies disease control in both human and animals.

REFERENCES

Bagale, K.B., Adhikari, R., & Acharya, D. (2023) Regional variation in knowledge and practice regarding common zoonoses among livestock farmers of selective districts in Nepal, *PLoS Neglected Tropical Disease*, 17(2), e0011082.*https://doi.org/10.1371/journal.pntd.0011082*

Devleesschauwer, B., Aryal, A., Sharma, B. K., Ale, A., Declercq, A., Depraz, S., Gaire, T. N., Gongal, G., Karki, S., Pandey, B. D., Pun, S. B., Duchateau, L., Dorny, P., & Speybroeck, N. (2016). Epidemiology, Impact and Control of Rabies in Nepal: A Systematic Review. PLOS Neglected Tropical Diseases, 10(2), e0004461. *https://doi.org/10.1371/journal.pntd.0004461*

Global Alliance for Rabies Control, (2013). World Rabies Day: Rabies elimination could save the world $124 billion annually. Retrieved from *https://rabiesalliance.org/media/press/world-rabies-day-rabies-elimination-could-save-the-world-124-billion-annually*

Gongal, G.N., Rai, J.N. (2001). Human rabies in Nepal. In: *Fourth International Symposium on Rabies Control in Asia.*, Dodet B, M.F.-X., Heseltine E, editors, ed. (Paris, John Libbey Eurotext), pp. 231–237.

Hampson, K., Coudeville, L., Lembo, T., Sambo, M., Kieffer, A., Attlan, M., Barrat, J., Blanton, J. D., Briggs, D. J., Cleaveland, S., Costa, P., Freuling, C. M., Hiby, E., Knopf, L., Leanes, F., Meslin, F. X., Metlin, A., Miranda, M. E., Müller, T., & Dushoff, J. (2015). Estimating the Global Burden of Endemic Canine Rabies, *PLOS Neglected Tropical Diseases*, 9(4), e0003709 https://doi.org/10.1371/journal.pntd.0003709

Pantha, S., Subedi, D., Poudel, U., Subedi, S., Kaphle, K., & Dhakal, S. (2020). Review of rabies in Nepal. *One Health*, 10. *https://doi.org/10.1016/j.onehlt.2020.100155*

Rupprecht, C. (2016). Overview of Rabies - Nervous System. *Veterinary Manual*. Retrieved from: *http://www.merckvetmanual.com/nervous-system/rabies/overview-of-rabies*

World Health Organization, (2018). Zero by 30: The Global Strategic Plan to End Human Deaths from Dog-Mediated Rabies by 2030. Retrieved from *https://www.who.int/rabies/resources/9789241513838/en*

Yousaf, M. Z., Qasim, M., Zia, S., Rehman Khan, M., Ashfaq, U. A., & Khan, S. (2012). Rabies molecular virology, diagnosis, prevention and treatment, *Virology Journal*, 9(1), 1-5. https://doi.org/10.1186/1743-422x-9-50

Transport Stress in Goats and its Effect on Lipid Peroxidation on The Basis of Serum Malondialdehyde Level

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ABSTRACT

This study aimed to determine lipid peroxidation effect that can be caused by transportation stress in goats. Transportation is an unavoidable component of livestock production and involves many physical and psychological stressors like exaust fumes, UV light, pollutants and noise of engine that results in oxidative stress. A comparative study of serum MDA level in goats which were undergone transportation stress and goats which were reared in intensive farm was done taking samples from Khasi bazar Kalanki (for treatment group n=30) and from different intensive goat farm near by Kirtipur (control group n=30).Treatment Groups were subdivided into three different levels of treatment on the basis of transported distance in kilometer as short (100 to less than 250km), Medium (250 to less than 400km) and Long (400 to less than 550km). Mean ± SD MDA levels in nmol/ml of treatment group was obtained to be 4.30 ±1.64 which was greater than control group 2.07± 0.66.Pearson's correlation (r)between distance travelled and MDA was obtained to be 0.92,suggesting that there was significantly high correlation between distance travelled and MDA level, which was statistically significant ($p < 0.01$). The levels of treatment were then compared with the control through an ANOVA, which revealed a statistically significant ($F = 109.4007$, $p< 0.01$) effect of treatment levels on MDA suggesting that animals were under huge stress during travel which may ultimately deteriorate their health and even meat quality.

Key words: Lipid peroxidation, MDA, Oxidative stress, transportation stress

INTRODUCTION

Transportation of animals is a vital component of livestock production. For many purpose domestic animals are transported i.e. breeding, biomedical purposes, slaughter etc. During transportation animals have to face many

stressful conditions like loud noise of engine , vibration and oscillation of means of transport, inadequate ventilation and many stressful factors such as handling, loading, unloading, unfriendly environments, social regrouping. Lack of good management of animals during transportation and deprivation of their food and water, exhaust fumes ejected from vehicles and other pollutants, distance of road and climate also play role in producing stress.

Both the physical and psychological stress promotes hypophyseal–pituitary–adrenal axis activity, causing an increased hypercortisolaemia (Snow and Mackenzie, 1977) and also cause sympathetic–adrenal axis activation, which results in catecholamine release (Freg et al., 1985) and the reaction and response of animals to stressors depends on the duration and intensity of the these stressors, it also depends on the animal's previous experience, its physiological status and other immediate environmental restraints .Stress can be the output of biochemical and physiological effects in animals. Animals show reactions and responses and these responses are changed with the duration of transport (Padalino, 2015).

Free radicals in animals are generated from endogenous sources like that from reactions within mitochondria, peroxisomes and various enzymatic systems or from exogenous sources such as transportation stress and these free radicals have toxic effects on biomolecules like lipids, proteins, DNA and carbohydrates. Therefore, it can cause functional and structural changes and deformities in cells (Sinastra and Demarco, 1995). Free radicals cause lipid peroxidation in lipids, resulting in membrane damage. One of the products generated because of free radicals peroxidation of two or more poly unsaturated fatty acids (PUFAs) in lipids in cell membranes is Malondialdehyde (MDA). MDA is most commonly used oxidative biomarker and indicator of oxidative degradation and tissue damage of lipids.

Free radicals and reactive oxygen species (ROS) in living systems can be produced during the organism's own metabolism for example leaking of electrons from coenzyme Q onto oxygen during electron transport chain leading to the formation of superoxide radical. These radicals are also produced by cytochrome P-450 and NADPH. Superoxide radical is the precursor for the most other ROs and this propagates oxidative chain of reactions . Free radicals can also be produced in animals body by various exogenous ways of activation of ROS like stressful conditions. Exhaust fumes, UV light and pollutants are the major exogenous sources of ROS which animal might be encountered when they are transported for long distance (Schroder and Krutmann,2005).

Several research done by animal biologists has shown that there is oxidative stress and corresponding lipid peroxidation effect in animals like horse, camel, cattle but there is little research in oxidative status of goat and most importantly the comparative study between goat which has undergone transportation stress and goat under normal condition has not yet been done thus the present study had tried to compare oxidative status of goats under transportation stress from that of normal goat.

Nowadays consumers have become increasingly aware and interested in how animals are raised and handled before slaughter, so it is important to acknowledge the effects of transit on animal well-being. These include the potential for injury and fatigue during transit as well as psychological stress of handling .The combination of these stressors that accompany transit of animals activate many biological pathways and cell signaling molecules leading to the development of oxidative stress.

Oxidative stress is defined as a disturbance in the prooxidant–antioxidant balance resulting in favor of prooxidants or those which reduces oxidative damage. (Sies, 1985). Lipid oxidation is also a primary cause of quality defects in meat products, including changes in parameters like flavor, color, texture, and nutritive value (Gray et al., 1996). Historically, oxidative stress research has focused mainly on aging and disease etiology in humans. However, in the past 20 yr, oxidative stress has gained the attention of animal scientists seeking to understand the role and implications of oxidative stress on livestock health, its efficiency, and quality of meat. Premortem oxidative stress has the potential to change or affect postmortem oxidative status and even meat quality (Xing et al., 2019) as muscle could not be able to maintain the cellular antioxidant defense system postmortem, which ultimately leads to an accumulation of Reactive oxygen species (Renerre et al., 1996).

MATERIALS AND METHODS

Selection of study Area

For the study Khasi bazaar /goat market at Kalanki was purposely selected for the collection of blood from stressed goats as it is the major area in Kathmandu municipality where goats from various areas of country are carried to and collected for sale. Control goats were selected from intensive goat farms nearby Kirtipur area like Hygeinic Agro, Kharibot Thankot; Bishnu Karki Agro; Naikap, New goat Farm, Kirtipur.

Sample size

Sixty goats (Terai breed) comprising of 30 goats under transport stress and 30 age andsex matched goats under normal environmental condition.

Distance travelled by animal was categorized as short (100 to less than 250 km), medium (250 to less than 400 km), and long (400 to less than 550 km), which represented different levels of treatments. The levels of treatment were compared with the control through an ANOVA.

Sampling procedure

Goats brought from different sites of the country for selling in Khasi bazaar (Goat market) were randomly selected for the study. Immediately after unloading the goats their transported distance was noted by the enumerator. Similarly intensive goat farms were purposely selected and visited for obtaining blood samples from normal healthy goat (control).

Blood collection and MDA monitoring

5 ml of blood samples were taken from each goat's jugular vein and collected in plain tube with clot activator and centrifuged for 10 minutes at 3000 r.p.m. after approximately 30 minutes of waiting time and their serums were separated. The collected serum samples were transferred into 1.5 ml eppendorf tubes by micropipette and stored at -24□C.

MDA estimation by ELISA method

Standard wells, testing sample wells were set in Microelisa Stripplate in duplicate. Standard 50µl was added to standard well and testing sample 10µl was added in sample well. Sample Diluent 40µl was then added to testing sample well. Nothing was added in blank well. 100µl of HRP-conjugate reagent was placed to each well, and covered with an adhesive strip and incubate for 60 minutes at 37°C.Each well was aspirated and washed 5 times with 400µl wash solution by auto washer. After the last wash, any remaining wash Solution was removed by aspirating or decanting. The plate was inverted and blotted against clean paper towels.50µl chromogen solution A and B was added to each well and gently mixed and incubated for 15 minutes at 37°C. 50µl. Stop Solution was added to each well. The colors in the wells were changed from blue to yellow. Optical Density (O.D.) was observed at 450 nm using a microtiter plate reader within 15 minutes.

Analysis of data

The distance travelled was categorized as short (100 to less than 250 km),

medium (250 to less than 400 km), and long (400 to less than 550 km), which represented different levels of treatments. The levels of treatment were then compared with the control through an ANOVA. Karl Pearson's correlation coefficient value was calculated and ANOVA test was done using Origin lab 2018 to know about any correlation between MDA and Transport duration.

RESULTS AND DISCUSSION

Goats were divided into two groups. Treatment Group, which were goats under the transportation stress and Control Group, which were goats reared in intensive goat farm. Treatment Groups was subdivided into three different levels of treatment on the basis of transported distance in kilometer as short (100 to less than 250km), Medium (250 to less than 400km) and Long (400 to less than 550km). Mean±SD MDA levels in nmol/ml of treatment group were obtained to be 4.30 ±1.64 which was greater thancontrol group 2.07± 0.66.

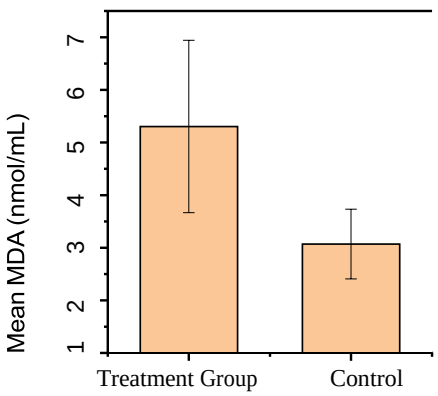

Figure 1. Comparison of mean ± SD of MDA levels between treatment (goats under the transportation stress) andcontrol groups

Similarly Pearson's correlation (r) between distance travelled and MDA was obtained to be 0.92, suggesting that there was significantly high correlation between distance travelled and MDA level. , which was statistically significant ($p < 0.01$). Further, the linear regression between distance and MDA was performed (Fig. 2), which wasalso statistically significant ($p < 0.01$).

Mean ± SD MDA level of long distance treatment group was found to be 6.33 ± 0.85 nmol/ml, which was higher than short distance (2.79 ± 0.59 nmol/ml and medium distance (3.80 ± 0.45 nmol/ml). That indicated higher rate of lipid per

oxidation and more oxidative stress in animals which were undergone long distance transportation stress.

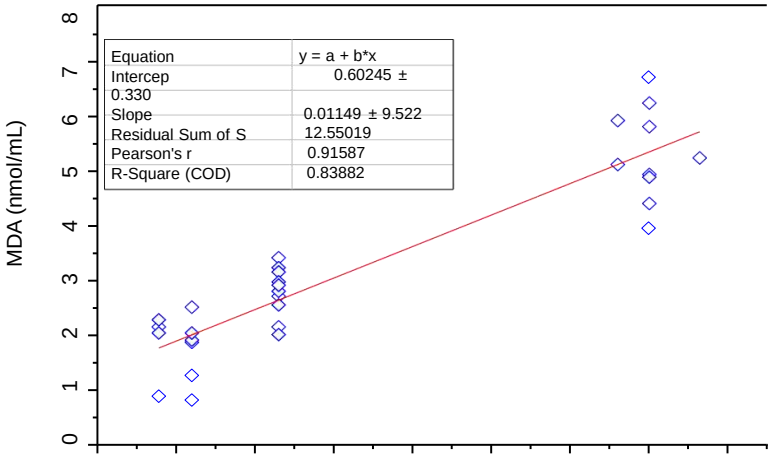

Figure 2. Relationship between distance travelled and MDA levels

Table 1. Mean ± standard deviation (SD) of MDA levels in different transport distance groups.

Transport distance groups	MDA (nmol/ml)
Short distance	2.79 ± 0.59
Medium distance	3.80 ± 0.45
Long distance	6.33 ± 0.85
Control	2.07 ±0.66

DISCUSSION

Present study revealed significant rise in MDA, which is an indicator of lipid peroxidation in goats under transportation stress as compared to control. The value of MDA of goats which has undergone short distance transportation stress was comparable to that of control but as transportation distance increases the value of MDA was found to be significantly larger this might be due to increase in free radical generation a result of higher duration of transportation stress. Similar study done in horses has shown to induce a significant increase in plasma MDA concentrations compared to baseline values when they have undergone 12hr journey (Onmaz *et al.*, 2011). Similarly study done by Mohammed *et al.*, (2015) in dromedary camel to find out the impact of transport distance on stress biomarkers disclosed the positive correlation between MDA

and transportation distance. Another study done in sheep by Hilal *et al.* (2021) to determine the effects of transport and altitude on hormones and oxidative stress also revealed the similar fact that transportation and altitude in sheep causes stress and raises the level of oxidative stress parameters like MDA significantly.

CONCLUSION AND SUGGESTIONS

In this study, the oxidative stress parameter (MDA) in goats which had undergone transportation stress was obtained to be higher in comparison to goats which were reared in intensive goat farms. It was also determined that the extent of oxidative stress in goat caused by transportation increases as transportation distance increased imparting knowledge on probable effect of lipid peroxidation due to stressors during transportation like exhaust fumes, UV light and pollutants. High levels of MDA deteriorate the animal health as well as degrade the meat quality. This study suggests and also prioritizes animal welfare to develop protocol for animals like feeding antioxidant such as vit E ,vit C, carotenoids, Selenium etc prior to transport to cope with stress and to prevent further deterioration of their health.

REFERENCES

CAMEL (CAMELUS DROMEDARIUS) (2015). *Emirates Journal of Food and Agriculture*, 27(6), pp. 507–512. doi:10.9755/ejfa.2015.04.058.

Gray, J. I., E. A. Gomaa, and D. J. Buckley. (1996). Oxidative quality and shelf life of meats. *Meat Sci*. 43S1:111–123. https://doi.org/10 .1016/0309-1740(96)00059-9

Mohammed, E. K., Youssef, C., Rita, B., Kaoutar, B., Islah, L., Najia, E. A., Abdarrahmane, B. and Bernard, F.(2015). *Impact of transport distance on stress biomarkers levels in dromedary*

Onmaz, A. C., R. Van Den Hoven, V. Gunes, M. Cinar, and O. Kucuk. (2011). Oxidative stress in horsesafter a12-hours transport period. Rev. *Médicine Vétérinaire* 162:213–217.

Renerre, M., F. Dumont, and P. Gatellier. (1996). *Antioxidant enzyme activities in beef in relation to oxidation of lipid and myoglobin*. M

Schröder, P., and J. Krutmann. (2005). Environmental oxidative stress—Environmental sources of ROS. Pages 19–31 In: *Oxidants and Antioxidant Defense Systems. Vol. 2. T. Grune, (ed*.) Springer, Heidelberg, Germany

Sies, H. (1985) *Oxidative stress: Introductory remarks. Pages 1–8 in Oxidative Stress. H. Sies, (ed),* Acad.Press, London, UK.

Sinatra ST, DeMarco J. (1995). Free radicals, oxidative stress, oxidized low density lipoprotein (LDL), and the heart: antioxidants and other strategies to limit cardiovascular damage. *Conn Med.* 1995 Oct; 59(10):579-88. PMID:7587173.

Tozlu Çelik, H., Aslan, F. A., Us Altay, D., Kahveci, M. E., Konanç, K., Noyan, T., & Ayhan, S. (2021). Effects of transport and altitude on hormones and oxidative stress parameters in sheep. *PloS one*, *16*(2), e0244911. *https://doi.org/10.1371/journal.pone.0244911*

Xing, T., F. Gao, R. K. Tume, G. Zhou, and X. Xu. (2019). Stress effects on meat quality: A mechanisticperspective. Compr. *Rev. Food Sci. Food Saf*. 18:380–401. *https://doi.org/10.1111/1541-4337.12417.*

From the Desk of Chief Editor

It is our pleasure to bring this 25th volume of the Nepalese Journal of Agricultural Sciences (NJAS) in light with the financial assistance of the Ministry of Agriculture and Livestock Devevelopment (MoALD) of Bagmati Province, Hetauda, Nepal. That assistance was indeed a part of bigger support for establishing Agriculture Research and Extention Center (AREC) under the Directorate of Research and Training (DORT) of Himalayan College of Agricultural Sciences and Technology (HICAST), Kirtipur, Kathmandu, Nepal. It is a matter of "misfortune" (if some one likes this word) of the farmers and entrepreneurs in the Developing countries that agricultural research outputputs have not been timely taken to the knowledge and practices of the entrepreneurs/ growers for addressing various SDGs. This initiative of the MoALD of Bagmati Province and HICAST was indeed meant for squeezing that gap, which is hindering the quicker processes of agricultural productivity and production growth. HICAST family has extended heartfelt thanks to the MoALD of Bagmati Province for this meaningful assistance.

This volume of the journal has two sections: i) original articles and review articles; and ii) the articles of the research projects conducted with the support of the MoALD. In the first section, there are seven original research articles written by the scientists, researchers and students of Nigeria, Russia and Nepal, and three review articles written by the faculties and students of HICAST. Topics of these articls are quite diverse and pertinent to agricultural development and livelihoods in developing countries of the tropics and subtropics. In the second section, there are altogether fifteen articles, which are based on researches conducted in various fields such as organic agriclture, integrated pest management (IPM), bio-pesticide (*Trichoderma*), hydroponic farming, draought tolerance, poultry meat production, veterinary diseases and their management, and animal nutrition in Nepal and other countries of the tropics and subtropics.

This publication, which is freely accessible online to all readers, will be helpful in taking the resurch results and recommendations to the concerned growers, entrepreneurs and implementing agencies. We would also like to extend our sincere thanks to all contributing Authors / Co-Authors, peer reviewers and editors for their engagement in this academic endeavor.

Dr Binayak P Rajbhandari, PhD
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