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MODIFIED ATMOSPHERIC PACKAGING AS ALTERNATIVE TO THE CONVENTIONAL PACKAGING FOR POSTHARVEST QUALITY AND SHELF LIFE OF CUCUMBER

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ABSTRACT

A comparative impact analysis about conventional packaging materials and modified atmosphere packaging (MAP) on the postharvest life of cucumber was conducted in the post-harvest lab of HICAST on mid June 2023. The experiment was conducted under ambient condition of 28-32℃ and 70-80% relative humidity. Five different treatments consisting of one control and 4 different packaging materials which included polythene bag, perforated polythene, muslin cloth and MAP bag were applied to access the effect on post-harvest life and different quality parameters of cucumber. The experimental setup was based upon completely randomized design with each treatment being replicated four times. The physiological loss of weight (PLW) across treatments ranged from 0.35% to 9.37% (days 1-4) and 1.13% to 9.55% (days 4-8) with cucumbers in non-perforated polythene bags recording lowest PLW at 0.35% and 1.13% in both cases. The firmness of cucumber initially which was at 2.856 kg/cm^2 decreased to a range of 1.410 to 2.410 kg/cm^2 by day8 with biodegradable MAP bags retaining the maximum firmness while the control group had lowest. MAP also ensured stable TSS, delayed chlorophyll degradation, and maintained cucumber freshness throughout storage. During the experiment MAP demonstrated superior performance in preserving various quality parameters and also significantly enhanced cucumber marketability over extended storage period. While polythene can reduce weight loss, it raises problems with firmness, marketability of the packaged material along with its pertinent environmental issues. The MAP stands superior over conventional polythene packaging by preserving the overall quality of cucumbers for longer period.

Key words: MAP, Post-harvest, Cucumber, Packaging Materials, shelf life

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an economically important crop which is used for pickling and eaten fresh. At immature stage cucumbers are widely consumed as salad (Jat *et al.,* 2021). Globally, cucumber is the third most cultivated vegetable after tomatoes and onions with China being the largest producer of cucumber. China accounts to 80% of total production of cucumber in the world followed by turkey in second position. The total area under cucumber production in the year 2021 was 2,172,193 ha with total production being 93,528,796 mt and the yield was 430,573 kg/ha (FAO, 2021). In Nepal it is cultivated from terai to mid hills with altitude ranging from 100-1800masl. The area, production, productivity of cucumber in Nepal is 9,978 hectare (ha), 152,862 ton (t), and 15.32 t/ha respectively (MoALD, 2022).

Cucumber fruits are a good source of antioxidants, magnesium, and vitamin C and are rich in dietary fiber (Shi *et al*., 2015). Fresh consumption of this crop provides a variety of health benefits including valuable antioxidant, anti-inflammatory, and anti-cancer benefits (Mukherjee *et al*., 2013). Despite being high-value cash crops, Nepalese farmers continue to experience low return from cucumber cultivation and one of the major reasons for it is the perishable nature of cucumber and improper way of storing and packaging after harvest and insufficient knowledge of proper post-harvest technology (Khanal *et al.,* 2020). Cucumber fruits have short storage duration, limited to less than 14 days due to loss of weight and firmness, discoloration, and fungal infections (Kahramanoğlu & Usanmaz, 2019). Cucumbers are classified as perishable fruits due to their high moisture content and delicate nature. As with many other fruits and vegetables, cucumbers have a limited shelf life and can spoil relatively quickly if not stored properly.

The post-harvest loss of cucumber fruit is around 27.1% (Kitinoja *et al*., 2018). It has been estimated that postharvest losses range from 20% to 30% for fresh fruits and vegetables, and in adverse conditions, these losses can exceed 50%. These losses in vegetables occur due to various factors such as harvesting at an inappropriate stage of maturity, direct packing, and shipping without removing field heat, inadequate packaging and sorting, subpar transportation and handling practices, and insufficient storage facilities (Bhattarai, 2021). However, the most significant losses occur during transportation, starting from the field to the collection center, and further on to the wholesale market and retail outlets (Adhikari & G.C., Post-harvest practices of horticultural crops in Nepal: Issues and management, 2021).

Modified atmosphere packaging (MAP) is a technology that has revolutionized the way we store and transport perishable food products. MAP works by modifying the composition of the air surrounding the food product, creating an environment that slows down spoilage and extends the shelf life of the product. MAP is an active or passive dynamic process of altering gaseous composition within a package. It relies on the interaction between the respiration rate of the produce, and the transfer of gases through the packaging material, with no further control exerted over the initial gas composition (Farber *et al*., 2003). Passive MAP can be generated inside a package by relying on the natural process of produce respiration and film permeability to attain the desired gas composition over time (Farber *et al.*, 2003). While, active MAP is a rapid process of gas replacement or displacement, or the use of gas scavengers or absorbers to establish a desired gas mixture within a package (Charles *et al*., 2006). This involves the addition of active agents into packaged food product, such as O_2, CO_2 and ethylene scavengers (Sandhya, 2009). This study aims to explore the potential of MAP as a packaging alternative for cucumbers, with broader applicability in commercial and household packaging for various fruits and vegetables in the future.

MATERIALS AND METHODS

The study was carried out on mid June 2023 in the post-harvest laboratory of HICAST College located at Kirtipur, Kathmandu. The research Centre lies at 27.6◦N latitude receiving annual rainfall of about 1025 mm with. Brishma hybrid F1 variety of cucumber was selected for research purpose because it seemed to be one of the most popular varieties which is being cultivated by local farmers in and around Kathmandu valley. The experiment was carried in ambient environmental condition with temperature ranging from 28 to 32℃ and 70-80% relative humidity (RH). The experiment was designed in completely randomized design (CRD) with 5 treatments and each treatment was replicated 3 times. The layout of the experiment was done based on lottery method and treatment was randomized to each experimental plot in such a way that each experimental plot has equal chance of getting a treatment. Overall, there was 20 experimental units and within each treatment there was 3 cucumber fruits. Experimental units were properly labeled for identification of the treatment applied.

Table 8. Outline of treatments

T1	Control	Cucumbers were kept as it is without any treatments
T2	Polythene Bag	High density polyethylene (HDPE) bags of thickness 40µ were used. No perforations were done.
T3	Perforated Polythene Bag	HDPE bags of thickness 40µ were used by making perforations. Overall, there were 12 perforations.
T4	Muslin Cloth	Muslin cloths were wrapped around the cucumbers.
T5	MAP Bags	Modified atmosphere packaging (MAP) bags which is biodegradable was used as packaging material.

Physiological loss in weight (PLW)

PLW was recorded by calculating the loss in weight of the fruit during storage over initial values.

$$\text{PLW}(\%) = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100\%$$

Chlorophyll content

The chlorophyll content was determined using the Wellburn's technique. Cucumber's outer peel samples weighing 0.2 g was extracted with 7 mL of 80% acetone and the optical density of the solution was measured at 645 nm and 663 nm (Wellburn, 1994). The chlorophyll content was determined by using equation given below:

- Chlorophyll a (mg/g) = (12.70 × A663 - 2.690 × A645) × V / (1000 × W)
- Chlorophyll b (mg/g) = (22.90 × A645 - 4.680 × A663) × V / (1000 × W)
- Total chlorophyll content = chlorophyll a + chlorophyll b

Where, V= Volume of acetone used and W = weight of the fresh cucumber peels

Total soluble solids (TSS)

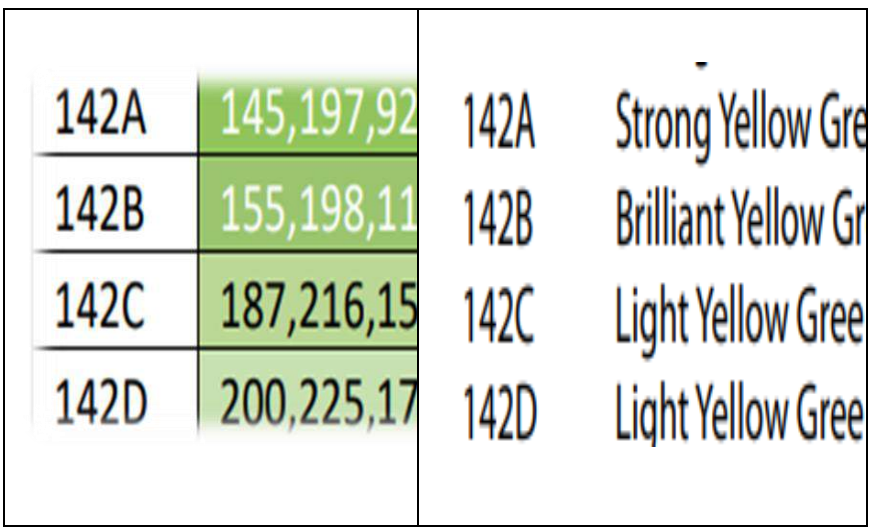
TSS was measured using refractometer and expressed in °Brix.

Firmness

The firmness of cucumber under different treatments was measured using fruit penetrometer and expressed in kg/cm^2.

Color of cucumbers

The color of cucumber was compared against a color chart with standardized color swatches and the color of the cucumber sample to the closest swatch on the chart of Royal Horticulture Society was matched to determine the color intensity or shade (Royal Horticulture Society, 2019). Every colour code specified a certain colour name and category whereas the alphabet A, B, C and D indicated the colour intensity within the category (Royal Horticulture Society, 2015).



Source : Royal Horticulture Society, (2019) , Royal Horticulture Society , (2015)

Statistical analysis

The data were systematically arranged and tabulated using MS-Excel program whereas statistical analysis was done using GENSTAT software.

RESULTS AND DISCUSSION

Physiological loss in weight (PLW)

The result showed that the different treatment had significant impact on the physiological loss in weight (PLW) of cucumber over the course of storage. During the first 4 days of storage all treatments namely T2, T3, T4, T5 had shown significantly lesser PLW than that of control. The PLW was maximum in control (T1) followed by muslin cloth (T4). The PLW of cucumber in control from Day

1 to Day 4 of the storage period was 9.366% whereas cucumber stored by wrapping in muslin cloth (T4) lost 5.568% of its initial weight during first 4 days of storage. The PLW was minimum in polythene bag without perforation (T2) in which the stored fruit lost only 0.355% of its initial weight during first 4 days of storage. Likewise, cucumbers stored in MAP bag (T5) and perforated plastic bag (T3) lost significantly less weight than both control and muslin cloth. Cucumbers in MAP bag lost 1.676% of its initial weight for 4 days storage period meanwhile cucumbers in perforated plastic bag (T3) lost 1.727% of its initial weight in the same period.

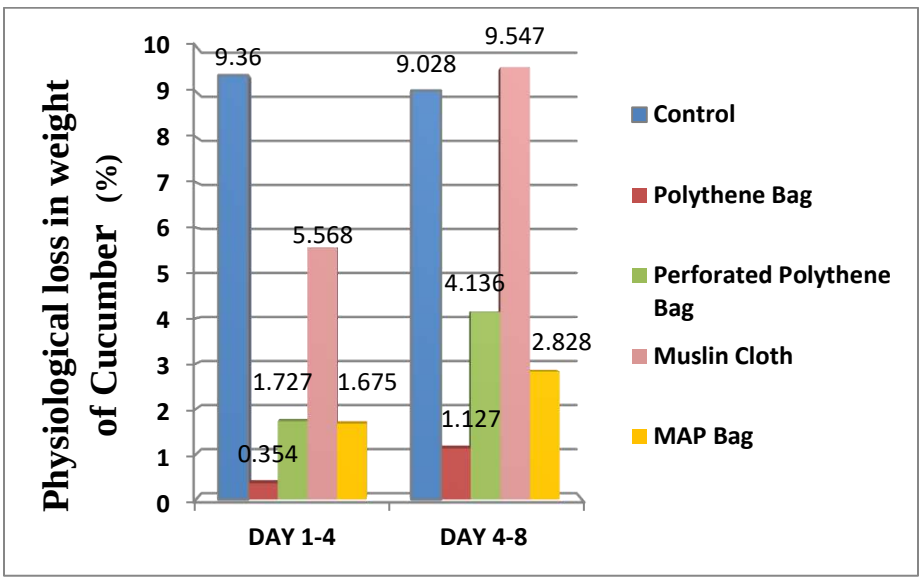


Figure 4. Effect of different packaging materials on PLW of cucumber

Meanwhile, during the next 4 days the trend of weight loss was slightly different which is evident on figure 1. The maximum PLW was recorded in cucumber wrapped in muslin cloth (T4). Cucumbers wrapped in muslin cloth (T4) lost 9.546% of its initial day 4 weights between Days 4-8 whereas PLW for cucumbers kept in control (T1) was about 9.029% which is slightly lower as compared to T4. Use of perforated polythene bag (T3) lowered the PLW to 4.136% but the most impressive result was observed with cucumbers stored in simple plastic bags (T2), where PLW was notably minimal at just 1.128%. Normal polythene bag (T2) showed considerable success in maintaining cucumber's weight loss. Additionally, the use of MAP bags made from biodegradable material (T5) also presented convincing result, resulting in PLW of 2.828% from day 4-8. Overall,

the outcome of this study demonstrated that there is significant impact on the PLW of cucumber due to different packaging materials used. The outcome is consistent with the findings of Poudel *et al*., (2022) who found that the PLW in cucumber is minimum when kept in polythene bag with no perforations. Suchitra *et al*., (2023), Dhall *et al*., (2011) , Owoyemi *et al*.,(2021) also came up with the same conclusions that adjustment or improvement of packaging material slows down the PLW of cucumber.

Impact on firmness of cucumber

Analyzing the firmness of cucumbers stored under diverse packaging materials at ambient condition of 28-32°C and 70-80% RH, we observed a gradual decline in firmness over the storage period from day 1 to day 8 as shown in Figure 2. Among the different treatments, the control group (T1) exhibited a reduction in firmness from an initial value of 2.856 kg/cm² to 1.410 kg/cm² by day 8. Cucumbers stored in polythene bags (T2) demonstrated a moderate decline, measuring 2.183 kg/cm² on day 4 and 1.958 kg/cm² on day 8. Similarly, cucumbers in perforated polythene bags (T3) showed a relatively modest decrease in firmness, reaching 2.144 kg/cm² on day 4 and 1.802 kg/cm² on day 8. The use of muslin cloth (T4) yielded a comparable firmness pattern, with values of 1.811 kg/cm² on day 4 and 1.520 kg/cm² on day 8. Notably, cucumbers stored in MAP bags (T5) displayed a distinct trend, with firmness values of 2.757 kg/cm² on day 4 and 2.410 kg/cm² on day 8. These results suggest that while all treatments led to a decline in firmness over time, variations exist in the degree and rate of decline, with the MAP bag treatment showing promising potential in maintaining cucumber firmness during storage.

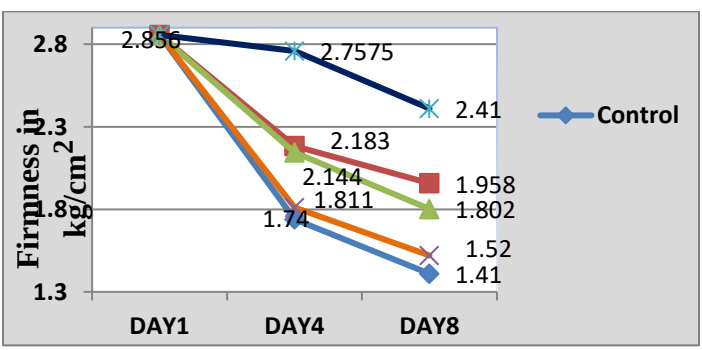


Figure 5. Effect of different packaging materials on firmness of cucumber

Decline of firmness is a natural outcome due to water loss and other physiological changes in the cucumber tissues. MAP (T5) appears to have the highest firmness

values on both day 4 and day 8 compared to the other treatments. The cucumbers stored in MAP bags showed the least decline in firmness over the storage period compared to other treatments. This suggests that the MAP is the most effective packaging material in preserving cucumber firmness. MAP involves modifying the atmosphere within the packaging to slow down spoilage and maintain product quality. This controlled atmosphere helped in reducing the rate of moisture loss and other physiological process thus contributing to better firmness retention. The result of this experiment is consistent with that of Dhall *et al*., (2011) , Suchitra *et al*., (2023), Manjunatha & Anurag, (2014) and Kahramanoğlu & Usanmaz, (2019). The statistical analysis indicates that there is significant difference in the firmness of cucumber as a result of different packaging materials used.

Total soluble solids (TSS) analyis

The study revealed that the TSS were considerably stable in the samples kept under MAP bags (T5) in comparison to samples under other treatments. The TSS content at the beginning of the experiment was measured around 3 brix showed increasing trend over the course of storage. Among the treatments, Treatment 5, involving MAP bags made from biodegradable materials, demonstrated the most favorable performance, with a minimal 0.050 Brix increase from the initial TSS value to 3.050 Brix on day 8. Among the treatments, the most notable increase in TSS values by Day 8 was observed in Treatment 4 (muslin cloth), where it increased by 0.750 Brix to reach 3.750, followed closely by Treatment 1 (control group), with an increase of 0.625 Brix to 3.625. In contrast, Treatment 2 (polythene bags) exhibited a moderate increase to 3.225 Brix. Likewise, the TSS of cucumbers in Treatment 3 (T3) increased to 3.375 by Day 8. The variations in TSS values among cucumbers subjected to various storage treatments did not show statistical significance until Day 4, but by Day 8, the differences became statistically significant at 0.05% level of significance as indicated by p-value on Table 2.

The more stable TSS in cucumbers stored in (MAP) bags compared to other treatments can be attributed to the controlled atmosphere within the bags which slowed down the metabolic processes in cucumbers, including respiration and ethylene production, which are known to increase agitation leading to suspension of solids particles that were previously settled. The present result is consistent with the findings of Miano *et al*., (2016) who concluded that TSS of cucumber stored by using polyethylene bag shows minimal fluctuations in comparison to other treatment. Likewise, Kahramanoğlu & Usanmaz, (2019) also highlighted the efficiency of MAP combined with propolis to maintain stable TSS of cucumber .MAP maintained stable TSS which indicated that taste of cucumbers

packed in MAP remained fairly constant and balanced which is neither overly sweet nor too mild.

Table 9 Effect of different packaging materials on TSS of cucumbers

Treatment	D4	D8
1	3.500	3.625
2	3.175	3.225
3	3.175	3.375
4	3.425	3.750
5	3.000	3.050
LSD (0.05)	0.2970	0.3442
S.E.M	0.0985	0.1142
p-value	0.016	0.004
C.V (%)	6.1	6.7
Grand Mean	3.255	3.405

Chlorophyll content of cucumbers under different treatments

Chlorophyll degradation of cucumber's peel is apparent during storage irrespective of the type of packaging materials used which is indicated in Figure 3. Despite the use of different packaging materials, the cucumbers stored underwent a noticeable decline in green coloration over the storage period. Although cucumbers in every packaging material experienced chlorophyll degradation the intensity with which the chlorophyll degradation occurred in different treatment varied significantly. The chlorophyll content which was determined by spectrophotometric analysis was 0.1mg/g at the beginning of the analysis.

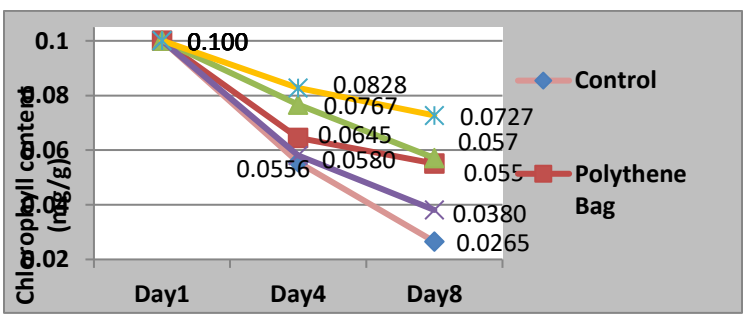


Figure 6. Effect of different packaging materials on chlorophyll content of cucumber

The degradation of chlorophyll was most prominent in cucumbers kept in control reaching 0.02652 mg/g by day 8. Similarly, Muslin cloth (T4) also displayed diminishing levels, recording chlorophyll content at 0.03809mg/g by day 8. The intensity of chlorophyll breakdown was slightly slower in polythene bag where the green pigment was retained better. Chlorophyll content of cucumbers stored in non-perforated and perforated polythene bag was 0.05509 and 0.05711 mg/g respectively on day 8. MAP exhibited slower degradation where chlorophyll content was measured around 0.7271 mg/g on day 8. Intensity of chlorophyll breakdown in MAP bags was slower which indicated that cucumber in MAP bag retained green color better in comparison with other packaging materials. Cucumber in control and muslin cloth lost chlorophyll faster than cucumbers kept in polythene bag due to increased exposure to oxygen that promoted chlorophyll degradation and polythene wrapping created a barrier that slowed down the process of chlorophyll degradation. However, polythene wrapped cucumbers lost chlorophyll faster than MAP (T5) made up of biodegradable materials because regular plastic is not designed to regulate the atmosphere because of which gas exchange is limited and moisture accumulation is also higher and favorable environment for enzymatic reactions is created that contributed to breakdown of chlorophyll. MAP limited airflow which impacted atmosphere inside the package by regulating moisture and gases and reduced enzymatic activity responsible for chlorophyll breakdown. The outcome of this experiment aligns with (Suchitra *et al*., 2023) who observed that shrink-wrapped cucumbers retained their green color for a longer duration compared to the control group, indicating the effectiveness of passive modified atmosphere packaging in retaining greenness.

Color changes of cucumbers under different treatments

The cucumber samples were monitored on a regular basis for any change of color, we observed distinct color changes in cucumbers under different treatments over the course of the experiment. The control group (T1) experienced a gradual degradation in color quality, transitioning from strong yellow-green (142A) on Day 1 to light yellow-green (142C) by Day 4, which further faded out to even lighter colour by Day 8. T4 employing muslin cloth showed similar trend by displaying less effective color preservation, transitioning from strong yellow-green (142A) on Day 1 to light yellow-green (142C) on Day 4 which faded further more towards 142D by Day 8. T2 involving polythene bags and T3 involving perforated polythene bag displayed similar trend of colour change and exhibited slower color degradation, transitioning from strong yellow-green (142A) on Day 1 to brilliant yellow-green (142B) by Day 4, which turned into light yellow green (142C) by Day 8.

MAP (T5) proved to be the most efficient packaging material in color retention. Cucumbers maintained strong yellow-green (142A) on Day 1 and Day 4, transitioning to brilliant yellow-green (142B) by Day 8, showcasing minimal color degradation. Passive MAP bags emerged as the suitable choice for enhancing cucumber shelf life and color quality during postharvest storage. Similar results regarding color changes in cucumbers under different packaging materials were demonstrated by previous studies conducted by Dhall, et al., (2011) , Manjunatha & Anurag, (2014) and Owoyemi, et al.,(2021).

CONCLUSION

In summary, MAP appeared to be the most efficient packaging alternative for cucumber as it preserved the valuable quality and extended the period of time over which cucumbers remained marketable. MAP slowed down chlorophyll degradation by creating a controlled environment that inhibited enzymatic processes responsible for chlorophyll breakdown, resulting in better retention of green colour. Cucumbers stored in MAP experienced minimal quality deterioration compared to other treatments. The MAP bags effectively retained cucumber freshness, firmness, and moisture levels throughout the storage period. Consequently, cucumbers in MAP bags didn't show any signs of shriveling or wilting even at the end of day 8. Furthermore, the use of MAP also contributed to maintaining a consistent TSS level in cucumbers, indicating a uniform and desirable taste throughout the storage period. Future research could be done to explore the optimization of MAP materials and storage conditions to further enhance postharvest quality and shelf life of other fruits and vegetables.

REFERENCES

Adhikari, B. & G.C., A., (2021). Post-harvest practices of horticultural crops in Nepal: Issues and management. *Archives of Agriculture and Environmental Science*, 6(2), 227-233.

Bhattarai, D. R., (2021). Postharvest horticulture in Nepal. *Horticult Intl J.*, 458-460.

Charles, F., Sanchez, J. & Gontard, N., (2006). Active modified atmosphere packaging of fresh fruits and vegetables: modeling with tomatoes and oxygen absorber. *Journal of Food Science*, 68(5), 1736-1742.

Dhall, R. K., Sharma, S. R. & Mahajan, B., (2011). Effect of shrink wrap packaging for maintaining quality of cucumber during storage. *Journal of Food Science and Technology*, 49(4), 495-499.

FAO. (2021). *Faostat.* Retrieved 2023, from https://www.fao.org/faostat/en/#compare.

Farber, J.N., Harris, L.J., Parish, M.E., Beuchat, L.R., Suslow, T.V., Gorney, J.R., Garrett, E.H. and Busta, F.F., (2003). Microbiological safety of controlled and modified atmosphere packaging of fresh and fresh-cut produce. *Comprehensive reviews in food science and food safety*, *2*, 142-160.

Jat, G. S., Behera, T. K., Lata, S. & Kumar, S., (2021). Classical Genetics and Traditional Breeding in Cucumber (Cucumis sativus L.). In *Cucumber Economic Values and Its Cultivation and Breeding*, Rijeka, Croatia: IntechOpen.

Kahramanoğlu, İ. & Usanmaz, S., (2019). Improving postharvest storage quality of cucumber fruit by modified atmosphere packaging and biomaterials. *HortScience*, 54(11), 2005-2014.

Khanal, S., Shrestha, J. & Lamichhane, J., (2020). Economics of production and marketing of Cucumber in Nawalpur district of Nepal. *Azarian journal of agriculture*, 7(3), 93-101.

Kitinoja, L., Yadav Tokala, V. & Brondy, A., (2018). A review of global postharvest loss assessments. *Journal of Postharvest Technology*, 6(4), 1-15.

Manjunatha, M. & Anurag, R. K., (2014). Effect of modified atmosphere packaging and storage conditions on quality characteristics of cucumber. *Journal of Food Science and Technology*, 51(11), 3470-3475.

Miano, T. F., Khaskheli, A. A., Miano, T. F. & Miano, F. N., (2016). Influence of Packaging Material on PhysicoChemical and Sensory Quality of Cucumber under. *European academic research*, 4(5), 4562-4585.

MoALD, (2022). Statistical Information on Nepalese Agriculture 2077/78 (2020/21).
Available at: https://moald.gov.np/wp-content/uploads/2022/07/statistical-information-on-nepalese-agriculture-2077-78.pdf

Mukherjee, P. K., Nema, N. K., Maity, N. & Sarkar, B. K., (2013). Phytochemical and therapeutic potential of cucumber. *Filoterapia*, 227-236.

Owoyemi, A., Porat, R. & Rodov, V., (2021). Effects of compostable packaging and perforation rates on cucumber quality during extended shelf life and simulated farm-to-fork supply-chain conditions. *Foods*, 10(2), 471.

Poudel, S. P., Upadhyay, K. P., Timilsina, C. & Basnet, R. B., (2022). Effect of thin paper polythene wrapping and chlorine water treatments in post harvest life of cucumber at Gandaki Province , Nepal. Kirtipur , Nepal Horticulture Society and National Centre For Fruit Development, 56-64.

Royal Horticulture Society, (2015). RHS colour chart - neue auflage 2015. Available at: https://www.torso.de/media/products/RHS_Colour_Chart_Farbliste.pdf

Royal Horticulture Society, (2019). Lilac-color-groups-by-RHS-columns. Available at: https://www.internationallilacsociety.org/wp-content/uploads/2019/12/Lilac-Color-Groups-by-RHS-columns.pdf?fbclid=IwAR1gBAubnBe9DZE3ujoJUoMqGltOR_CMinQUra7JKjBZbztTlvywyCGHkZQ

Sandhya, (2009). Modified atmosphere packaging of fresh produce: Current status and future needs. *LWT - Food Science and Technology*, 43(3), 381-392.

Shi, J., Wang, J., Li, R., Li, D., Xu, F., Sun, Q., Zhao, B., Mao, A.J. and Guo, Y.D., (2015). Expression patterns of genes encoding plasma membrane aquaporins during fruit development in cucumber (Cucumis sativus L.). *Plant Physiology and Biochemistry*, *96*, 329-336.

Suchitra, V., A, C., Dhurve, L. & Flora, N., (2023). Post-harvest treatments for extending the shelf of European Slicing Cucumber. *The Pharma Innovation Journal*, 12(2), 3004-3006.

Wellburn, A. R., (1994). The Spectral Determination of Chlorophylls a and b, as well Total Carotenoids, Using Various Solvents with Spectrophotometers of Different Resolution. *Journal of Plant Physiology*, 144(3), 307-313.