Assessment of Rheological Properties of Round Gourd under different Storage Conditions

Abstract

The study was conducted to ascertain rheological properties of round gourd under cold storage conditions and was compared with the normal conditions. The cold storage developed at the Department of Farm Machinery and Power Engineering, Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar and was employed for the effective storage of round gourd. Some samples of round gourd were stored under cold storage (control) conditions and some were stored under normal (ambient) conditions. The study involved the evaluation of rheological properties viz. physiological weight loss, volume shrinkage, total soluble salts (TSS), firmness, stiffness and pH. The volume shrinkage (%) of round gourd ranged from 0% during initial to 58% for sample A and 0% to 63% for sample B at ambient temperature condition, whereas, it ranged from 0% during initial to 33% for both the samples at control condition. TSS ranged from 3.00 to 5.30 and from 3.50 to 4.10 for ambient and control condition respectively. pH ranged from 7.80 to 8.50 and from 7.10 to 7.65 for ambient and control condition respectively. It was investigated that the physiological weight loss of round gourd was substantially maximum at ambient temperature compared to the weight loss at cold storage temperature. The effect of storage period of round gourd on the weight loss was highly significant. The storage days exhibit a highly significant effect on volume shrinkage of round gourd samples. The l, a, b values depends on the color change of fruits and vegetables, the sample color changes significantly from initial day to 12^{th} day of storage period. The ripening stage was faster in ambient condition as compared to cold storage condition.

1. Introduction

Round gourd (Praecitrullus fistulosus) commonly known as Cucumis melo is an important tropical vegetable of Indian subcontinent. It is one of the most important cucurbitaceae vegetable due to high nutritional and medicinal values. It is native to India and is widely cultivated in South Asia. The vegetable has a smooth, pale green outer skin and a white, fleshy interior. Its texture is tender, and its taste is mild, slightly sweet, and subtly earthy. The crop is grown during June–September (summer season) and from February to May (spring season) remains in the field up to September.

Round gourds are highly versatile and are often used in various culinary preparations, such as curries, stir-fries, and stews. They are valued for their cooling properties and are considered a healthy food option due to their high water content, dietary fiber, and low calorie count. Rich in vitamins and minerals, the round gourd supports digestion and hydration.

In India the round gourd is commonly cultivated in the states of Punjab, Haryana, Uttar Pradesh, Rajasthan, Bihar, Madhya Pradesh and Gujarat (Nath & Subramanyam, 1972). This vegetable is important sources of different vitamins and minerals. he fruit can be prepared in a variety of ways, either on its own or combined with other vegetables. However, its high respiration rate leads to a shorter shelf life at room temperature, influenced by physiological factors governed by genetic mechanisms. During storage, the main changes observed include weight loss due to moisture evaporation, chlorophyll breakdown, color changes, reduced firmness, altered texture, diminished nutritional content, and decreased market appeal. Even with minimal water loss, surface wrinkling is particularly noticeable in round gourd. (Guharoy, Bhattacharyya, Mukherjee, Mandal, & Khatua, 2006).

Under ambient room temperature storage conditions, round gourd has a very short shelf-life of about 3– 4 days. Depletion of chlorophyll takes place very fast in ambient condition, which results in yellowing of the skin and the pulp which are least accepted and rejected by buyers in the market place (Koley, Asrey, Samuel, & Sasikala, 2009).

Literature review revealed that no attempts have been made so far to uncover a suitable polymeric packaging material and technique to extend the shelf-life of highly perishable round gourd. Keeping this in view, the present work has been undertaken to find out the most suitable packaging materials and technique to enhance storage life of pointed gourd, during storage.

2. Material and methods

The study was conducted at the Department of Farm Machinery and Power Engineering, Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar. The cold storage developed at the department was employed for the effective storage of round gourd. Some samples of round gourd were stored under cold storage (control) conditions and some were stored under normal (ambient) conditions.

2.1 Mass loss: The fruits and vegetables samples were each weighed using a calibrated weighing scale after harvest and at the end of each storage period. The mass loss equation (Koraddi, V.V. and Sumangala, P.R. 2008), was used to determine the percentage mass loss of pointed gourd at the end of each storage interval.

$$\text{Mass loss (\%)} = \frac{m1-m2}{m1} \times 100$$

where,

m_1= the mass measured immediately after harvest and before storage and

m_2= the mass measured after storage according to days spent inside the various cooling system.

2.2 Actual volume shrinkage loss

Volume shrinkage loss refers to the reduction in volume or weight of a product, such as fruits, vegetables or other perishable of a items, due to various factors like water loss, respiration, temperature and humidity fluctuations, physical damage and microbial growth.

The fruit and vegetable samples were each dipped in the measuring cylinder filled with water (700ml) after harvest and at the end of each storage period . For each sample there was an initial and final volume shrinkage loss was recorded by using measuring cylinder and the difference between the two mass considered as the total volume shrinkage loss during the storage period. As previously described by Md. Mahiuddin *et. al.* (2018). The given equation was used to determine the percentage volume shrinkage loss of each vegetable and fruit sample at the end of each storage interval.

$$\text{Volume shrinkage (\%)} = \frac{x1-x2}{x1} \times 100$$

Where,

x_1= the volume shrinkage measured immediately after harvest and before storage

x_2 = the volume shrinkage measured after storage according to days spend inside the cooling system.

2.3 Firmness: Firmness refers to the crispness of a fruit or vegetable. It can be primarily measured by applying pressure. The firmness of the round gourd was measured employing a texture analyser.

2.4 Stiffness: Stiffness in fruits and vegetables refers to the resistance of the produce to deformation or compression under an applied force. The texture analyser was employed for the measurement of the stiffness of round gourd.

2.5 Total soluble solids (TSS): Total Soluble Solids (TSS) indicates the total amount of soluble constituents of the juice, wine or other beverage. The TSS of round gourd was determined using a digital refractometer.

2.6 pH: pH was determined according to the standard methodology employing digital pH meter. A suspension was prepared by mixing 20gms of the sample in 100 mL of purified water, and its pH was measured using a pH meter. Prior to use, the pH meter was calibrated using buffer solution of pH4 and pH7. The average value was reported as result of pH.

2.7 Fruit colour: The colour of each sample of fruits and vegetables was assessed by determining the colour coordinates readings which were recorded as L*, a* and b* values. These values forms the basis of International Commission on Illumination (CIE) 1976 (L*,

a*, b*) colour space. The relationship between the various colour coordinates is depicted by the following relations enumerated below:

L* represents the lightness coefficient. It ranges from black = 0 to white = 100 and is roughly analogous to the Munsell value scale times 10.

a*: On the horizontal axis, positive a* indicates a hue of red-purple; negative a*, of bluish-green. The values of a* ranges from -127 to +127 (Hunter, R.S. 1942).

b*: On the vertical axis, positive b* indicates yellow and negative b* blue. The values of b* also ranges from -127 to +127 (Hunter, R.S. 1942).

3. Results and discussion

3.1 Physiological Weight loss of round gourd at ambient and cold storage temperature

The weight loss (%) of round gourd for sample A at the onset was assessed as 0% followed by 11%, 14%, 25% and 38% at 3rd, 6th, 9th and 12th (final storage day) respectively at ambient temperature whereas, it was 6%, 13%, 15% and 21% at 3rd, 6th, 9th and 12th day respectively at cold storage temperature as enumerated in table 1. Similarly, for sample B, for the given days of storage, the physiological weight loss was recorded from 0- 28% at ambient temperature and 0- 21% at cold storage temperature as presented fig 1. Same results was assessed by Singh R. (2014), Sharma K. D. (2018), Singh S. (2020) and Yeboah S. (2023).

Statistically, paired t test was applied for the comparison of physiological weight loss at different conditions. It was deduced that there was no significant effect of different storage conditions on physiological weight loss as the p-value was evaluated as 0.1034 which is greater than the common significance level (e.g., 0.05). This indicates that the difference in physiological weight loss between ambient and cold storage is not statistically significant at the 5% level. In other words, the test does not provide strong evidence to conclude that the weight loss between the two storage conditions is significantly different.

Table 1 Comparison of weight loss of different samples of round gourd at ambient and cold storage conditions

Days	**Sample A**		**Sample B**	
	Ambient temperature	**Cold storage temperature**	**Ambient temperature**	**Cold storage temperature**
0	0	0	0	0
3	11	6	11	6
6	14	13	18	9
9	25	15	22	12
12	38	21	28	21

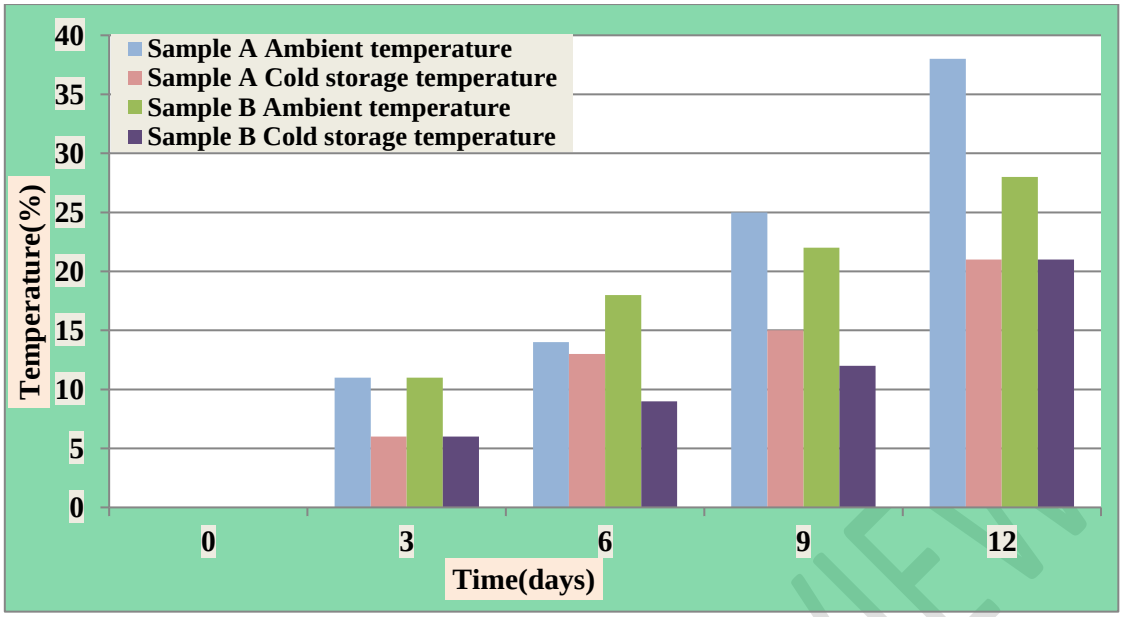

Fig 1 Weight loss percentage of round gourd with the storage period of 12 days at ambient temperature and cold storage temperature

3.2 Comparison of actual volume shrinkage of different samples of round gourd at ambient and cold storage conditions

The volume shrinkage (%) of round gourd ranged from 0% during initial to 58% for sample A and 0% to 63% for sample B at ambient temperature condition, whereas, it ranged from 0% during initial to 33% for both the samples at control condition as enlisted in table 2 and demonstrated in fig. 2. Same interpretation was established by Singh R. (2014), Sharma K. D. (2018), Singh S. (2020) and Yeboah S. (2023).

Statistically, two-way ANOVA approach was applied on the dataset of the volume shrinkage of round gourd and it was deduced that there was a strong relationship between the storage duration and the extent of volume shrinkage, indicating that as the number of storage days increases, the volume shrinkage of round gourd was significantly increased (as p-value 5.93 e^{-06}< 0.05). The effect of storage conditions was marginally significant (p ~ 0.0826) specifying that conditions could affect volume shrinkage of round gourd, but it does not reach statistical significance. However, there was no significant effect of combined sample type (sample A vs. sample B) on volume shrinkage (**p-value**: 0.3316 > 0.05).

The interaction effect between storage days and storage conditions was statistically significant (p-value: 0.0356 < 0.05). This suggests that the effect of the number of storage days on volume shrinkage of round gourd varies depending on the storage conditions (ambient vs. control), indicating a potential combined effect.

Table 2 Comparison of actual volume shrinkage of different samples of round gourd at ambient and cold storage conditions

Days	Sample A	Sample B

	Ambient temperature	Cold storage temperature	Ambient temperature	Cold storage temperature
0	0	0	0	0
3	25	25	25	22
6	33	38	25	27
9	50	31	31	28
12	58	33	63	33

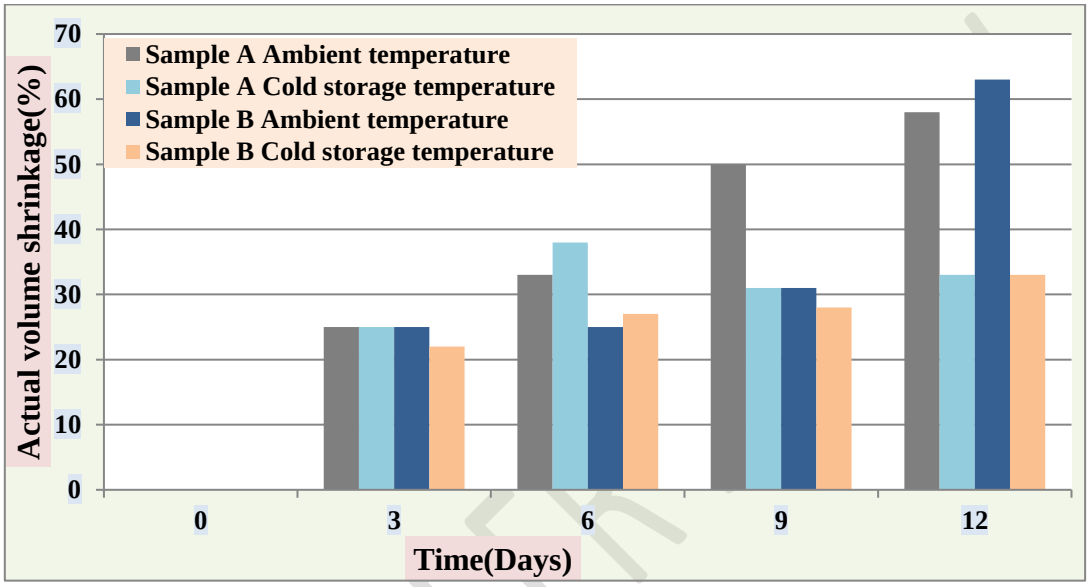

Fig 2 Actual volume shrinkage of different samples of round gourd at ambient and cold storage conditions

3.3 TSS (°Brix) of round gourd under ambient and cold storage condition

The total soluble salt TSS of round gourd under ambient condition was assessed as 3.00, 4.50, 4.80, 5.00 and 5.30 for for the initial, third, sixth, ninth and twelfth day respectively, whereas, it was 3.50, 3.50, 3.60, 4.00 and 4.10 for the same storage time interval. Therefore, it ranged from 3.00 to 5.30 and from 3.50 to 4.10 for ambient and control condition respectively as given in table 3. It was deduced that the value of TSS of round gourd under both the storage conditions was considerably increased. Similar results were investigated by Zomo S. A. *et al.* (2014).

The TSS dataset was subjected to statistical analysis and the two-way ANOVA was applied which demonstrated that the effect of storage days (time) on TSS of round gourd was highly significant as the obtained p-value i.e. 0.00389 is very small compared to that of standard significance level of 0.05, thereby, indicating a significant effect of storage days on TSS of round gourd samples. Similarly, the storage conditions (ambient and control conditions) also possess a significant difference on TSS value of capsicum (p value: 0.01 < 0.05). This indicates that TSS of round gourd differs depending on the storage temperature.

Nevertheless, the interaction effect between **storage days** and **storage conditions** was non-significant (p-value = 0.06 > 0.05) and shows a near-significant trend.

Table 3 TSS of round gourd at ambient and cold storage temperature

	TSS (˚Brix)	
Days	**Ambient temperature**	**Cold storage temperature**
0	3.00	3.50
3	4.50	3.50
6	4.80	3.60
9	5.00	4.00
12	5.30	4.10

3.4 Firmness of round gourd under normal and control condition

The firmness of round gourd (sample A) was 706.21, 211.90, 187.60, 161.10 and 61.49 for the initial, third, sixth, ninth and twelfth day respectively, whereas, for sample B, it was 655.14, 249.19, 170.41, 151.45 and 70.27 for the same order of storage time (days) under normal condition. Similarly, for control condition (cold storage), the firmness was 1591.60, 485.07, 336.41, 173.37 and 75.51 for the initial, third, sixth, ninth and twelfth day respectively for sample A, whereas, for sample B, the firmness was 924.32, 582.77, 560.01, 201.30 and 190.57 respectively for the same number of days as shown in table 4.

The firmness of sample A ranged from 61 to 706 g and from 75 to 1592 g for normal and control conditions respectively. While, the firmness of sample B ranged from 70 to 655g and from 190 to 925 g for normal and control conditions respectively (Fig. 3). The inference shows that the firmness of round gourd gradually decreases with the storage time for both the samples under both normal and control conditions. A constant decline in firmness of round gourd was witnessed throughout the storage period. Similar findings were reported by Zewdie B. (2022) and Venkatachalam K. (2024) under the same conditions for evaluating firmness.

From statistical viewpoint, the storage days exhibits a significant effect on the firmness of round gourd (**p-value: 0.0229** < the significance level of 0.05). This indicates that the firmness changes significantly over different days.

Conversely, the **storage condition** (Ambient vs. Cold storage) does **not have a statistically significant effect** on the firmness as **p-value (1.00)** is far greater than standard value of significance 0.05. This means that the firmness does not differ significantly between the two storage conditions. Similar trend was followed by the interaction effect of storage days and storage conditions (p-value: 0.1859 > 0.05), as there was no significant interaction between them. This means the effect of storage days on the firmness was consistent across both storage conditions.

Table 4 Assessment of firmness (g) of round gourd at ambient and cold storage temperature

		Firmness (g)	
Days	**Samples**	**Ambient**	**Cold storage**
0	**A**	706.21	1591.60
	B	655.14	924.32
3	**A**	211.90	485.07
	B	249.19	582.77
6	**A**	187.60	336.41
	B	170.41	560.01
9	**A**	161.10	173.37
	B	151.45	201.3
12	**A**	61.49	75.51
	B	70.27	190.57

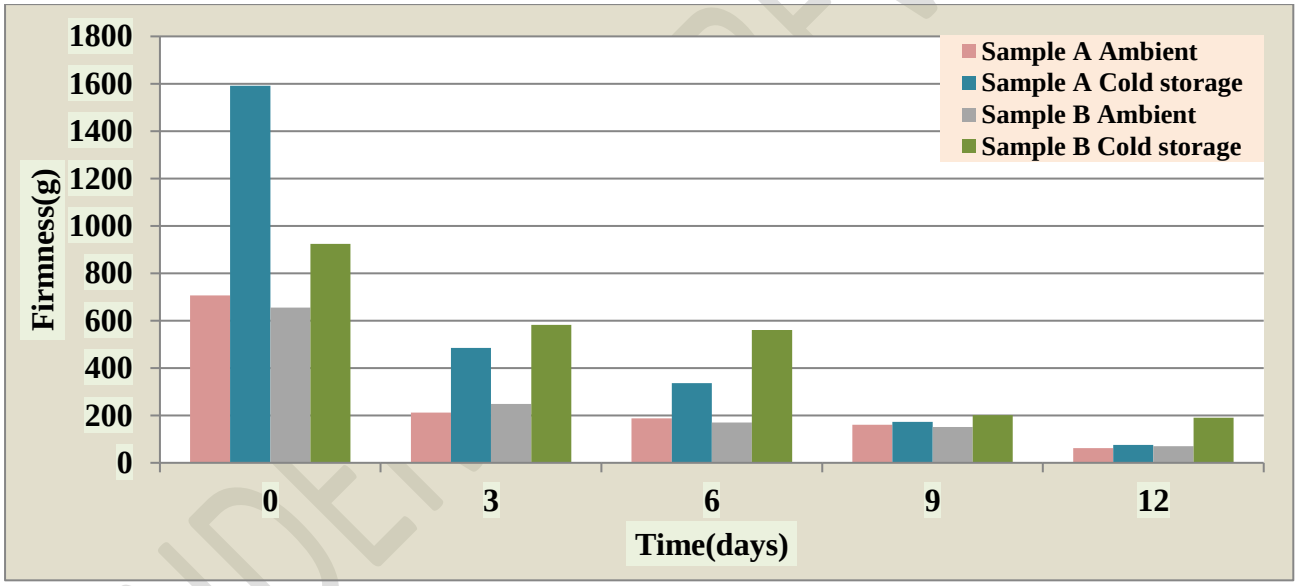

Fig 3 Firmness (g) of round gourd at ambient and cold storage temperature

3.5 Stiffness of round gourd at ambient (normal) and cold storage (control) temperature

The stiffness of round gourd (sample A) was 748.90, 625.67, 548.68, 513.00 and 494.48 for the initial, third, sixth, ninth and twelfth day respectively, whereas, for sample B, it was 804.59, 598.13, 568.40, 559.09 and 544.66 for the same order of storage time (days) under normal condition (ambient temperature) as enlisted in table 5. Likewise, for control condition (cold storage), the stiffness was 960.80, 810.92, 786.04, 659.22 and 401.51 for the initial, third, sixth, ninth and twelfth day respectively for sample A, whereas, for sample B, the firmness was 969.72, 893.19, 759.87, 712.02 and 530.39 respectively for the same number of days.

The stiffness of sample A ranged from 494 to 749 g and from 401 to 961 g for normal and control conditions respectively. Whereas, the firmness of sample B ranged from 544 to 805 g and from 530 to 970 g for normal and control conditions respectively (all in decreasing order). It was established that the stiffness of round gourd steadily falls with the storage time for both the samples under both normal and control conditions. A continual descent in the stiffness of round gourd was reckoned during the course of the storage period. Similar investigation was reported by Zewdie B. (2022) and Venkatachalam K. (2024) under the same conditions for evaluating stiffness.

The statistical analysis was also conducted and two-way ANOVA was applied for the same dataset of stiffness. It was revealed that the storage days a (time) possess a significant effect on the stiffness of round gourd (**p-value (0.0203)** < significance level of 0.05). This suggests that there are substantial changes in the stiffness as the number of days increases.

However, the **storage condition** (ambient vs. cold storage) does **not have a substantial effect** on the stiffness of round gourd (**p-value: 1.00** > 0.05). Similarly, the interaction effect of samples (A and B) on the stiffness was also non-significant as **p-value (0.4476)** is greater than significance level of 0.05.

Table 5. storage condition of samples

		Stiffness (g/s)	
Days	**Samples**	**Ambient**	**Cold storage**
0	**A**	748.90	960.80
	B	804.59	969.72
3	**A**	625.67	810.92
	B	598.13	893.19
6	**A**	548.68	786.04
	B	568.40	759.87
9	**A**	513.00	659.22
	B	559.09	712.02
12	**A**	494.48	401.51
	B	544.66	530.39

3.6 pH of round gourd under ambient and cold storage condition

The pH of round gourd under ambient condition was assessed as 7.80, 7.92, 7.94, 8.04 and 8.50 for the initial, third, sixth, ninth and twelfth day respectively, whereas, it was 7.10, 7.15, 7.23, 7.38 and 7.65 for the same storage duration. Therefore, it ranged from 7.80 to 8.50 and from 7.10 to 7.65 for ambient and control condition respectively as enlisted in table 6. It was investigated that the value of pH of round gourd under both the storage conditions was considerably increased. Same inference were examined by Zomo S. A. *et al.* (2014).

The pH dataset of round gourd was subjected to statistical analysis and the two-way ANOVA was employed which shows that the effect of storage days (time) on pH of round gourd was particularly significant with obtained p-value i.e. 0.03 marginally small compared to that of standard significance level of 0.05, thus, indicating that pH values of round gourd samples changes significantly as the number of storage days increases. In addition, the storage conditions (ambient and control conditions) too possess a significant difference on pH value of capsicum (p value: = $9.11e\text{-}^{05}$< 0.05). This contemplates that pH of round gourd differs depending on the storage conditions. Furthermore, the interaction effect between **storage days** and **storage conditions** on pH of round gourd samples was also significant (p-value = 0.00167 < 0.05) concluding that the relationship between days of storage and pH is different for each storage conditions.

Table 6 pH of round gourd at ambient and cold storage temperature

	pH	
Days	**Ambient temperature**	**Cold storage temperature**
0	7.80	7.10
3	7.92	7.15
6	7.94	7.23
9	8.04	7.38
12	8.50	7.65

3.7 Assessment of l, a, b values of round gourd at ambient temperature

The data provided for round gourd samples A and B shows changes in color parameters (l, a, and b values) over a 12-day period. Initially, on day 0, sample A exhibits higher lightness (l = 56.33) and a less negative green-red value (a = -6.30) compared to sample B (l = 47.33, a = -10.30), while B has a higher yellow-blue value (b = 47). By day 3, A's lightness decreases to 44.30, while B's lightness increases significantly to 63.00, with B showing a more intense yellow tone (b = 51.33). On day 6, A’s lightness slightly improves to 45.66, and B's decreases to 55.66, with minimal changes in the green component. By day 9, A shows increased lightness (49.33), while B's values drop to 43.33, reflecting a decline in color intensity. By day 12, A’s values fall to zero, indicating possible spoilage or cessation of color measurement, while B retains measurable values (l = 40.33, b = 35.33). These results suggest that sample B maintains its color stability better over time compared to sample A. The similar trend was investigated by Kablan T. (2008), Singh R. (2014), Chitravathi K. (2016) and Samuel Y. (2023).

Table 7 l, a, b values of round gourd at ambient temperature

Samples	**Days**	**l**	**a**	**b**
A	**0**	56.33	-6.30	41.33
B		47.33	-10.30	47
A	**3**	44.30	-14.30	41

B		63.00	-10.30	51.33
A	**6**	45.66	-14.33	41
B		55.66	-13.66	47.66
A	**9**	49.33	-10.00	39.33
B		43.33	-13.66	40
A	**12**	0.00	0.00	0
B		40.33	-8.60	35.33

3.8 Assessment of l, a, b values of round gourd at cold storage temperature

The data for round gourd samples A and B shows noticeable variations in color parameters (l, a, and b values) over a 12-day period. On day 0, sample B exhibits higher lightness (l = 56.00) and a more negative green-red value (a = -11.33) compared to sample A (l = 49.00, a = -6.60), while both have similar yellow-blue values, with B showing a stronger yellow tone (b = 57.66). By day 3, both samples become lighter, with B reaching a peak lightness of 72.66, though its a-value shifts closer to neutral green. In contrast, sample A increases in lightness (57.33) but has a deeper green hue (a = -13.33). On day 6, A's lightness improves significantly to 69.66, while B's lightness decreases to 55.66, indicating a potential color shift. By day 9, lightness decreases slightly for A (66.33) and increases for B (62.00), though A's yellow value (b) drops sharply to 33, suggesting reduced yellowness. By day 12, both samples show a decline in lightness and b-values, with A's lightness falling to 44.00 and B stabilizing at 56.66, indicating that sample B retains better color stability over time. The similar trend was investigated by Singh R. (2014), Chitravathi K. (2016) and Samuel Y. (2023).

Table 8 l, a, b values of round gourd at cold storage temperature

Samples	Days	l	a	b
A	**0**	49.00	-6.60	51
B		56.00	-11.33	57.66
A	**3**	57.33	-13.33	53.33
B		72.66	-2.60	50.66
A	**6**	69.66	-8.60	51
B		55.66	-14.66	46.66
A	**9**	66.33	-13.33	33
B		62.00	-9.60	41
A	**12**	44.00	-12.33	36
B		56.66	-3.00	47

4. Conclusion

The physiological weight loss of round gourd was substantially maximum at ambient temperature compared to the weight loss at cold storage temperature. The effect of storage period of round gourd on the weight loss was highly significant. The storage

days exhibit a highly significant effect on volume shrinkage of round gourd samples. Likewise, storage conditions also possess highly significant effect showing that normal and control conditions affect the volume shrinkage differently. Moreover, the interaction effect between storage days and temperature was also significant. The firmness and stiffness of round gourd samples steadily decreases with the storage time under both normal and control conditions. It was concluded that there was a significant effect of storage time on the firmness and stiffness of round gourd. The TSS (ºBrix) value for round gourd samples under both the storage conditions was considerably increased. There was highly significant effect of storage days and storage conditions on TSS of round gourd. The pH of round gourd samples under both the storage conditions was considerably increased. The storage days and storage conditions holds a significant effect on pH of different fruits and vegetables. The l, a, b values depends on the color change of fruits and vegetables, the sample color changes significantly from initial day to 12^{th} day of storage period. The ripening stage was faster in ambient condition as compared to cold storage condition.

References

Basediya, A., Samuel, D. V. K. and Beera, V. (2013). Evaporative cooling system for storage of fruits and vegetables - A Review. Journal of food science and technology, 50 (3): 429-442.

Chadha, K. L. (2001). Handbook of horticulture. Handbook of horticulture.

Chitravathi, K., Chauhan, O.P. and Raju, P.S. 2016. Shelf life extension of green chillies (Capsicum annuum L.) using shellac-based surface coating in combination with modified atmosphere packaging. *J. Food Sci. Technol.*, 53(1): 3320-3328.

Guharoy, S., Bhattacharyya, S., Mukherjee, S. K., Mandal, N., & Khatua, D. C. (2006). Phytophthora melonis associated with fruit and vine rot disease of pointed gourd in India as revealed by RFLP and sequencing of ITS region. Journal of Phytopathology, 10, 612–615.

Koley, T. K., Asrey, R., Pal, R. K., & Samuel, D. V. K. (2009a). Shelf-life extension in pointed gourd (Trichosanthes dioica Roxb.) by post-harvest application of sodium hypochlorite, potassium metabisulphite and carnauba wax. Journal of Food Science and Technology, 46, 581–584.

Koraddi, V.V. and Sumangala, P.R. 2008. Analysis of physiological loss of weight of vegetables under refrigerated condition. *Haryana J. Hortic. Sci.*, 37(2): 174-176.

Nath, P., & Subramanyam, S. (1972). Pointed gourd can be a popular crop. Indian Horticulture, 17, 20–21.

Ranjan, J.(2023). Post-harvest storage structures for fruits and vegetables in India. Ropan, 11(3): CHHBIL/2020/79641.

Samuel, D.V.K., Sharma, P.K. and Sinha, J.P. 2016. Solar-powered evaporatively cooled vegetable vending cart. *Curr. Sci.,* 111(12): 2020-22.

Sharma, K.D., Cardona, J.A., Sibomana, M.S., Herrera, N.G.S., Nampeera, E. and Fallik, E. 2018. Quality attributes of modified atmosphere packaged bell pepper (Capsicum annuum L.) during storage. *J. Nutr. Food Res. Technol.,* 1(2): 56-62.

Singh, R., Giri, S.K. and Kotwaliwale, N. 2014. Shelf-life enhancement of green bell pepper (Capsicum annuum L.) under active modified atmosphere storage. *Food Packag. Shelf Life,* 1(2): 101-112.

Singh, S., Chaurasia, S.N.S., Prasad, I., Khemariya, P. and Alam, T. 2020. Nutritional quality and shelf-life extension of capsicum (Capsicum annum) in expanded polyethylene biopolymer. *Asian J. Dairy Food Res.,* 39(1): 40-48.

Venkatachalam, K., Lekjing, S., Noonim, P. and Charoenphun, N. 2024. Extension of Quality and Shelf Life of Tomatoes Using Chitosan Coating Incorporated with Cinnamon Oil. *Foods,* 13(7): 1000.

Yeboah, S., Hong, S.J., Park, Y., Choi, J.H. and Eum, H.L. 2023. Postharvest Quality Improvement of Bell Pepper (Capsicum annuum L. cv Nagano) with Forced-Air Precooling and Modified Atmosphere Packaging. *Foods,* 12(21): 3961.

Zomo, S.A., Ismail, S.M., Jahan, M.S., Kabir, K. and Kabir, M.H. 2014. Chemical properties and shelf life of banana (*Musa sapientum* L.) as influenced by different postharvest treatments. *The Agric.,* 12(2): 6-17.

Zewdie, B., Shonte, T.T. and Woldetsadik, K. 2022. Shelf life and quality of tomato (Lycopersicon esculentum Mill.) fruits as affected by neem leaf extract dipping and beeswax coating. *Int. J. Food Prop.,* 25(1): 570-592.