



Impact of polysaccharide and lipid based edible coatings on storage life and quality of muskmelon (*Cucumis melo*) fruits during low temperature storage

BINDU H¹*, SUDHAKAR RAO D V¹, NARAYANA C K, ¹ ANSARI M F¹, SRINIVASA RAO E²,
SATISHA J², SELVAKUMAR G² and SHIVASHANKARA K S²

ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka 560 089, India

Received: 29 November 2023; Accepted: 18 June 2024

ABSTRACT

Climacteric type muskmelons (*Cucumis melo* L.) are highly perishable and susceptible to moisture loss and decay during storage and transport, and possess very short storage life under ambient conditions. The present study was carried out during 2021 to 2023 at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka to study the effect of different edible coatings in combination with cold storage on various physico-chemical parameters of muskmelon. Muskmelon cv. Arka Siri was coated with different edible coatings, viz. shellac based (NISA, Ranchi formulation), sodium alginate (1%), chitosan (1%) and gum arabica (5%) along with control. The experiment was laid out in a factorial completely randomised design (FCRD). The results revealed that muskmelon fruits coated with shellac based formulation had least physiological loss in weight, lower respiration rate and lower ethylene production during storage at 10°C. The shellac based coating was able to maintain highest mean firmness and biochemical parameters such as total soluble solid (8.53%), acidity, ascorbic acid (4.66 mg/100 g), sugars, total carotenoids (2034.14 µg/100 g), total phenolic content and total antioxidant activity of muskmelon fruits and extended the storage life to 21 days compared to 14 days in control when stored at 10°C. Muskmelon fruits coated with shellac based coating were much appreciated for their appearance, flavour, taste and overall acceptability by the panelists.

Keywords: Cantaloupes, Climacteric fruit, Postharvest quality, Shellac based coating

Muskmelon (*Cucumis melo* L.) belonging to family Cucurbitaceae originated in South and East Africa. In India it is popularly called as 'kharbooja' in Hindi language. It is one of the popular fruit grown worldwide with China being the largest producer. Its production, consumption and trade are increasing due to its desirable taste, texture, and versatility. In India, it is cultivated in 71 thousand ha area with 1.56 million MT production (Anonymous 2022). Major growing states are Uttar Pradesh, Andhra Pradesh, Punjab, Madhya Pradesh, Haryana, Karnataka, Bihar and Maharashtra. The ripe fruits have attractive colour and aroma. Muskmelon contains about 92% water and has good amount of potassium, vitamins A, C and vitamin B6 (Sangamithra and Ragavi 2020). It possesses anti-ulcer, anti-oxidant and anti-diabetic properties (Milind and Kulwant 2011). Muskmelon cv. Arka Siri is a high yielding and popular variety released by ICAR-Indian Institute of Horticulture

Research, Bengaluru, Karnataka. It possesses shelf life of 5–6 days under ambient conditions. For long distant transportation and marketing, further extension of storage life is needed. This can be achieved by cold storage which is an effective way to control the metabolic activities. Apart from this basic approach, a lot of pre-storage or post-harvest treatments are being developed by the researchers such as physical (heat, radiation treatments and surface coatings), chemical (antioxidants, anti-browning, and antimicrobials), use of biological agents and gaseous treatments (Dhall 2013). Edible coatings give fruits and vegetables a protective edible covering and act as effective barrier against moisture, water vapour, oxygen, and carbon dioxide. This creates a semi-permeable membrane on the surface that inhibits respiration and regulates moisture loss (Raghav *et al.* 2016). In melons water loss and transpiration occurs mainly due to netted surface of the peel. From the earlier experiment, critical temperature for storage was standardized and found to be 10°C. However, scientific information on effect of edible coatings and their interaction with low temperature in extending the storage life is limited. Hence the present investigation was proposed to study the effect of different edible coatings in combination with cold storage on various physico-chemical parameters of muskmelon.

¹ICAR-National Institute of Secondary Agriculture, Ranchi, Jharkhand; ²ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka. *Corresponding author email: bindushree73@gmail.com

MATERIALS AND METHODS

Experimental material: Muskmelon (climacteric type cantaloupe) cv. Arka Siri fruits were procured from ICAR-Indian Institute of Horticulture Research, Bengaluru Karnataka during 2021–22. Fruits were harvested manually at full slip stage (TSS 10–12°B) and brought to the laboratory of Division of Postharvest Technology and Agricultural Engineering. Fruits of uniform maturity, without any blemishes, free from pest and diseases, mechanical injury were selected by visual sorting. Fruits were then surface cleaned to remove any dust and soil particles.

Treatment and storage conditions: In the present investigation one lipid based surface coating (shellac coating formulation) was compared against three polysaccharide based surface coatings (sodium alginate, chitosan and gum arabica). Based on the preliminary study with different concentrations of polysaccharide based edible coatings, sodium alginate (1%), chitosan (1%) and gum arabica (5%) concentrations were selected to compare with the lipid based coating. The lipid based shellac coating formulation was procured from the National Institute of Secondary Agriculture, Ranchi, Jharkhand. The solution was directly used in the experiment without any dilution. To prepare sodium alginate coating (1%), 10 g of sodium alginate was dissolved slowly in 500 ml water using glass rod and the final volume was made up to 1000 ml. Similarly gum arabica (5%) solution was prepared by dissolving 50 g in 500 ml water and the final volume was made up to 1000 ml. Chitosan (1%) solution was prepared by dissolving 10 g of chitosan in 1% glacial acetic acid solution and the volume was made up to 1000 ml using 1% glacial acetic acid solution. The fruit surface was gently cleaned using muslin cloth and individual fruits were immersed in respective edible coating solution for 2 min. Excess edible coating solution was drained using strainer and allowed to completely dry on the working table under the fan. After complete drying of the edible coating, a total of 15 fruits from each treatment were numbered and the weights were recorded. Three replicates (10 fruits in each) were shifted to cold rooms maintained at $10^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$. Various quality parameters of the muskmelon fruits were studied at regular intervals during storage.

Fruits sampling and evaluation: Five fruits from each treatment were selected for the measurement of respiration and ethylene production rate. CO_2 evolution of muskmelon fruits was recorded using automatic gas analyzer (Model: Checkmate 9900 O_2/CO_2 , Denmark) and expressed as $\text{mg CO}_2/\text{kg/h}$. Ethylene evolution was also measured by using ethylene gas analyzer (Model: Bioconservation, ppm ethylene). Ethylene concentration was calculated and expressed as $\mu\text{l C}_2\text{H}_4/\text{kg/h}$ (Rao and Rao 2008). Physiological loss in weight was calculated by measuring the weight of individual fruits from each treatment at each interval using an electronic balance (Model: Sartorius, BSA320 2S $d=0.01$ g) and expressed as cumulative PLW in per cent. The firmness of fruit peel and pulp was measured on opposite sides of each fruit using Instron-Universal

testing machine (Model 4201, USA), with 8 mm diameter probe by adjusting cross head speed of 100 mm/min, load 25 kg, load cell 500 kg and expressed in kg/cm^2 (Rao and Rao 2008)

Quality analysis was carried out using randomly in selected five fruits from each treatment. Fruit pulp was extracted and homogenized using a homogenizer (IKA T25 digital ultra Turrax) before analysis. TSS in °Brix was measured by squeezing the fruit juice onto the prism of a hand refractometer calibrated to 25°C (Erma Inc., Tokyo, Japan). Other quality parameters like titratable acidity (TA%), ascorbic acid ($\text{mg}/100$ g) and total sugars (TS%) were estimated using standard methods of analysis (AOAC 1995) and expressed on fresh weight basis. Carotenoid pigments were extracted by grinding 5 g pulp using a solution of petroleum ether and acetone (3:2) mixture and using acid washed sand for complete extraction of the pigments. The absorbance values were read in spectrophotometer (T80+ UV/VIS spectrophotometer, PG instruments Ltd. UK) at 452 nm using the same mixture of petroleum ether and acetone solution as blank. Total carotenoid content was then calculated with reference to the standard curve prepared with β -carotene and expressed as $\mu\text{g}/100$ g pulp (fresh weight basis). The total phenolic content was estimated and expressed as milligram of gallic acid equivalent per 100 g of fresh weight ($\text{mg GAE}/100$ g FW) (Singleton *et al.* 1999). Total antioxidants were estimated using FRAP (ferric reducing antioxidant power) assay, and expressed as mg ascorbic acid equivalent (AAE) 100 g/FW (Benzie and Strain 1996). Sensory evaluation was carried out by semi trained panelists for various parameters on fivepoint hedonic scale for different parameters such as appearance, flavour, texture, taste and overall acceptability (5-Very good, 4-Good, 3-Average, 2-Bad and 1-Very Bad).

Statistical analysis: The observations recorded under each parameter were statistically analysed with factorial completely randomised design (FCRD) using online statistical software OPSTAT (Sheoran *et al.* 1998). The level of significance used was 5%.

RESULTS AND DISCUSSION

Physiological parameters: Physiological loss in weight (PLW) was greatly affected by edible coatings and storage conditions. At the end of 21 days of storage at 10°C , the highest PLW was noticed in control fruits (13.90%) while muskmelon fruits coated with shellac based coating recorded the lowest mean PLW (6.89%) (Fig. 1). Shellac based coating is a lipid based coating which has good barrier properties against moisture and gas in comparison to the polysaccharide based coatings tried in the present investigation which thereby reduces the transpiration rate more effectively. The results are in agreement with the studies conducted by (Hazarika *et al.* 2017) who reported that papaya fruits coated with lipid based paraffin wax (100%) recorded lowest PLW after 16 days of storage.

Highest respiration rate was noted in control (without coating) fruits while lowest respiration rate was recorded in

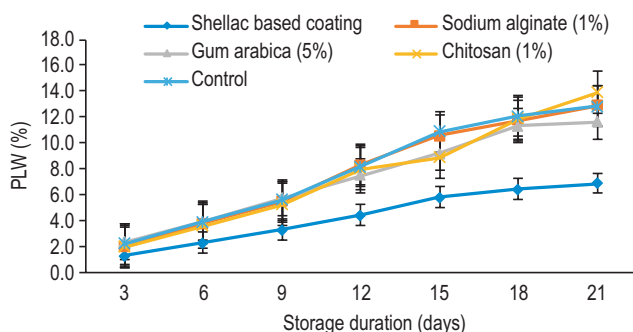


Fig. 1 Effect of different edible coatings on physiological loss in weight (PLW) of muskmelon stored at 10°C temperature.

fruits with shellac based coating during 21 days of storage at 10°C. Respiration rate reached peak value of 14.24 mg CO₂/kg/h on 9th day in shellac based coating, while control fruits reached peak value of 22.74 mg CO₂/kg/h on 6th day itself (Fig. 2A). The lower respiration rate in coated fruits attributed to the less gas interchange and consequently the lower oxygen availability to the fruit tissues for respiration (Barman *et al.* 2011, Meighani *et al.* 2015). Apart from this, low temperature also reduces the metabolic activity by reducing respiration rate. Sapodilla fruits treated with chitosan 10% when combined with lipid based beeswax also had slower respiration and ethylene production compared to control (Foo *et al.* 2019).

Since the fruits were harvested at full slip stage, the ethylene production commenced on first day itself and it continued to increase in control fruits whereas fruits with shellac based coating slowed down ethylene production rate up to 6th day which gradually increased up to 15th day (5.36 µl C₂H₄/kg/h) and declined at the end of storage period (Fig. 2B).

In the present study shellac based coating coupled with low temperature storage exhibited a lower production of ethylene which can be attributed to low enzyme activity. The results are in line with the findings of Hazarika *et al.* (2017) in papaya fruits coated with paraffin wax (100%) which resulted in lower respiration and ethylene production compared to control fruits.

Physical parameters

Peel and pulp firmness: During storage at 10°C, the highest mean peel and pulp firmness was recorded in muskmelon fruits with shellac based coating (20.52 and 1.98 kg/cm², respectively). Control fruits recorded the lowest mean firmness values for peel and pulp (10.97 and 0.83 kg/cm², respectively) (Table 1). The shellac based coating being a lipid based coating act as effective barrier for moisture and gas compared to other polysaccharide edible coatings thereby reduced the water loss and also reduced the activity of enzymes responsible for cell wall degradation thereby maintained the firmness. Similar studies were conducted by Sidhu *et al.* (2009) who reported maintenance of highest firmness in pear cv. Punjab Beauty waxed with Citrashine[®] coupled with cold storage. The papaya fruits coated with paraffin wax (100%) reported highest maintenance of firmness during storage (Hazarika *et al.* 2017).

Biochemical parameters: Muskmelon fruits with the shellac based coating recorded the mean maximum values of TSS whereas mean minimum TSS values were recorded in control (Table 1). As the respiration rate was less with this coating the TSS content was found to be on higher side. Maximum retention of TSS could be because of slow utilization of sugars in respiration process. Similar trend was reported by Hazarika *et al.* (2017) where TSS increased to certain extent in papaya upto 4th day but decreased till 16th day of storage. TSS content in plum fruits coated with lac based coating (2:3) was also high during storage at 2 ± 1°C and 90–92% relative humidity for 35 days.

In the present investigation, the acidity content decreased in all the treatments irrespective of storage duration (Table 2). However highest acidity was maintained in muskmelon fruits with shellac based coating which could be due to the retention of acidity by reducing the respiration rate and reducing the oxidation of organic acids by its barrier properties. The results are in accordance of Kumar *et al.* (2017) who reported maintenance of highest acidity during cold storage of plum with lac based coating (2:3). Hazarika *et al.* (2017) also reported a decrease in acidity but maintenance of highest acidity till the end of storage

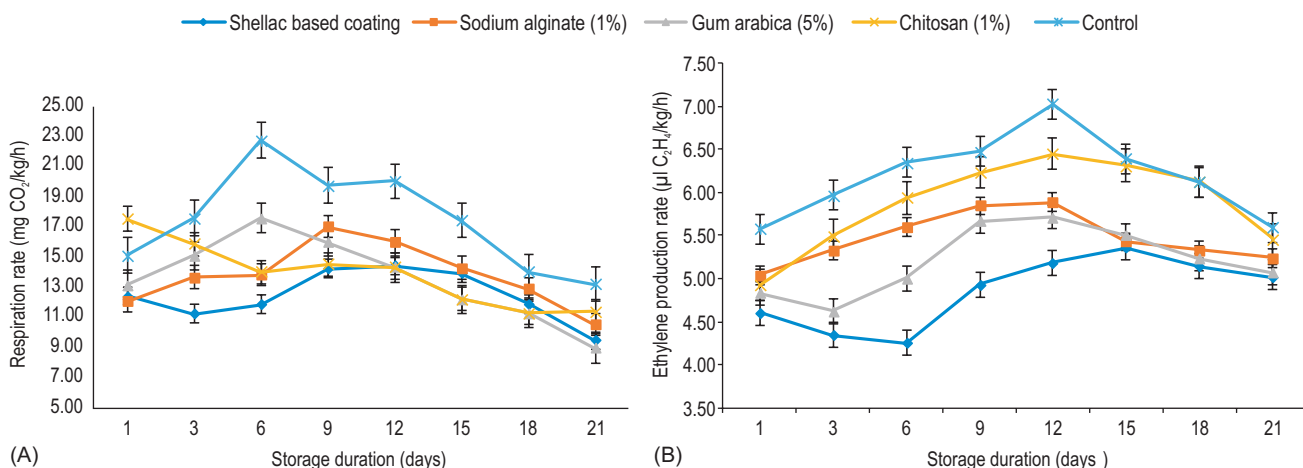


Fig. 2 Effect of different edible coatings on respiration rate (A) and ethylene production rate (B) of muskmelon stored at 10°C temperature.

Table 1 Effect of different edible coatings on fruit, pulp firmness and total soluble solid of muskmelon stored at 10°C temperature

Treatment	Peel firmness (kg/cm ²)			Mean (Treatment)	Pulp firmness (kg/cm ²)			Mean (Treatment)	Total soluble solid (°B)			Mean
	7 days	14 days	21 days		7 days	14 days	21 days		7 days	14 days	21 days	
Shellac based coating	25.72	20.74	15.09	20.52	2.60	1.97	1.39	1.98	9.87	8.23	7.50	8.53
Sodium alginate (1%)	19.19	14.22	9.26	14.22	1.63	1.35	0.81	1.26	7.50	7.13	5.83	6.82
Gum arabica (5%)	22.05	16.27	13.04	17.12	2.03	1.53	1.15	1.57	8.93	8.03	7.00	7.99
Chitosan (1%)	17.97	12.77	7.91	12.88	1.45	1.21	0.98	1.21	7.03	6.17	5.17	6.12
Control	14.07	11.08	7.76	10.97	1.11	0.79	0.60	0.83	6.63	5.90	5.03	5.86
Mean (storage days)	19.80	15.02	10.61		1.76	1.37	0.98		7.99	7.09	6.11	
	T	D	T×D		T	D	T×D		T	D	T×D	
F test	*	*	*		*	*	*		*	*	*	
SEm ±	0.11	0.08	0.19		0.02	0.01	0.03		0.04	0.03	0.06	
CD (P=0.05)	0.31	0.24	0.54		0.05	0.04	0.09		0.10	0.08	0.18	

Table 2 Effect of different edible coatings on acidity, ascorbic acid and total sugars of muskmelon fruit stored at 10°C temperature

Treatment	Acidity (%)			Mean (Treatment)	Ascorbic acid (mg/100 g)			Mean (Treatment)	Total sugar (%)			Mean (Treatment)
	7 days	14 days	21 days		7 days	14 days	21 days		7 days	14 days	21 days	
Shellac based coating	0.22	0.20	0.14	0.19	5.75	4.79	3.45	4.66	7.21	6.10	5.66	6.33
Sodium alginate (1%)	0.19	0.17	0.12	0.16	4.79	3.45	3.07	3.77	6.08	6.00	4.99	5.69
Gum arabica (5%)	0.21	0.18	0.13	0.17	5.37	4.60	3.26	4.41	6.27	5.34	5.12	5.58
Chitosan (1%)	0.19	0.18	0.12	0.16	4.60	3.83	2.49	3.64	5.82	4.99	4.81	5.21
Control	0.17	0.14	0.09	0.13	4.41	3.45	2.30	3.39	5.36	4.66	4.26	4.76
Mean (storage days)	0.20	0.17	0.12		4.98	4.03	2.91		6.15	5.42	4.97	
	T	D	T×D		T	D	T×D		T	D	T×D	
F test	*	*	*		*	*	*		*	*	*	
SEm ±	0.01	0.01	0.01		0.08	0.06	0.14		0.05	0.04	0.09	
CD (P=0.05)	0.02	0.01	0.03		0.23	0.18	0.40		0.15	0.12	0.26	

in papaya fruits coated with lipid paraffin wax (100%).

The ascorbic acid content of muskmelon fruits decreased with the increment of storage period at 10°C. But when compared to other treatments, muskmelon fruits with shellac based coating retained higher ascorbic acid content owing to its limited gas diffusion characteristics (Table 2) which decreased the conversion of dehydroascorbic acid to diketogulonic acid owing to oxidation. Similar studies were reported by Kumar *et al.* (2017) where lac based coating (2:3) in plum fruit maintained highest ascorbic acid during cold storage of 35 days. Yadav *et al.* (2010) also reported highest maintenance of ascorbic acid in waxol (8%) treated mandarin fruits during storage period of 20 days.

When the muskmelon fruits were stored at 10°C, irrespective of the treatments total sugars decreased over the storage period. However, significantly ($P<0.05$) higher mean total sugars were noticed in fruits with shellac based coating having 33% higher total sugars than the control fruits, which showed lowest mean total sugars (Table 2). This might be due to lower respiration of shellac coated fruits owing to its better effectiveness towards curbing gas exchange that helped in retention of more sugar compared to other coating treatments. Similar trend was observed in papaya fruits treated with paraffin wax (100%) that resulted in higher maintenance of total sugars during storage (Hazarika *et al.* 2017).

Table 3 Effect of different edible coatings on total phenols, total antioxidant capacity and total carotenoid content of muskmelon fruit stored at 10°C temperature

Treatment	Total phenol (mg GAE/100 g)			Mean (Treatment)	Total antioxidant capacity (mg AAE/100 g)			Mean (Treatment)	Total carotenoid content (µg/100 g)			Mean (Treatment)
	7 days	14 days	21 days		7 days	14 days	21 days		7 days	14 days	21 days	
	T	D	T×D		T	D	T×D		T	D	T×D	
Shellac based coating	33.78	32.99	30.89	32.55	26.45	24.36	22.49	24.43	2226.26	2074.04	1801.99	2034.10
Sodium alginate (1%)	29.77	27.87	25.66	27.77	22.87	21.25	19.35	21.16	1841.07	1514.52	1447.92	1601.17
Gum arabica (5%)	32.88	30.13	27.21	30.07	24.13	22.74	20.02	22.30	1997.93	1723.82	1509.63	1743.79
Chitosan (1%)	26.89	25.88	23.71	25.49	22.08	21.07	19.02	20.72	1679.08	1530.46	1209.04	1472.86
Control	25.78	22.11	19.19	22.36	21.34	20.79	17.69	19.94	1373.61	1152.99	972.74	1166.44
Mean (storage days)	29.82	27.80	25.33		23.37	22.04	19.72		1823.59	1599.16	1388.26	
F test	*	*	*		*	*	*		*	*	*	
SEm ±	0.19	0.15	0.33		0.08	0.07	0.15		22.37	17.32	38.74	
CD (P=0.05)	0.56	0.43	0.97		0.24	0.19	0.42		64.60	50.04	111.88	

Higher mean carotenoid content was observed in the muskmelon fruits with shellac based coating (2034.10 µg/100 g) and least values were observed in control (1166.44 µg/100 g) (Table 3). The carotenoid content in the muskmelon fruits decreased in all the treatments during storage at 10°C which is probably due to oxidation of carotenoid pigments. However, muskmelon fruits with shellac based coating maintained highest carotenoid content when stored at 10°C owing to its suppression effect on respiration rate. The low respiration rate reduced the oxidation of pigments thereby maintaining the highest carotenoid content.

Total phenolic content and total antioxidant activity of muskmelon fruits also followed a decreasing trend during storage. But shellac based coating retained maximum mean total phenolic content as well as higher total antioxidant activity compared to other surface coatings and control (Table 3). Higher phenols were maintained in muskmelon fruits with shellac based coating which might be due to lesser activity of oxygen dependent phenol degrading enzymes that is rendered by low respiration of shellac based coated fruits. The results are in agreement with Kumar *et al.* (2017) where total phenolic content was retained highest in plum fruits coated with lac based coating (2:3) during storage at 2 ± 1°C and 90–92% relative humidity for 35 days.

Similarly, fruits with shellac based coating maintained highest antioxidant capacity because of the modified atmosphere created by the coating internally which act as effective barrier for oxygen and retention of higher antioxidant capacity which can also be correlated with the maintenance of highest ascorbic acid content. The results are better supported by the findings of Nasirifar *et al.* (2018) in *Citrus sinensis* fruits coated with carnauba wax incorporated with nano clay and orange peel essential oil

that maintained higher activity.

Sensory evaluation: Mean scores of fruits given shellac based coating for fruit appearance (4.00), pulp colour (3.75), texture (3.84), flavour (3.75), taste (3.9), overall acceptability (3.85) was highest among all other treatments while control fruits had lowest mean scores for fruit appearance (3.4), pulp colour (3.0), texture (3.4), flavour (3.69), taste (3.6) and overall acceptability (3.28) at the end of storage period (Fig. 3). The reason behind this could be that edible coatings such as shellac coating act as barriers to the volatile compounds that give fruits and vegetables their natural aromas. Also low temperature coupled with edible coating resulted in creation of favourable atmosphere for retaining the fruit quality. Also fruits coated with shellac

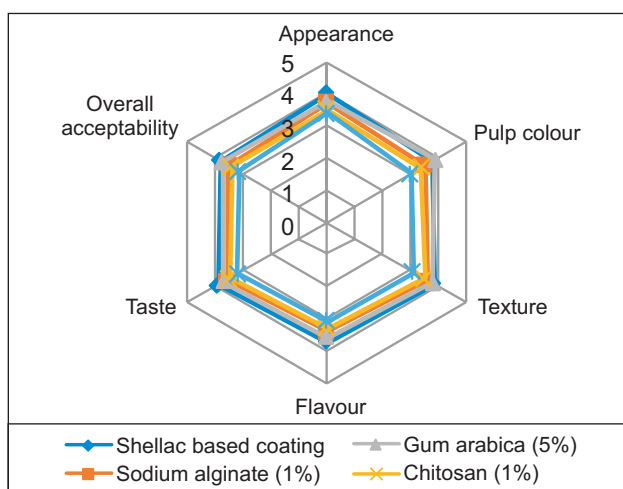


Fig. 3 Effect of different edible coatings on sensory scores of muskmelon fruits after 21 days of storage at 10°C temperature.

based coating had better gloss properties than those fruits coated with polysaccharide based coatings. Similar results were seen in pear cv. Punjab beauty waxed with citrashine® that had highest palatability score during cold storage (Sidhu *et al.* 2009). Hassan *et al.* (2014) reported higher scores for colour, odour, flavour, texture, taste and overall acceptability in sweet orange fruit cv. Siam Banjar coated with 10 and 12% bees wax emulsion and stored at 5°C.

The present study indicated that muskmelon fruits could be stored up to 21 days by maintaining better physical, physiological, biochemical and sensory properties by coating them with shellac based coating compared to 14 days storage life without coating and storing at 10°C. The shellac based coating maintained about 33% higher total sugar and 46% higher TSS than control. Hence, this eco-friendly technology can be used at the farm level or at pack houses after harvest to enhance the shelf life of muskmelon fruits.

REFERENCES

- Anonymous. 2022. Agricultural Statistics at a Glance. <https://desagri.gov.in/wp-content/uploads/2023/05/Agricultural-Statistics-at-a-Glance-2022.pdf>
- AOAC. 1995. *Official Methods of Analysis*, 16th edn. Association of Official Analytical Chemists. Washington DC, USA.
- Barman K, Asrey R and Pal R K. 2011. Putrescine and carnauba wax pre-treatments alleviate chilling injury, enhance shelf-life and preserve pomegranate fruit quality during cold storage. *Scientia Horticulturae* **130**(4): 795–800.
- Benzie I F and Strain J J. 1996. The ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. *Analytical Biochemistry* **239**(1): 70–76.
- Dhall R K. 2013. Advances in edible coatings for fresh fruits and vegetables: A review. *Critical Reviews in Food Science and Nutrition* **53**(5): 435–50.
- Foo S Y, NurHanani Z A, Rozzamri A, Ibadullah W W and Ismail-Fitry M R. 2019. Effect of chitosan-beeswax edible coatings on the shelf-life of sapodilla (*Achras zapota*) fruit. *Journal of Packaging Technology and Research* **3**: 27–34.
- Hassan Z H, Lesmayati S, Qomariah R and Hasbianto A. 2014. Effects of wax coating applications and storage temperatures on the quality of tangerine citrus (*Citrus reticulata*) var. Siam Banjar. *International Food Research Journal* **21**(2).
- Hazarika T K, Lalthanpuii L and Mandal D. 2017. Influence of edible coatings on physico-chemical characteristics and shelf-life of papaya (*Carica papaya*) fruits during ambient storage. *The Indian Journal of Agricultural Sciences* **87**(8): 1077–83.
- Kumar P, Sethi S and Sharma R R. 2017. Combined effect of edible coatings and low temperature on plum fruit quality. *International Journal of Current Microbiology and Applied Sciences* **6**(7): 4210–18.
- Meighani H, Ghasemnezhad M and Bakhshi D. 2015. Effect of different coatings on post-harvest quality and bioactive compounds of pomegranate (*Punica granatum* L.) fruits. *Journal of Food Science and Technology* **52**: 4507–14.
- Milind P and Kulwant S. 2011. Muskmelon is eat-must melon. *International Research Journal of Pharmacy* **2**(8): 52–57.
- Murlee Y, Neeraj K, Singh D B and Singh G K. 2010. Effect of post-harvest treatments on shelf-life and quality of Kinnow mandarin. *Indian Journal of Horticulture* **67**(2): 243–48.
- Nasirifar S Z, Maghsoudlou Y and Oliyai N. 2018. Effect of active lipid-based coating incorporated with nanoclay and orange peel essential oil on physicochemical properties of *Citrus sinensis*. *Food Science and Nutrition* **6**(6): 1508–18.
- Raghav P K, Agarwal N and Saini M. 2016. Edible coating of fruits and vegetables: A review. *Education* **1**(2): 188–204.
- Rao D V S and Rao K P G. 2008. Controlled atmosphere storage of mango cultivars ‘Alphonso’ and ‘Banganapalli’ to extend storage-life and maintain quality. *The Journal of Horticultural Science and Biotechnology* **83**(3): 351–59.
- Sangamithra A and Ragavi P. 2020. Post-harvest attributes of muskmelon (*Cucumis melo*): A mini review on the potential of value addition. *Current Nutrition and Food Science* **16**(6): 854–59.
- Sheoran O P, Tonk D S, Kaushik L S, Hasija R C and Pannu R S. 1998. Statistical Software Packages for Agricultural Research Workers, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.
- Sidhu G S, Dhillon W S and Mahajan B V C. 2009. Effect of waxing and packaging on storage of pear cv. Punjab Beauty. *Indian Journal of Horticulture* **66**(2): 239–44.
- Singleton V L, Orthofer R and Lamuela-Raventos R M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-ciocalteu reagent. *Methods in Enzymology* **299**: 152–78.