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REVOLUTIONIZING MUSKMELON PRESERVATION: THE ROLE OF INNOVATIVE PRETREATMENTS IN ENHANCING SHELF LIFE AND QUALITY

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ABSTRACT

The study focused on evaluating the impact of pretreatments and modified atmosphere packaging (MAP) on the quality of fresh-cut muskmelon (*Cucumis melo* L.) during low-temperature storage. Minimally processed muskmelon (MPM) slices were treated with 1.5% calcium chloride, calcium propionate, 100 ppm sodium hypochlorite, and gaseous treatments including 1-MCP, SO_2 (GRAPVIN®), and UV-C (254 nm). The optimal treatment involved dipping slices in 1.5% calcium propionate, surface drying, and packaging in cling film (12 µm), achieving an equilibrium MAP of 9–10% O_2 and 6% CO_2, which extended marketability to 11 days at 5°C. Microbiological quality remained optimal for 9 days, with aerobic plate count, pectinolysers, and pseudomonads increasing afterward. Sensory and physicochemical properties, including in-pack gas composition, color, texture, TSS, acidity, and vitamin C, total phenol, antioxidant, flavonoid and carotenoid content, were effectively maintained during storage.
Keywords: Minimal processing, calcium propionate, Modified atmosphere, pectinolysers, flavonoids, FRAP, MPM.

Introduction

In recent years, ready-to-eat fresh fruits and vegetables have gained significant importance in the HORECA (Hotel, Restaurant and Catering) industry due to their convenience, health benefits, food safety assurances, versatility and longer shelf life. However, certain fruits such as muskmelon, present challenges in peeling and cutting, resulting in time-consuming operations and significant wastage for retailers in their fresh form. Therefore, adopting minimal processing methods for these fruits offers advantages such as enhanced convenience, improved quality, extended shelf life, and reduced wastage for retailers. However, fresh cut produce deteriorates faster than the unprocessed raw materials, mainly due to the damages caused by minimally processing methods (peeling, slicing, dicing, shredding, *etc*.). These processing operations usually shorten the shelf life of fresh-cut fruits and vegetables by a series of typical symptoms, such as tissue softening, cut surface browning, decreased nutritional value, presence of off-flavor and microbiological spoilage during storage. Here, research has been carried out to extensively exploit the effect of decontamination of fresh produce with different groups of safe chemical as human health is of great concern (Vivek *et al*., 2019).

Materials and Methods

The experiment was conducted in the Dept. of Post Harvest Technology and Agriculture Engineering, ICAR-IIHR Bengaluru. Muskmelon variety of Arka siri were procured from farmer's field of Andhra Pradesh. In all treatments freshly, harvested produce was washed in potable water and surface dried.

The general protocols for minimal processing of muskmelon were schematically given as shown below.

Collection of muskmelons from farmer's field (Arka siri)

↓

Sorting to remove defective fruits

↓

Washing of fruits with potable water to remove dirt

↓

Peeling and deseeding, cutting

↓

Application of different treatments

↓

Packaging and cold storage at 5° C

Fig. 1 : Flow chart for minimal processing of muskmelon

Experiment to study the effect of pretreatments suitable for extending the shelf life

The freshly cut muskmelon pieces were dipped for 5 min in solutions of different pretreatment chemicals viz., 100 ppm sodium hypochlorite, 1.5 % calcium chloride, 1.5 % calcium propionate, gaseous treatments which includes 1-MCP and SO_2 (GRAPVIN®) and UV-C (254 nm). Muskmelon pieces without any dip treatment served as the control for comparison. The slices were then surface dried and 200 g of samples were packed in plastic trays over wrapped with cling film (12 µm). All samples were stored at 5 °C for 11 days. Six replications were maintained for each treatment. These chemicals and their concentrations were chosen based on earlier scientific reports of their utility in minimal processing of other vegetables and fruits (Rico *et al*., 2007).

Samples in the above experiments were analyzed for sensory, colour, firmness, nutritional quality and microbiological quality at four days of interval during storage period. Sensory properties viz., color, firmness, odour and overall marketability of the stored samples in the above experiments were measured using a 5 point Hedonic scale (5 = excellent, 4 = very good, 3 = good, 2= average 1 = poor) and the packs were sampled for biochemical and microbiological analysis at four days of interval during storage period.

In-pack oxygen and carbon dioxide levels during storage of the packages were analyzed using a Gas analyzer (Checkmate-9900, PBI Dansensor, Denmark) at regular intervals. Colour readings (*L**, *a**, *b** values) of the minimally processed muskmelon were measured using a Colour reader (CR-10, Minolta Co. Ltd., Osaka, Japan). Firmness of the cut pieces were analyzed using firmness analyzer (Instron-4201 Universal testing machine, Instron Corporation, USA) with a 8 mm probe and the values were expressed as N/mm^2. TSS using digital refractometer (ATAGO Pocket refractometer PAL-3, Japan). Acidity was measured by titration using phenopthalien indicator and pH measure using pH meter (Esico model 1015). Vitamin C was measured colorimetrically (Davies and Masten, 1991). Ferric reducing anti-oxidant potential (mg ascorbic acid equivalent antioxidant capacity, AEAC mg g^{-1}), total phenols (mg gallic acid equivalent g^{-1}, GE mg g^{-1}) and total flavonoids (catechin equivalent mg g^{-1}, CE mg g^{-1}) were measured spectrophotometrically using the standard methods (Benzie & Strain, 1996; Singleton & Rossi, 1965) after 11 days storage. Microbiological quality was assessed by enumerating total aerobes (plate count agar), yeast and mold (PDA, YEPD agar) and coliforms (violet red bile agar) by standard plating method. Data obtained in the analytical studies were subjected to statistical analysis using OPSTAT software (O.P. Sheoran, Computer Programmer at CCS HAU, Hisar, India). Analysis of variance was carried out and Fisher's LSD values were calculated at 1% confidence level.

Results and Discussion

The sensory scores for the minimally processed muskmelon, affected by various pretreatments, are depicted in Fig. 1. The data on sensory qualities, colour values, in pack gas concentration and firmness of fresh-cut muskmelon stored at 5 °C for 11 days are given in Fig 1 and table 1. Among the pretreatments tested, Fruit pieces dipping in 1.5 % calcium propionate was found to be the best for maintaining the shelf life till 11th day of storage at 5 °C along possessed high firmness (0.174 N/mm^2) and Hunter's *L** (53.83), *a** (14.80) and *b* (37.50) * colour values closely approaching the freshly cut muskmelon. Calcium ions inhibit browning enzymes such as PPO, peroxidase *etc*., which would have contributed in reducing the color and flavor changes. Martin Diana *et al*. (2007). Highest texture attributed to the mechanism wherein fruit parenchyma cells interact with calcium salt solutions Aguayo *et al*. (2008). The assessment of overall acceptability was based on quality scores derived from the evaluation of color, flavor, taste, and texture of fresh-cut muskmelon.

Details on the effect of different packaging film on in-pack gas composition of MPM are presented in

Table 1. Treatment with calcium propionate maintained lower oxygen concentration (9.00%) and a higher carbon dioxide concentration (5.65%), which was followed by 1-MCP-treated (T_6) packs with lower oxygen (9.83%) and higher carbon dioxide (4.87%) concentrations. The sodium hypochlorite-treated (T_4) fruits had a higher oxygen concentration (13.83%), whereas the UV-C-treated packs had a lower carbon dioxide (1.57%) concentration inside the packs. This phenomenon may be attributed to the gas composition achieved in the headspace inside the package, which is influenced by the interaction between the film's permeability and the respiratory activity of the produce (Lucera *et al*., 2011).

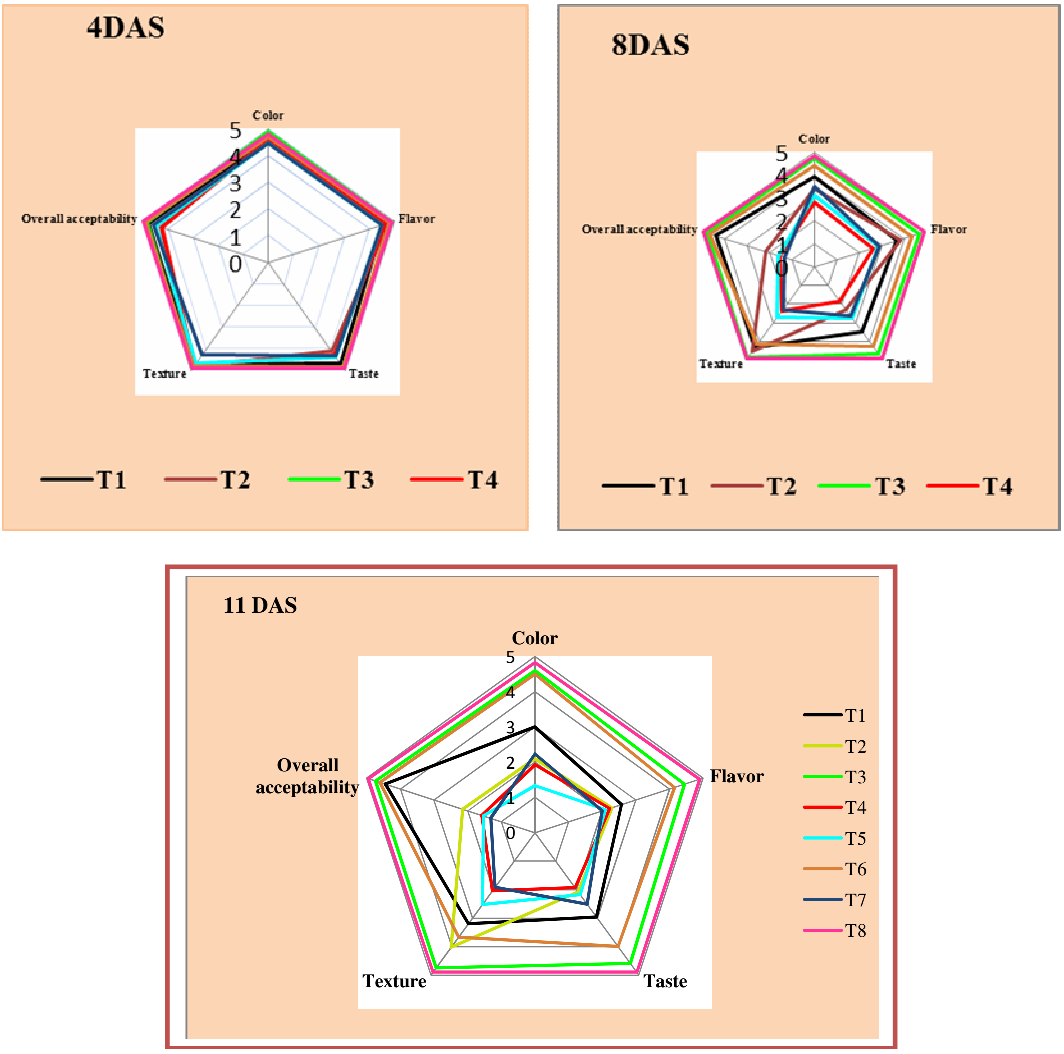

Fig. 1: The sensory scores for the minimally processed muskmelon, affected by various pretreatments

The total soluble solids (TSS) in minimally processed muskmelon fruits decreased gradually with storage duration, irrespective of the treatments the lowest reduction in TSS content was recorded in treatment T_3 (11.23°B) with calcium propionate at 1.5%, which was on par with fresh sample (11.77°B) This was followed by treatment T_6 (10.87°B) and T_2 (8.17°B) to the potential antioxidant properties of calcium propionate, which may aid in mitigating oxidative stress and preserving bioactive compounds, such as sugars and other soluble solids.

During storage, a decrease in acidity corresponds to an increase in pH values. Comparable outcomes were noted in minimally processed muskmelon subjected to various pretreatment agents (Table1). Fruits treated with 1.5% calcium propionate notably retained a pH of 6.0, closely resembling the pH of freshly cut muskmelon, which was 6.40. In contrast, regarding acidity, fruits treated with sodium hypochlorite exhibited the highest rate of acidity increase (T_4: 0.20%), making them unfit for consumption after 8 days. On the other hand, fruits treated with calcium propionate demonstrated the lowest change in acidity (T_3: 0.08%) this value closely approaches the fresh value, followed by T_6 (0.19%) after 11 days of storage.

Table 1: Effect of different pretreatments on Physico-chemical properties of minimally processed muskmelon after 11 days of storage at 5 °C

Treatment details	Storage Days (D) at 5 °C								
	In-pack gas levels		*L**	*a**	*b**	Texture (N/mm^2)	TSS (° B)	Acidity (%)	pH
	O_2 (%)	CO_2 (%)							
T_1: Control	13.70	3.53	48.63	13.67	35.73	0.077	8.07	0.16	4.90
T_2: Calcium chloride	12.90	2.73	48.90	13.83	35.63	0.085	8.17	0.14	5.20
T_3: Calcium propionate @1.5 %	9.00	5.65	53.83	14.80	37.50	0.174	11.23	0.08	6.00
T_4: Sodium hypochlorite @100ppm	13.83	1.83	48.43	11.67	35.40	0.068	7.93	0.20	5.37
T_5: SO_2 pads	13.73	1.93	48.10	11.23	34.20	0.061	8.17	0.17	5.23
T_6: 1 MCP	9.83	4.87	52.20	13.87	36.73	0.156	10.87	0.10	5.80
T_7: UV-C	13.77	1.57	48.37	13.30	35.80	0.056	7.93	0.15	5.57
Fresh Sample			54.53	15.47	38.23	0.180	11.77	0.05	6.40
Mean	**12.39**	**3.16**	**49.78**	**13.20**	35.86	**0.097**	**8.91**	**0.14**	**5.44**
SE(m)	0.122	0.095	0.041	0.051	0.045	0.002	0.048	0.002	0.035
CD @ 1%	**0.176**	**0.314**	**0.168**	**0.219**	**0.184**	**0.006**	**0.167**	**0.008**	**0.098**

Key assays relevant to plant-based foods include ferric reducing antioxidant potential, total phenolics, total flavonoids, as well as estimations of ascorbic acid, total sugars, and reducing sugars (Shahidi and Zhong, 2015). Among the various pretreatments, minimally processed muskmelon (MPM) treated with 1.5% calcium propionate (T_3) demonstrated notable retention of vitamin C (28.82 mg/100g), total sugars (10.27%), reducing sugars (7.20%), ferric reducing antioxidant potential (17.40 mg AEAC/100g), total phenols (30.59 mg GAE/100g), total flavonoids (23.43 mg CE/100g), and total carotenoids (5.31 mg/100g) after 11 days of storage. These values were closely aligned with those of freshly cut muskmelon, as detailed in Table 2. A similar study by Mirshekari et al. (2017) highlighted that calcium propionate treatment helps mitigate oxidative stress in fruit tissue. Oxidative stress often accelerates the degradation of phenolic compounds. By minimizing such damage, calcium propionate-treated fresh-cut muskmelons effectively preserve their sugar content and phenolic compounds during storage.

Table 2: Effect of different pretreatments on biochemical properties of minimally processed muskmelon after 11 days of storage at 5 °C

Treatment details	Storage at 5 °C						
	Total sugar (%)	Reducing sugar (%)	Vitamin C (mg Ascorbic acid/100g)	Total phenol (mg GAE/ 100g)	FRAP (mgAEAC /100g)	Total flavonoids (mgCE /100g)	Total carotenoids ((mg/100g)
T_1: Control	7.68	5.73	10.48	17.87	16.11	16.11	3.22
T_2: Calcium chloride	7.58	5.82	12.23	18.17	16.19	16.50	4.13
T_3: Calcium propionate @1.5 %	12.47	7.20	28.82	30.59	17.40	23.43	5.31
T_4: Sodium hypochlorite @100ppm	7.13	5.81	10.48	17.80	16.61	15.49	3.14
T_5: SO_2 pads	7.13	5.77	20.96	17.64	16.99	15.21	3.17
T_6: 1 MCP	11.94	6.04	23.58	28.02	17.03	21.25	4.57
T_7: UV-C	7.41	5.86	10.48	17.28	15.99	19.69	3.08
Fresh Sample	13.77	7.68	34.06	33.23	18.13	28.02	5.81
Mean	**8.76**	**6.03**	**16.72**	**21.05**	**16.61**	**18.24**	**3.80**
SE(m)	0.021	0.016	0.330	0.043	0.008	0.082	0.001
CD @ 1%	**0.065**	**0.050**	**1.011**	**0.132**	**0.026**	**0.251**	**0.004**

Microbiological quality as evidenced by aerobic plate count, yeast and mold, lactic acid bacteria pectinolytic, pseudomonads and coliforms population. freshly cut muskmelon dipped in 1.5% calcium propionate and wrapped with cling film showed least microbial growth throughout the storage period as detailed in fig 2. Apart from acting as calcium source, calcium propionate and calcium lactate are antimicrobial compounds. Calcium propionate possess antibacterial and antifungal activity by interfering cellular respiration steps (Luna- Guzman and Barrett 2000). It is a food additive designated as GRAS (Generally Recognized as Safe) by the U.S. Food and Drug Administration (SCOGS report No.79, 1979).

This study showed that calcium propionate treatment and subsequent storage in trays overwrapped with cling wrap was effective in retaining nutritional and microbiological quality of fresh-cut muskmelon till 11th day of storage.

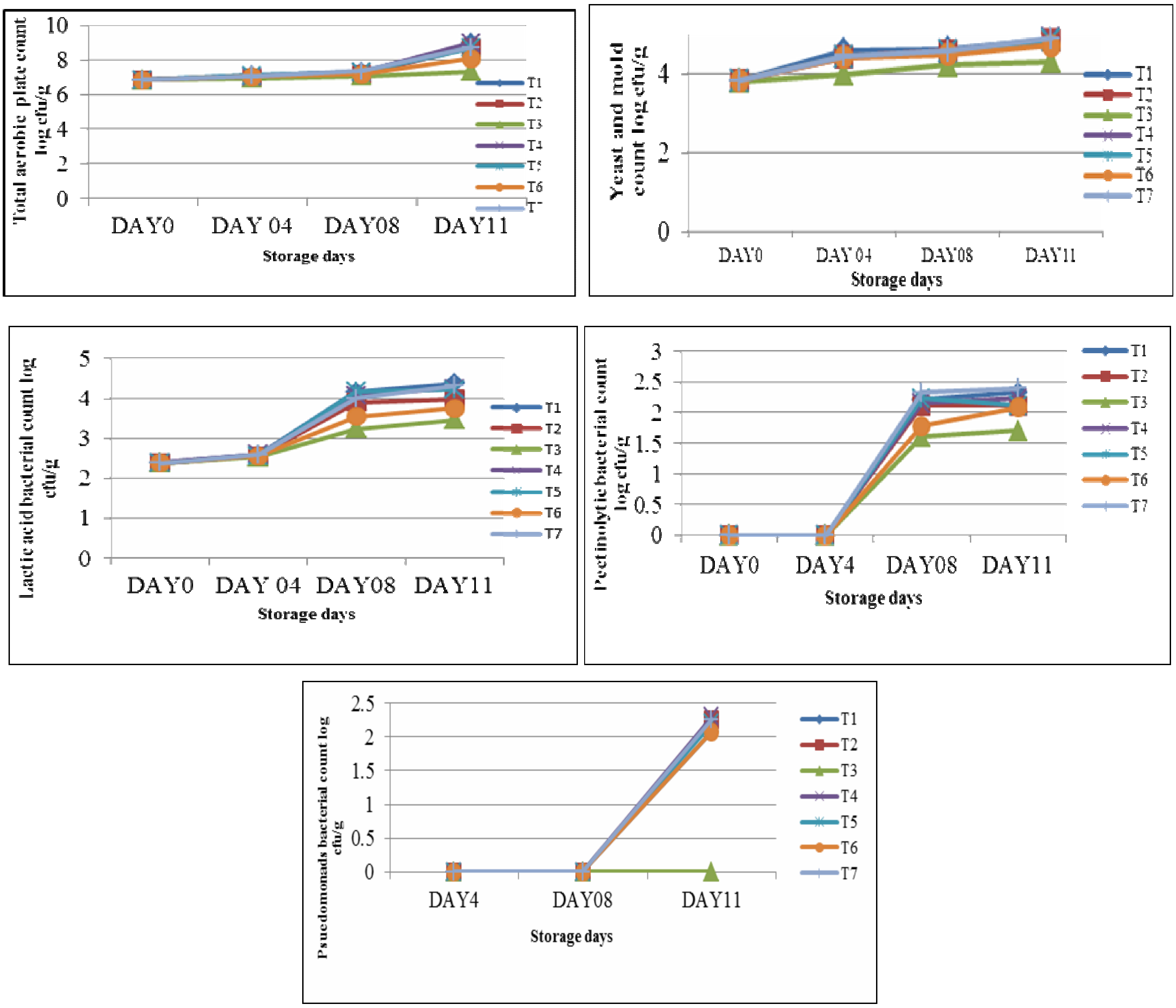

Fig 2: Changes in the population of spoilage bacterial groups during storage of minimally processed muskmelon at 5 °C a). total aerobic plate count b). Yeast and mold c). lactic acid bacteria d). pectinolytic bacteria e). pseudomonads

Conclusion

Among the treatments, dipping of the fruit pieces in calcium propionate (1.5%) for five minutes was found best in extending the shelf life of muskmelon and pommelo. This best pretreatment extended the shelf life to 11 days respectively, compared to 7 days in untreated control samples. The superior pretreatments identified as given above helped to retain sensory, sugar, color, antioxidants, phenolic compounds, and pigment qualities in the fresh cut fruits, along with a slower progression in microbial proliferation.

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