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DIFFERENTIAL RESPONSES OF EDIBLE COATINGS ON SHELF LIFE AND FRUIT QUALITY OF KINNOW MANDARIN

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ABSTRACT

To assess the effect of various oil coatings on quality and shelf life of Kinnow mandarin (*Citrus reticulata* Blanco) a research trail was conducted at Department of Agriculture, Mata Gujri College, Fatehgarh Sahib during the year 2024-2025. Laboratory experiment was carried out under Factorial Complete Randomized Design (FCRD) with six treatments T₁ (Lemongrass oil), T₂ (Rosemary oil), T₃ (Neem oil), T₄ (Mustard oil), T₅ (Olive oil), T₆ (Control) replicated four times. After coating with various oils, the fruits were stored under refrigerated condition (5±1°C). The fruits were then analyzed periodically various quality attributes. Results of the study revealed that the lemongrass oil coated fruits had as immense effect on the reduction of physiological loss of weight (16.34%) and spoilage (27.70%), TSS (11.02%), total sugars (9.12%) and ascorbic acid (18.92mg/100ml) and non detection of microbes and growth up to 21 days of storage. Hence, lemongrass oil coated fruits proved quite effective in prolonging the shelf-life and maintaining the quality of Kinnow mandarin fruits for 21 days compared to only 7 days in untreated fruits.

Key words : Kinnow mandarin, Oil coatings, Quality attributes, Refrigerated condition, Storage, Shelf life.

Introduction

Citrus is among the most diverse and economically significant fruit crops cultivated extensively in tropical and subtropical regions, spanning over 140 countries worldwide (Uppendar *et al.*, 2021). Within the citrus genus, the Kinnow mandarin holds a particularly prominent position due to its unique horticultural attributes and commercial importance. The widespread cultivation of Kinnow mandarin in Punjab is largely attributed to its high yield potential, early maturation, appealing golden-yellow peel, and juice-rich, flavourful pulp that caters well to the sensory preferences of the Indian consumer (Joshi *et al.*, 2024). In India about 10% area of the fruit crops has been occupied by citrus fruits and has the 3rd position in production after mango and banana (Mahawar *et al.*, 2020).

India ranks as the fifth-largest producer of citrus fruits globally, with citrus cultivation occupying approximately 10% of the total fruit-growing area. The district of Abohar

alone contributes about 1.3 million tonnes from an estimated 35,000 hectares, with other key growing regions including Fazilka, Muktsar and Bathinda districts (Asrey *et al.*, 2021). The rise of Kinnow in north western India is underpinned by its adaptability to the agro-climatic conditions, early bearing habit, and superior productivity, factors which have cemented its reputation as the “King of fruits” within the Punjab citrus industry (Kumar *et al.*, 2024).

Nutritionally, Kinnow mandarin is a dense source of essential vitamins and minerals, most notably vitamin C, with juice concentrations ranging from 80 to 200 mg per 100 grams (Lado *et al.*, 2016). Kinnow mandarin is classified as a non-climacteric fruit characterized by a low respiration rate and it is highly susceptible to rapid postharvest deterioration. Unlike climacteric fruits such as mango and banana, which can continue to ripen after harvest, citrus fruits do not ripen postharvest and therefore require meticulous postharvest handling to maintain

quality. The peak harvesting period in Punjab, occurring between mid-December to mid-February, coincides with cool and foggy weather conditions that often lead to overproduction and market saturation. This seasonal glut results in substantial postharvest losses estimated to be between 35 and 40 per cent, severely impacting the profitability and livelihood of citrus farmers (Bhan *et al.*, 2022).

Among the emerging postharvest technologies, edible coatings have attracted significant research and commercial interest as a means to extend the shelf life of perishable fruits like Kinnow mandarin. These coatings, formulated from oils, waxes, polysaccharides, proteins and biodegradable polymers, create a semi-permeable barrier on the fruit surface that helps retard moisture loss, reduce respiration rates, and inhibit microbial proliferation (Bajaj *et al.*, 2024). As a result, edible coatings contribute to the retention of fruit firmness, minimize physiological weight loss and preserve key biochemical parameters including TSS, sugar content, and vitamin C levels (Bisen *et al.*, 2012).

In addition to functional benefits, coated fruits typically display improved external appearance, increased brightness and delayed senescence, attributes that enhance marketability, especially in export markets where fruit quality standards are stringent. The partial occlusion of surface pores by edible coatings also modifies the internal atmosphere of the fruit, reducing oxygen ingress and carbon dioxide egress, which collectively help maintain freshness during ambient storage. Among various postharvest interventions, oil-based edible coatings stand out for their cost-effectiveness, ease of application, and suitability for adoption by resource-limited farmers and small-scale handlers.

Materials and Methods

The collection of mature Kinnow mandarin fruits were harvested during the first week of January from the orchard at Sandhu Fruit Farm House, Jhurar Khera, Abohar, District Fazilka in Punjab. Fruits were selected for uniform size, maturity, and free from physical damage and disease. Harvesting was carried out using secateurs by clipping the fruit stalk just above its attachment point. The fruits were transported in plastic crates to the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab. Upon arrival, the fruits were washed with clean water, sorted and graded to ensure homogeneity. They were then divided into experimental lots for subsequent treatments.

Experimental details

The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with six treatments T_1 (Lemongrass oil), T_2 (Rosemary oil), T_3 (Neem oil), T_4 (Mustard oil), T_5 (Olive oil), T_6 (Control) and four replications per treatments. Each replication consisted of ten fruits and total 240 fruits were used in this study. Observations were recorded at seven-day intervals throughout the storage period under refrigerated condition.

Observations recorded

Fruit physical parameters

Physiological loss in weight (PLW)

The physiological loss in weight (PLW) of the fruits was calculated based on their initial weight. Initially, a set of nine fruits was weighed prior to the application of treatments to determine the baseline weight. Subsequent weightings were conducted at each storage interval. The percentage of weight loss at each interval was determined by subtracting the final weight from the initial weight and converting the result into a percentage using the following formula:

$$\text{Fruit weight loss \%} = \frac{W_i - W_s}{W_i} \times 100$$

Where,

W_i = fruit weight at initial period

W_s = fruit weight at sampling (storage) period

Spoilage

The percentage of fruit spoilage was determined by counting the total number of spoiled fruits at each storage interval and expressing it as a percentage of the total number of fruits using the following formula:

$$\text{Fruit spoilage (\%)} = \frac{\text{Number of spoilage fruits}}{\text{Total number of fruits}} \times 100$$

Juice content

Fruit juice was extracted using a screw-type extractor (make: Kalsi) and subsequently strained through a 32 mm mesh. The weight of the extracted juice was recorded and the juice content was calculated as a percentage of the fresh fruit weight.

$$\text{Juice content (\%)} = \frac{\text{Weight of extracted juice}}{\text{Fruit weight}} \times 100$$

Evaluation of Fruit biochemical parameters

Using a handheld refractometer, the total soluble solids (TSS) of apple fruit were measured, and the results

were reported in Brix equivalents. By titrating against 0.1 N NaOH with two or three drops of phenolphthalein indicator that became pink, the titratable acidity of apple pulp was ascertained and expressed as citric acid equivalent (AOAC, 2000). The 2,6-Dichlorophenol indophenol titration method, which relies on the dye's reduction of ascorbic acid, was used to measure ascorbic acid (AOAC, 2000).

The fruit pulp (25 g) was homogenized, treated with potassium oxalate and lead acetate, and filtered. The filtrate was then hydrolyzed with HCl, neutralized with NaOH, and titrated with Fehling's solution using methylene blue to determine the total sugars (AOAC, 2016).

Statistical analysis

Yearly data obtained for various parameters was tested for homogeneity of variance (Bartlett's test) described by Snedecor and Cochran, (1983) and the pooling of data was done as per procedure given Mosteller (1948). The yearly and pooled data was statistically analyzed by using the MS-Excel, OP stat statistical package the analysis of variance (ANOVA) procedure and two Factorial Completely Randomized Designs proposed by Sheoran (1998).

Results and Discussion

Physiological loss in weight

It is evident from the data that lemongrass oil coated Kinnow fruits stored at refrigerated condition showed significantly increase in the PLW with passage of time as compared to control. Minimum PLW (16.34%) was recorded in T_1 i.e. lemongrass oil coated Kinnow fruits stored in refrigerated condition. Maximum PLW (29.61%) was recorded in the T_6 i.e. untreated Kinnow fruits stored in refrigerated condition (Fig. 1).

Spoilage

There was no spoilage of fruits in all the treatments (different edible coatings) and control up to 7 days of storage. After the 7 days of storage interval rotting in fruits starts, maximum spoilage of fruits was found in untreated fruits. Minimum spoilage (22.50%) was recorded in the T_1 i.e. lemongrass oil coated fruits stored at refrigerated condition whereas the maximum spoilage (45.30%) was recorded in T_6 i.e. untreated Kinnow fruits stored in refrigerated condition (Fig. 2).

Juice content

It is evident from the data that lemongrass oil coated Kinnow fruits at refrigerated condition in the maintaining maximum juice content (34.88%) was recorded in T_1 i.e. lemongrass oil coated Kinnow fruits stored in refrigerated

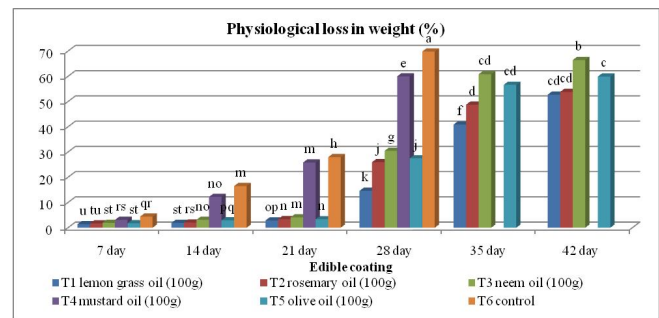


Fig. 1: Effect of different edible coatings and storage condition on physiological loss in weight (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

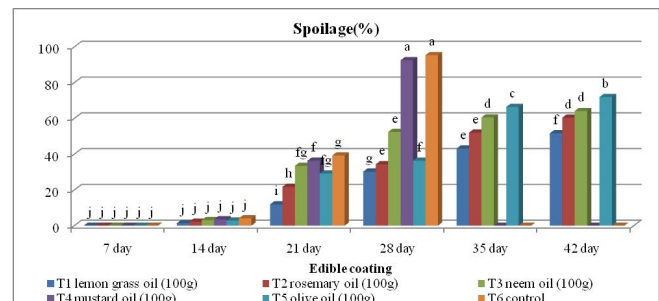


Fig. 2: Effect of different edible coatings and storage condition on spoilage (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

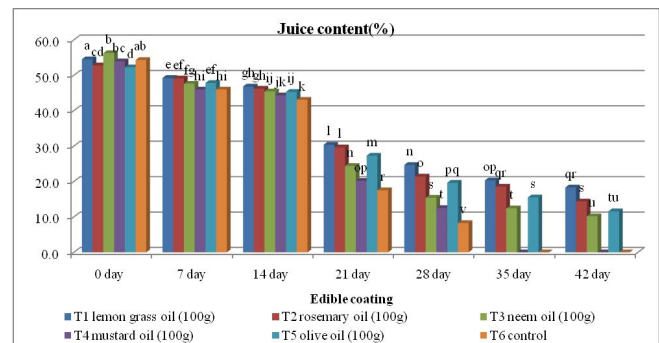


Fig. 3: Effect of different edible coatings and storage condition on juice content (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

condition. Minimum juice content (24.16%) was recorded in the T_6 i.e. untreated (without coating) Kinnow fruits stored in refrigerated condition (Fig. 3).

Total soluble solids

The trend showed that the advancement of storage intervals 42 days of refrigerated condition the TSS value of Kinnow fruits increased. The maximum TSS (11.02 °Brix) was recorded in T_1 i.e. lemongrass oil at refrigerated condition and minimum TSS (7.78 °Brix) was

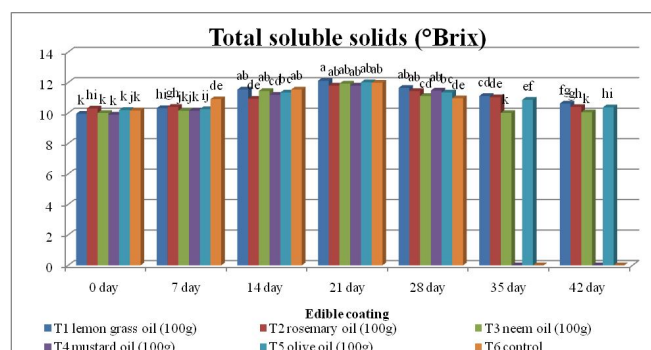


Fig. 4 : Effect of different edible coatings and storage condition on total soluble solids (°Brix) Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

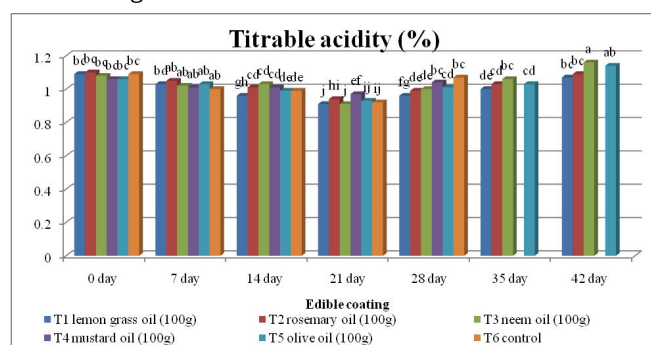


Fig. 5 : Effect of different edible coatings and storage condition on titrable acidity (%) Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

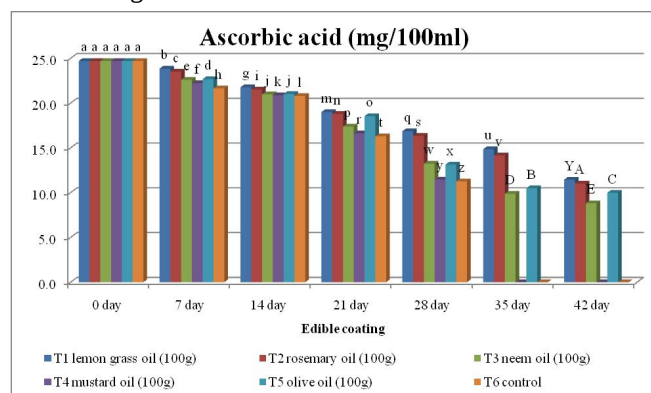


Fig. 6 : Effect of different edible coatings and storage condition on ascorbic acid (mg/100ml) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

observed in T₆ i.e. untreated Kinnow fruits (Fig. 4).

Titratable acidity

The minimum Titratable acidity (1.00%) was recorded in T₁ i.e. lemongrass oil coated Kinnow fruits stored at refrigerated condition whereas maximum

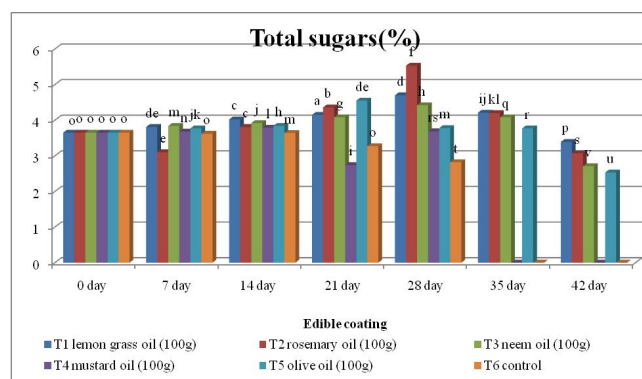


Fig. 7 : Effect of different edible coatings and storage condition on total sugar (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

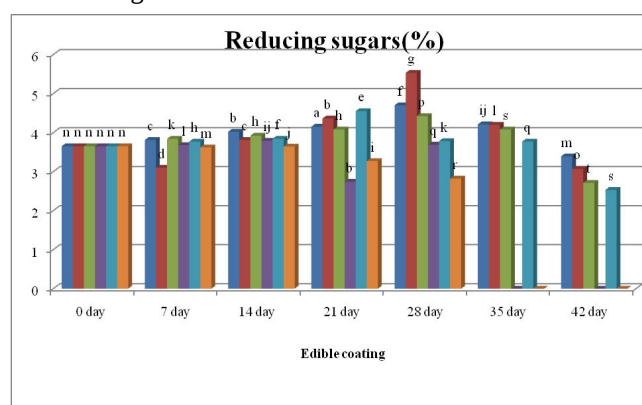


Fig. 8 : Effect of different edible coatings and storage condition on reducing Sugars (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

titratable acidity (1.06%) was recorded in T₆ i.e. untreated Kinnow fruits stored at refrigerated condition (Fig. 5).

Ascorbic acid

The maximum ascorbic acid (18.92 mg/100ml) was recorded in T₁ i.e. lemongrass oil coated Kinnow fruits stored at refrigerated condition. However, minimum ascorbic acid (13.52 mg/100ml) was recorded T₆ i.e. untreated Kinnow fruits stored at refrigerated condition (Fig. 6).

Total sugar

The results shows that the maximum total sugars content (9.12%) was observed in Kinnow fruits coated with T₁ i.e. lemongrass oil and stored in refrigerated condition whereas minimum total sugars content (5.32%) was observed in T₆ i.e. untreated Kinnow fruits at refrigerated condition (Fig. 7).

Reducing sugars

The minimum reducing sugar content (4.95%) was

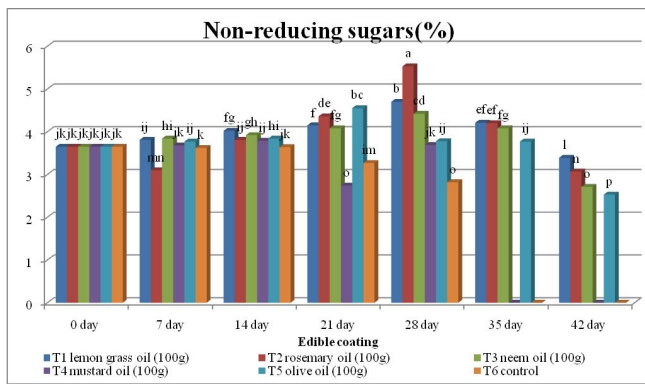


Fig. 9 : Effect of different edible coatings and storage condition on non-reducing Sugars (%) of Kinnow mandarin. *Means with the same letter(s) do not differ significantly ($p \leq 0.05$) according to Duncan's multiple range test.

recorded in the T_1 i.e. lemongrass oil at refrigerated condition whereas, the maximum reducing sugars content (2.80%) was recorded in T_6 i.e. untreated Kinnow fruits the untreated fruits resulted higher reducing sugar content as compared to lemongrass oil during the entire interval (Fig. 8).

Discussion

Physiological loss in weight

According to essential oil-based coatings are effective in preserving fruit quality by reducing oxidative stress and microbial contamination, which indirectly contributes to reduced weight loss. The essential oil forms a semi-permeable film on the fruit surface, effectively slowing down respiration and transpiration rates. Maqbool *et al.* (2011) demonstrated similar outcomes where citrus fruits coated with essential oil-based emulsions exhibited reduced water loss and better retention of freshness. Hasheminejad *et al.* (2014) demonstrated that edible coatings enriched with essential oils enhanced shelf life by reducing respiration rates and acting as a barrier to water vapor and gases. The outcomes of present research findings, as Kinnow fruits coated with lemongrass oil maintained better firmness, appearance and marketable weight over a 42-day cold storage period.

Spoilage

The present finding was supported by Amit and Malik (2010) indicated that the vapours of lemongrass oil damaged the cell membrane mainly due to membrane deformation. However, the variation in the antifungal effect of the essential oils depends on the solubility and capacity to interact with the cytoplasmic membrane (Tripathi and Shukla, 2007). The efficacy of lemongrass was found Similar results were reported by Gandarilla-Pacheco *et al.* (2020) in citrus fruits.

Juice content

The present study revealed that the Kinnow fruits coated with lemongrass oil stored under refrigerated conditions ($5 \pm 1^\circ\text{C}$) retained significantly higher juice content. Maqbool *et al.* (2011) observed similar results were essential oil-based edible coatings significantly reduced dehydration and helped maintain internal quality in citrus fruits. Raji *et al.* (2022) also reported that lemongrass oil emulsions were effective in maintain juice content and firmness in citrus fruits under cold storage. The lemongrass coating maintain cell turgidity, slow down enzymatic activities related to senescence and ultimately preserves juice content for a longer period Khan *et al.* (2023) confirmed that edible coatings enriched with essential oils such as lemongrass significantly enhanced internal quality parameters of citrus fruits by forming a protective barrier and modulating ethylene production.

Total soluble solids

Fruits treated with essential oils showed higher retention of Titratable acidity during the storage period which might due to delayed in physiological ageing and alteration in metabolism. According to Raji *et al.* (2022) lemongrass oil-based coatings can act as respiration modifiers by forming a semi-permeable layer that reduces oxygen availability, slowing down sugar accumulation and senescence. The results observed in the current study, where the coating helped maintain a more stable TSS level, contributing to better taste retention and overall fruit quality. The present results are in line with Mahajan *et al.* (2010) suggesting that organic acids were used in the respiratory process. The higher titratable acidity in wax with lemongrass treatment is aligned with the finding of Fatemi *et al.* (2012). Khan *et al.* (2023) reported that essential oil-based edible coatings delayed ripening and reduced enzymatic activity in citrus fruits, resulting in more gradual changes in TSS levels.

Titrateable acidity

The slow degradation of organic acids in lemongrass oil-coated fruits can be attributed to the semi-permeable film created by the essential oil. Which modulates respiration and slows down enzymatic activity Patel *et al.* (2019) reported that citral-rich coatings significantly reduced the oxidation of organic acids in mandarins. Similarly, Rashmi and Karuna (2022) found that lemongrass coatings maintained higher acid levels compared to synthetic waxes or untreated controls during refrigerated storage. Most recently, Singh *et al.* (2024) demonstrated that lemongrass oil coatings delayed acid loss and improved sensory perception in citrus fruits up to six weeks of storage. The results are confirmed by

Bajpai *et al.* (2016) demonstrated that these components inhibit a broad spectrum of spoilage microbes and oxidative enzymes, preserving both internal quality and surface integrity. Additionally, reported that lemongrass-coated fruits delayed ethylene production and maintained higher levels of essential nutrients under refrigerated conditions.

Ascorbic acid

Experimental findings suggest that a lemongrass oil concentration between 1.0-2.0% with 0.5-1.0% ascorbic acid delivers optimal results. According to Youssef *et al.* (2023), such composite coatings can effectively preserve over 80% of vitamin C content and delay microbial spoilage for up to 42 days. The coating forms a semi-permeable film that modifies internal atmosphere by limiting oxygen and moisture transfer, thereby lowering respiration rate and ethylene production. This slows down metabolic processes responsible for ripening and spoilage. As demonstrated in recent studies by Rathore *et al.* (2022), the combined application leads to improved visual appeal, texture retention, and extended marketability of coated Kinnow mandarins.

Total sugar

In treatments where lemongrass oil was combined with cold storage, the total sugar levels were better retained compared to untreated or air-stored fruits. This can be attributed to the reduction in respiration rate and lower metabolic activity due to the semi-permeable barrier formed by the coating, which limits oxygen entry and moisture loss (Bhatia *et al.*, 2023). By forming a thin lipid-based film, it acts as a gas exchange barrier, lowering ethylene production and respiration rate, thereby reducing the enzymatic breakdown of complex carbohydrates into simpler sugars and slowing down their utilization.

Reducing sugars

These findings are consistent with recent studies where edible coatings incorporating essential oils delayed ripening and preserved sugar stability. The coated fruits maintained reducing sugar levels around 4.3-4.5%, indicating reduced sugar conversion and utilization compared to uncoated controls. These results show slows down starch hydrolysis and other enzymatic reactions responsible for increasing reducing sugars during ripening (Verma and Thakur, 2021). Additionally, the antimicrobial nature enzyme activity that could accelerate sugar degradation. Fruits retain their sweetness and nutritional quality for a longer duration under storage.

Conclusion

On the basis of present investigation, it concludes

that application of different edible coatings fruits is stored at refrigerated condition significantly improved the quality and post-harvest life of fruits. The present study showed a significant effect of coatings on shelf life and fruit quality on Kinnow mandarin fruits. The highest shelf life was found with the application of EC₁ i.e. lemongrass oil coating and the lowest shelf life of Kinnow mandarin was recorded in control (non-treated fruits) i.e. C₀. From our overall study, we suggested that edible coatings are more suitable for increment on the shelf life of Kinnow mandarin up to longer duration. The lemongrass and rosemary oil are more beneficial and eco-friendlier for Kinnow fruits to extending their shelf life and fruits quality.

References

- Amit, K., Kumar G. and Malik S. (2010). Impact of lemongrass oil vapors on cell membrane integrity and spoilage reduction in fruits. *J. Food Sci. Technol.*, **5(1)**, 2091-2098.
- Bajaj, K., Kumar A. and Arora R. (2024). Ameliorative effect of gum Arabic and essential oil coatings on postharvest preservation of Kinnow mandarin (*Citrus reticulata* Blanco). *J. Food Measurement and Characterization* **18(1)**, 7884-7893.
- Bajaj, K., Kumar A., Arora R. and Singh A. (2024). Guar gum and essential oil-based composite coatings preserve antioxidant enzymes activity and postharvest quality of Kinnow mandarin. *Food Biosci.*, **61(1)**, 112-119.
- Bajpai, E.A., Bruns J.K. and Misir J. (2016). Inhibition of oxidative enzymes and spoilage microbes in fruits using essential oil-based edible coatings. *Asian J. Horticult.*, **25(1)**, 159-163.
- Bhan, C., Asrey R., Meena N.K. and Rudra G.S. (2022). Guar gum and chitosan based composite edible coating extends the shelf life and preserves the bioactive compounds in stored Kinnow fruits. *Int. J. Biolog. Macromole.*, **222(1)**, 2922-2935.
- Bhatia, S. and Singh A. (2023). Effect of edible coatings on respiration rate and sugar retention in citrus fruits during cold storage. *Postharvest Biology and Technology*, **1(01)**, 123-128.
- Bisen, A., Pandey S.K. and Patel N. (2012). Effect of skin coatings on prolonging shelf life of kagzi lime fruits (*Citrus aurantifolia* Swingle). *J. Food Sci. Technol.*, **49(6)**, 753-759.
- Fatemi, H.K., Singh G.B. and Singh K. (2012). Influence of was and lemongrass treatments on titratable acidity and respiratory activity in fruits. *J. Agricult. Res. Develop.*, **11(1)**, 77-84.
- Gandarilla, P., Malik A. and Kumar S. (2020). Preservation of citrus fruits using natural essential oil coatings for spoilage control. *Food Biosci.*, **51(1)**, 116-121.
- Hasheminejad, R.S., Ali S. and Khan R.K. (2014). Essential oil-enriched edible coatings to enhance postharvest shelf life of fruits by reducing respiration and water vapor

- loss. *J. Food Sci. Technol.*, **59**(6), 853-859.
- Jadhav, S.K., Khan M. and Shah A. (2023). Post-harvest sugar retention in Kinnow using various edible coating treatments. *J. Appl. Nat/ Sci.*, **6**(1), 177-183.
- Joshi, B.K., Thapa P. and Acharya U. (2024). Mandarin orange landraces, diversity, conservation and potential for geographical indication. *History, Science and Technology in Nepal*, **1**(1), 7848-5824.
- Khan, P., Sharma A. and Panday J.K. (2023). Enhancement of internal fruit quality using essential oil coatings by modulating ethylene production in citrus fruits. *Int. J. Scientific Res. Manage.*, **1**(1), 7207-7209.
- Kumar, V. and Gupta K.A. (2024). Optimization of pretreatments to enhance quality characteristics and storage period of Kinnow (*Citrus reticulata* Blanco) using response surface methodology. *Scientific Reports*, **1**(1), 10-15.
- Lado, J., Cuellar F. and Rodrigo J.M. (2016). Nutritional composition of mandarins. *Nutritional Composition of Fruit Cultivars*, **1**(1), 419-443.
- Mahajan, B. and Mahesh K. (2010). Organic acid metabolism and respiratory changes during postharvest storage of waxed citrus fruits. *Int. J. Agricult.*, **2**(1), 421-428.
- Mahawar, M.K., Jalgaonkar K. and Sonkar K.R. (2020). Post-harvest processing and valorization of Kinnow mandarin (*Citrus reticulata* L.). *J. Food Sci. Technol.*, **57**(1), 799-815.
- Maqbool, S., Ali A. and Khan S.K. (2011). Effect of essential oil-based edible coatings on dehydration and internal quality retention citrus fruits. *Food Biosci.*, **4**(1), 111-117.
- Meena, M., Kaur G. and Kaur S. (2024). Antioxidant and antimicrobial role of essential oils in maintaining sugar composition in Kinnow. *J. Food Sci. Technol.*, **18**(4), 621-669.
- NHB (2024). *Indian Horticulture Data Base*. National Horticulture Board, Ministry of Agriculture Government of India. WWW.nhb.gov.in.
- Patel, R.K. and Bisen S. (2021). Effect of lemongrass oil coatings on enzymatic activity and sugar breakdown in citrus fruits. *Int. J. Agricult.*, **18**(1), 613-628.
- Raji, A.K., Kumar S.R. and Kumar G. (2022). Role of lemongrass oil emulsions in maintaining juice content and firmness of citrus fruits during cold storage. *Int. J. Pure Appl. Biosci.*, **9**(4), 35-38.
- Rashmi, P.R., Karuna S. and Seedhar P. (2022). Retention of higher organic acid levels in citrus fruits using lemongrass oil coating under refrigerated storage. *J. Plant Sci.*, **7**(1), 1098-1105.
- Rathore, P.R., Gautam D.M., Shresha A.K. and Paudyal K.P. (2022). Extended shelf life and marketability of Kinnow mandarins using combined lemongrass oil treatments. *Food Sci. Technol.*, **15**(2), 155-163.
- Shah, S.W.A., Jahangir M., Qaisar M., Khan S.A., Mahmood T., Saeed M., Farid A. and Liaquat M. (2016). Storage stability of Kinnow fruit (*Citrus reticulata*) as affected by CMC and Guar Gum-based Sliver Nanoparticles coating. *Indian J. Horticult.*, **20**(6), 22645-24661.
- Shireen, F., Jaskani M. and Nawaz M.A. (2018). Exogenous application of naphthalene acetic acid improves fruit size and quality of Kinnow mandarin (*Citrus reticulata*) through regulating fruit load. *J. Anim. Plant Sci.*, **28**(4), 1080-1085.
- Singh, J., Sidhu G.S. and Dhillon W.S. (2024). Impact of lemongrass oil coatings on acidity retention and sensory perception in citrus fruits during cold storage. *Indian J. Horticult.*, **66**(2), 239-244.
- Singh, R., Upendar K. and Nisha R. (2024). Non-destructive of mandarin orange fruit quality during the ripening stage using machine-learning-based spectroscopic techniques. *J. Food Measurement and Characterization* **19**(1), 862-875.
- Tripathi, K. and Shukla S.A. (2007). Antifungal properties of essential oils and their interaction with cytoplasmic membranes in fruits. *The J. Horticult. Sci. Biotechnol.*, **92**(4), 12-18.
- Verma, S. and Thakur K.A. (2021). Slowing enzymatic sugar degradation in citrus using plant-based edible coatings. *Int. J. Pure Appl. Biosci.*, **4**(7), 25-32.
- Youssef, Aml R.M. and Eman Hala E. (2023). Effect of composite edible coatings on ascorbic acid retention and microbial spoilage and prevention. *J. Post harvest Technol.*, **1**(1), 137-142.