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RESEARCH ARTICLE

Shelf-life extension of guava and eggplant fruits using chitosan-sodium alginate based antimicrobial composite coating functionalized with clove-soy lecithin nanoemulsion

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Abstract

In the present study, effects of chitosan-sodium alginate composite coatings functionalized with clove-soy lecithin nanoemulsion were investigated on the postharvest shelf life and quality characteristics of guava and eggplant fruits at room storage condition (23±3 °C, RH- 60-65 %). The postharvest characteristics such as weight loss, acidity, TSS, respiration rate, antioxidant activity and visual appearance of the fruits were determined up to 12 days of storage. The results revealed that the application of chitosan-sodium alginate composite effective to maintained higher postharvest characteristics of guava and eggplant fruits as compared to control and coating with alone chitosan and sodium alginate. The F3 (50:50, chitosan-sodium alginate) composite coating was found most significant with retarded the weight loss in guava and eggplant. On 12 days of storage, the significantly ($p>0.05$) lower weight loss (9.24 %, 10.9 %), respiration rate (22.48 mg $CO_2kg^{-1}h^{-1}$, 18.78 mg $CO_2kg^{-1}h^{-1}$), total soluble solids (9.87°Brix, 4.96 °Brix) with higher maintained of titratable acidity (0.49 %, 0.36 %), antioxidant activity (53.745 %, 33.09 %) and total phenolic content (129.74 mg/100g, 49.09 mg/100g), respectively was found in guava and eggplants fruits treated with F3 composite coating formulation followed by F4 and F2 coating formulations. The control (distilled water) samples showed higher weight loss (18.02 %, 21.84 %), TSS (10.78 °Brix, 5.78°Brix), with lower values of acidity (0.29 %, 0.22 %), antioxidant (39.12 %, 23.01 %) and total phenolic content (89.64 mg/100 g, 32.86 mg/100 g), respectively in both guava and eggplant fruits, respectively.

Keywords: antioxidant; edible packaging; nanoemulsion; postharvest management; respiration rate

Introduction

The postharvest characterises and shelf life maintained of the fruits and vegetables are significant challenges to the food sector. Postharvest losses accounted around 20-30 % due to physical, mechanical and biological damage throughout the supply chain process. It may cause significant loss to the society and environment by economic losses and emission of greenhouse gases (1). The guava (*Psidium guajava* L.) and eggplant (*Solanum melongena* L.) fruits are considered important crops in the food sector. Guava possess good amounts of nutritive components such as vitamin A, B1, B2 and vitamin (2). Whereas, eggplant fruits contain good amounts of vitamins, minerals, phenolic and flavonoid compounds (3). These nutritive components and bioactive compounds present in the guava and eggplant fruits have significant impacts on the improving health and immunity. The guava and eggplant are susceptible to the microorganism and have very short shelf life up to 3-4 days at room conditions (3-6).

In past decades, there are several attempts have been done by the research communities to minimizing the post-harvest losses for a sustainable process in agriculture sector. There are numerous postharvest management strategies such as modified atmosphere packaging, control atmosphere packaging, edible/composite packaging and intelligence packaging have been utilized to reduce the usage of plastic and synthetic types of packaging to overcome the environmental issues for a sustainable process (7, 8). Despite, the several postharvest management practice, the edible and composite is eco-friendly solution to shelf-life extension of fruits and vegetables. It can be used as an alternative of the plastic and synthetic based packaging for the postharvest management. In addition, this composite edible coating ca be developed by the naturally derived plant and animal sources such as polysaccharide, proteins and their composites. These biopolymers are non-toxic and biodegradable in nature, also acts as carrier of the bioactive compounds to the releasing on surface of fruits and vegetables to retarded the microbial load. The composite coating has great water barrier and gas barrier properties, which inhibit the oxidation and water losses from the fruits throughout the storage and help in the boost up the postharvest shelf life and characteristics of the fruits and vegetables (9). The several bioactive compounds such as plant extract, essential oils and antimicrobial compounds derived from natural sources can be incorporated in the edible composite coating to influencing their antioxidant ad antimicrobial potential (10).

Moreover, the addition of essential oils significantly improved the properties and efficiency of the composite coating but there may be a chance for the affecting natural flavour of aroma due to its presence of higher phenolic compounds in the essential oil. Therefore, the nanoemulsion is an oil-water droplet system, general have 100-600 nm of particle size range, which helps to maintained the controlled mechanism and masking flavour of the essential oil is a good concept to encapsulate in the composite coating to improving the retention of higher bioactive compounds with less affecting of the fruits and vegetables natural flavour (11). The addition of nanoemulsion significantly improved the antimicrobial efficiency of the composite coating, which directly helps to provide protection of fruits and vegetables from microbial damage. There is very limited no. of studies has been available on the investigation of effects of chitosan-sodium alginate composite coatings functionalized with clove-soy lecithin nanoemulsion on the postharvest shelf life and quality characteristics on fruits and vegetables. Therefore, the objective of the present study was to investigate the impacts of chitosan-sodium alginate composite coatings functionalized with clove-soy lecithin nano emulsion on the postharvest shelf life and quality characteristics of guava and eggplant fruits at room storage condition (23±3 °C, RH- 60-65 %).) up to 12 days of storage.

Materials and Methods

Chemical and reagents

The food grade of liquid soy lecithin (E322, Urban paltter) was online purchase from online store. The pure clove essential oils procured from Sigma Aldrich. Thermo fisher and Hi-Media, Pvt., Ltd. Supplied i.e. chitosan, sodium alginate, PDS and chemical & reagents and media such as Mueller Hinton agar and Potato Dextrose Agar.

Location of the study

The present study was investigated at National Institute of Food Technology and Entrepreneurship and Management, Kundli, Sonepat (Haryana) and Sharda University, Noida (UP), India in year 2024-2025.

Preparation of chitosan-sodium alginate composite coating formulations /film with encapsulated nanoemulsion

The five different chitosan-sodium alginate composite coating formulations with encapsulated clove-soy lecithin nanoemulsion was prepared. 2 % chitosan (0.5 % acetic acid aqueous solution) and sodium alginate (aqueous) were prepared and used for the preparation of composite coatings in different ratio (100, 75:25, 50:50, 25:75 and 100 %) with encapsulation of 1 % clove-soy lecithin nanoemulsion (12). The formulation mixed using magnetic stirred and ultrasonicated for 10 min at 50 % of amplitude power. The details of the composite coating formulation are shown in Table 1.

Application of chitosan-sodium alginate composite coating formulations on eggplants and guava fruits and storage

The procured guava and eggplants fruits samples were directly transferred to the laboratory and thoroughly washed and dried to removed dirt and other particle. randomly devised in 6 different groups including 1 control (distilled water) and 5 treatments. Each group were dipped in to the composite coating solutions and allowed to dried coating materials on fruits surface. Thereafter the fruits were transferred into fruit basket and stored at room conditions (23±3 °C, RH- 60-65 %). The effects of composite coating on the postharvest characteristics and shelf life of fruits were determined up to 12 days of storage with 3 days of intervals. The schematic illustration of process and methodology application of chitosan -sodium alginate composite coating on guava and eggplant fruits are illustrated in Fig. 1.

Experiment methodology

Effects of composite coating postharvest quality of eggplants and guava fruits

Physiological loss in weight: The PLW of the guava and eggplants during the storage period was measured using weight differential method (6). The initially measured weight was divided from the actual weight during the storage at 3, 6, 9 and 12 days of storage. The results were expressed in terms of percentage loss. The equation used to calculate the PLW in control and treated fruits.

$$PLW\ (\%) = W_i \times W_f / W_i \times 100$$

Where,

W_i = initial weight of fruits x W_f = initial weight of fruits

Respiration rate: Respiration rate of the eggplant and guava fruits during storage was determined using digital O_2 / CO_2 analyser (Dansensor®). The control and treated fruit samples was kept in airtight closed glass jar at 25 °C at 2 hrs for further estimation of oxygen/carbon dioxide. Thereafter, the present gas inside the jar was determined using gas analyser through insert a 0.25 mm size of syringe. The respiration rate of the samples was calculated using equation.

Respiration rate (ml CO_2 $^{kg-1.h-1}$) = CO_2 (%) × Head space/ 100 × Weight (kg) × Time (hr)

Total Soluble Solids (TSS): The effects of chitosan-sodium alginate composite coating on the TSS of the fruits was measured using digital refractometer (Atago, Japan) at 20 °C (13). The prism of the refractometer was cleaned and calibrated

Table 1. Composite coating formulations with encapsulation of nanoemulsion

Chitosan	Sodium alginate	Plasticizer (%) V/V (Glycerol)	Nano-emulsion (Clove oil: soy lecithin)
100	0	0.9 %	1 %
75	25	0.9 %	1 %
50	50	0.9 %	1 %
25	75	0.9 %	1 %
0	100	0.9 %	1 %

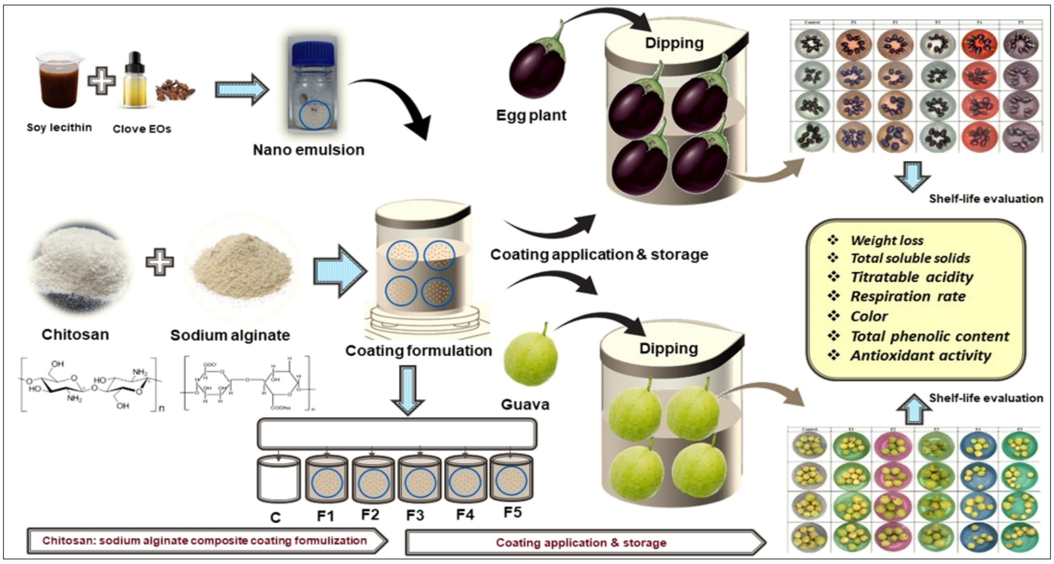


Fig. 1. Schematic illustration of application of chitosan-sodium alginate composite coating on eggplants and guava fruits.

with distilled water and average results of the samples reported as °Brix.

Titratable Acidity (TA): TA of the control and chitosan-sodium alginate composite coated samples were determined using standard procedure of AOAC (942.15) (14) with minor modifications. About, 10 mL of fruit juice diluted in 250 mL of distilled water. 50 mL of solution was titrated with 0.1 N NaoH and results was expressed as TA % by calculated using equation.

TA % = Titrant reading x Normality of titrant x 0.064/Sample weight x100

Antioxidant activity (DPPH): Antioxidant activity of the control and chitosan-sodium alginate composite coated samples were determined using standard DPPH (2, 2 diphenyl-1-pickrylhydrazyl) method with minor changes (13) . The fruits extract of guava and eggplant (0.1 mL) was dissolved in 3.94 mL of DPPH solution (1 M). The solution was allowed to incubate for 30 min at room temperature under dark conditions. The methanol was used as blank. the absorbance of the samples was recorded in UV spectrophotometer at 517 nm wave length. The sample DPPH (%) inhibition was calculated using below equation and results reported in terms of % inhibition.

DPPH % = Control ^{Abs} x Sample ^{Abs} / Control ^{Abs} x100

Total Phenolic Content (TPC): TPC of the control and composite coated fruits under storage conditions were measured using standard Folin Ciocalteu (FC) reagent procedure with some minor modifications (13) . About, 1 mL of fruit sample extract was dissolved in 70 mL of distilled water and mixed it well. Thereafter, 5 mL of FC reagent (10-fold diluted) was added in the mixture followed by added of 15 mL of sodium bicarbonate (20 %) in the mixture. The mixture was mixed well and incubated for 2 hrs at room temperature. The absorbance of the mixtures was determined at 765 nm using UV spectrophotometer. The absorbance value was calculated against gallic acid standard curve and results of TPC reported as mg/100 g.

Visual appearance: The visual appearance of the both fruits throughout the storage period were observed with three days of intervals to investigate the effects of chitosan-sodium alginate composite coating formulations on postharvest characteristics and shelf life of eggplants and guava fruits at room storage.

Statistical analysis

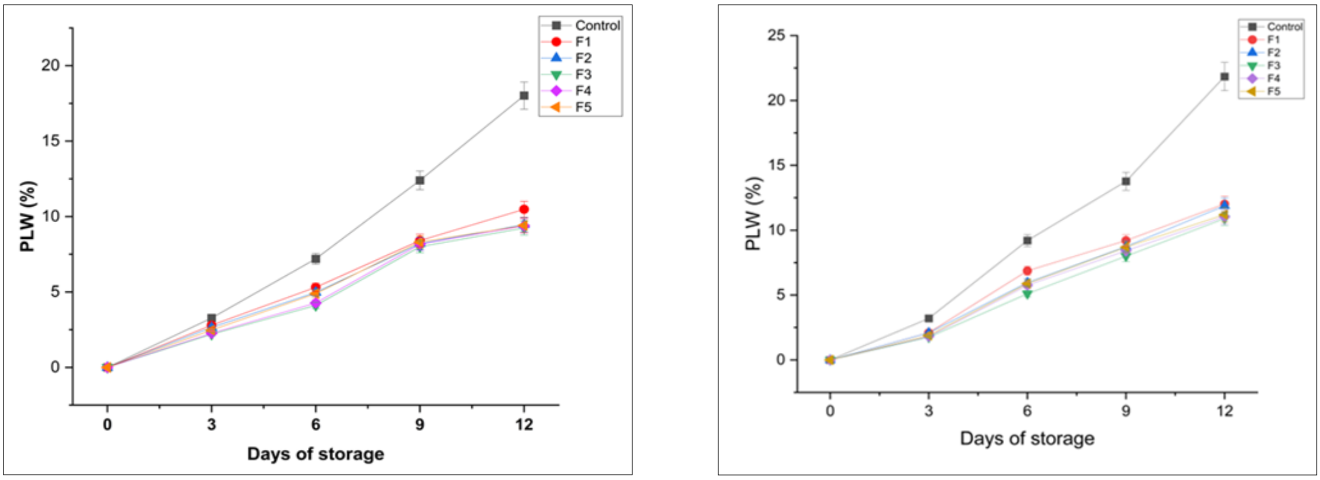
Average value of the data has been reported as results with standard deviation/standard errors. Two Way ANOVA (IBM SPSS) was used to statistical analysis of the data with appointed Duncan multiple range test at 5 % of significance level to determine the significant difference between among the treatments. Origin Pro 2019b was used to graphical representation of the data.

Results & Discussion

Physiological loss in weight

The effects of composite coatings on the physiological loss in weight of guava and eggplants are shown in Fig. 2. The results revealed that the PLW in all the coated and control guava and eggplants fruits were gradually decreased with increasing time of storage period but the significantly ($p>0.05$) lower weight loss was found in treated samples. On 9 days of storage, the control guava (12.40 %) and eggplant (13.77 %) sample PLW marked more than 10 %, which indicated the unacceptability of the fruits. The higher weight loss in the control samples was observed between 6 to 9 days. The guava and eggplants treated with the F3 (50:50) composite coating formulations exhibited lowest PLW in guava (9.24 %) and eggplants (10.09 %) followed by fruits treated with F4 and F2 composite coating formulation on 12 days of storage period.

The results indicated that the composite of chitosan-sodium alginate composite coating was most significant to reduce the PLW in the guava and eggplants fruits as compared to control and chitosan and sodium alginate based alone coating with nanoemulsion. This might be possible due to higher barrier property of composite coating against water transpiration and gas oxidation/respiration. The findings of guava fruits are aligned with previous reports (6), those reported the similar trends in results of guava fruits during storage by the application of mango kernel seed starch based edible coating functionalized with lemongrass essential oils. The results of eggplants fruits are good corroborated with the previous findings (3), those reported the similar trends of results in eggplants during storage treated with carnauba wax based edible coating. The significant reduction in the weight



2a **2b**

Fig. 2. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on PLW of guava (2a) and eggplant (2b) fruits under room storage conditions.

loss of eggplants was achieved by the application of aloe vera gel based edible coatings (15). Moreover, the PLW of the different fruits and vegetables was significantly reduced using beeswax based nano emulsion as a food grade and edible coatings (16). This might be possible due to retarded the water loss by barrier properties in the coated fruits and vegetables as compared to control samples throughout the storage period (17).

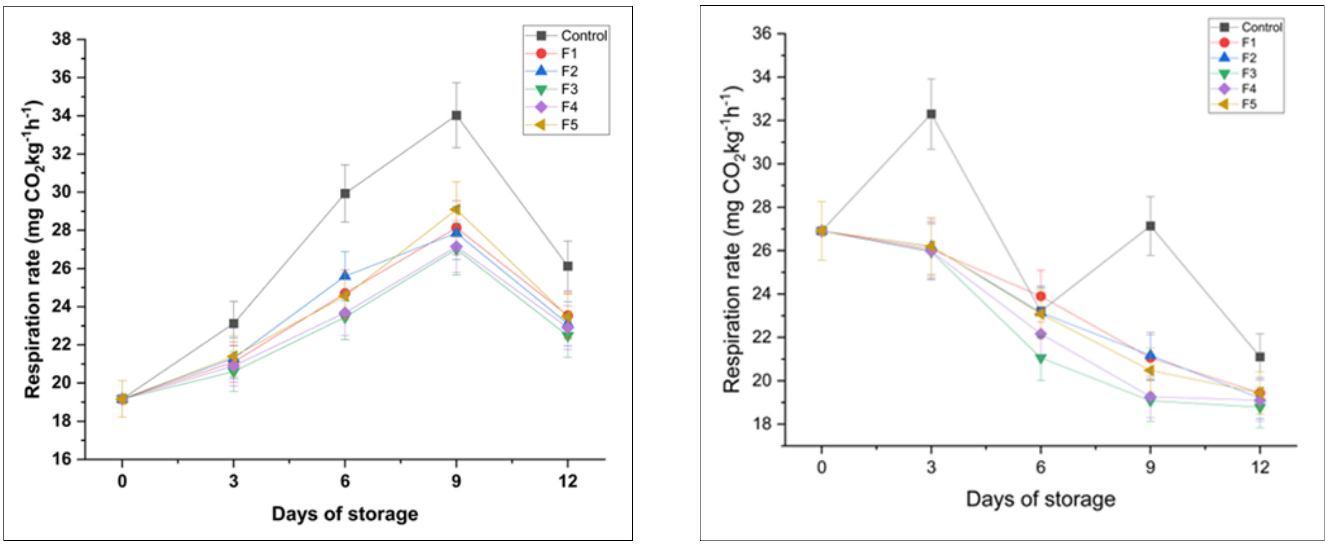
Respiration rate (mg $CO_2 kg^{-1}h^{-1}$)

The effects of chitosan-sodium alginate composite coatings on the respiration rate of guava and eggplant fruits are shown in Fig. 3. The results revealed that the application of composite coatings significantly ($p>0.05$) reduced the respiration rate in the treated fruits throughout the storage period. The higher respiration rate was observed in the control samples as compared to the treated. Initially (0 day), the respiration rate in the all the guava and eggplants samples were 19.17 mg $CO_2 kg^{-1}h^{-1}$and 26.91 mg $CO_2 kg^{-1}h^{-1}$, respectively. The value of respiration rate gradually increases in all the samples with advancement of time storage period. On 12 days of storage, the higher respiration rate was recorded in control guava (26.13 mg $CO_2 kg^{-1}h^{-1}$) and eggplants (21.10 mg $CO_2 kg^{-1}h^{-1}$) samples. The guava and eggplants treated with the F3 (50:50) composite coating formulations exhibited lowest respiration rate in guava (22.48 mg $CO_2 kg^{-1}h^{-1}$) and eggplants (18.78 mg $CO_2 kg^{-1}h^{-1}$) followed by fruits treated with F4 and F2 composite coating formulation on 12 days of storage period.

The lower respiration rate in the composite coating treated fruits might be possible due to barrier properties of composite coating, which helps to retarded the synthesis of ethylene, lowering respiration rate and mass loss (18). The results of guava fruits are in line with the previous findings (6, 18). The similar trends of results for eggplant fruits have been reported in early works (15, 3), they minimized the respiration rate in the eggplants during storage with the application of aloe vera and carnauba wax based edible coating, which resulted in maintained higher postharvest shelf life and quality attributes in eggplants throughout the storage period.

Total soluble solids

The effects of chitosan-sodium alginate composite coatings on the guava and eggplant fruits are indicated in Fig. 4. The results revealed that the application of composite coatings



3a **3b**

Fig. 3. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on respiration rate of guava (3a) and eggplant (3b) fruits under room storage conditions.

significantly (p>0.05) maintained the lower TSS in the guava fruit throughout the storage period. The higher TSS was observed in the control samples as compared to the treated one. Initially (0 day), the TSS in the all guava and eggplant fruits were recorded 8.39 °Brix and 4.69 °Brix, respectively. The value of TSS rate gradually increases in all the samples with advancement of time storage period. On 12 days of storage, the higher TSS was recorded in control guava (10.17 °Brix) and eggplants (5.78 °Brix). The lowest respiration rate was found in the guava fruits (9.87 °Brix) and eggplants (5.08 °Brix) treated with F3 followed by F4 composite coating formulation.

The results are evident that the application of composite of chitosan-sodium alginate coating was most significant to maintained lower TSS in the guava fruit and eggplants samples as compared to control by reducing the breakdown of the sugar components and inhibited enzymatic activity. The lower TSS is an indicator of non-conversion of sugar in fruits. The results of guava fruits are in good comparison with the previous research (19), those have investigated the effects of plant-based materials (aloe vera and gum Arabic) and plant extract (garlic and ginger extract) on the postharvest shelf life of guava fruits at room conditions. The results of eggplant of present study are in good comparison with the previous research (15, 3), they maintained the TSS value in eggplants throughout the storage period by the application of aloe vera and carnauba wax based edible coating, which resulted in minimized the degradation of sugar molecules due to lower water loss and oxidation. TSS indicated the ripeness, sweetness and presence of sugar content in the fruits and vegetables. The higher TSS in the fruits and vegetables during storage generally associated with breakdown of the complex carbohydrate in simple sugar, which is responsible for the leading water loss in fruits and causing syneresis in fruits and vegetables. Moreover, the application of edible coatings may help to retarded the hydrolysis and breakdown the sugar molecules in the fruits and vegetables during storage, resulted lower maintained TSS in treated fruits compared to control samples (20).

Titratable Acidity (TA)

The effects of chitosan-sodium alginate composite coatings on the TA of guava and eggplant fruits are shown in Fig. 5. The results revealed that the application of composite coatings significantly (p>0.05) maintained higher acidity (TA) in the guava and eggplants fruit throughout the storage period. The lowest degradation of TA was observed in the control samples as compared to the treated samples. Initially (0 day), the TA in the all guava and eggplants fruits were recorded 0.67 % and 0.53 %, respectively. The value of TA gradually decreased in all the samples with advancement of time storage period. On 12 days of storage, the F3 composite coating was significantly found effective to maintained higher TA value in guava (0.42 %) and eggplant ((0.36 %) fruits followed by samples treated with F4 and F2 composite coatings. On 12 days of storage the lowest value of TA was found in control guava (0.29 %) and eggplant (0.22 %), respectively as compared to treated samples.

The higher maintained of TA value in treated fruits might be possible due to minimizing the utilization of organic acids in invertase enzymes activity by restricted availability of oxygen in fruits (3, 21). These findings of guava fruits are in good comparison with the previous report (13), they have reported the similar trends of results in citrus fruits by the application of different types of coating materials functionalized with clove essential oils. Overall, results concluded that the application of chitosan-sodium alginate composite coating significantly (p>0.05) retarded the loss in acidity of fruits and maintained the consumer acceptability of fruits throughout the storage period. The results of eggplant of present study are in good comparison with the previous research (15, 3), they maintained the TA values in eggplants throughout the storage period by the application of aloe vera and carnauba wax based edible coating, which resulted in minimized the degradation of sugar molecules due to lower water loss and oxidation. The results revealed that the application of chitosan-sodium alginate composite coating significantly (p>0.05) maintained higher acidity of fruits and maintained the consumer acceptability of fruits throughout the storage period. The presence of several natural organic acid (citric, mailc, tartaric acids and others) is mainly responsible for

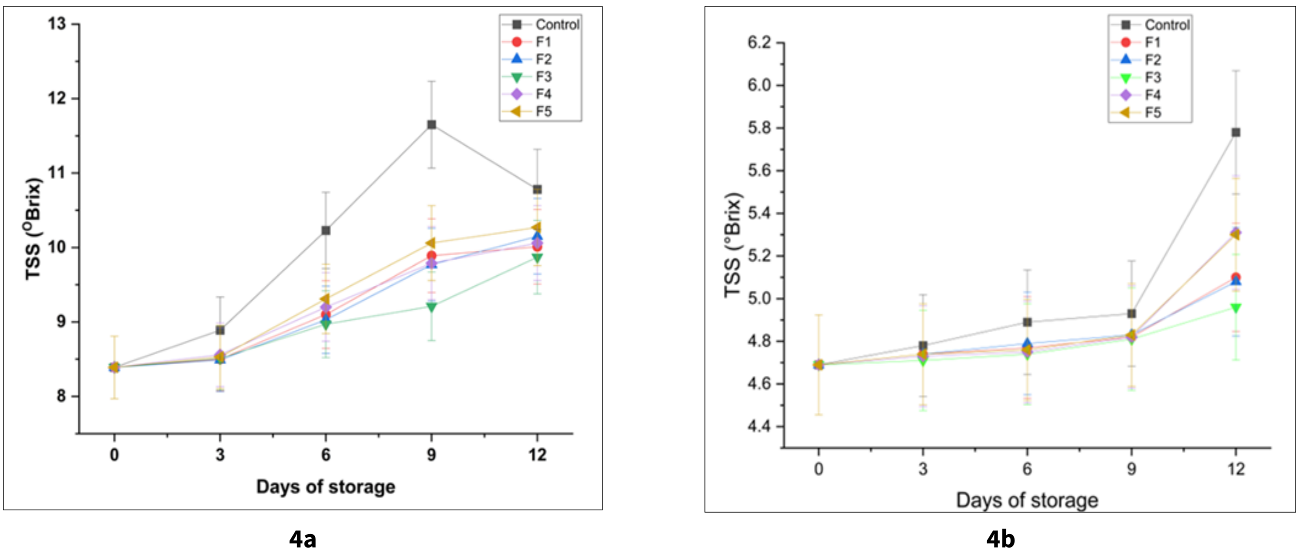
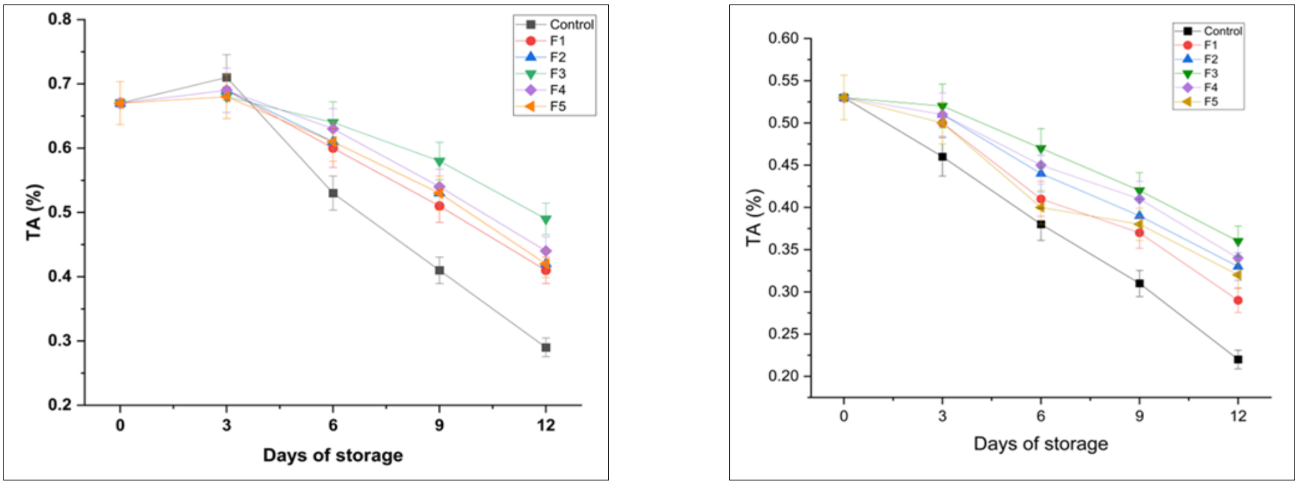


Fig. 4. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on TSS of guava (4a) and eggplant (4b) fruits under room storage conditions.



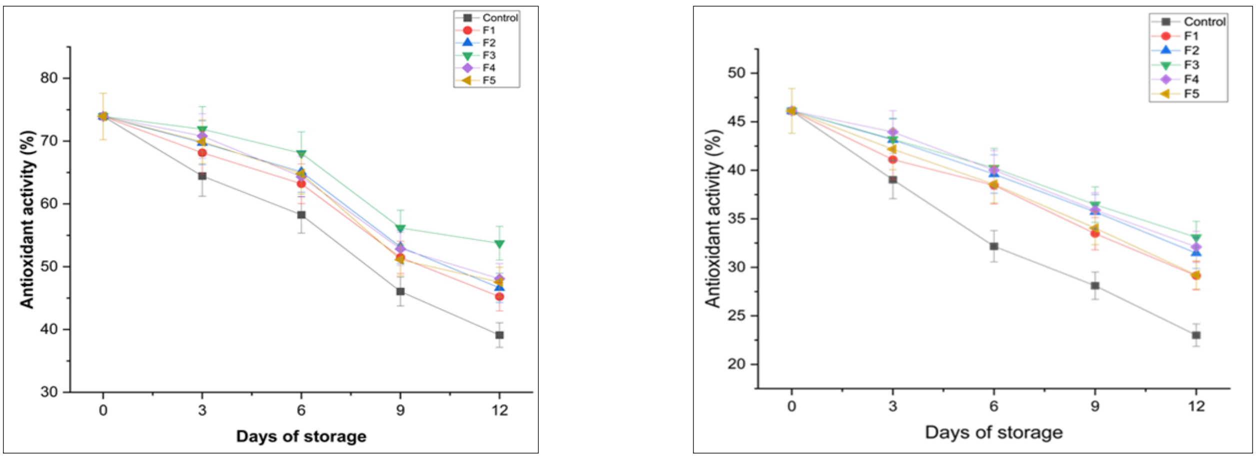
5a 5b

Fig. 5. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on TA of guava (5a) and eggplant (5b) fruits under room storage conditions.

the higher acidity in the fruits and vegetables. Therefore, the application of edible coatings are generally potentials to minimizing the utilization of organic acids in the fruits and vegetables due to gas and water barrier mechanism of edible coatings, which slow down the metabolic process including enzymatic activity (22, 23).

Antioxidant activity (DPPH)

The effects of chitosan-sodium alginate composite coatings on the DPPH antioxidant activity of guava and eggplant are shown in Fig. 6. The results revealed that the application of composite coatings significantly ($p>0.05$) maintained higher DPPH antioxidant activity in the treated fruit throughout the storage period. The significantly ($p>0.05$) higher degradation of antioxidant activity was observed in the control samples as compared to the treated samples. Initially (0 day), the DPPH activity in the all guava and eggplant samples was recorded 73.93 % and 46.12 %, respectively. The value of DPPH activity decreased in all the samples with advancement of time storage period. On 12 days of storage, the higher DPPH activity was recorded in guava (53.74 %) and eggplant fruits (33.09 %) treated with F3 composite coating formulations followed by F4 and F2 treatment. The lowest value of DPPH activity was found in the control guava fruits (39.12 %) and eggplants (23.01 %) on 12 days of storage. The higher retention of DPPH activity in treated fruits might be possible due to barrier properties of composite coatings and encapsulation of clove essential oils based nanoemulsion. The clove oil has possessed good antimicrobial and antioxidant activity, which helps in the minimizing oxidation and eliminated the free radical. Overall, the chitosan-sodium alginate composite coatings encapsulated with clove oil based nanoemulsion were significantly effective to possess and maintained higher DPPH antioxidant activity in fruits due to presence of bioactive compounds (eugenol) in the coating formulations. The results are similar with the previous findings (13), they have reported, the addition of clove oil and nanoemulsion significantly improved the antioxidant capacity of the coating formulations as well as treated fruits throughout the storage period. The initial value of the DPPH antioxidant is in line with the previous reports (24), those reported the antioxidant activity of eggplants between 25.17-40.35 % of DPPH activity. The antifungal and antimicrobial activity of the strawberry fruits was maintained higher by using edible coating with cinnamon oil during the storage at cold conditions (25). This might be possible due to synergistic effects of edible coatings with essential oils and cold temperature due to retention of bioactive compounds. The retention of higher amounts of bioactive compounds may help to showed higher antioxidant and antimicrobial activity due to minimizing the free radical scavengers (26).



6a 6b

Fig. 6. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on DPPH of guava (6a) and eggplant (6b) fruits under room storage conditions.

Total Phenolic Content (TPC)

The effects of chitosan-sodium alginate composite coatings on the TPC of guava and eggplant fruits are shown in Fig. 7. The results of study indicated that the application of composite coatings significantly (p>0.05) maintained higher phenolic activity in the guava and eggplant fruit throughout the storage period. The significantly (p>0.05) higher degradation in phenolic activity was observed in the control samples as compared to the treated samples. Initially (0 day), the TPC value in guava and eggplant fruits were recorded 157.12 mg/100g and 63.29 mg/100 g, respectively. The value of TPC decreased in all the guava and eggplant fruits samples with advancement of time storage period. On 12 days of storage, the higher phenolic activity was recorded in guava (129.74 mg/100 g) and eggplant fruits (49.09 mg/100 g) treated with F3 composite coating formulations followed by F4 and F2 treatment. The lowest value of TPC was found in the control guava fruits (89.64 mg/100 g) and eggplant 32.86 mg/100 g) on 12 days of storage. The higher retention of phenolic content in treated fruits might be possible due to barrier properties of composite coatings and encapsulation of clove essential oils based nanoemulsion.

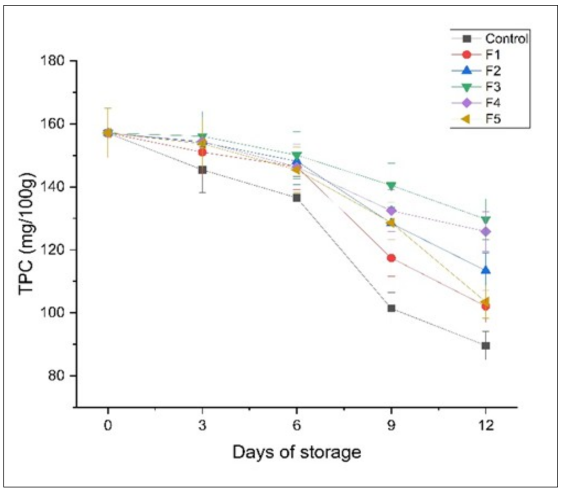
The clove oil has possessed good antimicrobial and antioxidant activity, which helps in the minimizing oxidation and eliminated the free radical (18). Overall, the chitosan-sodium alginate composite coatings encapsulated with clove oil based nanoemulsion were significantly effective to possess and maintained higher phenolic activity in fruits due to presence of bioactive compounds (eugenol) in the coating formulations. The results are similar with the previous findings (9, 13), they have reported, the addition of essential oils (orange peel, clove) and nanoemulsion significantly improved the phenolic profiles of the coating formulations as well as treated fruits throughout the storage period. The initial values of the total phenolic content are in line with the previous research (27, 28). Those reported the TPC range in the eggplants between 34.57-61.11 mg/100. Based on the previous studies it has been proved that the higher retention of phenolic content activity in coated fruits and vegetables using different types of edible coatings may be due to reducing the enzymatic activities such as polyphenol oxidase, which minimizing the oxidation and water loss in the treated fruits (29, 30). Moreover, the findings of this study are in good corroborated with the previous study (31), they have maintained the overall postharvest characteristics including phenolic activity in guava fruits using gelatin based edible coating functionalized with pomegranate seed oils due to minimizing the enzymatic activity and browning in treated fruits compared to control samples (32).

Visual appearance and shelf life

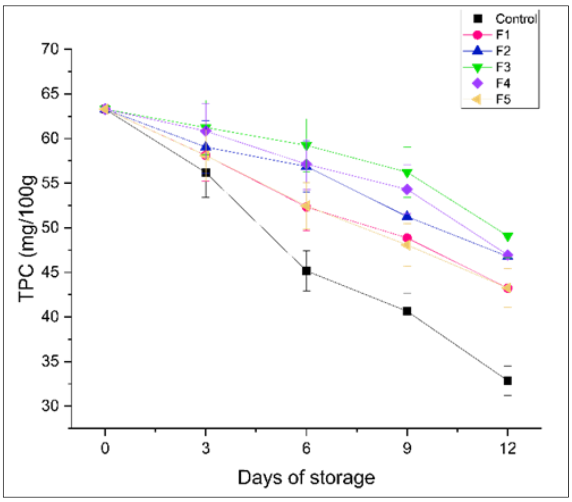
The effects of the edible coatings on the colour and visual appearance of the guava and eggplants fruits are shown in Fig. 8 (a & b). The results showed that the application of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) significantly (p>0.05) maintained the postharvest characteristics and overall quality attributes by retarded the loss in the fruits color. As visual showed the control fruits was not available on 12 days of storage and on 9 days of storage the fruits were dried as compared to treated fruits, which indicated the higher weight loss and respiration rate.

Conclusion

The objective aim was to investigated effects of chitosan-sodium alginate composite coatings functionalized with clove-soy lecithin nanoemulsion were investigated on the postharvest shelf life and quality characteristics of guava and eggplant fruits at room storage condition (23±3 °C, RH- 60-65 %). The results revealed that the application of composite coatings significantly effective to maintained the postharvest quality of the both fruits as compared to the control. The composite coatings such as F3 were most significant to maintained higher postharvest quality attributes of guava and eggplants followed by F4 and F2, respectively up to 12 days of storage. The lower values of postharvest characteristics were found in the control samples of both guava and eggplants followed by F1 and F5 treated samples throughout the storage period. The prepared coating formulations effects on the other commodity of fruits and vegetables should be explore in future as a sustainable approach to minimizing the postharvest losses.



7a



7b

Fig. 7. Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on TPC of guava (7a) and eggplant (7b) fruits under room storage conditions.

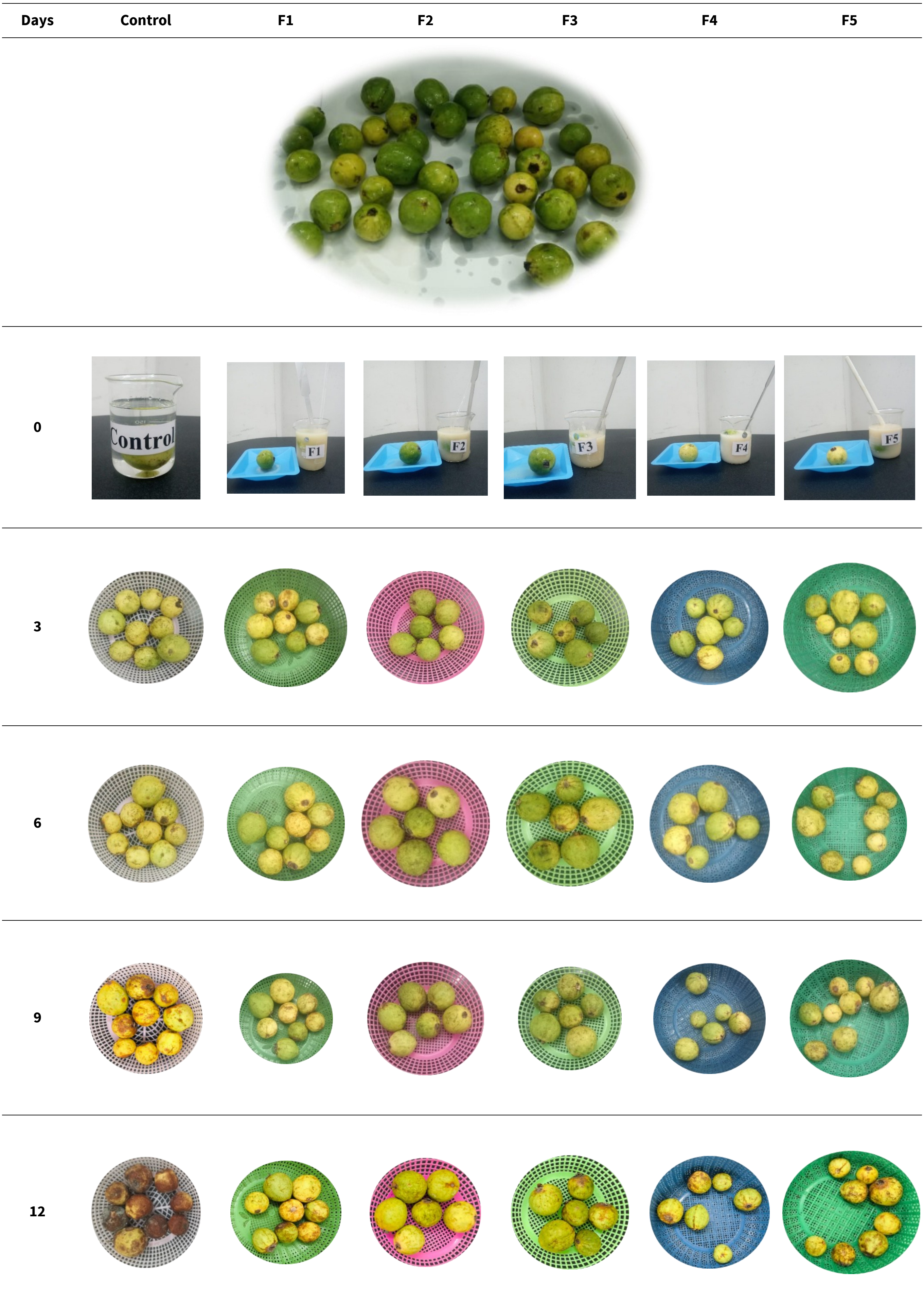


Fig. 8(a). Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on visual appearance and postharvest characteristics of guava fruits under room storage conditions.

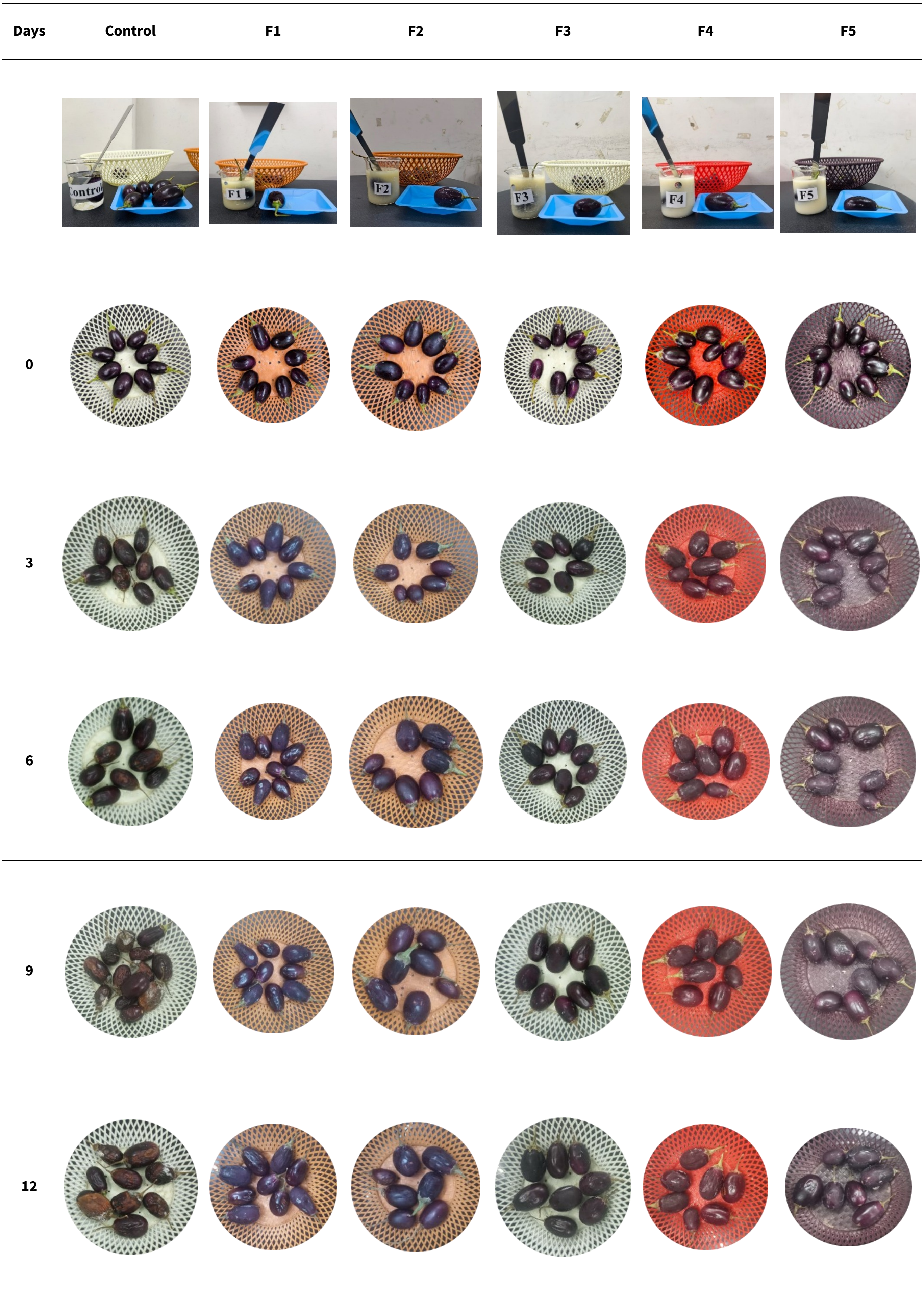


Fig. 8(b). Effects of chitosan-sodium alginate composite coatings functionalized with nanoemulsion (clove oil: soy lecithin) on visual appearance and postharvest characteristics of eggplant fruits under room storage condition.

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Authors' contributions

JP, NK, and SPS were involved in the conceptualization of the study. JP and NK contributed to the original draft writing, while all revisions were collaboratively undertaken. Investigation and methodology were carried out by JP and NK, with additional methodological input from SPS. Validation was performed by NK, and SPS provided overall supervision. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

1. Ali M, Ali A, Ali S, Chen H, Wu W, Liu R, et al. Global insights and advances in edible coatings or films toward quality maintenance and reduced postharvest losses of fruit and vegetables: An updated review. Comprehensive Reviews in Food Science and Food Safety. 2025;24(1):e70103. https://doi.org/10.1111/1541-4337.70103
2. Yadav A, Kumar N, Upadhyay A, Fawole OA, Mahawar MK, Jalgaonkar K, et al. Recent advances in novel packaging technologies for shelf-life extension of guava fruits for retaining health benefits for longer duration. Plants. 2022;11(4):547. https://doi.org/10.3390/plants11040547
3. Singh S, Khemariya P, Rai A, Rai AC, Koley TK, Singh B. Carnauba wax-based edible coating enhances shelf-life and retain quality of eggplant (*Solanum melongena)* fruits. Lwt. 2016;74:420-6. https://doi.org/10.1016/j.lwt.2016.08.004
4. Gill KS, Dhaliwal HS, Mahajan BV, Paliyath G, Boora RS. Enhancing postharvest shelf life and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda by pre-harvest application of hexanal containing aqueous formulation. Postharvest Biology and Technology. 2016;112:224-32. https://doi.org/10.1016/j.postharvbio.2015.09.010
5. Sharma S, Prasad RN, Tiwari S, Chaurasia SN, Shekhar S, Singh J. Effect of chitosan coating on postharvest quality and enzymatic activity of eggplant (*Solanum melongena* L.) cultivars. Journal of Food Processing and Preservation. 2021;45(1):e15098. https://doi.org/10.1111/jfpp.15098
6. Yadav A, Kumar N, Upadhyay A, Singh A, Anurag RK, Pandiselvam R. Effect of mango kernel seed starch-based active edible coating functionalized with lemongrass essential oil on the shelf-life of guava fruit. Quality Assurance and Safety of Crops & Foods. 2022;14(3):103-15. https://doi.org/10.15586/qas.v14i3.1094
7. Kumar N. Polysaccharide-based component and their relevance in edible film/coating: A review. Nutrition & Food Science. 2019;49(5):793-823. https://doi.org/10.1108/NFS-10-2018-0294
8. Suhag R, Kumar N, Petkoska AT, Upadhyay A. Film formation and deposition methods of edible coating on food products: A review. Food Research International. 2020;136:109582. https://doi.org/10.1016/j.foodres.2020.109582
9. Kumar N, Upadhyay A, Shukla S. Effects of essential oils and ultrasonic treatments on properties of edible coatings and their application on citrus fruits. Starch-Stärke. 2024;76(11-12):2300104. https://doi.org/10.1002/star.202300104
10. Kumar N, Upadhyay A, Shukla S, Bajpai VK, Kieliszek M, Yadav A, et al. Next generation edible nanoformulations for improving post-harvest shelf-life of citrus fruits. Journal of Food Measurement and Characterization. 2024;18(3):1825-56. https://doi.org/10.1007/s11694-023-02287-8
11. Prasad J, Dixit A, Sharma SP, Mwakosya AW, Petkoska AT, Upadhyay A, et al. Nanoemulsion-based active packaging for food products. Foods and Raw materials. 2024;12(1):22-36. https://doi.org/10.21603/2308-4057-2023-1-547
12. Prasad J, Sharma SP, Effects of microfluidization on stability, functional and antimicrobial properties of soy lecithin – clove essential oil based nanoemulsion. Nanotechnology Perceptions. 2024;20(7):2004-22. https://doi.org/10.62441/nano-ntp.v20i7.4268
13. Kumar N, Khan AA, Pyngrope D, Alanazi AM, Upadhyay A, Shukla S. Development and characterization of novel starch (mango kernel and litchi seed) based active edible coatings and films using ultrasonication: Effects on postharvest shelf life of Khasi mandarins. Sustainable Chemistry and Pharmacy. 2024;39:101610. https://doi.org/10.1016/j.scp.2024.101610
14. Mahnoor, Ainee A, Hussain A, Kausar T, Bibi B, Kabir K, et al. Effect of water chestnut based edible coating on the physicochemical quality and shelf life of apples. Discover Applied Sciences. 2024;6(8):442. https://doi.org/10.1007/s42452-024-06114-7
15. Amanullah S, Jahangir MM, Ikram RM, Sajid M, Abbas F, Mallano AI. Aloe vera coating efficiency on shelf life of eggplants at differential storage temperatures. Journal of Northeast Agricultural University (English Edition). 2016;23(4):15-25. https://doi.org/10.1016/S1006-8104(17)30003-X
16. Shehu MA, Garba UM. Development of nano emulsion as an edible coating on fresh fruit and vegetable for postharvest quality evaluation. Journal of Health, Wellness and Safety Research. 2025. https://doi.org/10.70382/hujhwsr.v7i3.008
17. Dai L, Wang X, Zhang J, Li C. Application of chitosan and its derivatives in postharvest coating preservation of fruits. Foods. 2025;14(8):1318. https://doi.org/10.3390/foods14081318
18. Formiga AS, Pereira EM, Junior JS, Costa FB, Mattiuz BH. Effects of edible coatings on the quality and storage of early harvested guava. Food Chemistry Advances. 2022;1:100124. https://doi.org/10.1016/j.focha.2022.100124
19. Zaidi M, Akbar A, Ali S, Akram H, Ercisli S, Ilhan G, et al. Application of plant-based edible coatings and extracts influences the postharvest quality and shelf life potential of "surahi" guava fruits. ACS omega. 2023;8(22):19523-31. https://doi.org/10.1021/acsomega.3c00930
20. Makhathini N, Kumar N, Fawole OA. Enhancing circular bioeconomy: Alginate-cellulose nanofibre films/coatings functionalized with encapsulated pomegranate peel extract for postharvest preservation of pomegranate arils. International Journal of Biological Macromolecules. 2025;309:142848. https://doi.org/10.1016/j.ijbiomac.2025.142848
21. Mehra M, Kumar N, Ojha A, Upadhyay A. Extending the postharvest shelf life of sweet orange (*Citrus sinensis* L.) fruits using muskmelon seeds flour based edible coatings functionalized with oregano essential oil. Journal of Food Measurement and Characterization. 2024;18(10):8472-88. https://doi.rg/10.1007/s11694-024-02815-0
22. El-Beltagi HS, Abdel-Haleem M, Al Saikhan MS, Shalaby TA, Mohamed AA, Khedr EH. Antibacterial coatings: pioneering solutions for maintaining fruit quality and prolonging storability. The Journal of Horticultural Science and Biotechnology. 2025:1-25. https://doi.org/10.1080/14620316.2025.2476660

23. Pandey VK, Shafi Z, Choudhary P, Pathak A, Rustagi S. Navigating the functional and bioactive landscape of sodium alginate-based edible coatings for modernized fruit preservation. Journal of Food Safety. 2025;45(3):e70020. https://doi.org/10.1111/jfs.70020

24. Kandoliya UK, Bajaniya VK, Bhadja NK, Bodar NP, Golakiya BA. Antioxidant and nutritional components of eggplant (*Solanum melongena* L.) fruit grown in Saurastra region. Int J Curr Microbiol. Appl. Sci. 2015;4(2):806-13.

25. de Lourdes Colín-Álvarez M, Rentería-Ortega M, Barrios-Francisco R, Berenice León-Espinosa E, Uriel Castañeda-Serna H. Antifungal effect of the edible coating added with cinnamon essential oil (*Cinnamomum verum*) on the shelf life of strawberries (Fragaria× ananassa). Agro Productividad. 2025;18(1). https://doi.org/10.32854/agrop.v18i1.2951

26. Rajan D, Subramani D, Kumaraguruparaswami M. Eco-friendly active packaging for fresh and minimally processed fruits and vegetables. ingreen materials for active food packaging. Springer Nature Singapore. 2025:417-54. https://doi.org/10.1007/978-981-96-0369-5_13

27. Nwanna EE, Ibukun EO, Oboh G. Inhibitory effects of methanolic extracts of two eggplant species from South-western Nigeria on starch hydrolysing enzymes linked to type-2 diabetes. African Journal of Pharmacy and Pharmacology. 2013;7(23):1575-84. https://doi.org/10.5897/AJPP2013.3606

28. Somawathi KM, Rizliya V, Wijesinghe DG, Madhujith WM. Antioxidant activity and total phenolic content of different skin coloured brinjal (*Solanum melongena*). Tropical Agricultural Research. 2015;26(1). https://doi.org/10.4038/tar.v26i1.8080

29. Champa WA, Weerasooriya AD. A systematic review on plant-based edible coatings for quality improvement and extended postharvest life of fresh fruits and vegetables. Journal of Horticulture and Postharvest Research. 2025:177-98. https://doi.org/10.22077/jhpr.2024.8159.1424

30. Shahsavari R, Rastegar S. Innovative gelatin-based edible coatings for preserving postharvest quality of guava (*Psidium guajava* L.) fruit. International Journal of Horticultural Science and Technology. 2025:909-22. https://doi.org/10.22059/ijhst.2024.377804.864

31. Hailu FW, Fanta SW, Tsige AA, Delele MA. Current status and challenges of colorimetric intelligent packaging for fruit and vegetables: A review. Journal of Food Quality. 2025;2025 (1):6669828. https://doi.org/10.1155/jfq/6669828

32. Kapoor H, Baswal AK, Gupta A, Gill KS, Ozturk B, Jain LK. Impact of post-harvest application of salicylic acid alone and/or in combination with ascorbic acid on storage life and quality of guava fruit cv. 'Allahabad Safeda' under ambient storage conditions. Applied Fruit Science. 2025;67(3):104. https://doi.org/10.1007/s10341-025-01326-6

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