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Full Length Research

Increasing the shelf-life and quality of matured scotch bonnet (*Ata rodo*) and tomato using chitosan coating

Kunle Ogungbemi[1*], Ilesanmi F. F.[2], Ilori A. O.[2], Odeniyi T. A.[2], Balogun D., Ajisafe S. S.[2], Balogun B.[2], Oke B. A.[2] and Adeniyi B. M.[1]

[1]Biochemistry/Chemistry Unit, (PCRD), Nigerian Stored Products Research Institute, Ibadan.
[2]Biochemistry/Chemistry Unit, (DCRD), Nigerian Stored Products Research Institute, Ibadan.
[3]Microbiology Unit, (PCRD) Nigerian Stored Products Research Institute, Ibadan.

*Corresponding author. Email: kunleoguns484@gmail.com; Tel: +234(0)8066970191.

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ABSTRACT: Loss in quantity and quality of several perishable crops occur between harvest and handling process to the final consumer. In tomatoes and scotch bonnet, the quality loss occurs majorly due to over-ripening, mechanical damage, fungal infection and decay. Extending the shelf life and storability of these perishable crops has been of major concern to researchers. Hence, this study was carried out to determine the protective effect of chitosan coating on post-harvest qualities of matured scotch bonnet and tomato. Freshly harvested scotch bonnets and tomatoes from a field plot at Nigerian Stored Products Research Institute, Ibadan were sorted on the basis of color, size and absence of external injuries. The selected crops were randomly divided into two groups (group with chitosan and without chitosan). Chitosan synthesized from Chemistry Department in Nigerian Stored Products Research Institute, Ibadan was used to coat the scotch bonnets and tomatoes crops in group 1 while group 2 served as the control. The coated scotch bonnets and tomatoes where kept at room temperature and monitored on daily basis for seven days for scotch bonnet and twenty days for tomato. Chitosan coating markedly reduced the weight loss, fungal infection, shrinking and decay, improving the firmness and titratable acidity in group coated with chitosan. It can be concluded that chitosan coating delays senescence and fungal infection in scotch bonnet and tomato most likely due to its ability to alleviate water stress and its anti-fungal activities.

Keywords: Chitosan, fungi infection, weight performance, titratable acidity.

INTRODUCTION

Postharvest loss is a major challenge hampering tomatoes production in most developing countries (Kasso and Bekele, 2018). Tomato being a perishable crop has high moisture content as such has a short shelf life of about 48 hours under tropical conditions (Negi and Wood, 2019). Loss in quantity and quality of several perishable crops occur between harvest and getting to the final consumer. In tomatoes and scotch bonnets, loss occurs majorly due to over-ripening, mechanical damage, fungal infection and decay. Extending the shelf life and storability of these perishable crops has been of major concern to researchers.

Chitosan (the deacetylated derivative of chitin) is one of the abundant, renewable, non-toxic and biodegradable carbohydrate polymers available in the exoskeletons of shellfish and insects (Yamada et al., 2005). Chitosan, a non-toxic natural polymer that has ideal preservative coating for fresh fruit because of its film-forming and biochemical properties (Muzzarelli and Muzzarelli, 2009). Unlike other coating materials, chitosan is known to be antifungal to several fungi. Chitosan has received much attention as a functional biopolymer for diverse applications, especially in pharmaceutics, food (as a source of crude fibre), and cosmetics (Dutta et al., 2004).

In the latest few years, many technologies, such as edible coating with antimicrobial agents, low temperature, high temperature, controlled atmosphere package, and so on, have been developed in order to maintain the quality and safety of fruits and vegetables, which could prolong its shelf life during the storage and market periods (Youwei and Yinzhe, 2013, Gualanduzzi et al., 2009, Yinzhe and Shaoying, 2013). However, some damaged is incurred to the nutritional status of these fruit and vegetables when optimum temperature is not considered. Also, the use of conventional packaging materials can create serious environmental problems when not properly disposed.

The exploration for the safe alternatives in increasing shelf life of fruits and vegetables, such as the development and application of crab-chitosan coating is been investigated in this work (Xing et al., 2015, Meng et al., 2009). Crab- chitosan coating is employed due to its excellent properties including the property to form the thin film on the fruit's surface, the property to avoid the loss of moisture and aromas, the inhibition of the oxygen penetration to the plant tissue or microbial growth, and the safety for using on the food (Mantilla et al., 2013). Hence, this study was carried out to determine the protective effect of chitosan coating on post-harvest qualities of matured scotch bonnet and tomato.

MATERIALS AND METHODS

Collection and sorting of crops

Freshly harvested matured scotch bonnets and tomatoes from a field plot at Nigerian Stored Products Research Institute, Ibadan were sorted on the basis of color, size and absence of external injuries. The selected crops were randomly divided into two groups (group with chitosan and without chitosan).

Crab shell collection and grinding

Crabs (*Scylla serrata*) were bought from Ojo market (coastal ragion), Lagos state. The crabs were killed by boiling in hot water for 20 minutes, after which the shells (exoskeleton) were separated from crabs manually. The crab shells were dried and ground to powder by a local grinding machine at Oluwo-keesin, Abeokuta, Ogun state.

Chitosan extraction

Chitosan extraction was carried-out by following the processes described by Burrows et al. (2007). The process involved three steps namely: deproteination, demineralization and deacetylation.

Deproteination

A sample (75 g) of the powdered exoskeleton was accurately weighed and then divided into three equal parts and placed in three different 250 ml beakers. Each of the samples was treated with 100 ml of 4% w/v NaOH solution and boiled for 1 hour in order to dissolve the proteins and sugar. The mixture was allowed to cool and the supernatant was decanted off. The sediment was dried on cardboard paper for 30 minutes at room temperature.

Demineralization

The resulting powder was demineralized with 135 ml of 1% w/v HCl and was left overnight. This was done to remove the calcium carbonate content of the sample. The demineralized crab shell was then treated for 1 hour with 50 ml of 2% w/v NaOH to decompose the albumin into water soluble amino acid which was drained off. The sample was washed with deionized water and then air-dried.

De-acetylation (conversion of chitin to chitosan)

The chitin was converted to chitosan by de-acetylation process. This was carried out by adding 100 ml of 50% w/v NaOH to each sample and then heating at 100°C for 2 hours in a water bath. The samples were then removed and cooled for 30 minutes at room temperature. Afterward, each sample was washed continuously with 50% w/v NaOH and filtered to retain the solid matter which is chitosan. Each sample of the chitosan was placed in a 250 ml beaker and air-dried for 3 hours and then oven-dried at 120°C for 24 hours to obtain dry chitosan (a creamy white powder). The chitosan obtained was washed with distilled water and then dried.

Coating of scotch bonnet and tomato

After sorting the wholesome scotch bonnets and tomatoes to be used for this study, the chitosan was applied to the scotch bonnets and tomatoes as a thin film layer coat. To improve the wettability of the chitosan, 0.1% tween 80 was used following the procedure of EL-Ghaouth et al. (1991).

RESULTS

The effect of chitosan coating on the weight performance of scotch bonnets and tomatoes was investigated from the first day to the 7th day and the 20th day of the experiment, respectively. The result showed that there were no significant difference in the weight performance of the crops (scotch bonnets and tomatoes) on the first day but

Table 1. Effect of chitosan coating on the weight performance of scotch bonnet and tomato.

Samples	Day 1 (g)	Day 3(g)	Day 5 (g)	Day 7 (g)
Tomato without Chitosan	4.7±0.302^a	3.6±0.002^a	2.60±0.002^a	2.1±0.023^a
Tomato with Chitosan	5.0±0.003^a	4.8±0.001^b	4.6±0.003^b	4.5±0.002^b
Scotch Bonnet without Chitosan	20.5±0.003^a	18.9±0.003^a	14.6±0.001^a	12.4±0.003^a
Scotch bonnet with Chitosan	22.6±0.003^b	20.6±0.002^b	19.8±0.003^b	19.0±0.002^b

Starting weight of scotch bonnet and tomato of coated and non-coated are equal. Values are mean ± SEM.

Table 2. Effect of chitosan coating on the titratable acidity of Scotch bonnet and tomato.

Samples	Titratable Acidity (mg/ml) Day 1	Titratable Acidity (mg/ml) Day 7
Tomato without Chitosan	101.51±0.28^a	106.34±0.92^a
Tomato with Chitosan	101.34±0.32^a	126.34±0.55^b
Scotch Bonnet without Chitosan	65.34±0.57^a	69.34±0.71^b
Scotch bonnet with Chitosan	66.42±0.63^a	84.34±0.74^b

Values are mean ± SEM.

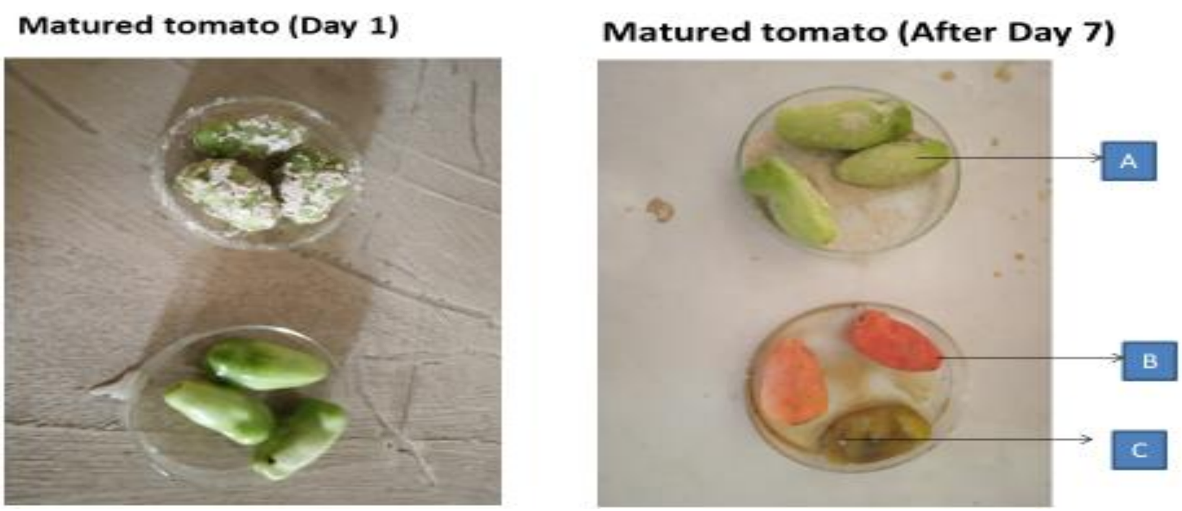

Plate 1. Outcome of coated and uncoated tomato from day 1 to day 7. **(A).** Intact matured tomato with chitosan coating experiencing delay in ripening and spoilage. **(B).** Matured but ripe tomato. **(C).** Fungal infection spoilage of the tomato.

on the seventh day, a significance reduction in weight of uncoated scotch bonnets and tomatoes was observed when compared to chitosan coated scotch bonnets and tomatoes (Table 1) while after 20 days of the experiment, ripening had taken place in tomatoes with spoilage experienced in tomato not coated with chitosan as seen in plate 2.

The effect of chitosan coating on the titratable acidity of scotch bonnets and tomatoes was investigated both on the first and seventh day of the research and the result showed that there was no significant difference in the titratable acidity of chitosan coated scotch bonnet and tomato on day 1. Whereas, an appreciable increase in the titratable acidity was observed on both chitosan coated scotch bonnets and tomatoes on day 7 (Table 2).

The effect of chitosan coating on the shelf-life, ripening, fungi infection and colour was also investigated on coated and uncoated tomatoes as seen in Plate 1. The result showed that after 7 days, there was an observable change in colour of tomato from green to red as seen in plate 1 (B) of uncoated tomato showing that ripening has taken place, also there was an early spoilage of one of tomato resulting from fungal infection (c) in uncoated tomatoes.

After 20 days of the experiment, the crab chitosan coated tomatoes became ripped and the uncoated has deteriorated already as seen in plate 2.

The effect of chitosan coating on the shelf-life, ripening, fungal infection and colour of coated and uncoated scotch

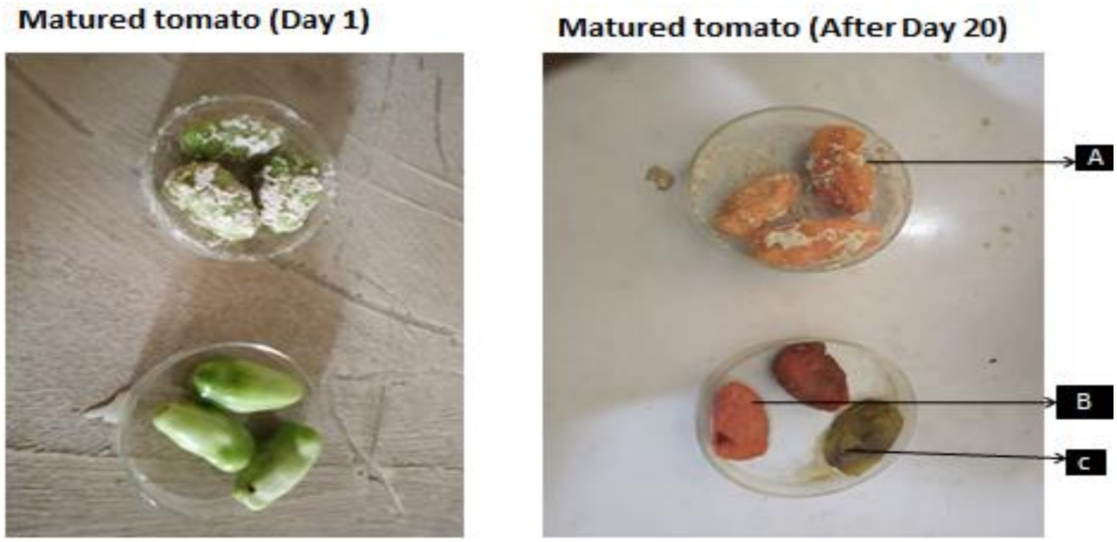

Plate 2. Outcome of coated and uncoated tomato from day 1 to day 20. **(A).** Intact matured tomato with chitosan coating experiencing delay in spoilage. **(B).** Matured but shrunk tomato. **(C).** Fungal infection leading to spoilage of the tomato.

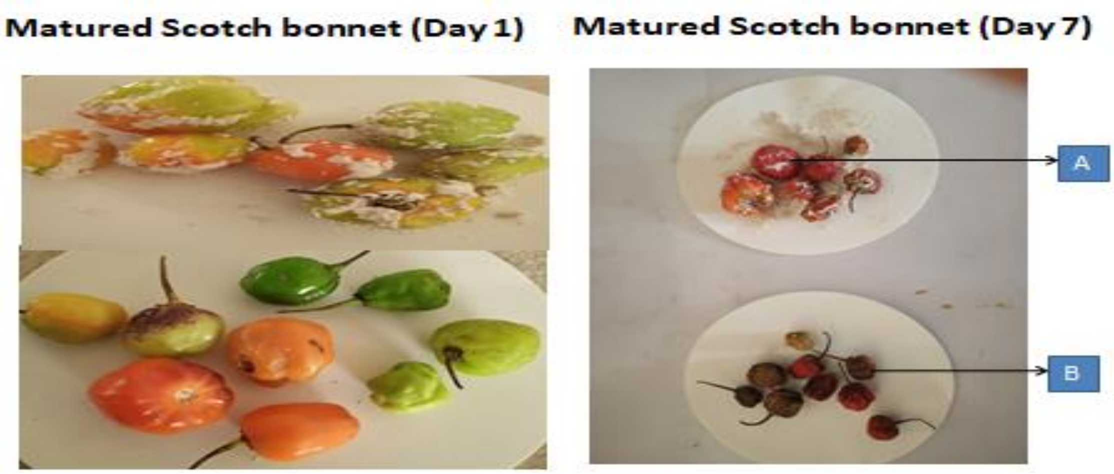

Plate 3. Outcome of coated and uncoated scotch bonnet from day 1 to day 7. **(A).** Intact matured scotch bonnet with chitosan coating experiencing delay in shrinking and spoilage. **(B).** Matured shrined scotch bonnet.

bonnet was investigated as seen in plate 3. The result showed that after 7 days, there was an observable change in color of scotch bonnet to a fully ripped reddish color as seen in plate 3 of coated scotch bonnet showing that ripening has taken place, whereas shrinking was observed in the uncoated scotch bonnet bringing about early spoilage in the scotch bonnet.

DISCUSSION

Fresh fruits and vegetables with good quality tends to be more acceptable to costumers and these good features have been researched upon to have benefits for the health of human body due to their good flavour, being colourful, and the contents in nutrients, such as vitamins, minerals, and amino acids (Xing et al., 2015). However, one of the major challenges for the storage safety of fruits and vegetables is related to its high decay rate and short shelf life period. This is due to the fact that they could undertake the metabolism interminably as the living organisms during the storage period (Duan and Zhang, 2013). Moreover, the shrink and loss of luster of surfaces and the rot of fruits could be observed due to high water transpiration, the loss of nutrients, and the infection of spoilage microorganism such as fungal infection during storage.

The result of the research showed that chitosan has a marked effect on the weight performance of both the scotch bonnet and tomato; there was a significant reduction in the weight of scotch bonnet and tomato. There was a 55% reduction in weight of uncoated tomatoes and 40% reduction in the weight of the uncoated scotch bonnets. There was however no significant different in the weight performance of tomatoes and scotch bonnets coated with edible chitosan; this could be attributed to the ability of chitosan to prolong the shelf life of perishable food products by reducing water loss and hereby controlling deterioration reactions (Olivas and Barbosa-Canovas, 2005). The uncoated tomatoes and scotch bonnet deteriorated easily due to water loss and various deterioration reactions. The main reason for weight loss of post-harvest fruits includes transpiration and the substrate consumption of respiration. And water loss is about 80% of the total weight loss (Velickova et al., 2013). This is in agreement with results obtained by several authors (Youwei and Yinzhe, 2013; Meng et al., 2009). Chitosan creates a selectively permeable barrier around the fruits and hereby prevent water loss and maintains structural integrity of tissues in the fruits. This observation may be that coating the fruits with chitosan may have increased the resistant of water permeability of the cell walls, thus resulting in decreased diffusivity of water vapour through the film matrix and a decrease weight loss (Han et al., 2004). Similar results on weight loss reduction trend were observed using calcium caseinate combined with chitosan based film coating (Mei and Zhao, 2003). There was an appreciable increase in the titratable acid of both scotch bonnets and tomatoes coated with chitosan, a 25% and 27% increase in the titratable acid of tomatoes and scotch bonnets were observed, respectively. There was however no significant difference in the titratable acid of tomatoes and scotch bonnets not coated with chitosan.

The use of edible coatings has been studied previously in the control of deterioration reactions to prolong shelf life of fresh produce (Olivas and Barbosa-Canovas, 2005). An increase in the titratable acid of fruits increases the shelf life of the perishable fruits (Dong et al., 2004). At the end of the 7 days observation period, it was observed that chitosan coated tomatoes and scotch bonnets were still intact and spoilage had not set in. This indicates that chitosan prevents the infection of scotch bonnet and tomato by acting as a barrier. Post-harvest fruits are vulnerable to all kinds of spoilage bacteria and fungi, and lead to rot. Usually the decay incidence of fruit indicates the invasion of microbes (Akbudak et al., 2006). Chitosan decreases respiration rate, maintains the protective enzymes higher activities, and solidifies cell membrane integrity which comprehensively strengthen the ability of fruits to defend itself from invading fungi. Even if the coated fruits are infected, disease incidence is greatly reduced. This result is in line with the findings of Jiang et al., (2012).

Numerous previous studies have shown that chitosan could directly inhibit spore germination, germ tube elongation and mycelial growth of many phytopathogens, such as Botrytis cinerea (Liu et al., 2007), Fusarium solani (Eweis et al., 2006), Rhizopus stolonifer (Hernández-Lauzardo et al., 2008), Penicillium (Liu et al., 2007), and Sclerotium rolfsii (Eweis et al., 2006). Liu et al. (2007) reported that chitosan completely inhibited spore germination of *Penicillium expansum*. Chitosan used as a coating enters fungal cells and adsorbs essential nutrients, which inhibit or slow down the synthesis of mRNA and protein and prevent the growth of fungi cells which is in line with the findings of Avadi et al. (2004). Chitosan coating markedly reduced the weight loss, fungal infection, shrinking and decay, improving the firmness and titratable acidity in group coated with chitosan.

Conclusion

This study has shown that chitosan coating delays senescence and fungal infection in scotch bonnet and tomato most likely due to its ability to alleviate water stress and its anti–fungal activities.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

Akbudak, N., Tezcan, H., Akbudak, B., & Seniz, V. (2006). The effect of harpin protein on plant growth parameters, leaf chlorophyll, leaf colour and percentage rotten fruit of pepper plants inoculated with Botrytis cinerea. *Scientia Horticulturae*, 109(2), 107-112.

Avadi, M. R., Sadeghi, A. M. M., Tahzibi, A., Bayati, K. H., Pouladzadeh, M., Zohuriaan-Mehr, M. J., & Rafiee-Tehrani, M. (2004). Diethylmethyl chitosan as an antimicrobial agent: Synthesis, characterization and antibacterial effects. *European Polymer Journal*, 40(7), 1355-1361.

Burrows, F., Louime, C., Abazinge, M., & Onokpise, O. (2007). Extraction and evaluation of chitosan from crab exoskeleton as a seed fungicide and plant growth enhancer. *American-Eurasian Journal of Agricultural and Environmental Science*, 2(2), 103-111.

Duan, J. L., & Zhang S. Y. (2013). Application of chitosan based coating in fruit and vegetable preservation: A review. *Journal of Food Processing and Technology*, 4(5), 227.

Dutta, P. K., Dutta, J., & Tripathi, V. S. (2004). Chitin and chitosan: Chemistry, properties and applications. *Journal of Scientific and Industrial Research*, 63, 20-31.

El Ghaouth, A., Arul, J., Ponnampalam, R., & Boulet, M. (1991). Use of chitosan coating to reduce water loss and maintain quality of cucumber and bell pepper fruits. *Journal of Food Processing and Preservation*, 15(5), 359-368.

Eweis, M., Elkholy, S. S., & Elsabee, M. Z. (2006). Antifungal efficacy of chitosan and its thiourea derivatives upon the growth of some sugar-beet pathogens. *International Journal of Biological Macromolecules*, 38(1), 1-8.

Gualanduzzi, S., Baraldi, E., Braschi, I., Carnevali, F., Gessa, C. E., and De Santis, A. (2009). Respiration, hydrogen peroxide levels and antioxidant enzyme activities during cold storage of zucchini squash fruit. *Postharvest Biology and Technology*, 52(1), 16-23.

Han, C., Zhao, Y., Leonard, S. W., & Traber, M. G. (2004). Edible coatings to improve storability and enhance nutritional value of fresh and frozen strawberries (Fragaria× ananassa) and raspberries (*Rubus ideaus*). *Postharvest Biology and Technology*, 33(1), 67-78.

Hernández-Lauzardo, A. N., Bautista-Baños, S., Velázquez-del Valle, M. G., Méndez-Montealvo, M. G., Sánchez-Rivera, M. M., & Bello-Pérez, L. A. (2008). Antifungal effects of chitosan with different molecular weights on *in vitro* development of *Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill. *Carbohydrate Polymers*, 73(4), 541-547.

Dong, H., Cheng, L., Tan, J., Zheng, K., & Jiang, Y. (2004). Effects of chitosan coating on quality and shelf life of peeled litchi fruit. *Journal of Food Engineering*, 64(3), 355-358.

Jiang, T., Feng, L., & Li, J. (2012). Changes in microbial and postharvest quality of shiitake mushroom (Lentinus edodes) treated with chitosan–glucose complex coating under cold storage. *Food Chemistry*, 131(3), 780-786.

Kasso, M., & Bekele, A. (2018). Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia. *Journal of the Saudi Society of Agricultural Sciences*, 17(1), 88-96.

Liu, J., Tian, S., Meng, X., & Xu, Y. (2007). Effects of chitosan on control of postharvest diseases and physiological responses of tomato fruit. *Postharvest Biology and Technology*, 44(3), 300-306.

Mantilla, N., Castell-Perez, M. E., Gomes, C., & Moreira, R. G. (2013). Multilayered antimicrobial edible coating and its effect on quality and shelf-life of fresh-cut pineapple (*Ananas comosus*). *LWT-Food Science and Technology*, 51(1), 37-43.

Mei, Y., & Zhao, Y. (2003). Barrier and mechanical properties of milk protein-based edible films containing nutraceuticals. *Journal of Agricultural and Food Chemistry*, 51(7), 1914-1918.

Meng, X., Han, J., Wang, Q., & Tian, S. (2009). Changes in physiology and quality of peach fruits treated by methyl jasmonate under low temperature stress. *Food Chemistry*, 114(3), 1028-1035.

Muzzarelli, R. A. A., & Muzzarelli, C. (2009). Chitin and chitosan hydrogels. In: *Handbook of hydrocolloids* (pp. 849-888). Woodhead Publishing.

Negi, S., & Wood, L. C. (2019). Transportation lead time in perishable food value chains: an Indian perspective. *International Journal of Value Chain Management*, 10(4), 290-315.

Olivas, G. I., & Barbosa-Cánovas, G. V. (2005). Edible coatings for fresh-cut fruits. *Critical reviews in Food Science and Nutrition*, 45(7-8), 657-670.

Velickova, E., Winkelhausen, E., Kuzmanova, S., Alves, V. D., & Moldão-Martins, M. (2013). Impact of chitosan-beeswax edible coatings on the quality of fresh strawberries (Fragaria ananassa cv Camarosa) under commercial storage conditions. *LWT-Food Science and Technology*, 52(2), 80-92.

Xing, Y., Xu, Q., Jiang, L., Cao, D., Lin, H., Che, Z., Ma, Y., Li, X., & Cai, Y. (2015). Effect of different coating materials on the biological characteristics and stability of microencapsulated Lactobacillus acidophilus. *RSC Advances*, 5(29), 22825-22837.

Yamada, M., & Honma, I. (2005). Anhydrous proton conductive membrane consisting of chitosan. *Electrochimica acta*, 50(14), 2837-2841.

Yinzhe, R., & Shaoying, Z. (2013). Effect of carboxymethyl cellulose and alginate coating combined with brewer yeast on postharvest grape preservation. *ISRN Agronomy*, Volume 2013, Article ID 871396, 7 pages.

Youwei, Y., & Yinzhe, R. (2013). Effect of chitosan coating on preserving character of post-harvest fruit and vegetable: a review. *Journal of Food Processing and Technology*, 4(8), 254.