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Research Article

Improvement of shelf life quality of tomatoes using a novel edible coating formulation

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Abstract

The development and use of novel formulations as edible coatings on fruits and vegetables has been a subject of intensive agro based research. The multifunctional and eco-friendly attributes of these coatings give added value to the final product. The present study focuses on the potential application of a novel coating suspension to extend the shelf life of whole tomato fruits. The film forming suspensions were made from *Hibiscus rosa-sinensis* mucilage with various concentrations of gelatin, chitosan, cassava starch. Tomatoes were coated with already standardized suspensions. Shelf-life was evaluated using parameters such as changes in weight loss, pH, appearance and sensorial analyses. Mucilage-based coatings significantly reduced the harvested fruit weight loss and maintained the general appearance and hence acceptability during the storage period in comparison to non-mucilage based coatings and uncoated ones. Thus, mucilage-based coatings appeared more useful than the non-mucilage-based coatings in extending the tomato shelf-life by providing an ideal microenvironment.

Keywords: Film forming suspensions; *Hibiscus rosa-sinensis* mucilage; tomatoes; shelf life evaluation.

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) being a climacteric fruit has a relatively short post-harvest life as many external and internal causes leads to the loss of quality and hence affecting its storability. These include high respiration rates, transpiration, postharvest diseases and acceleration in ripening process and senescence (1). The quality of tomato rapidly changes after harvesting. Fruit quality parameters include firmness, flavour, colour and nutritional value, as well as shelf life, processing attributes and resistance to pathogens (2). Tomatoes are one among the common fruit vegetables that undergo deterioration rapidly after harvest especially during transport and marketing. This has led to a tremendous economic loss. Subsequently, synthetic chemicals have been rampantly used to overcome the problem (3). But recent health concerns regarding the safety of foods containing synthetic chemicals have given a lot of attention to naturally derived compounds and natural products (4). One

Table 1: Weight loss values of the tomatoes

Days after coating	Weight loss		
	Control group	NB group	MB group
1st	0.82 ± 0.06 g	nil	nil
4th	4.00 ± 0.42 g	1.13 ± 0.16 g	1.00 ± 0.32 g
8th	-	3.31 ± 0.43 g	2.00 ± 0.38 g
10th	-	-	3.22 ± 0.23 g

Table 2: pH values of the tomatoes

Days after coating	pH value		
	Control group	NB group	MB group
1st	4.01 ± 0.16	3.93 ± 0.12	3.97 ± 0.23
4th	4.10 ± 0.31	4.07 ± 0.56	4.09 ± 0.41
8th	-	4.12 ± 0.24	4.11 ± 0.16
10th	-	-	4.23 ± 0.45

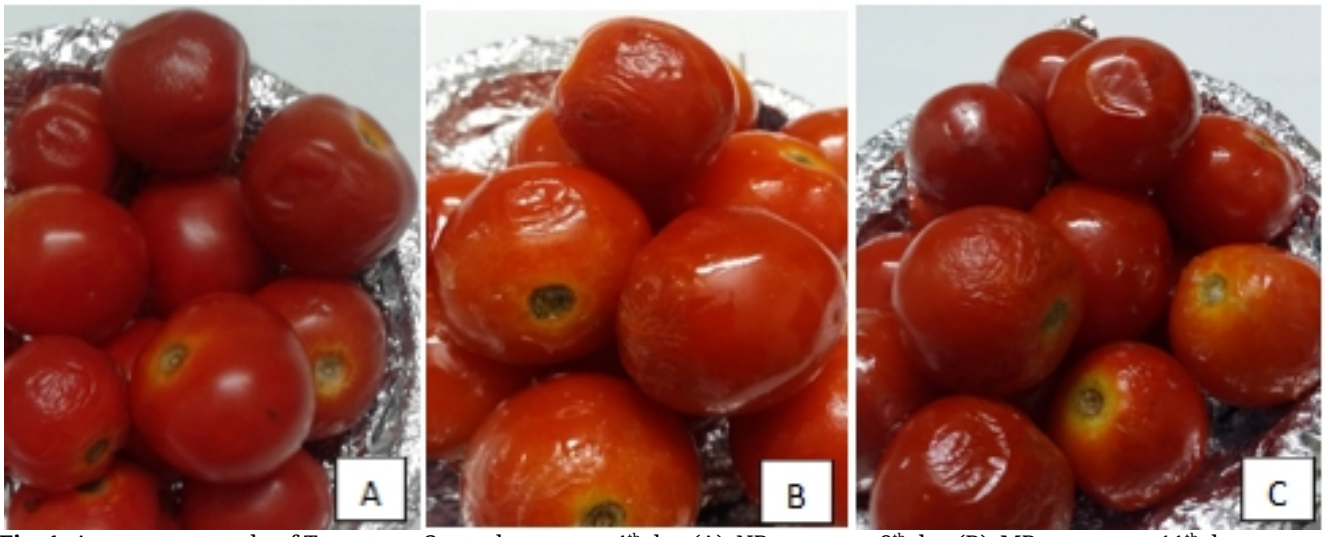

Fig. 1. Appearance study of Tomatoes: Control group on 4th day (A); NB group on 8th day (B); MB group on 11th day

of the main foci in current researches in postharvest biology is to explore suitable edible coating formulations as safer alternative over synthetic chemicals to extend the shelf life of perishable food crops. Moreover, such coatings have an added advantage as they improve the appearance of the food product (5). Different compounds have been used as edible coatings to prevent harvested fruit weight loss, including wax, milk proteins, celluloses, lipids, starch, zein and alginate (6).The use of plant mucilages as an ideal coating material is less explored and utilized. *Hibiscus rosa-sinensis* being a member of family Malvaceae, is known for its rich source of mucilage. The detailed studies on the physicochemical and bioactive characterization has been earlier reported by Vignesh and Nair (7). The previous studies revealed that the mucilage has good antimicrobial properties which makes them ideal to serve as a novel coating agent.

The main aim of the current study was to understand the effect of Hibiscus mucilage based composite coatings on the change in different physico-chemical parameters related to tomato fruit quality during postharvest storage. Tomato is widely used in most Indian cuisines and suffers huge postharvest losses in India (8). Hence, tomato was chosen as the candidate fruit in the present study

Materials and Methods

***Raw materials*:** Tomatoes of a common consumer variety, were purchased from a local home garden on the day after harvest. Fruit selection criteria adopted were: physiological maturity (light red, semisolid), uniformity in size, absence of skin damage (no signs of microbial infections) and intense red colour.

***Grouping of tomatoes*:** The selected tomatoes were washed with distilled water and wiped with clean cloth. The tomatoes were sorted (at random) into three treatment groups and each group consisted of 15 fruits. Each experiment consisted of three replications. Uncoated tomatoes serve as

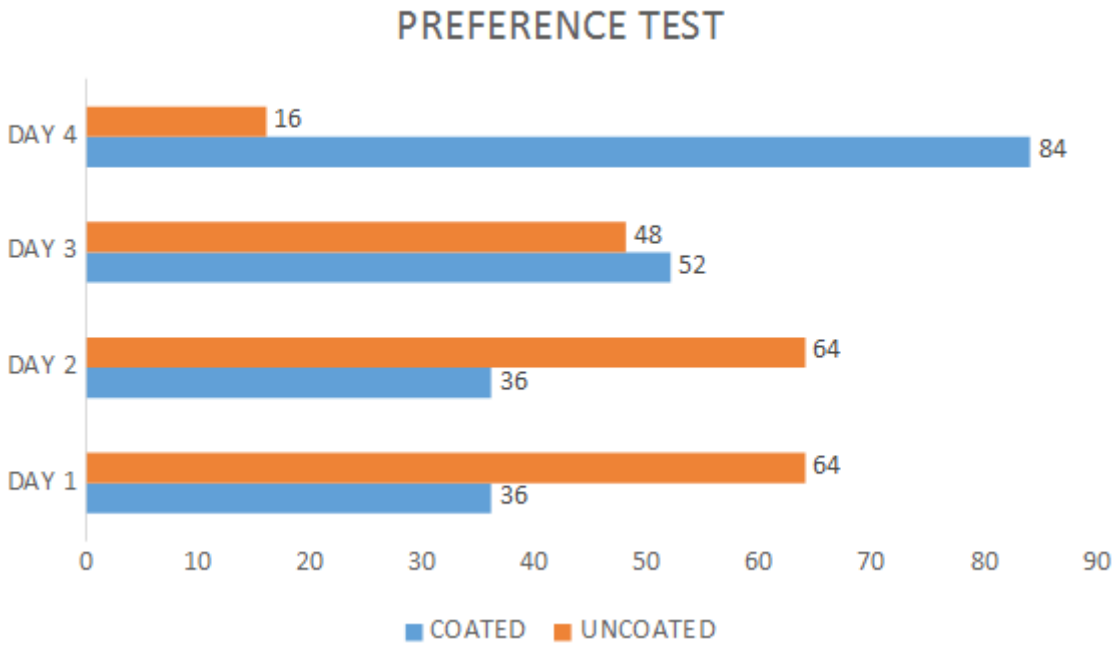

Fig. 2. Preference test: Preference percentage of coated and uncoated tomatoes

the control and the suspension coated as the other groups. The treatment groups were NB (Normal Blend) suspension coated tomatoes and MB (Mucilage Blend) suspension coated tomatoes.

***Coating of tomatoes*:** Coating suspensions were earlier standardised considering the criteria of sensorial parameters, ease of preparation and film forming ability (9).The two film forming suspensions prepared were NB suspension and MB suspension. The NB suspension was used to prepare control films, while MB included *Hibiscus* mucilage. The NB suspension was prepared by mixing gelatin (1g in 100 ml distilled water), chitosan (0.5 g in 100 ml of 5% acetic acid), cassava starch (0.5 g in 100ml distilled water) and final volume made upto 500 ml using distilled water along with 0.5ml of glycerol as plasticiser whereas MB suspension included *Hibiscus* mucilage (0.5g in 100ml distilled water) in addition to NB components.

Tomatoes were dipped in the coating solution for 30 seconds; the excess coating was drained and the coated tomatoes were dried in a forced-air dryer (Philips model HP8100/06) for 30 minutes. After coating, tomatoes were kept at room temperature for 12 days. The fruits were analysed daily for any visible change and after every 1, 5 and 10 days for sensorial analysis.

***Thickness of the coated films*:** The fruit surface was coated by dipping into the NB and MB suspensions and the coated films were peeled off from the tomato surface and analysed for uniformity in thickness. The measurements were carried out with a digital vernier callipers (Mitutoyo Ltd. Japan)

***Evaluation of shelf life quality*:** The shelf life quality of the control as well as treated fruits was evaluated through weight loss study, pH value, appearance changes (10) and sensorial analyses (11).

1. ***Weight loss*:** Weight loss measurements were carried out as a quantitative parameter to evaluate the shelf life of tomatoes of all treatment groups (uncoated tomatoes (control), NB coated and MB coated tomatoes). Weight of the samples were measured using electronic weighing balance with unit in gram (Shimadzu, Japan). The weight of each sample in each group was measured and the average weight of each group was calculated as the weighted arithmetic mean of samples in each group. Measurements were taken after every 24 hrs (daily). Weight loss was computed as the difference between the initial and the final average weight of the sample group. The final weight is the average weight of the groups on the day in which the signs of decay first appeared.
2. ***pH value*:** The pH value is a quantitative measurement of acidity which in turn affects the taste and flavour of fruits and hence is used as a parameter to evaluate shelf life quality. Change in pH value in stored fruits is an indication of change in quality. The tomatoes juices were used for the measurements. Measurements were taken on the first day after coating and on days in which majority samples of the group showed first signs of decay.
3. ***Appearance study*:** The appearance changes were evaluated using a photographic camera (Sony DSC HX1 Digital still camera, Japan). The three groups were analysed daily for any visible change. The photographs were captured for groups before and after coating. The particular groups were also photographed on the specific

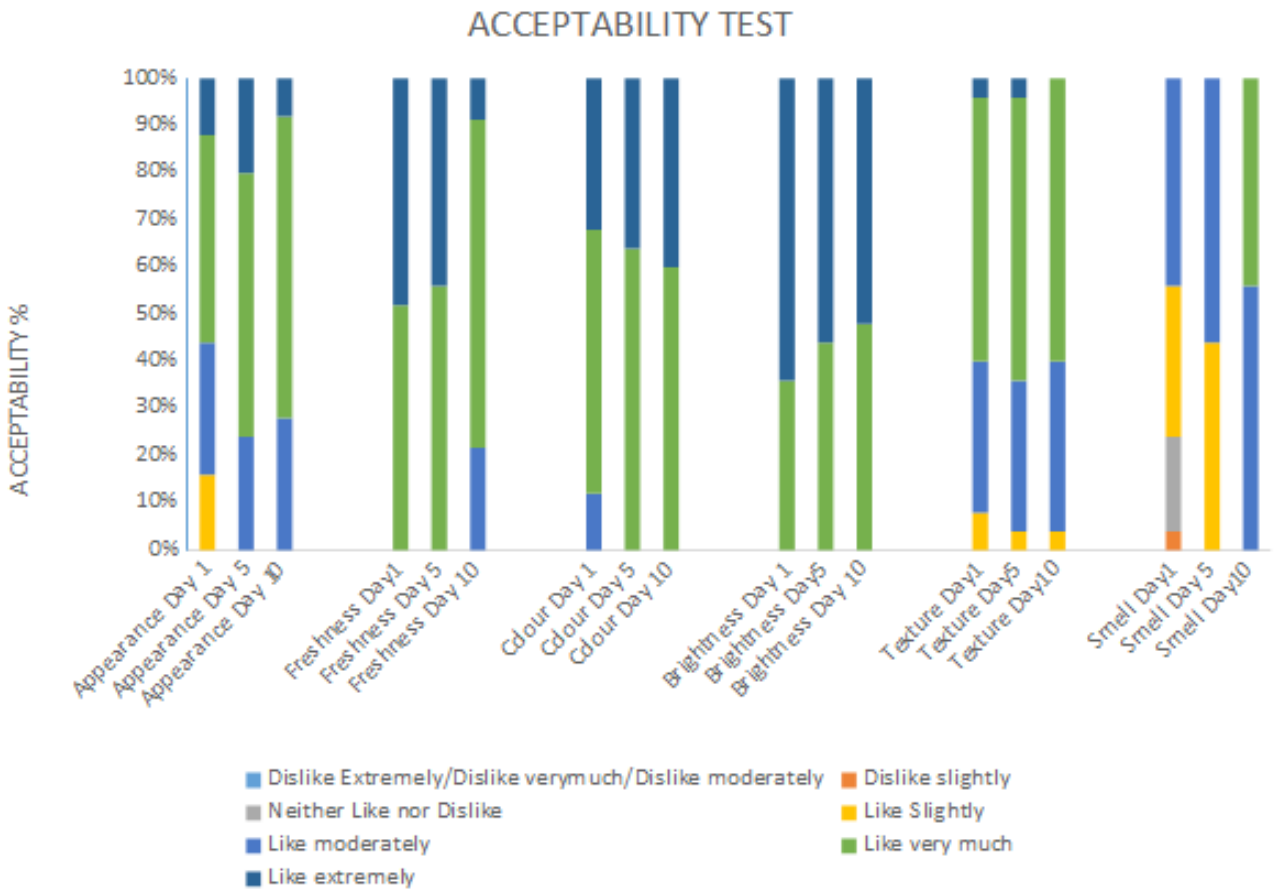

Fig. 3. Acceptability test: Acceptability percentage of attributes

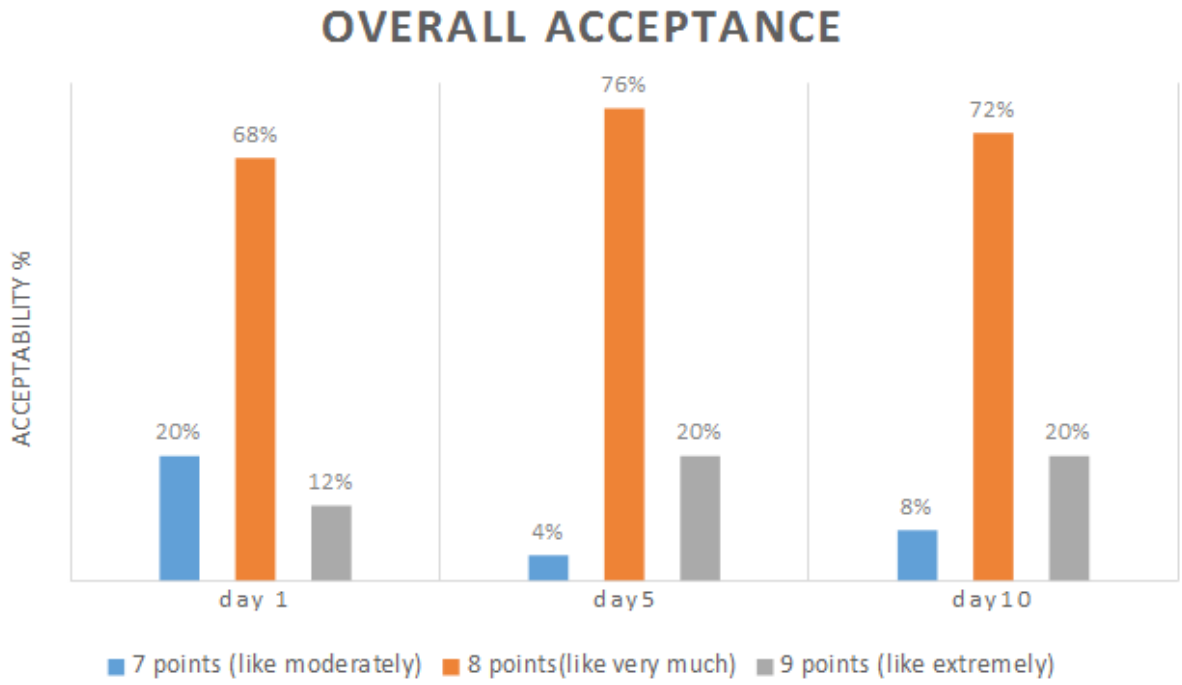

Fig. 4. Acceptability test: Overall acceptance of the MB coated tomatoes

day in which the majority of the samples in the group exhibited the first signs of decay.

4. ***Sensorial analysis***: Sensorial analysis was carried out for MB coated tomatoes. A testing panel consisting of 25 adult persons carried out the sensory analysis. Two kinds of tests were performed:

    1. A preference test
    2. An acceptability test with a nine-point hedonic scale.

In the preference test, the members of testing panel had to choose one preferred sample according to their general preferences. Both uncoated and MB coated tomatoes were subjected to preference test. The test was carried out for three consecutive days after coating. The acceptability test was carried out using semi-structured hedonic scales, scoring one (lowest) to nine (highest). The attributes evaluated were: i) visual appearance, ii) freshness, iii) colour, iv) brightness, v)texture and vi) smell. Overall acceptability was also evaluated through the questionnaire. The average response of the members of testing panel was calculated for each attribute. Samples were considered acceptable if their mean value for overall acceptability was equal to or above five (neither like nor dislike). Acceptability test for MB group was carried out on 1st, 5th and 10th day after coating.

5. ***Statistical analyses*:** The quantitative parameters tested were carried out in triplicate. The values were expressed as mean ± standard deviation (SD). The statistical analysis was performed using SPSS statistical software (version: IBM Statistics 22).

Results

***Thickness of the coated films*:** The films peeled out just after coating were found to have a uniform thickness of about 50 microns in both NB and MB coated tomatoes. Coatings of 50 microns were the expected thickness when using the film suspensions of standardised formulation.

Evaluation of shelf-life quality

1. ***Weight loss:*** Fruits in all the three treatment groups were found to lose weight during the evaluation period. Weight loss was less apparent in the NB and MB coated tomatoes than in the control. The weight loss values of the tomatoes during the study period are shown in the Table 1.
2. ***pH value:*** Values of pH slightly increased during storage period. There was not any significant difference in values observed among NB and MB treatment groups. The pH values of the tomatoes during the study period are shown in Table 2.
3. ***Appearance study:*** The change in appearance was recorded (photographed) separately for uncoated (control), NB and MB coated tomatoes. The coated tomatoes were found to have a longer shelf life compared to uncoated ones. Coated tomatoes were glossy in appearance and had a much more smooth surface compared to uncoated ones. Among the coated ones, MB coated tomatoes appeared better compared to NB coated ones in terms of shelf life.

Control group showed first signs of decay by the 4th day (Fig. 1A). More than 50% showed wrinkles, loose skin and about 24% showed dark spots (bacterial infection). Tomatoes became very soft and on gentle pressing, their shape got altered. The fruits were being attacked by fruit flies. By 5th day, the black spots spread to larger portions. Also, tomatoes present on lower side of the box were found with white patches (fungal mycelium) on sunken regions.

NB coated tomatoes exhibited damages by 8th day (~16% had wrinkled skin while more than 70% of fruits lacked firmness) (Fig. 1B). By 9th day, white patches were seen localised on wrinkled regions. White frothy fluid was noticed to ooze out from the stalk region in few tomatoes.

MB coated tomatoes lasted for longer duration (~10 days). They developed the above-mentioned signs of unacceptability only by the 11th day (Fig. 1C) where about 35% showing the deformities. While the general appearance was fresh, on pressing, the interior appeared fluid-filled. Still the tomatoes returned to their original shape on removing the pressure applied with fingers. Few tomatoes showed white frothy fluid oozing out from the stalk region. The deformation was very fast afterwards. The samples formed a wrinkled mass on the application of gentle pressure on the very next day (12th day) itself. About 50% coated tomatoes especially those present on the lower side of the box stuck together such that the coating was removed at the touch site. Interestingly fruit flies were not seen around either NB or MB coated tomatoes.

4. Sensorial analysis

Analyses of sensory parameters were further carried out through standard preference and acceptability tests. Based on the initial appearance study, MB coated tomatoes showed better results. Hence, only MB coated ones were chosen for subsequent sensorial studies.

a. ***Preference test:*** Uncoated tomatoes were preferred during the initial period of evaluation but later the preference shifted to the coated tomatoes (Fig. 2).

b. ***Acceptability test:*** Percentage of likes and dislikes for each of the following attributes such as visual appearance, colour, brightness, texture, smell for specific time intervals (day1, day5, day10 respectively) is depicted separately (Fig. 3).

It was found that the most liked attributes of coated tomatoes were brightness, appearance, and colour. For both texture and smell, widest choices were opted among judges on 1stday. For majority of attributes, choices opted among members of testing panel narrowed to just two on 5th day. There was a sharp shift to the right side of the hedonic scale with all the members of testing

panel choosing either "like moderately" or "like very much" for the attribute, smell on 10th day. And a slight widening of choices to the left side of the hedonic scale was evident for the attribute freshness, compared to day 5 results with 20% members of testing panel opting "like moderately".

The Fig. 4 shows the overall acceptance scores of the product (*i.e*. MB coated samples). On all the 3 days of study, majority of members of testing panel gave point 8 ("very much like") for the product, *i.e.* 68% on day 1; 76% on day 5 and 72% on day 10.

Discussion

Shelf life is "the recommended maximum time for which products or fresh (harvested) produce can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under expected (or specified) conditions of distribution, storage and display" (12). Evaluation of shelf-life is significant to reduce postharvest storage losses. Therefore, it is necessary to monitor fruit quality in storage to facilitate long distance transportation. Parameters usually monitored during shelf-life evaluation include weight loss, pH changes (10), firmness, colour, brightness, smell, texture, taste and general appearance (11).

In the present study, the coated films were peeled, and their thickness were evaluated to understand uniformity in suspension coating on the tomatoes. The peeled films were found to have an average thickness of 50 µm.

Weight loss values increased during the evaluation period in both experimental groups and in control group. Samples with coating, recorded the lowest percentage of weight loss from a comparative study made on the first and fourth day after coating. This could be attributed to the reduction in open area of the polymeric network in coatings, which restricts the water vapour transport from the inside of the tomato as described by Marrero *et al.* (13). Moreover, the coating formulations could have externally closed the stomatal openings thereby reducing transpirational water loss as suggested by Bisen *et al.* (14).

The acidity of tomato plays a major role and imparts taste to the fruit (15). In the current study, the pH values increased slightly in all the three experiments during the study period. The increase in pH value may be due to break up of acids with respiration during storage as explained by Athmaselvi *et al.* (16). Ochoa-Reyes *et al.* (10) observed a slight decrease in the pH value of green bell pepper coated with polysaccharide-lipid based formulations and explained it as due to the liberation of the large quantity of organic acids during irradiation and vapour treatments as reported earlier by Rico *et al.* (17).

The coated tomatoes had a visually pleasing appearance and suggested better quality. Glossy and smooth surface of the coated tomatoes may be attributed to the smooth and transparent nature of the film forming suspension. A longer shelf life for the coated tomatoes could be due to the closure of the stomatal openings, reduction in transpiration and respiration rate and lesser incidence of microbial activity by the coating formulation as reported previously by many workers (18). Among the coated ones, the increased shelf-life quality offered by MB coated fruits could be attributed to the synergistic antimicrobial action offered by both chitosan (19, 20) and *Hibiscus* mucilage (7). Furthermore, the coatings might have modified the fruit internal atmosphere, with high levels of carbon dioxide and low levels of oxygen, which slows the process of deterioration as opined earlier by Bosquez-Molina *et al.* (22) and Gonzalez-Aguilar *et al.* (23).

Preference test carried out as part of the sensorial analysis revealed that coated tomatoes were preferred during later periods of study. This could be attributed to better moisture retention ability of components in the coating formulations. Since mucilage is a hygroscopic agent, its incorporation into the hydrocolloid formulation can have a beneficial effect with storage time on coated tomatoes, helping to retain moisture on the fruit surface and imparting a fresh appearance later on (11). Acceptability test revealed that the most liked attributes were colour, brightness and appearance. Since majority of judges gave point 8 (*ie*. like very much) on all the three days of survey, the product *i.e.* MB coated tomatoes was considered acceptable.

Conclusion

Hibiscus rosa-sinensis mucilage-based coating maintained the morphological form and physico-chemical quality of the tested tomatoes for a longer duration compared to the control and non-mucilage based coating. Sensorial analyses involving attributes like firmness, freshness, brightness, colour and smell suggested that the members of the testing panel preferred the mucilage blend coated tomatoes during the later stages of the study. Overall, better results were obtained when mucilage based coating suspension was used as less damage was noticed in the fruit morphology in comparison to normal blend of coating suspension thereby prolonging the shelf life of tomatoes. However commercialization of this mucilage composite requires further research.

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Conflict of interest

The authors declared that they have no conflict of interest.

Authors' Contribution

BRN and VRM designed the objectives and plan of work. VRM carried out the work, analyzed the data and wrote the manuscript. BRN helped in data analysis, interpretation and manuscript correction.

References

1. Maqbool M, Ali A, Alderson PG, Zahid N, Siddiqui Y. Effect of a novel edible composite coating based on gum arabic and chitosan on biochemical and physiological responses of banana fruits during cold storage. Journal of agricultural and food chemistry. 2011;59(10):5474-82. https://doi.org/10.1021/jf200623m
2. Rico D, Martin-Diana AB, Barat JM, Barry-Ryan C. Extending and measuring the quality of fresh-cut fruit and vegetables: a review. Trends in Food Science & Technology. 2007 Jul 1;18(7):373-86. https://doi.org/10.1016/j.tifs.2007.03.011
3. Reddy KV, Zehr UB. Novel strategies for overcoming pests and diseases in India. InProceedings of the 4th international crop science congress on new directions for a diverse planet, Brisbane 2004 Sep 26 (Vol. 25, pp. 1-8).
4. Zanetti M, Carniel TK, DalcaCnton F, dos Anjos RS, Riella HG, de Araújo PH, de Oliveira D, Fiori MA. Use of encapsulated natural compounds as antimicrobial additives in food packaging: A brief review. Trends in Food Science & Technology. 2018 Sep 5. https://doi.org/10.1016/j.tifs.2018.09.003
5. Dhall RK. Advances in edible coatings for fresh fruits and vegetables: a review. Critical reviews in food science and nutrition. 2013 Jan 1;53(5):435-50. https://doi.org/10.1080/10408398.2010.541568
6. Yousuf B, Qadri OS, Srivastava AK. Recent developments in shelf-life extension of fresh-cut fruits and vegetables by application of different edible coatings: A review. LWT-food science and technology. 2017 Oct 24.
7. Vignesh RM, Nair BR. Extraction and Characterisation of mucilage from the leaves of *Hibiscus rosa-sinensis* Linn.(Malvaceae). International Journal of Pharmaceutical Sciences and Research 2018 Apr;6(2): 542-555.
8. Singh B.M.K. Banerjee, K.P.Singh, P.K.Pandey, P.Sudhakar,M.Rai, (2004). AICRP on Vegetables in India:Evolution and Achievements, Impact of Vegetable Research in India; National Centre for Agricultural Economics and Policy Research, ICAR New Dellhi, pp.65-79.
9. Vignesh R.M. Bindu R. Nair. Development and Characterisation of edible films based on the mucilage of *Hibiscus rosa-sinensis* Linn. International Journal of Creative Research Thought. 2018 Jul 1;9(7):2883-90.
10. Ochoa-Reyes E, Martínez-Vazquez G, Saucedo-Pompa S, Montañez J, Rojas-Molina R, de Leon-Zapata MA, Rodríguez-Herrera R, Aguilar CN. Improvement of shelf life quality of green bell peppers using edible coating formulations. The Journal of Microbiology, Biotechnology and Food Sciences. 2013 Jun 1;2(6):2448.
11. Del-Valle V, Hernández-Muñoz P, Guarda A, Galotto MJ. Development of a cactus-mucilage edible coating (Opuntiaficusindica) and its application to extend strawberry (*Fragaria ananassa*) shelf-life. Food Chemistry. 2005 Aug 1;91(4):751-6. https://doi.org/10.1016/j.foodchem.2004.07.002
12. Omenetto F, Kaplan D, Marelli B, Brenckle M, inventors; Tufts University, assignee. Biopolymer-based preservation of perishable products. United States patent application US 15/121,799. 2015 Mar 6.
13. Marrero A, González M, Báez O, Lobo MG. Control of artificial ripening of bananas through atmosphere modification and refrigeration. InVIII International Controlled Atmosphere Research Conference 600 2001 Jul 8 (pp. 393-399).
14. Bisen A, Pandey SK, Patel N. Effect of skin coatings on prolonging shelf life of kagzi lime fruits (*Citrus aurantifolia* Swingle). Journal of food science and technology. 2012 Dec 1;49(6):753-9. https://doi.org/10.1007/s13197-010-0214-y
15. James JB, Ngarmsak T, Rolle RS. Processing of fresh-cut tropical fruits and vegetables: A technical guide. RAP Publication (FAO) eng no. 2010/16. 2010.
16. Athmaselvi KA, Sumitha P, Revathy B. Development of *Aloe vera* based edible coating for tomato. International Agrophysics. 2013 Dec 1;27(4):369-75. https://doi.org/10.2478/intag-2013-0006
17. Rico CW, Kim GR, Ahn JJ, Kim HK, Furuta M, Kwon JH. The comparative effect of steaming and irradiation on the physicochemical and microbiological properties of dried red pepper (*Capsicum annum* L.). Food Chemistry. 2010 Apr 1;119(3):1012-6. https://doi.org/10.1016/j.foodchem.2009.08.005
18. Das R, Medhi G. Physio-chemical changes of pineapple fruits under certain postharvest treatments. South Indian Horticulture. 1996;44:5-7.
19. Roller S, Covill N. The antifungal properties of chitosan in laboratory media and apple juice. International Journal of Food Microbiology. 1999 Mar 1;47(1-2):67-77. https://doi.org/10.1016/S0168-1605(99)00006-9
20. Tsai GJ, Su WH. Antibacterial activity of shrimp chitosan against Escherichia coli. Journal of food protection. 1999 Mar;62(3):239-43. https://doi.org/10.4315/0362-028X-62.3.239
21. Vignesh RM and Bindu R Nair. A study on the antioxidant and antibacterial potential of the mucilage isolated from *Hibiscus rosa-sinensis* Linn. (Malvaceae). Journal of Pharmacognosy and Phytochemistry 2018; 7(2): 1633-1637
22. Bosquez-Molina E, Guerrero-Legarreta I, Vernon-Carter EJ. Moisture barrier properties and morphology of mesquite gum–candelilla wax based edible emulsion coatings. Food Research International. 2003 Jan 1;36(9-10):885-93. https://doi.org/10.1016/S0963-9969(03)00097-8
23. González-Aguilar GA, Ruiz-Cruz S, Soto-Valdez H, Vázquez-Ortiz F, Pacheco-Aguilar R, Wang CY. Biochemical changes of fresh-cut pineapple slices treated with antibrowning agents. International journal of food science & technology. 2005 Apr;40(4):377-83. https://doi.org/10.1111/j.1365-2621.2004.00940.x