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Effect of Chitosan Coating on the Physicochemical Characteristics of Brinjal Quality during Storage

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Authors' contributions

This work was carried out in collaboration between all authors. Author GV designed the study and wrote the protocol. Author ASR managed the literature searches and author LD managed the analyses of the study. Author SMZ performed the laboratory experiments. All authors read and approved the final manuscript.

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ABSTRACT

Chitosan-based coating was preferred in recent years owing to its non-toxic, biodegradable, and biocompatible properties. The main purpose of Chitosan coating is to maintain the quality and to extend shelf-life of fresh fruits. This will also prevent the microbial spoilage. Chitosan has been proven one of the best biomaterial to be edible and biologically safe as it is a polysaccharide. Chitosan coating offers a defensive barrier against bacterial contamination and loss of moisture from the surface of food products, thus extending their shelf life.
The objective of the study was to evaluate the effectiveness of the different Chitosan containing

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solutions in Brinjal to improve the shelf-life. This was evaluated by determining the ripening stages like weight loss, firmness, pH, total sugars, reducing sugars and non- reducing sugars. The results have proved that the addition of Lactic acid at 1% (w/v based on chitosan) and Tween 80 at 0.1% (v/v) in chitosan solution improved coating properties delaying the ripening stages with lowest weight loss (8.8%), lowest firmness (49%), with no change in pH (4.6-4.7), high total sugars (91%), high reducing sugars(50%) and low non-reducing sugars (45%) in brinjal.

Keywords: Chitosan; food; fruits; lactic acid; shelf life; brinjal; vegetable.

1. INTRODUCTION

Chitosan is not native to animal sources and is generally obtained by the deacetylation of chitin (extracted from exoskeleton of prawns) using sodium hydroxide. Most chitosan is manufactured from shellfish because a large amount of shellfish exoskeleton is available as a by-product of food processing. Plant sources of chitin include algae, commonly known as marine diatoms, protozoa and the cell wall of several fungal species [1].

Chitosan, is a natural, non-toxic, biodegradable, high molecular weight polycationic polymer. It has been described as "nature's most versatile biomaterial". Chitosan is composed primarily of glucosamine, or 2- amino-2-deoxy-D-glucose linked together by β (1-4) glycosidic bonds [2]. The physical & chemical characteristics of Chitin and Chitosan influence their functional properties such as solubility, chemical reactivity and biological activities [3] like biodegradability [4,5], which differs depending on the crustacean species and preparation methods [6].

Edible coatings are traditionally used to improve food conservation and appearance due to their environmentally friendly nature. They are obtained from both animal and vegetable or plant agricultural products. The type and concentration of edible components have important effects on the quality characteristics of coated fruits such as weight loss, pH, firmness, colour, reducing sugars, total sugars and Non reducing sugars.

The application of Chitosan coating (with optimum concentration 20 g/kg) could be beneficial and considered for commercial application in extending the shelf-life and maintaining quality and to some extent controlling decay of mushroom. In using Chitosan for decay control, consider that it may be suitable in the treatment of mushroom stored for shorter periods (e.g. 3 days) or for short-distance transport and distribution. However, for longer storage and marketing, chitosan coating to control discolouration and decay in mushroom could be better [7].

The Post-harvest treatment of Allahabad Safeda guava fruits with 1% Chitosan coating delayed the ripening process. This prolonged the storage life up to 7 days at ambient conditions (28-32℃ and 32 - 41% RH) [8]. Chitosan coating could prolong fresh-cut Fa-lun mangoes during storage at 6℃ for 7 days. Chitosan could reduce weight loss, maintain total soluble solids and retard the growth of microorganisms in fresh-cut Fa-lun mangoes [9].

The effect of different chitosan based edible coatings on the postharvest parameters of fresh-cut melon fruits were investigated. It was demonstrated that low molecular weight chitosan coatings improve all the investigated parameters [10]. The major factors responsible for extending the shelf life of fruits and vegetables include: careful harvesting so as not to injure the product, harvesting at optimal horticultural maturity for intended use, and good sanitation [11].

2. MATERIALS AND METHODS

2.1 Preparation of Chitosan

The process was carried out by adding 50% sodium hydroxide to the obtained chitin sample on a hot plate and boiling it for 2 hrs at 100℃. The sample was then allowed to cool at room temperature for 30 minutes. Then they were washed continuously with 50% sodium hydroxide. The sample obtained is filtered and oven-dried for 6 hrs at 110℃ to obtain Chitosan [12].

2.2 Brinjals

Brinjal production is about 3000 tonnes on an average in a year in India [13]. The result of post-harvest losses in vegetables on the bhabhar farms, reveal that maximum loss was in brinjal (11.00%). One of the most important causes of postharvest losses is harvest at inappropriate maturity, resulting in erratic ripening and poor quality. Therefore, there is an urgent need of training the vegetable growers on scientific post-harvest techniques, if the vegetable production is to be sustained on a profitable basis in the region [14].

Long life brinjals of nearly 80 numbers was procured from a local market. Brinjals were selected based on uniformity of size, ripening stage, absence of physical damage and fungal infection.

2.3 Edible Coating Formulations

A Chitosan aqueous solution (1.5%, w/v) was prepared dissolving Chitosan powder in a solution of lactic acid (1%, v/v) and acetic acid (1% v/v) at 40℃, since Chitosan is only soluble in an acidic medium. Then Tween 80 at 0.1% (v/v) was added for improving wettability for 24 h. After wards chitosan solution was added into pretreated Lactic acid solutions. The resulting mixture was stirred vigorously with heating using a magnetic stirrer during 60 min until Chitosan was dissolved. After the Chitosan was dissolved the solutions were filtered to remove foam and any un-dissolved impurity.

2.4 Coating Applications

80 Brinjals were randomly distributed into four groups. Three groups were assigned to one of three treatments whilst the fourth group provided the untreated control. Coatings were applied by double immersion of fruits in the film-forming solutions for 5 min, depending on treatments: (i) Chitosan at 1.5% (w/v) in lactic acid 1% (v/v); (ii) Chitosan at 1.5% (w/v) in lactic acid 1% (v/v) and Tween 80 at 0.1% (w/v); and (iii) Chitosan at 1.5% (w/v) in acetic acid brinjals were allowed to dry by natural air for 1 h at 25ºC and were subsequently stored for future use.

2.5 Physical Parameters-quality Attributes

2.5.1 Classification according to ripening stages

The brinjals were classified according to their ripening stage using a visual scale [15]. These changes during ripening period (loss of greenness and increase in yellowness) may occur as breakdown of the chlorophyll in the peel tissue. Maximum polyphenol oxidase activity was observed at maturity stage four days which was gradually decreased as ripening progressed. The results were expressed as the predominant ripening stage in each treatment.

2.5.2 Weight loss

The selected 80 brinjals, corresponding to each treatment, were weighed at the beginning, just after coating and air-drying, and thereafter each sampling days during the storage. Weight loss was expressed as the percentage loss of the initial total weight and of every day weight.

2.5.3 Firmness /texture analysis

The firmness of a brinjal is linked to the state of maturity and ripeness and may be influenced by the variety as well as the region of production and the growing conditions. The Penetrometer instrument used consists of a cone, set in position so that the rake of the dial touches the upper end of the stick. The dial gauge is set on "0" postion by a small knob. Now arm with dial and cone set is lowering till the tip of cone touch the surface of brinjal the bottom of arm is pressed for 5 seconds and the cone can down in to the brinjal. Four replicates in individual brinjal were done for each treatment. Each brinjal was measured in the central point and both sides' points. Firmness was measured as the maximum penetration distance reached during penetration time.

2.6 Chemical Parameters

2.6.1 pH

After firmness analysis, brinjals were cut into small pieces and homogenized in a grinder, and 10 g of ground brinjal was suspended in 100 mL of distilled water and then filtered. The pH samples were assessed using a pH meter (SYSTRONICS).

2.6.2 Titratable acidity (TA)

After firmness analysis, brinjals were cut into small pieces and homogenized in a grinder, and 10 g of ground brinjal was suspended in 100 mL of distilled water and then filtered. The titrable acidity of the samples was titrated using 0.1 N

NaOH. Titrable acidity was expressed as grams of citric acid per 100 g of brinjal weight.

2.6.3 Extraction and determination of total sugar and reducing and non reducing sugar from brinjal pulp

Extraction of sugar from brinjal pulp [16]. Four brinjals pulps were cut into small pieces and immediately plunged into boiling ethyl alcohol and were allowed to boil for 5 to 10 minutes (10 to 20 ml of alcohol was used per gm of pulp). The extract was filtered through the two layers of cheese cloth and the ground tissue was re-extracted for 3 minutes in hot 80% alcohol, using 2 to 3 ml of alcohol per gm of tissue. The second extraction was ensured complete removal of alcohol suitable substances. The extract was cooled and passed through the two layers of cheese cloth. Both extracts were filtered through Whatman No.41 filter paper.

The volume of the extract was evaporated to about 25% of the volume over steam bath and cooled. This reduced volume of the extract was transferred to a 100 ml volumetric flask and it was made up to the mark with distilled water. Total sugar content of brinjal pulp was determined by phenol sulphuric acid method. Reducing sugar content of brinjal pulp was determined by dinitrosalicylic acid method [17] and non reducing sugar was calculated by subtracting reducing sugar from the total sugar.

3. RESULTS AND DISCUSSION

Classification according to ripening stages:

The following figures show the changes in ripening stages of uncoated (Control) and coated brinjals.

The highest weight loss was observed in control fruit (12%).The lowest weight loss was observed in coated fruits the Chitosan and Tween 80 and Lactic acid coated fruit (8.8%). Whereas [18] reported that it was 8.98% with 2% Chitosan concentration in strawberry fruit.

There is no particular changes or differences in coated fruits Chitosan and Lactic acid (12%), Chitosan and Acetic acid (12%) (Fig. 2).

The highest firmness loss was observed in control brinjal (60%).The lowest firmness loss was observed in coated brinjals with Chitosan, Tween 80 and Lactic acid coated fruits (49%). The useful effect of the increased chitosan concentration on firmness has also been reported in tomato [19], peach, Japanese pear, kiwifruit [20] and 'Murcott' tangor [21].

The percentages obatined for coated brinjals Chitosan and Lactic acid (51%), Chitosan and Acetic acid (51%) have not shoemmuch differences.

The lowest pH was observed in uncoated brinjal (4.1). There are no changes observed in coated brinjals with Chitosan, Lactic acid and Tween 80 (4.7), Chitosan and Lactic acid (4.6), Chitosan and Acetic acid (4.6) (Fig. 4).

The highest Titratable Acidity was observed in coated brinjal of Chitosan, Tween 80 and lactic acid (24%). Whereas [18] reported that it was 25.92% with 2% Chitosan concentration in strawberry fruit.

(A) Uncoated brinjals (Control)

(B) Coated brinjals with solution (i)

(C) Coated brinjals with solution (ii)

(D) Coated brinjal with solution (iii)

Fig. 1(A). Effect of Chitosan coating on ripening stages of brinjal during storage (Represent on day 1)

(A) Uncoated brinjals (Control)

(B) Coated brinjals with solution (i)

(C) Coated brinjals with solution (ii)

(D) Coated brinjals with solution (iii)

Fig. 1(B). Effect of Chitosan coating on ripening stages of brinjal during storage (Represent after Day 20)

The percentage difference in coated brinjals Chitosan and Lactic acid (17%), Chitosan and Acetic acid (17%) have not changed much. The lowest titratable acidity was observed in uncoated brinjal (15%) (Fig. 5).

The highest Total Sugar content was observed in coated brinjal with Chitosan, Tween 80 and lactic acid (91%). There is no particular difference in percentages obtained for coated brinjals with Chitosan and Lactic acid (85%), Chitosan and Acetic acid (80%). The lowest total sugar content was observed in uncoated brinjal (72%) (Fig. 6). [22] reported that on 12 days, the total sugar level of control fruit was 32.3% of soluble solids, whereas total sugar level of coated fruit ranged between 19.3 and 23.7% in sugar-apples.

The increase in reducing sugar as the ripening stage progress besides storage time, was due to the degradation of starches to glucose and fructose by the activities of amylase and maltase enzymes. The highest reducing sugar content was observed in coated fruit of Chitosan, Tween 80 and lactic acid (50%). The percentage of difference in coated brinjals with Chitosan and Lactic acid (46%), Chitosan and Acetic acid (38%) have not changed. Chitosan was found to be more effective at delaying of reducing sugar contents. The lowest reducing sugar content was observed in uncoated brinjal (30%) (Fig. 7). The gradual increase in reducing sugars in coated mango fruits as compared to control treatment might be due to its slow ripening process as reported in [23]. Maximum amount of reducing sugars in untreated control fruits might be due to rapid conversion of starch to sugars as a result of moisture loss and decrease in acidity by physiological changes during storage as stated by [24].

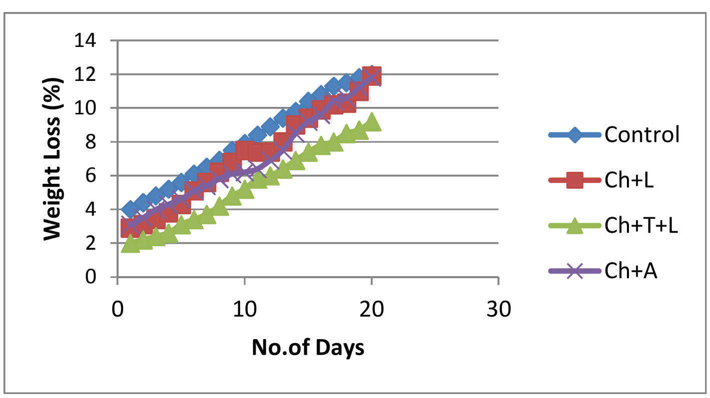

Fig. 2. Effect of Chitosan coating on weight loss of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

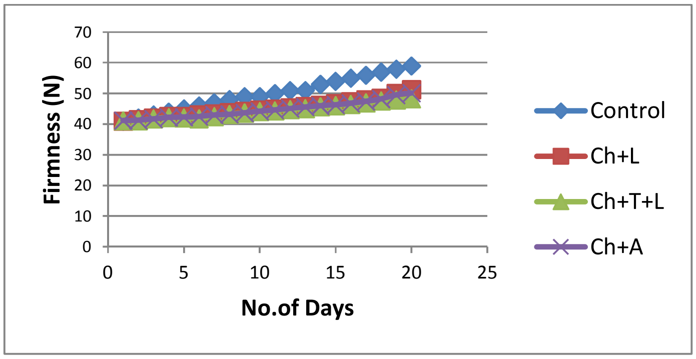

Fig. 3. Effect of Chitosan coating on firmness of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

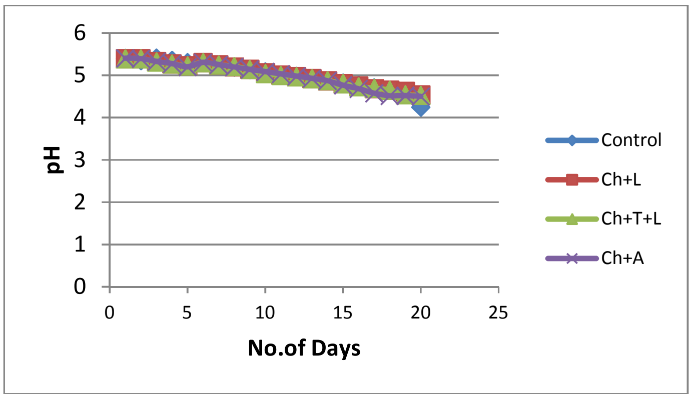

Fig. 4. Effect of Chitosan coating on pH of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

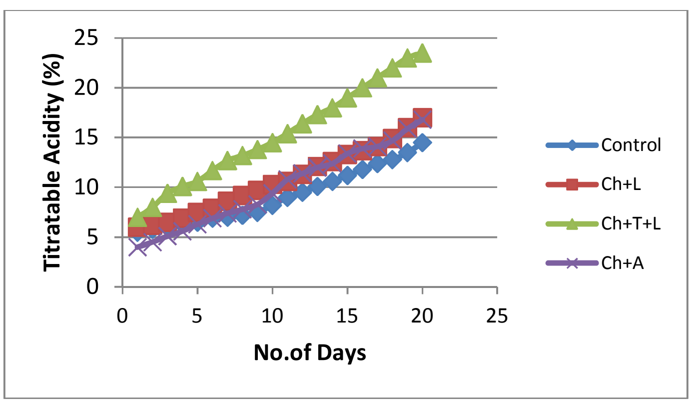

Fig. 5. Effect of Chitosan coating on Titratable Acidity of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

Chitosan coated brinjal were observed to have non-reducing sugar content gradually increased both in uncoated and coated ones during storage. The maximum non-reducing sugar contents were found in uncoated brinjal (control) (50%). The lowest non-reducing sugar content was observed in Chitosan, Tween 80 and lactic acid (45%). There are no changes in coated brinjals with Chitosan and Lactic acid (46%), Chitosan and Acetic acid (48%) combinations (Fig. 8). Similar trend of increase in total sugar content during storage at ambient temperature and slight decrease during low temperature was observed by [25].

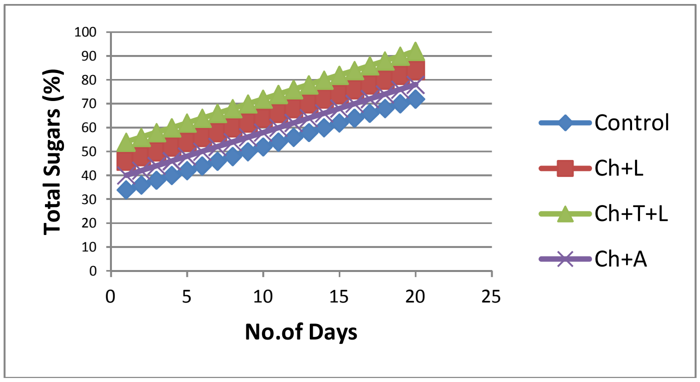

Fig. 6. Effect of Chitosan coating on Total Sugars of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

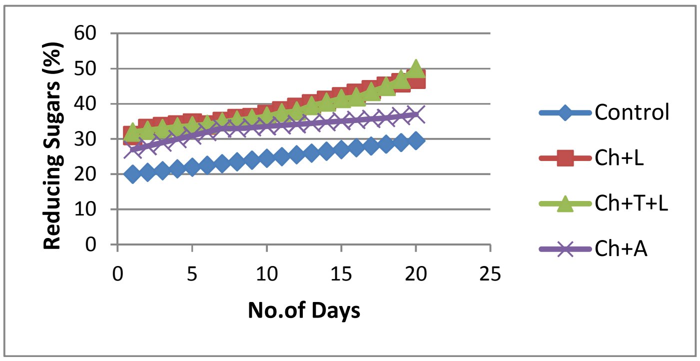

Fig. 7. Effect of Chitosan coating on Reducing Sugar of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

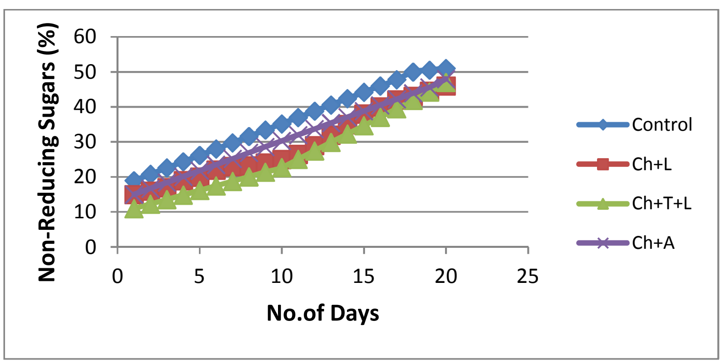

Fig. 8. Effect of Chitosan coating on Non-Reducing Sugar of brinjal during storage
(Ch+L = Chitosan +Lactic Acid, Ch+T+L = Chitosan+Tween 80+Lactic Acid, Ch+A = Chitosan+Acetic Acid)

4. CONCLUSION

The application of chitosan with different physical and chemical parameters were determined. Chitosan coating on brinjal have shown results that the weight loss and Firmness is low in coated brinjal, showing the fruit is stable and eatable. The pH decreased in uncoated brinjal compared to the coated ones. Total sugars levels gradually increased in both coated and uncoated brinjals. Reducing sugar levels increased only in coated brinjals Whereas Non reducing sugar levels increased in uncoated brinjal. Better results were found in brinjals coated with solution of chitosan at 1.5% (w/v) in lactic acid 1% (v/v) and Tween 80 at 0.1%. Our results demonstrate that this is a valuable product for the commercial production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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