IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 14, Issue 2Ser. II (February. 2020), PP 51-58
www.iosrjournals.org

Effect of Edible Coating on Functional Properties and Nutritional Compounds Retention of Air Dried Green Banana (*Musa Sapientum L.*)

Mahabub Alam[1], Mohammad Afzal Hossain[1]and Animesh Sarkar[1]*
[1]*Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh*
**Corresponding author: Animesh Sarkar, Ph.D*
Email: animeshsarkarbau@gmail.com/animesh-fet@sust.edu

Abstract: *Bangladesh produces a huge amount of Banana (Musa sapientum L.) every year but the postharvest loss of these produces is almost 25-40% due to lack of proper storage methods. The aim of the study was to make an effort to preserve the green banana by using an edible coating of starch, chitosan and mixture of starch and chitosan and studying the quality parameters during storing and air dried green banana slices. The coating of starch, chitosan and mixture of starch and chitosan with same concentration (1%) were applied to evaluate its effects on retention of nutritional compounds in air dried banana at various drying temperature 50˚C, 60˚C & 70˚ C. The pH value, total soluble solids (TSS), titrable acidity, total antioxidant scavenging activity, concentration of ascorbic acid, total phenolic content of air dried bananas were determined. The results demonstrated that, mixture of starch and chitosan coating retained a significant amount of bioactive compounds and lower drying temperature showed the lower percentage losses in all cases of coating. Ascorbic acid retention of 70.93% was found in mixture of starch and chitosan coating at 50˚C drying temperature. In this similar condition, higher total phenolic content (10.52 ± 0.34 [a] mg GAE/100g) and DPPH scavenging activity (45.48 ± 1.13 [a]) was obtained which indicated the success of mixtures of coating over single coating. The coating of starch and chitosan on bananas delayed the ripening and extended the shelf life and edibility up to 15 days.*

Background: *In case of fruits and vegetables, the post-harvest losses are a highly considerable fact especially for those countries whose economy largely depends on agriculture. Bangladesh is an agricultural country which grows an excessive amount of fruits and vegetables each year. Banana is a climacteric fruit, ripens very fast after reaping and that's why it has short shelf-life, making its marketing more troublesome. Chemical preservatives have an adverse effect on environment as well as human health. On the other hand, Bio preservatives are eco-friendly and having no adverse effect on health can be used to prolong the post-harvest shelf life of Banana. This study will allow producers to use these technologies for long term preservation of green banana fruit because of their ingenuousness, cheap and has no deleterious effect on human body rather expanding the total economic value without refrigeration. Drying is a well-known and noble technique of preservation but a considerable amount of nutrients is lost during the drying process. In addition of prolonging shelf life, the coating also significantly prevents the loss of ascorbic acid, antioxidant, phenolic content and several nutrients during drying.*

Method: *pH and TSS of the samples were calculated by the method of AOAC. Titrable acidity, Antioxidant activity, Ascorbic acid and total Phenolic content were determined by the method of Athmaselvi et al. 2013, Wang et al. 2007, Ranganna et al. 2001 and Amorim et al. 2008 respectively.*

Results: *TA content was found to be much higher in control fruits than the coated produce which was 0.36 ± 0.05 [a], 0.32 ± 0.06 [bc], 0.31 ± 0.10 [c]and 0.29 ± 0.07 [d] respectively for control, 1 % starch, 1 % chitosan, 1 % starch and chitosan solution at 50 ˚C. The percentage of DPPH inhibition (45.48 ± 1.13 [a]), vitamin C retention (70.93%) and Phenolic content (10.52 ± 0.34 [a]) are also significantly higher in case of 1% Starch and Chitosan coated banana at 50˚C.*

Conclusion: *This research proves the effectiveness of edible coating as a bio-preservation method and recommends the mixture of starch and chitosan solution as an effective bio-preservative and an excellent substitute to chemical preservative. Having no adverse effect on fruit, environment and consumer health, the mixture of starch and chitosan coating can easily and safely be applied to banana fruit.*

Keywords: *Banana, post-harvest loss, starch coating, chitosan coating, Biopreservatives, hot air drying, shelf-life extension.*

Date of Submission: 03-02-2020 Date of Acceptance: 18-02-2020

I. Introduction

Bangladesh is an agrarian nation that grows a copious amount of leafy foods consistently and about 19.29% of GDP comes from agriculture in the year 2011-12 [1]. Banana is an organic climacteric product [2], matures quickly after harvest and that's why it has ephemeral time span of usability, making its marketing progressively troublesome. Banana contains a significant quantity of fiber, potassium, sodium, phosphorus, magnesium, iron and vitamin A, B1, B2 and C [3]. Bangladesh produced 807,104 metric tons of banana in 120,203 acres of farmable land during 2016-17 [1]. About 35%-40% post-harvest loss of banana was filed from harvesting to utilization in Bangladesh [4] and added up to a monetary loss of 299.15 crore taka in 2016-17 [4]. Also, there is no standard technique for the growers and sellers of banana in Bangladesh to expand the time span of usability of banana and the low temperature storage of banana is not plausible as it is delicate to low temperature preservation [5].

Edible coatings have for some time been used to safeguard quality and increase the timeframe of usability of some fruits and vegetables, for example, citric fruits, cucumbers and apples [6]. Organic fruits or vegetables are commonly covered by immersing in, brushing or showering with a scope of edible materials, all together that a semi penetrable layer is generated superficially for stifling respiration, preventing loss of moisture and giving other functions [7]. Considerably more than thermoplastic materials, edible films may have the capability for fuse of further utilitarian elements, for example, antimicrobials, cancer prevention agents, flavors, and supplements [8]. Chitosan is a high atomic weight and a direct polymer that is regularly acquired by the alkaline digitization of chitin extricate from rich source of shrimp's exoskeletons [9]. This perishable cationic sugar has antimicrobial activity and magnificent film-shaping capacity and makes it exactly proper for the formulation of edible coating that has confirmed to be powerful at expanding the time span of usability of products [10]. Chitosan-based covering is compelling in extending the timeframe of realistic usability and improving nature of organic products by managing maturing, lessening respiration rate [11] diminishing desiccation [12] controlling gas exchange, diminishing transpiration losses, adjusting the inside environment, keeping up the standard of harvested natural products containing organic products fairness, solidness, weight, titrable acidity, soluble sugars and Vitamin C and decreasing mold development [13]. In addition, the reducing sugar content and total dissolvable solids of coated natural product were below uncoated, recommending that the past integrated reducing sugars at a slower rate, having slowed down the metabolism [14].

The utilization of mixture of starch and chitosan coating for keeping up quality and broadening shelf life of fresh banana has not yet been accounted for in Bangladesh till now so far we know. Therefore, this present investigation was carried out to evaluate the effect of coating and drying condition on physicochemical and antioxidant properties of banana slice and powder as well as investigate the shelf life of the treated and control samples.

II. Material and Methods

Collection of Sample: Freshly harvested bananas (*Musa sapientum L.*) were collected from local banana wholesale market Bondor Bazar, Sylhet. Visual blemished, diseased, damaged bananas were removed to minimize biological variability. For each treatment, 5 samples of bananas were used.

Instruments and apparatus: Hand refractometer, pH meter, electrical balance machine, refrigerator, electrical blender machine, hot plate, spectrophotometer etc. were used to analyze the functional properties of samples. Various apparatus and glassware like biuret, pipette, volumetric flask, conical flask, beaker, test tube etc. were also used.

Preparation of starch solution: To prepare 1% starch solution 1 g Starch was mixed with 100 mL distilled water.The solution was heated with continuous stirring until gel formation (at 70˚C) is obtained in the solution.Starch solution was then cooled at room temperature.

Preparation of chitosan solution: To prepare 1% starch solution 10 g Starch was mixed with 500 mL distilled water and 500 mL of 1% Acetic acid was added to dissolve the powder. The solution was heated with continuous stirring for 10 hours at 70˚C to dissolve the chitosan powder completely and then cooled at room temperature.

Sample preparation for shelf life evaluation test: To evaluate the shelf life changes after coating bananas of uniform size with no physical damage was selected.The samples were then treated with 1% Starch, 1% Chitosan and 1% Starch + 1% chitosan solution in different containers and 3 bananas were untreated for comparing their characteristics with the coated samples. After that bananas were kept in room temperature for 20 minutes for surface drying and coating formation and stored in tray by wrapping with newspaper. They were kept to continuous observation for almost two weeks storage period at room temperature.

Edible coating and drying of green banana slices: Green bananas without any physical damage were selected for coating and drying. After washing bananas were peeled and cut transversely into thin slices. For checking enzymatic browning banana slices were immersed in ascorbic acid (Conc. 1%) for 1 minute. 1% Starch, 1% Chitosan and 1% Starch + 1% chitosan solution were used for coating. Samples without coating were also made to compare their characteristics with coated ones. Those were let to dry in room temperature for 15 minutes for successful coating of the samples. Drying was done in air dryer (OF-21E, Korea). 1% starch, 1% chitosan and 1% starch + 1% chitosan coated bananas were dried for 8 hours at 50 ˚C, 60 ˚C and 70 ˚C respectively to obtain 12 treatments.

Physicochemical evaluation of prepared samples

Determination of pH: The pH of the samples was estimated by the method of AOAC depicted by Horwitz [15] by using a pH meter (H1 98106, HANNA) at room temperature (28±2˚C). The decision of the pH was made by setting up a buffer at pH 7.0 and the temperature was set to 28°C.

Determination of total soluble solid (TSS): TSS of sample juice was determined by the method of AOAC suggested by Horwitz [15] using a hand refractometer and the data were recorded as degree Brix.

Determination of percentage of total acidity: Titrable acidity was determined by the suggested method of Athmaselvi, Sumitha [16]. Whole samples were passed through an electric juicer (Nova Osaka Japan, NJ-506). Filtered 10 mL juice was taken in a beaker and 25 mL of distilled water was added. After that it was titrated with 0.1M NaOH, using 2 drops of phenolphthalein as an indicator.

$$\text{The weight of citric acid} = \frac{0.1\ M\ NaOH\ X\ Vol.of\ NaOH\ \ (in\ liter\ )\ X\ 192.43*}{3}$$

$$\%\ \text{of total acidity} = \frac{wt.of\ acid}{wt.of\ sample}\ \text{X}\ 100$$

Determination of antioxidant activity assay: The antioxidant activity of each sample was measured by DPPH scavenging activity and the stable DPPH radical-scavenging activity was estimated using the modified method suggested by Wang, Yuan [17]. Accordingly, 2 mL of 0.2 mg methanol DPPH solutions was mixed to 2 mL of extract solution at various concentrations and the substances were agitated thoroughly for 15 seconds. Then the solutions were allowed to stand at a dark place at room temperature for 10 min for reaction to occur. After 10 min. absorbance was taken using a Double beam Thermo Scientific UV-Vis spectrophotometer against a blank at 517 nm. DPPH radical-scavenging activity (%) of each sample extract was determined by using the following formulae:

$$\text{DPPH radical-scavenging activity (\%I)} = \frac{A_{\circ}-A}{A_{\circ}} \times 100$$

Determination of ascorbic acid: Ascorbic acid was determined by the following method of Rangana [18]. 5 mL of sample juice was taken and mixed with 3% HPO_3 and made up the volume to 50 mL with 3% HPO_3 and filtered. Now 10 mL of the aliquot was taken in a 100 mL conical flask. This was titrated with standard dye to a light pink color (endpoint), which persisted for 15 seconds. The equation used for the estimation of vitamin C were:

$$\text{Vitamin-C (mg/100 g)} = \frac{(T \times D \times V1)}{W \times V2} \times 100$$

Determination of total phenolic content: The total phenolic content was determined using the Folin-ciocalteu Phenol reagent as reported by Silva, Sobrinho [19] with slight modification. Briefly, 0.5 mL of the sample extract was added with 8.5 mL of distilled water and added 0.5 mL of folin-ciocalteu Phenol reagent and kept at ambient temperature for 5 minutes and after that 1 mL of 35% sodium carbonate solution was mixed. The mixture was shaken well, kept at room temperature for 20 minutes and absorbance was taken at 765 nm. We prepared the blank with water instead of the sample. A set of standard solutions of Gallic acid was read against a blank. The results of phenolic content were expressed in terms of Gallic acid in mg/g of dry extract.

Determination of weight loss: The physiological loss of mass was calculated according to the procedure described by Valverde, Valero [20]. Weight loss was determined considering the fresh weight at harvest using a balance with an accuracy of 0.0001 g. Weight loss was then determined from the weight of each sample measured before storages and after 0, 05, 10, 15 days.

$$\%\ \text{Weight loss} = \frac{Initial\ \ weig\,ht - Final\ \ weig\,ht}{Initial\ \ weig\,ht} \times 100\%$$

Statistical analysis

All of the data were analyzed using SPSS software (SPSS Inc., Chicago, IL, USA), version 25 for Windows. We also used One-way analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT) (multiple comparison post-hoc test) to test the statistical difference. Differences with p-values among the samples < 0.05 were considered statistically significant.

III. Results

3.1 pH value

Among twelve treatments pH was maximum in control at 50 ˚C (5.47 ± 0.09 ^{a}) and minimum in 1% starch + 1% chitosan coated banana at 70˚C (5.03 ± 0.10 ^{a}) (Table 01).

3.2 Total soluble solids

The initial value of TSS for banana was 5.44. The lowest TSS value was found 1.8 ± 0.05 ^{b} in case of 1% starch + 1% chitosan coating at 70˚C and highest was 3.2 ± 0.07 ^{a} in case of control at 50 ˚C (Table 01).

3.3 Titrable acidity (TA)

TA content was found to be much higher in control fruits than the coated produce which was 0.36 ± 0.05 ^{a} and 0.32 ± 0.06 ^{bc}, 0.31 ± 0.10 ^{c}, 0.29 ± 0.07 ^{d} respectively for control, 1 % starch, 1 % chitosan, 1 % starch + 1 % chitosan at 50 ˚C (Table 01).

Table 01: Physicochemical properties of air dried green banana slices. T1, T5, T9=Uncoated banana slices (control); T2, T6, T10=1% starch coated banana slices; T3, T7, T11=1% chitosan coated banana slices; T4, T8, T12=1% starch+1% chitosan coated banana slices. The values are mean ± SD of three independent determinations

Parameter	50 ˚C				60 ˚C				70 ˚C			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
pH	5.47 ± 0.09 ^{a}	5.46 ± 0.11 ^{a}	5.43 ± 0.08 ^{a}	5.42 ± 0.05 ^{a}	5.27 ± 0.04 ^{a}	5.24 ± 0.07 ^{a}	5.23 ± 0.11 ^{a}	5.22 ± 0.09 ^{a}	5.19 ± 0.03 ^{a}	5.15 ± 0.14 ^{a}	5.06 ± 0.05 ^{a}	5.03 ± 0.10 ^{a}
TSS (°Brix)	3.2 ± 0.07 ^{a}	2.9 ± 0.09 ^{b}	2.8 ± 0.04 ^{b}	2.6 ± 0.06 ^{c}	2.9 ± 0.03 ^{a}	2.7 ± 0.05 ^{b}	2.6 ± 0.09 ^{b}	2.4 ± 1.00 ^{c}	2.2 ± 1.10 ^{a}	2.1 ± 0.07 ^{a}	1.9 ± 0.03 ^{b}	1.8 ± 0.05 ^{b}
TA	0.36 ± 0.05 ^{a}	0.32 ± 0.06 ^{bc}	0.31 ± 0.10 ^{c}	0.29 ± 0.07 ^{d}	0.28 ± 0.06 ^{a}	0.26 ± 0.07 ^{bc}	0.25 ± 0.09 ^{c}	0.23 ± 0.04 ^{d}	0.19 ± 0.09 ^{a}	0.17 ± 0.05 ^{b}	0.16 ± 0.04 ^{c}	0.14 ± 0.07 ^{d}

3.4 Antioxidant activity

Antioxidant activity of fresh banana juice was 56.4 ± 1.34%. The percentage of DPPH inhibition (45.48 ± 1.13 ^{a}) is significantly higher in case of 1% S + 1% C coated banana at 50˚C (Fig. 01).

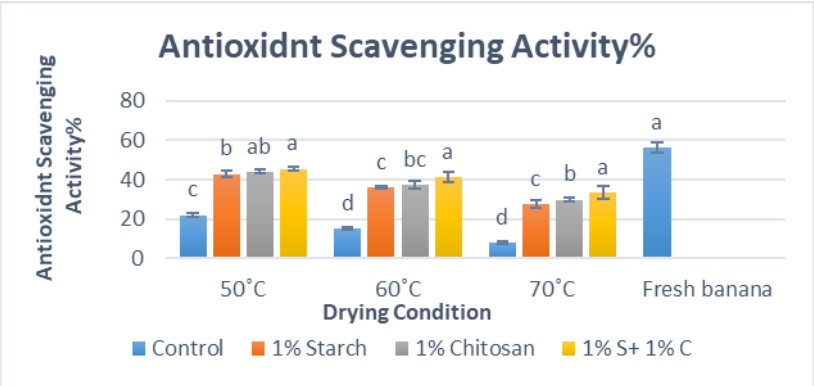

Figure 01: Antioxidant activity (%) in air dried coated green banana slices. Error bars indicate ± SD of mean.

3.5 Ascorbic acid content

Vitamin C of fresh banana juice was 20.13 ± 1.80 ^{a} mg/100g. Vitamin C retention in the 1% S + 1% C coated banana slices (49.13%) were very low when dried at 70˚C on the contrary at 50 ˚C higher vitamin C retention (70.93%) was obtained than other drying conditions (Fig. 02).

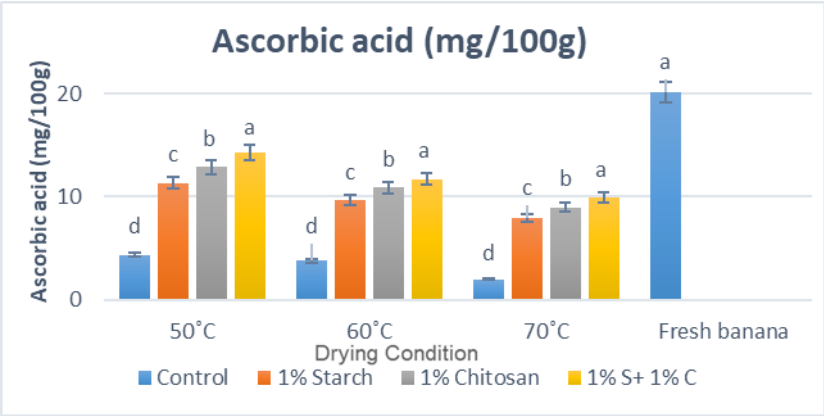

Figure 02: Ascorbic acid content (mg/100g) in air dried coated green banana slices.Error bars indicate ± SD of mean.

3.6 Total phenolic content

The total phenolic content in the 1% S + 1% C coated sample (7.85 ± 0.97 [a]) was comparatively low in 70˚C from other two drying temperature. Furthermore, higher phenolic content (10.52 ± 0.34 [a]) was observed in 1% S + 1% C coated sample at 50˚C (Fig. 03).

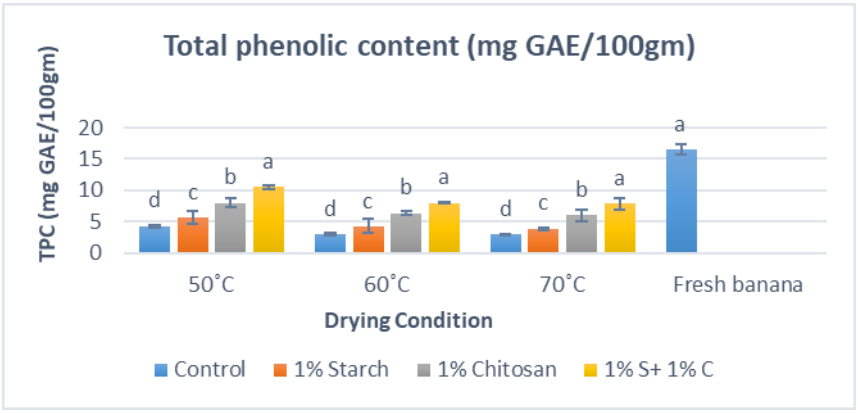

Figure 03: Total phenolic contents(mg GAE/100g) in air dried coated green banana slices.Error bars indicate ± SD of mean.

3.7 Percentage of weight loss during storage period

The minimum weight loss after 15 days of storage period was observed in the banana sample coated with 1 % S + 1 % C solution (12.15 ± 1.57 [d]) and maximum was in case of control (21.46 ± 0.98 [a]) (Fig. 04)

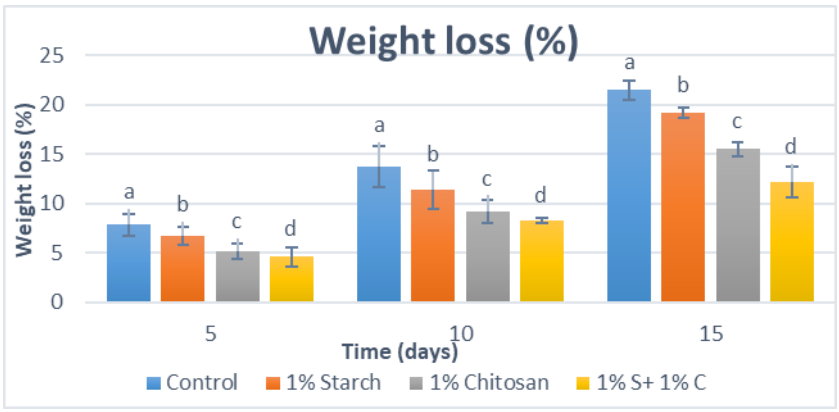

Figure 04: Percentage of weight loss in fresh coated green banana during storage period. Error bars indicate ± SD of mean.

3.8 Change of firmness during storage period

There was no significant difference in the firmness at day 5 (moderately firm to firm) but at 10 and 15 a drastic loss in firmness is observed in control sample (Table 02).

Table 02: Change of firmness in fresh/coated green banana during storage period. Where 6 = Very firm; 5 = Firm; 4 = Moderately firm; 3 = Slightly soft; 2 = Soft; 1 = Very soft

Time (days)	Coating condition			
	Control	1 % S	1 % C	1 % S + 1 % C
0	6	6	6	6
5	4	4.32	5	5
10	3	3.32	3.66	4
15	1.66	2.33	2.66	3.32

3.9 Peel color change in fresh / coated green banana during storage period

We observed bright green color of control and coated fruits changed to yellow during storage period. Yellowness was found after 5 days of storage period in control. The same noticeable condition was observed after 10 days of storage period in other coated banana (Table 03).

Table 03: Peel color change in fresh/coated green banana during storage period. BG = Bright green, GSLYS = Green skin with light yellow stripe, GSWYS = Green skin with well- defined yellow stripe, CYSGA = Clearly yellow colored skin with some green areas, ** = Completely spoiled.

Coating	1st day				5th day				10th day				15th day			
	BG	GSL YS	GSW YS	CYS GA	BG	GSL YS	GSW YS	CYS GA	BG	GSL YS	GSW YS	CYS GA	BG	GSL YS	GSW YS	CYS GA
Fresh	100 %	-	-	-	15 %	85 %	-	-	-	40 %	20 %	40 %	**	**	**	**
1 % S	100 %	-	-	-	60 %	40 %	-	-	-	60 %	16 %	14 %	-	70 %	20 %	10 %
1 % C	100 %	-	-	-	76 %	24 %	-	-	-	13 %	75 %	12 %	-	75 %	15 %	10 %
1%S+1%C	100 %	-	-	-	78 %	12 %	-	-	-	15 %	75 %	10 %	-	80 %	10 %	10 %

IV. Discussion

4.1 Effect of coating on functional properties of green banana slices

With an increase in drying temperature there is decrease observed in pH value (Table 01). The increase in pH value may be due to break down of acids with respiration during storage [16]. Coating slowed down the changes in pH which in turn effectively delays the produce senescence. This was may be due to the semipermeable coating on the surface of the fruit might have modified the internal atmosphere i.e. the endogenous CO_2 and O_2 concentration of the fruit thus slowing down senescene.

Bio preservative coating led to a lower increase in TSS content than the control fruits. It was also found that with the increase of temperature, There was a gradual decrease in TSS value. The control fruit showed a more increase in TSS values than the coated fruits (Table 01). The development in TSS of control fruits was mainly due to the continuous enhancement of free sugars of fruit during storage. Coated fruits hindered TSS development which was due to coating might decrease the respiration and eventually metabolism of sugars. This result complies with the findings of coated nectarines [21].

There was a progressive reduction in TA of control and coated produce however this decline was slower in coated fruits contrasted with the control fruits. There was a slow decline in titrable acidity with the increase of temperature (Table 01). TA is an important parameter that determines the quality of produce and affects consumer acceptance. This kind of results was also found in Aloe Vera gel in table grapes [22], aloe gel in "star king cherries [23]. This may due to the protective effect of gel coating barrier of O_2 from the surrounding atmosphere [20].

Edible coating was proven to preserve more antioxidant activity. It is also observed that after drying the antioxidant activity is greatly reduced (Fig. 01). But significant loss during drying is prevailed by pretreatment of coating. Use of edible coating to improve antioxidant activity in fruits for example pears, can be seen in the study conducted by [24]. There was no specific relation of DPPH inhibition with temperature.

We found comparatively higher amount of vitamin C in 1% Starch + 1% Chitosan coated sample and comparatively lower amount is found in the uncoated sample (Fig. 02). This can be explained by oxidative barrier properties of coating which prevents the destruction of vitamin C. These findings comply with the findings of [25]. This result suggests high temperature is responsible for more destruction of vitamin C during drying. These findings comply with the findings of [26]. The edible coating acts as a potential active carrier of ingredients. This AA could have incorporated into the fruit and might have a role in the increase in AA content of coated fruit. The coated fruits were exposed to more light intensity during growth that's why they contain

higher AA than control fruits. In this work, there was much increase of AA in coated fruits than the control fruits. This could be due to the low oxygen permeability of coating [27]. Protecting produce from oxygen exposure delays deteriorative oxidation reaction of AA [27].

Edible coatings can create abiotic stress on fruits and vegetables, adjusting its metabolism and influencing the production of such auxiliary metabolites as phenolic and flavonoid compounds.Total phenolic content was significantly higher in case of mixture of starch and chitosan coated banana slices than the control samples (Fig. 03). Past research indicated that low O2 (2.5 KPa) and high CO2 (7 KPa) concentrations expanded the production of phenolic compounds during the storing of fresh cut melons, which was identified with oxidative stress [28]. Though it is not absolute that total phenolic content will only decrease with increasing temperature.

4.2 Shelf life study of fresh coated green banana during storage period

Major determinant of shelf life study of banana fruit is weight loss. Coatings fundamentally decreased the weight loss of the banana fruit during storage contrasted with the control (Fig. 04). In a study by [29] shows that the major pathway for water loss is through the peel. Therefore, this study indicates that coating reduces the weight loss probably as a result of covering the cuticles on the fruit surfaces. Fruit firmness is a major characteristic that indicates the postharvest life and quality of fruit. Finally, based on the results this study indicates that coating successfully prevented excess firmness loss during storage period (Table 02) [30]. Color of the peel is one of the most important visual attributes to determine ripening of banana. Delay of color change from bright green to yellow indicates a delay in the ripening process. Study shows coated fruits take more time to ripen (Table 03). Finally, it can be said, modified atmosphere created by edible coating material retarded the ethylene production rate, therefore delaying the ripening, chlorophyll degradation and carotenoid synthesis thus color change of fruits. The results of this research are complied with the findings of [31].

V. Conclusion

Bangladesh faces tremendous loss of fruits and vegetables due to obsolete and old preservation techniques and lack of knowledge about the preservation strategies. Chemical preservatives which are being widely used nowadays have perilous consequences on human health and also to the environment. Bananas are one of the significant fruits of our country and due to their perishable nature, they are subjected to a colossal quantity of loss at consistently. Our study suggested that the bio preservative can be used to reduce the post-harvest loss. The shelf life of banana was found highest (15 days) in 1% S + 1% C coated sample compared to control samples (5 days). Drying is a well-known and noble technique of preservation but a considerable amount of nutrients, vitamins and antioxidants are removed during the drying process. In addition of prolonging shelf life, the coating also significantly prevented the loss of ascorbic acid, antioxidant, phenolic content during drying.

Our study demonstrates the effectiveness of edible coating as a bio-preservation method and prescribes the mixture of starch and chitosan solution as a predominant bio-preservative and a useful substitute to chemical preservative. Having no antagonistic effect on fruit, the environment and the consumer health, the mixture of starch and chitosan coating can easily and safely be applied to banana fruit.

Acknowledgements

The authors are appreciative to the Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology for nonstop material support and specialized help.

References

[1]. Sikder, M.B.H. and M.M. Islam, *Effect of Shrimp Chitosan Coating on Physico-chemical Properties and Shelf Life Extension of Banana.* International Journal of Engineering Technology and Sciences, 2019. **6**(1): p. 41-54.
[2]. Akamine, E.K. and T. Goo, *Respiration and ethylene production in fruits of species and cultivars of Psidium and species of Eugenia.* Journal of the American Society for Horticultural Science, 1979. **104**(5): p. 632-635.
[3]. Menezes, E.W., et al., *Chemical composition and nutritional value of unripe banana flour (Musa acuminata, var. Nanicão).* Plant foods for human nutrition, 2011. **66**(3): p. 231-237.
[4]. Hossain, M., et al., *Postharvest loss assessment of major fruits grown in hill regions of Bangladesh.* Bangladesh Journal of Agricultural Research, 2017. **42**(1): p. 171-184.
[5]. Malmiri, J.H., et al., *Evaluation of effectiveness of three cellulose derivative-based edible coatings on changes of physico-chemical characteristics of'Berangan'banana (Musa sapientum cv. Berangan) during storage at ambient conditions.* International food research journal, 2011. **18**(4): p. 1381.
[6]. Li, P. and M.M. Barth, *Impact of edible coatings on nutritional and physiological changes in lightly-processed carrots.* Postharvest Biology and technology, 1998. **14**(1): p. 51-60.
[7]. Thompson, A.K., *Fruit and vegetables: harvesting, handling and storage*. 2008: John Wiley & Sons.
[8]. Debeaufort, F., J.-A. Quezada-Gallo, and A. Voilley, *Edible films and coatings: tomorrow's packagings: a review.* Critical Reviews in Food Science, 1998. **38**(4): p. 299-313.
[9]. Saputra, K.A., et al., *Application of chitosan as preservatives on organic fruits.* Asian Journal of Food and Agro-Industry, 2009. **2**(Special Issue).

[10]. Vargas, M., et al., *Characterization of chitosan–oleic acid composite films.* Food Hydrocolloids, 2009. **23**(2): p. 536-547.
[11]. El Ghaouth, A., et al., *Chitosan coating effect on storability and quality of fresh strawberries.* Journal of food science, 1991. **56**(6): p. 1618-1620.
[12]. Zhang, D. and P.C. Quantick, *Effects of chitosan coating on enzymatic browning and decay during postharvest storage of litchi (Litchi chinensis Sonn.) fruit*. Postharvest Biology and Technology, 1997. **12**(2): p. 195-202.
[13]. Jiang, Y., et al., *Postharvest biology and handling of longan fruit (Dimocarpus longan Lour.).* Postharvest Biology and technology, 2002. **26**(3): p. 241-252.
[14]. Pesis, E., et al., *Production of acetaldehyde and ethanol during maturation and modified atmosphere storage of litchi fruit.* Postharvest Biology and Technology, 2002. **26**(2): p. 157-165.
[15]. Horwitz, W., *Official methods of analysis*. Vol. 222. 1975: Association of Official Analytical Chemists Washington, DC.
[16]. Athmaselvi, K., P. Sumitha, and B. Revathy, *Development of Aloe vera based edible coating for tomato*. International Agrophysics, 2013. **27**(4): p. 369-375.
[17]. Wang, J., et al., *Free radical and reactive oxygen species scavenging activities of peanut skins extract.* Food chemistry, 2007. **104**(1): p. 242-250.
[18]. Rangana, S., *Sensory evaluation handbook of analysis and quality control for fruit and vegetables product.* Tata margay hill Publication Company limited. New Delhi, 2001. **94**.
[19]. Silva, C.H.T.P.d., et al., *Antioxidant capacity and phenolic content of Caesalpinia pyramidalis Tul. and Sapium glandulosum (L.) Morong from Northeastern Brazil.* Molecules, 2011. **16**(6): p. 4728-4739.
[20]. Valverde, J.M., et al., *Novel edible coating based on Aloe vera gel to maintain table grape quality and safety.* Journal of Agricultural and Food Chemistry, 2005. **53**(20): p. 7807-7813.
[21]. Ahmed, M.J., Z. Singh, and A.S. Khan, *Postharvest Aloe vera gel‐coating modulates fruit ripening and quality of 'Arctic Snow'nectarine kept in ambient and cold storage.* International journal of food science & technology, 2009. **44**(5): p. 1024-1033.
[22]. Castillo, S., et al. *Using Aloe vera as a preharvest treatment to maintain postharvest organic table grape quality*. in *XXVIII International Horticultural Congress on Science and Horticulture for People (IHC2010): International Symposium on 933*. 2010.
[23]. Martínez-Romero, D., et al., *Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: a new edible coating.* Postharvest Biology and Technology, 2006. **39**(1): p. 93-100.
[24]. Oms-Oliu, G., R. Soliva-Fortuny, and O. Martín-Belloso, *Physiological and microbiological changes in fresh-cut pears stored in high oxygen active packages compared with low oxygen active and passive modified atmosphere packaging.* Postharvest Biology and Technology, 2008. **48**(2): p. 295-301.
[25]. Garcia, C.C., et al., *Influence of edible coating on the drying and quality of papaya (Carica papaya).* Food and bioprocess technology, 2014. **7**(10): p. 2828-2839.
[26]. Ahmed, N., et al., *Different drying methods: Their applications and recent advances.* Int. J. Food. Nutr. Saf, 2013. **4**: p. 34-42.
[27]. Ayranci, E. and S. Tunc, *A method for the measurement of the oxygen permeability and the development of edible films to reduce the rate of oxidative reactions in fresh foods.* Food Chemistry, 2003. **80**(3): p. 423-431.
[28]. Odriozola-Serrano, I., R. Soliva-Fortuny, and O. Martín-Belloso, *Changes in bioactive composition of fresh-cut strawberries stored under superatmospheric oxygen, low-oxygen or passive atmospheres.* Journal of Food Composition and Analysis, 2010. **23**(1): p. 37-43.
[29]. Tucker, G., et al., *Biochemistry of fruit ripening.* 1993.
[30]. Ali, A., et al., *Effect of chitosan coatings on the physicochemical characteristics of Eksotika II papaya (Carica papaya L.) fruit during cold storage.* Food chemistry, 2011. **124**(2): p. 620-626.
[31]. Ergun, M. and F. Satici, *Use of Aloe vera gel as biopreservative for 'Granny Smith'and 'Red Chief'apples.* 2012.