**CAFEi2016-157**

# Effect of chitosan coating on physico-mechanical properties and shelf life extension of tomato (*Solanum Lycopersicum*)

Z. Nasreen[1,a], S.A. Samad[2], A.M.S. Chowdhury[2].

[1]Department of Chemistry, Faculty of Science, Dhaka University of Engineering and Technology, Gazipur-1700, Bangladesh; [2]Department of Applied Chemistry and Chemical Engineering, Faculty of Engineering and Technology, University of Dhaka, Dhaka-1000, Bangladesh.

***Abstract***

**Tomato is perishable in fresh form and shelf life is limited. The current study was conducted to investigate the effects of non-irradiated chitosan coating on different quality parameters (ripping, biochemical) and shelf life extension of tomato over a storage period of 10 days at ambient environment. The preserved tomato maintained their characteristic quality during whole storage period without visual fungal growth. Dry matter content, moisture content, deterioration index, reducing sugar was also experimentally observed. All of the results were analyzed statistically and found to be significantly different. The overall results showed the superiority of non-irritated chitosan in extending shelf life of tomato.**

**Keywords:** tomato, gamma irradiation, chitosan, self life

## INTRODUCTION

Chitosan is deacetylated product of chitin, which is one of the naturally most abundent mucopolysaccharides and supporting materials of crustaceans and insects. Research has shown that chitosan, which can be extracted from the shell ofcrustaceans has many beneficial uses. One of these benefits is that chitosan can form physical and chemical barriers against invading pathogens. The tomato (*Solanum lycopercicum*) fruit is one of the most popular, as wellas important, commodities in the world.It is often refered to as "the poor man's orange" because of tits high vitamine, malic acid and citric acid contents and the fact that it surves as a fine appitizer. it provides high nutritation in many forms such as raw in salads, cooked in soups , preserves, tomato puree, sauces, pickled and in other forms. Tomato fruit quality is determined mainly by colour, texture and flavour. Amoung those, colours and flavours are the most useful criteria for estimation maturity of tomato fruit. High quality is associated with redness of colour and prominnance of flavour. The flavour of tomato becomes pronounced when the sugar content is at its maximum, at which time the skin aquires its richest colour.

The annual production of tomato in Bangladesh is 7, 20,000 metric ton (Wills et al., 2004) in which 45% tomato was gone astray every year (BBS, 2007-2009). The higher loss of tomato was moastly due to the short life time. Therefore, there is a need for substitute novel practices for preservation of fresh tomato quality attributes during handling, distribution and retail sale.

The coating of tomato fruits with Chitosan delays the rate of ripening and the occurance of decay (El-Ghaouth et al., 1991; Hasan et al., 2010). The controles of diseases in fruit and vegtables by chitosan could account for the anti-fungal activity of chitosan and its capacity to provoke defence and enzymes phytalexins in plant tissue or combination of both. Several mechanisms were proposed for antibacterial and antifungal activity by chitosan (Hadwiger et al., 1981; Wang, 1992; El-Ghaouth et al., 2000).In one mechanism, the polycationic nature of

[a] E-mail: zinia@duet.ac.bd

chitosan interferes with the negatively charged residues of macromolecules at the surface. Chitosan interects with the membrane of the cell to alter cell permeability. The other mechanism involves the binding of chitosan with DNA to inhibit RNA synthesis (Young et al., 1982). Chitosa and its derivatives have been used as food wraps due to their film forming properties. The Chitosan film controls moiure movement between food and surounding environment thus decreasing the rate of metabolism, respiration and rendering in high in permeability to certain substances such as fats and oils, in addition to temperature. These would lead to a delay of the ripening of fruits (Shahidi et al., 1999; Xiao et al., 2001).

Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. In such environment, tomatos (*Solanum lycopercicum*) are more vernarable to mold and bacterial attacks. It is impossible to preserve tomatoes for extended periods. Different techniques and technologies are avialable to preserve fruits and vegtables, these includes food irradiation, freezing, dehydration, food coatings and so on depending on the qiality and character of the fruit. Irradiation has been reported to be more effective but its less cost effective and controlling the doses is a matter of prime concern. Freezing and dehydration accompains with food degradation and sometimes even deteriorates the food quality. These technicues are also proved to be less cost effective depending upon transportation and maintainng food flavour ans taste. Concerning all these facts we have prepared an edible Chitosan coationg in a solution form and applied it on tomatoes to extend its shelf-life (Yeung et al., 2001).

## MATERIALS AND METHODS

### Plant materials

Mature tomatos were obtained from a local area of Gazipur, Bangladesh and transported to the laboratory. Fruits of same variety were selected according to good appearance and free from mold attack and mechanical injuries. Edible Coating Formulations and Irradiation Chitosan was prepared in the laboratory of Institute of Radiation and Polymer Technology (IRPT), Bangladesh Atomic Energy Commission (BAEC) from prawn shell using chemical extraction method (Ur Rashid et al., 2012). Degree of deacetylation of the chitosan was 83%. 20g of chitosan was dispersed in 980 ml of 2% acetic acid to prepare 1L 2% chitosan solution and blended with15% egg albumin to improve the wettability and maintain the $p^H$ of the prepared solution within 5.4.

### Coating application

We have selected medium sized pink colored tomatoes for these experiments. Tomatoes were randomly distributed into five groups. Each group contain 10 tomatoes of similar size without any visible fungal/mold growth observed. Fruits were washed using distilled water, air dried at room temperature and then chitosan solutions were sprayed. After the treatment fruits were air dried and stored at ambient environment (23.5±1$^o$C/65 ± 3% RH} up to complete damage of the control (7 days). Tomatoes were analyzed for different parameters at a regular intervel of 2 days.

### Biochemical Analysis

Moisture content, Ash content, Acidity, total soluble solids (TSS) and pH were determined according to the official methods of analysis of the Association of Official Analytical Chemists (AOAC) (Cheah et al., 1997). For total soluble solids (TSS) determination hand refractometer, (Model: ATAGO 9099) was used and portable pH meter (Model: H1 98106) was used for pH determination. Ascorbic acid content was measured through methods of vitamin Assay (*Methods of vitamin Assay 1966).* Reducing sugar was determined using Nelson-Somogyi method.

### Statistical analysis

The experiments were arranged in completely randomized design, and each was comprised of five replicates. The data were subjected to one way ANOVA using SPSS softwere (17.5 versions), while Duncan Multiple Range Test (DMRT) was used to compare difference between treatments at 95% confidence level of each variable.

## RESULTS AND DISCUSSION

### Physical appearance of tomato at Ambient Environment

Quality of tomatoes during storage has been tested by spoilage ratio and capability of ripening with color change. Tomatoes with chitosan coating had no spoilage after 15 days of storage. Fungi could not be observed visually in chitosan treated fruits. At the preliminary stage of preservation (0 day) 60-80% fruits of each group were pink. Treated tomatoes had strong texture compared to control. Tomato is a perishable fruit (Sarder et al., 2008) but after application of chitosan solution as preservative the shelf life has extended.

### Effect on Weight Loss

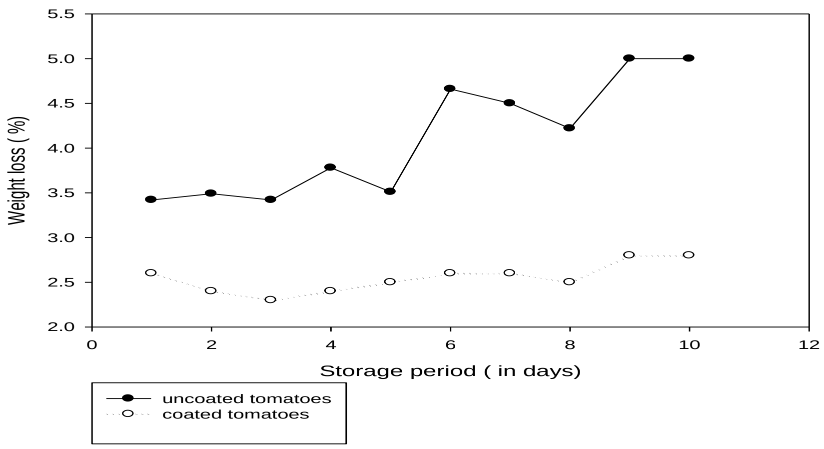


Figure 1. Effect of edible coatings on weight loss per centage content of both coated and uncoated tomatoes during 15 days of storage at 23.5±1$^0$C

Figure 1 shows the change in weight loss percentage of coated and uncoated tomatoes during the 15 days storage period. The application of coating treatments retarted significant reduction ($p<0.05$) in weight loss as compared with the control samples. The control samples had significantly ($p<0.05$) higher weight loss percentage (5.04%) after 7 days of storage. The application of Chitosan coating on the tomatoes was observed to prevent weight loss more than that of other tested coating treatments (2.82%) throughout the storage period. The weight loss in tomatoes might be due to water loss by transpiration and other physiological mechanism, the substrate loss by respiration (Islam and Kabir, 2001). The less decrease in weight loss of coated ones was due to the effects of these coatings to form a semi-permeable barrier against gases like oxygen, carbon dioxide, moisture and other solute movement due to which it reduces respiration, moisture loss and oxidation (Sonti, 2003). The obtained results were also in complies with the findings of Sheikh et al., (2013) who reported that chitosan in combination with protein and polysaccharide was very effective in reducing the respiration rate and inhibiting water loss. Figure 2 represents the change in moisture Moisture content which were performed from the beginning to end of the storage period. From the graph it was observed that moisture content was decreased significantly as the storage time proceeded. The minimum moisture loss occurred in fruits treated with Chitosan solution as compared with untreated fruit (T1). The untreated fruits showed significantly lower moisture content than treated ones. Maximum moisture lost in untreated control might be due to high rate of respiration and transpiration (Chien et al., 2005). It provides an addition barrier against diffusion through stomata. Thus the coating was more effective in forming a physical barrier to moisture loss and therefore retarding dehydration, membrane permeability and senescence.

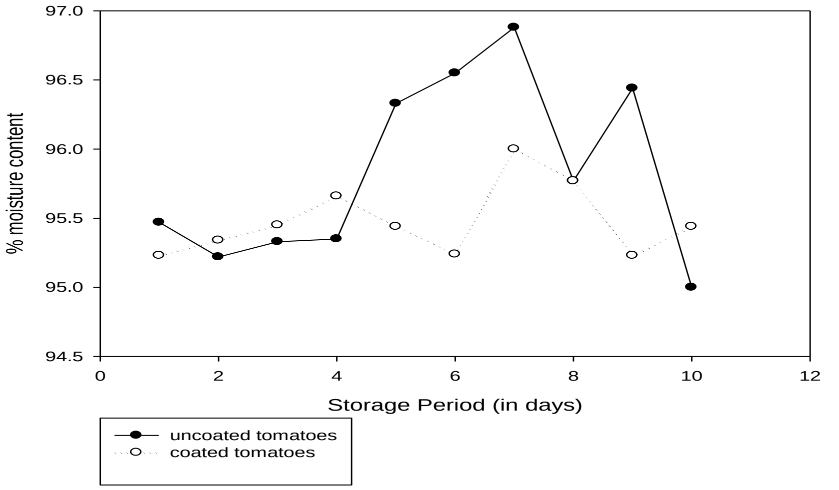


Figure 2. Effect of edible coatings on moisture content of both coated and uncoated tomatoes during 15 days of storage at 23.5±1°C

**Effect on Total soluble solids (TSS) and pH**

The TSS of the control samples increases and then decreases with storage time while the coated tomatoes experienced slower increase which then become constant during storage (Figure 3). Edible coatings were better in lowering soluble solids concentration. There was no statistically significant difference between the treatments according to the data.

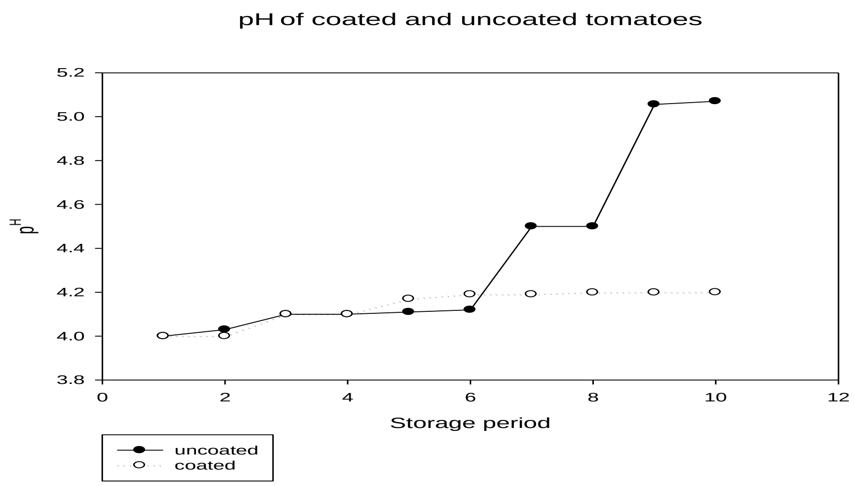


Figure 3. Effect of chitosan coating on pH value of tomatoes at ambient environment (23.5±1°C/ 65± 3% RH).

The higher levels of total soluble solids in the fruit coated with chitosan may be due to protective O2 barrier reduction of oxygen supply on the fruit surface which inhibited respiration (Yonemoto et al., 2002). The decrease of total soluble solids is caused by a decline in the amount of carbohydrates and pectins, partial hydrolysis of protein and decomposition of glycosides into sub-units during respiration (Ball, 1997). The pH value increased within the range from 4.0 – 5.2 of different tomatoes sample both treated and untreated ones. Uncoated fruits showed higher increasing rate than coated fruits but no significant difference was encountered. Chitosan treated fruits showed better result than without treatments. It was found that a small change in pH represents a large change in hydrogen ion concentration. The change in pH is associated with number of reasons; it might be due to the effect of treatment on the biochemical condition of the fruit and slower rate of respiration and metabolic activity (Jitareerat et al., 2007) and the breakup of acids with respiration during storage.

**Measurement of Acidity and Sugar/Acid ratio**

The results showed that acidity percentage was decreased along with the storage period in both coated and uncoated fruits (Figure 4) and then increased and there was no significant differences found. Results also suggested that treated tomatoes had a slower decreasing trend than control. Titratable acidity is directly related to the concentration of organic acids present in the fruits. The decreasing acidity at the beginning of storage might be due to the metabolic changes in fruits or due to the use of organic acid in respiratory process that is compatible with other scientists. Increased activity of citric acid during ripening or reduction in acidity may be due to their conversion into sugars and their further utilization in the metabolic processes of the fruit (Abbasi et al., 2009).

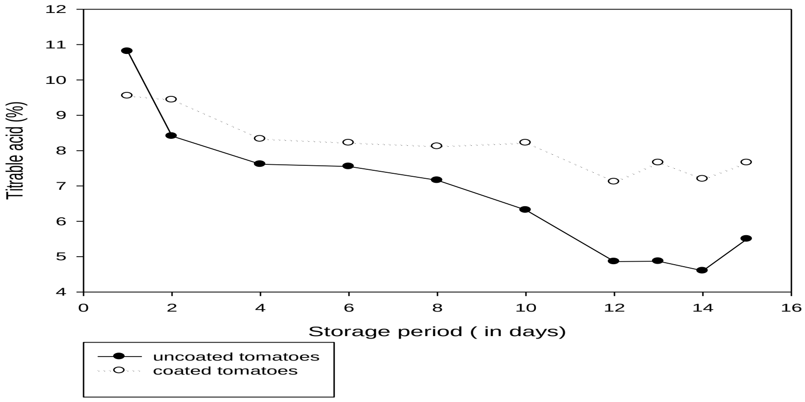


Figure 4. Effect of chitosan coating on titrable acid value of tomatoes at ambient environment (23.5±1°C/ 65± 3% RH).

As, chitosan coating can lead to develop oxygen barrier on the fruit surface and thus reduce metabolic rate so, treated fruits showed less decreasing trend of titrable acid. Further, increase in acidity at higher storage period might be due to the conversion of macromolecules into titrable acids. Figure 5 complies with the results found for titrable acidity. It gives an idea for the sugar/acid ratio based on the Brix value of the tomatoes. The results show that the sugar/acid ratio which contributes towards giving many fruits their characteristic flavor and so is an indicator of commercial and organoleptic ripeness, at the beginning of the ripening process the sugar/acid ratio is low, because of low sugar content and high fruit acid content, this makes the fruit taste sour. During the ripening process the fruit acids are degraded, the sugar content increases and the sugar/acid ratio achieves a higher value. Overripe fruits have very low levels of fruit acid and therefore lack characteristic flavor.

**Measurement of Reducing Sugar**

The chitosan treated fruits showed gradual increase in reducing sugar content (Figure 6) and the results showed significant differences between treated and untreated fruits. Generally, reducing sugar content of fruits increases with the breakdown of non-reducing sugar. The gradual increase in reducing sugars in coated tomatoes as compared to control treatment might be attributed the slow ripening process (Ghasemnezhad et al., 2010). The related result also found in mango fruits where the effectiveness of crab and shrimp chitosan along with radiation doses was studied (Abbasi et al., 2009).

Maximum amount of reducing sugars in treated fruits might be due to gradual conversion of starch to sugars, moisture loss and decrease in acidity by physiological changes during storage. Besides, less bacterial or fungal growth on treated tomatoes can be another reason for higher reducing sugar content. Further decrease of reducing sugar in higher storage period may be due to utilization of sugars by bacteria or fungus.

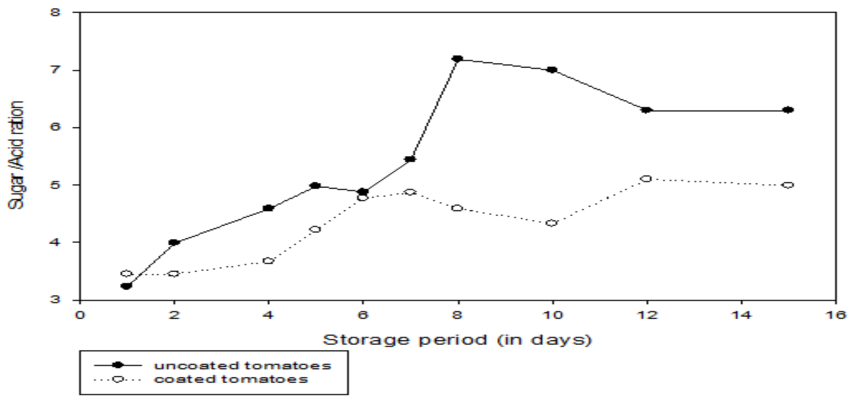


Figure 5. Effect of chitosan coating on sugar/ acid ration in tomatoes at ambient environment (23.5±1°C /65 ± 3% RH).

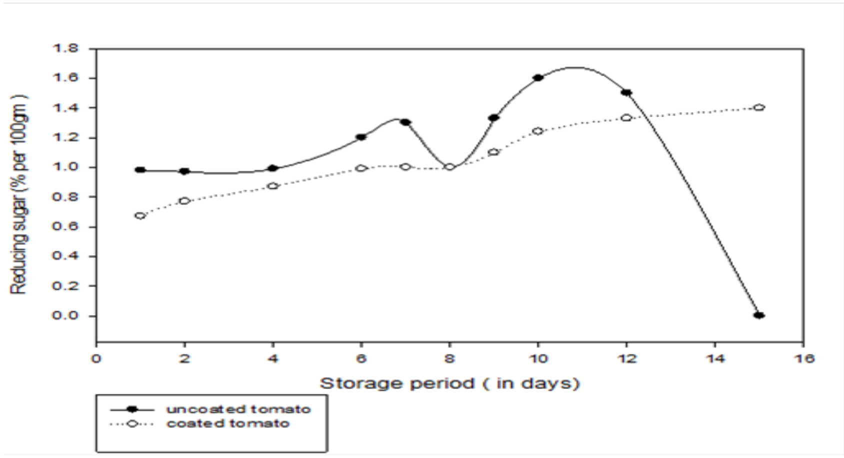


Figure 6. Effect of chitosan coating on reducing sugar in tomatoes at ambient environment (23.5±1°C /65 ± 3% RH).

**Measurement of Ascorbic acid (V-C)**

The Vitamin C of samples increased until tomatoes are fully rotten (Figure 7) and there was no significant differences found for coated tomatoes. The results are strongly supported by other scientists worked on apricot (Sritananan et al., 2005).

**Effect on Visual Appearance**

One of the beneficial effect of edible coating include improvement of appearance, shine, natural gloss of tomatoes as compare to uncoated ones which leads to better marketability and customer acceptability. Table 1 shows the difference in visual appearance of both coated and uncoated tomatoes during storage. After 7th days, the uncoated tomatoes turned unattractive because of the formation of wrinkles, shrinkage and shriveling of skin which was due to loss of water from the tubers. Evaluation of controlled ones was discontinued after 7 days. On the other hand, even after 15 days of storage, coated tomatoes maintained good appearance and texture. This was probably due to the edible coating that forms coating that forms a partial barrier on the surface which controls the exchange of water from the commodity surface. In some cases, molds started to develop during the storage period, which perhaps can also be due to anaerobic respiration (Sultan, 2014). Chitosan in combination with albumin shows good shine and less wrinkles on the surface of the tomato. Edible coating can also delay ripening and prevent the occurrence of plant diseases. Amarante and Banks (Amarante and Banks, 2001). Suggested that coating can form a physical barrier against pathogenic infections, hence it can reduce the incidence of post-harvest disease. Similar reporting was also suggested by Gol and Rao, (2011).

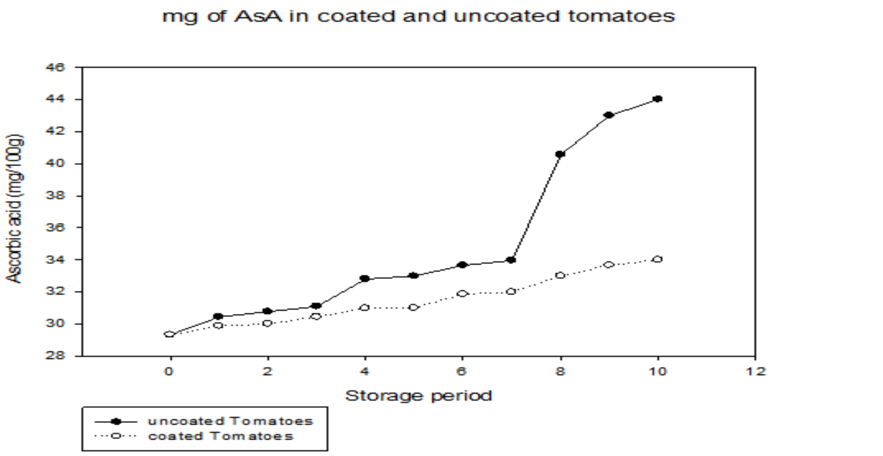


Figure 7. Effect of chitosan coating on ascorbic acid in tomatoes at ambient environment (23.5±1°C /65 ± 3% RH).

Table 1. Effect of edible coatings on visual appearance of both coated and uncoated tomatoes during 15 days of storage at 23.5±1°C.

| Treatment | 0th Day | 5th Day | 10th Day | 15th Day |
|---|---|---|---|---|
| **Uncoated tomatoes** | Intact | Loose skin with some mold/fungal attack and shrinkage started | Completely rotten | Completely rotten |
| **Coated Tomatoes** | Intact and pink shiny gloss | Intact with red shiny and Gloss | Intact No loss in texture | Loosening of skin with wrinkles. But no visible Fungal or mold attack |

## CONCLUSIONS

The following conclusions can be drawn from the study:

- In our study, we found that chitosan coating in combination with albumin (15%) are simple, environmentally friendly and relatively inexpensive technology that can extend the storage life of common commodities like tomatoes.
- The application of these edible coatings on the surface of tomatoes reduces its weight loss and respiration rate, which implies that they are forming a protective barrier on the surface of the tomato. Shelf life of coated tomatoes increases to 15 days with no smell, blemishes, spoilage and rot in comparison with uncoated one.
- Treated tomatoes showed best behavior throughout storage period with minimum loss of moisture, shrivel, increased ascorbic acid content and able to conserve better sensory characteristics. Chitosan coating also protected tomato fruits from visual fungal growth.
- So, this study recommends chitosan as a very promising edible coating material that is very effective and safer way in maintaining the overall quality of tomato.

## Literature cited

Abbasi, N.A., Iqbal, Z., Maqbool, M., and Hafiz, I.A. (2009). Postharvest quality of mango (*Mangifera indica l.*) fruit as affected by chitosan coating. Pak. J. Bot. *41(1),* 343-357.

Amarante, C., and Banks, N.H. (2001). Hort. Rev. *26,* 161-238.

Ball, J.A. (1997). Evaluation of two lipid-based edible coatings for their ability to preserve postharvest quality of green bell peppers. Master Thesis, Faculty of the Virginia PolytechnicInstitute and State University, Blacksburg, Virginia, USA.

BBS, Yearbook of Agricultural Statistics of Bangladesh, Bureau of Statistic. (2007-2009). Ministry of Planning, Govt. of Peoples Republic of Bangladesh, Dhaka.

Cheah, L.H. (1997). Page BBC and Shephered R, Chitosan coating for inhibition of sclerotinia rot of carrots. New Zeal. J. Crop Hort. Sci. *25,* 89-92.

Chien, P.J., Sheu, F., and Yang, F.H. (2005). Effect of ediblechitosan on quality and shelf life of sliced mango fruit. *J.* Food. Eng. *29(3),* 23-29.

El-Ghaouth, A., Rathy, J.A., and Boulet, P.M. (1991). Use of chitosan coating to reduce water loss and maintain quality of cucumber and bell pepper fruits. J. Food Process Preserv. *15*, 359-368.

El-Ghaouth, A., Smilanick, J. L., and Wilson, C.L. (2000). Enhancement of performance of *Candida saitoana* by the addition of glycolchitosan for the control of postharvest decay of apple and citrus fruit. Postharvest Biol. Technol. *19,*103-110.

Ghasemnezhad, M., Shiri, M.A., and Sanavi, M. (2010). Effect ofchitosan coatings on some quality indices of apricot (*Prunus armeniaca L.*) during cold storage. Caspian J. Env. Sci. *8(1),* 25-33.

Gol, N.B., and Rao, T.V.R. (2011). Int. J. Fruit Sci. *11(2),* 119-135.

Hadwiger, L.A., Beckman, J.M., and Adams, M.J. (1981). Localization of fungal components in the pea- Fusarium interaction defected immunochemically with anti-chitosan and antifungal cell wall antisera. Plant Physiol. *67*, 170-175.

Hasan, M.K., Chowdhury, B.L.D., and Akhter, N. (2010). National Food Policy capacity Strengthening Programs. pp 118- 126.

Islam, M.S. and Kabir, A.H.M.F. (2001). Pak. J. Biol. Sci. *4,* 1149-1152.

Jitareerat, P., Paumchai, S., and Kanlayanarat, S. (2007). Effect ofchitosan on ripening, enzymatic activity, and disease development in mango (Mangifera indica) fruit. New Zeal. J. Crop Hort. Sci. *35,* 211–218.

Sarder, A.H., Rashid, H., Munshi, M.K. and Begum, R. (2008). Shelf- life extension of mango using natural preservative chitosan at room temperature. Bangladesh J. Environ. Res. *6*, 31-37.

Shahidi, F., Arachchi, J. K. V., Jeon, Y. J. (1999). Food applications of chitin and chitosans. Trends Food Sci. Tech. *10,* 37-51.

Sheikh, R.A., Mali, M.A., Al-Thabaiti, S.A., and Sheikh, M.A. (2013). Food Sci. Technol. Res. *19(2),* 139-155.

Sonti, S. (2003). Consumer perception and application of edible coatings on fresh-cut fruits and bvegetables. MSc. Thes, B.S., Osmania University College of Technology. pp11-13.

Sritananan, S., Uthairatanakij, A., Jitareerat, P., Photchanachai, S., and Vongcheeree, S. (2005). Effects of Irradiation and chitosan coating on physiological changes of mangosteen fruit stored at room temperature. Int. Symp. New Frontier of Food and Non-Food Products, KMUTT, Bangkok, Thailand.

Sultan, M.Z. (2014). Acta. Hort. (ISHS). *1029*, 345-351.

Ur Rashid, T., Rahman, M.M., Kabir, S., Shamsuddin, S.M. and Khan, M.A. (2012). A New Approach of Chitosan from gamma Irradiation of Prawn shell: Effects of radiation on the Characteristics of Chitosan. Polym. Int. 1302-1308.

Wang, G.H. (1992). Inhibition and inactivation of five species of foodborne pathogens by chitosan. J. Food Prot. *55,* 916-919.

Wills, R., McGlasson, B., Graham, D., and Joyee, D. (2004). Postharvest, in Introduction to the physiology and handling Fruits, Vegetables and Ornamentals (4th Edition). University of New South Wales Press Ltd., Sydney 2052, Australia. pp 262.

Xiao, F.L., Yun, L. G., Dong, Z. Y., Zhi, L., and Kang, D.Y. (2001). Antibacterial Action of chitosan and Carboxymethylated chitosan. J. Appl. Polym. Sci. *79,* 1324-1335.

Yeung, Ruth, M.W., and Joe, M. (2001). Food safety risk: Consumer perception and purchase behaviour. Brit. Food J. *103 (3),* 170-187.

Yonemoto, Y., Higuchi, H., and Kitano, Y. (2002). Effects of storage temperature and wax coating on ethylene production, respiration and shelf- life in cherimoya fruit. J. Japanese Soc. Hort. Sci. *71,* 643-650.

Young, D.H., Kohle, H., and Kauss, H. (1982). Effect of chitosan on membrane permeability of suspension- cultured *glycine max* and *phaseolus vulgaris cells.* Plant Physiol. *70,* 1449-1454.