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IMPACT OF VARIOUS BIODEGRADABLE COATINGS ON SHELF LIFE OF MINIMALLY PROCESSED MELON

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Shelf life of food products is one of most debated issue in the regime of food processing and technology. Edible coating is a thin layer of edible material which provides a barrier against transfer of gasses, water vapors and solute particles across the food membrane. Melon is a rich source of nutrients like vitamins, minerals, flavonoids and phenolic compounds. It provides cooling effect to stomach. The present research is an effort to extend the shelf life of minimally processed melon fresh-cuts. Minimal processing offers additional value to fresh-cut produce regarding convenience and ready-to-eat attributes. For the purpose, different edible coating formulations like carbohydrate based chitosan 1% (T_1), chitosan 2% (T_2), chitosan 3% (T_3) and alginate 1% (T_4), alginate 2% (T_5) and alginate 3% (T_6) were developed. Additionally, coated fruit were also compared with that of control (T_o). During storage, melon dices were evaluated for various physicochemical analysis e.g. weight, color, total soluble solids, ascorbic acid after three days of interval to check the effect of edible coatings on these quality traits along with shelf life extension. It has been concluded after the analysis that T_3 has proved to be effective treatment in maintaining acidity, total soluble solids and color as compared to other treatments.
Keywords: Edible Coating, Melon, Alginate, Chitosan

INTRODUCTION

Nature has endowed Pakistan with ideal climatic condition for the growth of numerous fruits and vegetables all the year round. Fruit and vegetables have a prominent part in the agriculture of Pakistan. It is documented that since 2010-11, the acreage under fruit cultivation has increased by 27.8% while production increased by 4.7%. But unfortunately, a large portion of fresh horticultural produce is going as waste due to inappropriate storage and handling facilities. Major losses in quantity and quality of fresh fruits occur between harvest and consumption. It has been estimated that approximately 25 to 40% of fresh horticulture produce is gone as waste lost due to inadequate handling, storage conditions leading to irreparable economic loss (GOP, 2012).

Factors like temperature, humidity, atmospheric composition, harvest and post-harvest handling practices greatly affect the quality. Furthermore, microorganisms and insects further worsen the type and degree of infection (Siddiqui *et al.,* 2011). Fresh-cut product is defined as fruit that has been peeled, trimmed or cut into pure usable product and offers convenience, health, nutrition and delightful flavor to consumer while still preserving wholesomeness and freshness (Campaniello *et al.,* 2008). Melon (*Cucumis melo*) is a predominant edible fruits belonging to *Cucurbitaceae* family. Due to rapid deterioration rate melon has lower shelf life so its market is not widespread. Effective microbial control is essential to restrict high respiration rate which causes spoilage and give unpleasant flavor and odor (Barry-Ryan *et al.,* 2000).

Melon contain considerable amount of minerals like calcium, potassium, magnesium and iron along with vitamins i.e. vitamin C, vitamin A, niacin, vitamin B_6 and folate (Szajdek and Borowska, 2008). Moreover, melon has therapeutic potential owing to the presence of various ingredients like myo-inositol which belongs to lipids and it is effective in controlling insomnia, anxiety and hardening of arteries. Investigations showed that melon is a rich source of digestive enzymes. American Cancer Society declared melons as a powerful agent against skin as well as intestinal cancer. Cantaloupes are among the fruits which contains highest quantities of Vitamin A which acts as a strong antioxidant and it is essential for good vision of eye. It plays important role in maintaining skin and healthy mucus membranes. Natural fruits rich in vitamin A protect against lung and oral cavity cancers (Perez *et al.,* 2003).

Reasonable amount of electrolyte e.g. potassium, is present in melon. 1kg of fruit gives 2.67g of potassium. Potassium helps to control blood pressure and heart rate. It provides protection against coronary heart diseases and stroke. Vitamin C is very effective in developing resistance against various infections because it scavenges free radicals. Melon also contains manganese which acts as co factor in body for various enzymes like superoxide dismutase. All over the world muskmelons are utilized for the commercial extraction of superoxide dismutase (SOD) (Thompson and Thompson, 2010).

Minimal processing operations may be applied at several stages of food distribution chain, during storage, processing and packaging. With lowered nutritional losses, minimally processed fruits have proven quality and sensory attributes. Minimal processing provides with additional value to lightly processed fruits regarding time saving and convenience and it holds significant place in modern lifestyle of humans. In particular, fresh-cut fruits attract consumers owing to its freshness, nutritional quality, low priced and ready-to-eat attributes (Ahvenainen, 2010).

Biofilms have received considerable attention owing to consumer demands for safe and edible grade material (Pavlath and Orts, 2009). It has been reported that edible coatings involving food grade emulsifying and wetting agents extend the shelf life of fruits through prevention of gas, water and solutes migration. These coatings have gained immense recognition in being environment friendly, biodegradable, non-toxic and rather safe choice to be used in food applications (Sánchez-González *et al.,* 2011).

Starch, alginate and Chitosan are among the polysaccharide based edible coatings with their usage assessed in different coating formulations (Tien *et al.,* 2001).

Considering the above mentioned facts the present study has been planned to address the socio-economic indicators of developing countries like Pakistan where large quantity of fresh horticulture produce goes waste as a victim to inadequate and improper handling and storage conditions. The conclusions of this research will inspire the exporters, producers, processors and growers to use latest techniques of edible coating for the purpose of enhancing shelf life and ultimately generating revenue through export. Coatings can expand shelf-life and marketability-delay ripening of the climacteric fruits, hindrance color changes, reduces weight loss, retain texture and lessen rot, straightforward technology and environmentally friendly (Mehdi *et al.*, 2011). The objectives of current research investigation are as under:

To develop and optimize alginate and chitosan based edible coatings

To enhance the nutritional quality and shelf life of minimally processed coated fruit

MATERIALS AND METHODS

Procurement of raw materials: Fresh melons were procured from local market on the basis of uniformity in size, shape, optimum color and absence of physical damage, abrasion or any evidence of fungal infection. Meanwhile chemicals and other expendables for coatings formulations were also purchased from local market.

Minimal processing of melon

Melons were sorted and graded on basis of physical appearance to prepare a uniform lot in the Postgraduate Research Laboratory of the National Institute of Food Science & Technology, University of Agriculture, Faisalabad. Later on, sorted fruits were washed to remove the dirt and grits adhered to the surface. Selected melons were then subjected to dicing after washing. Uniform dices of melon were prepared and kept at refrigerated temperature 4°C prior to coating to avoid enzymatic browning and allied metabolic changes.

Development of edible coatings

Carbohydrate based coatings namely chitosan and protein based coatings involving whey protein were developed in the Postgraduate Research Laboratory of the National Institute of Food Science & Technology, University of Agriculture, Faisalabad.

Development of chitosan coating:

Chitosan based coatings were prepared according to procedures given by Chien *et al.* (2007) and Simões *et al.* (2009).

Development of alginate coating:

Alginate coating was prepared according to the method described by Rojas-Grau *et al.* (2008).

Storage of the treated fruits: The tested material was kept in controlled climate chamber at 4°C and 85% relative humidity to determine their effects on the respective treatments. The treated melon dices were evaluated after every three days interval for physicochemical and sensory evaluation for twelve days. Similarly, the optimal shelf life of the uncoated fruits was analyzed.

Physicochemical analysis: Following physicochemical analyses were conducted at selected intervals (after every 3 days) to examine the shelf-life stability of both coated and uncoated melon dices.

Weight loss, Color, Extraction of Juice, pH, Total soluble solids, Reducing sugars and Titratable acidity

Weight loss: Weight loss percentage was determined according to procedure as mentioned in AOAC (2006).

Color

Color was determined according to the method of Rocha and Morais (2003).

Total soluble solids: The total soluble solids of the treated samples were directly recorded by Digital Refractometer (Mod. RA-600 refractometer, Kyoto Electronics Manufacturing Co., Ltd., Japan) according to the standard procedure of AOAC (2006).

Reducing sugars: The estimation of reducing sugar was carried out according to Lane and Eynon method as described in AOAC (2006).

Acidity: The acidity of each sample was determined using digital fruit acidity meter QA Supplies LLC, Model GMK-835, USA. Pour distilled water up to 30ml line in a dilution bottle by using a barrel syringe. Squeeze melon juice into a cup. Take 300µl of the juice sample with a pipette and put it in the dilution bottle. Close the cap of the dilution bottle and shake it well. Place some diluted melon juice fully on sample well. Press MEAS button to take test result. Test result was appeared on LCD within 10 seconds. Clean sample well after measurement. Without any sample, meter shows 0.00%.

Ascorbic acid (Vitamin C): The ascorbic acid content was estimated using 2, 6-dichlorophenol indophenol dye, according to the prescribed method of AOAC (2006). Ascorbic acid reduces 2, 6- dichlorophenol indophenol from light pink to a colorless solution.

Table: Treatments was used in study

Treatments	Chitosan coatings (%)	Alginate coatings (%)
***T_o**	–	–
T_1	1	–
T_2	2	–
T_3	3	–
T_4	–	1
T_5	–	2
T_6	–	3

* T_o (act as control) = uncoated melon samples

Statistical analysis: The data obtained for each parameter was subjected to statistical analysis to determine the level of significance and comparison of means was also carried out according to the methods as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

The current research project was an effort to embark the senescence of minimally processed melon dices and to evaluate the role of edible coatings towards their shelf-life stability and quality improvement. Fresh melons were procured from the local market subjected to dicing after washing. Carbohydrate based coatings namely chitosan and alginate based coatings were developed in the Postgraduate Research Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Melon dices were dipped in the prepared coating formulations for 2 minutes and allowed to dry for 15-20 minutes at ambient temperature. Both coated and uncoated melon dices were then stored in controlled climate chamber at 4-6°C and 85% relative humidity for 12 days period. During storage, physico-chemical analyses were performed on the coated melon dices after every 3 days interval to evaluate the efficiency of edible coatings towards preserving the dices quality.

Effect on weight loss:

Weight loss is a primary problem in losing weight by reducing moisture content from fruits through rapid ripening and respiration processes which ultimately become the reason of quick transpiration process (Mir and Beaudry, 2004; Toivonen and Brummell, 2008). By decreasing the turgor pressure and firmness of fruit, the weight loss start to increase which become reason for becoming softer fresh cut fruits (Beaulieu and Gorny, 2002).

Fruits are accepted on its water content which ultimately reveals its freshness and shelf life. The lowest weight loss was observed in T_6 (alginate 3%) followed by T_3 whereas the highest weight loss was found in T_o (control) followed by T_1 (chitosan 1%) and T_4 (alginate 1%) with the storage losses respectively as presented in Graph 1. These results are in accordance with the study of Chiumarelli *et al*. (2011), who reported that cassava starch and alginate based coatings showed minimizing weight loss in fresh-cut mango than untreated fruit.

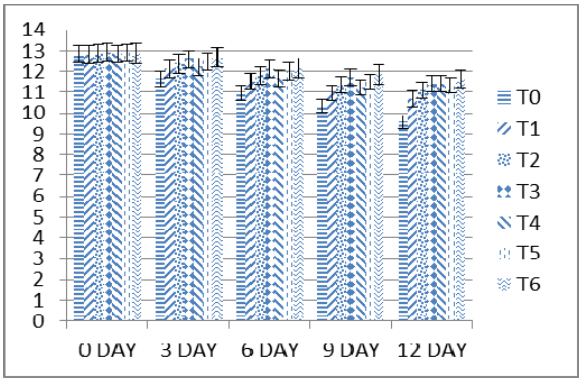
It is obvious from the Table 5 that weight loss of treated melon gradually decrease during whole storage intervals. Where quite lower loss was observed on zero day while the highest loss was observed at 12^{th} day (last day) of storage. Similarly higher loss of peeled litchi was observed by Dong *et al*. (2004) during its whole storage time. This weight loss might become the reason of rapid respiration process as Perdonesa *et al.* (2012) found in his study while treating strawberry through chitosan and alginate along with 3% lemon essential oil.

The interaction between chemical treatment and storage intervals also showed high significantly result in weight loss of melon dices. The lowest weight loss observed in T_3 at zero day of storage time followed by T_5, T_2 and T_6 on same day of storage. However, the highest stability with lowest degree of weight loss was observed in T_6 on 3^{rd} day of storage followed by T_3 and T_5 . Whereas, during whole storage time the highest weight loss was recorded in untreated treatment (T_o) on 12 day of storage followed by T_1 and T_2.

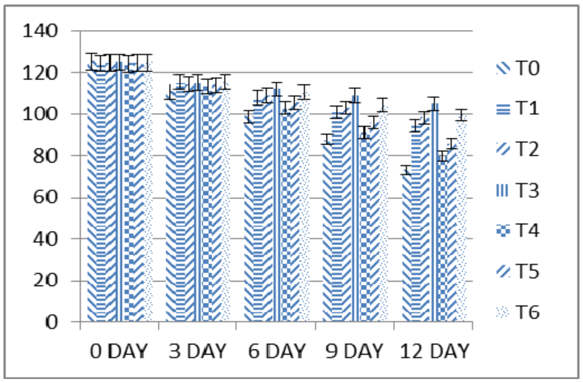
Effect on Color: Ripening of fruits is a character develops through losing their green color (Basetto *et al*., 2005) for changing to their respective color. In present experiment, selective concentrations of chitosan and alginate were used for reducing the color changes of fresh-cut melon during storage. The least color change (CTn) was observed in T_3 followed by T_6 and T_2 whereas the highest color change was found in T_o followed by T_4 and T_5 with the storage losses of respectively as presented in Graph 2.

Color change of treated melon dices showed decrease in color change during whole storage intervals. Where quite lower color was observed on zero day, maximum color change was observed at the last day (12^{th}) of storage. Similarly, Rocha and Morais (2003) observed a decline in color of apples with the passage of time. The interaction between chemical treatment and storage intervals also found highly significantly different in color change of melon slices. The minimum color change was observed in T_o at storage interval of zero day followed by T_3, T_6 and T_2 with the color variation of and respectively on same day of storage. However, T_1 showed higher stability with minimum color change on 3rd day of storage followed by T_6 whereas the maximum color deviation was observed in T_o on 12 day of storage. Moreover, Olivas *et al.* (2007) explicated that alginate coatings delayed browning in fresh-cut apples then control during whole storage time.

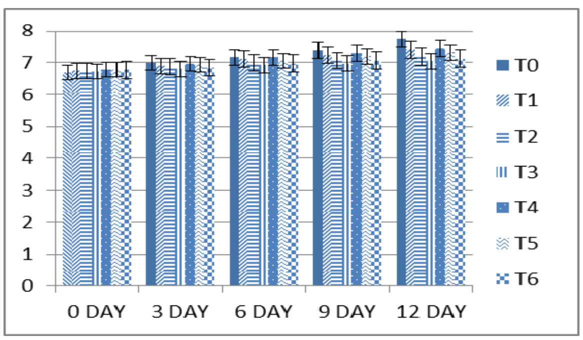
Total soluble solids: Decrease in the moisture content of fruits due to rapid respiration results in enhancement of total soluble solids (TSS). In present experiment, selective concentrations of chitosan and alginate were used for reducing



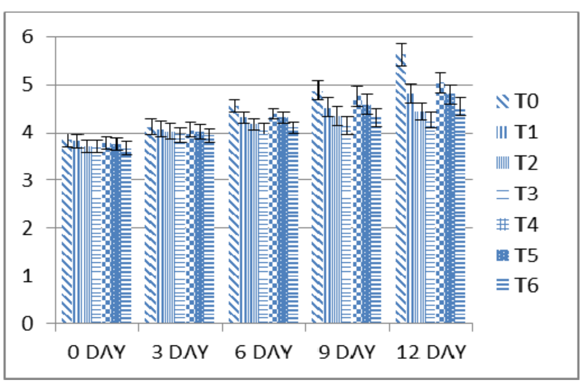
Graph 1: Weight Loss



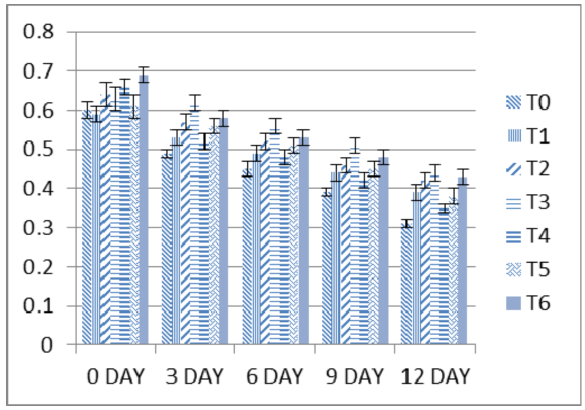
Graph 2: Effect on Color



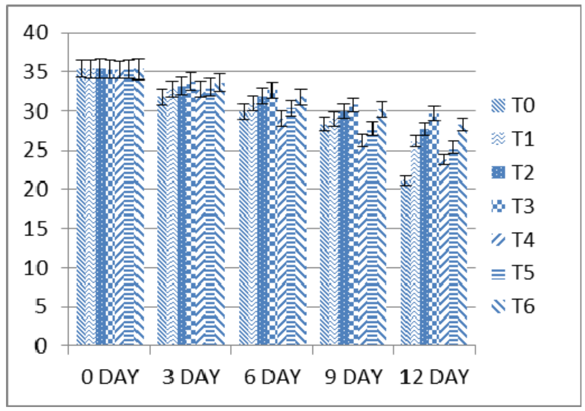
Graph 3: Effect on Total Soluble Salts



Graph 4: Reducing Sugars



Graph 5: Acidity



Graph 6: Effect on ascorbic acid

the respiration process which might become the reason of increasing total soluble solid (TSS) contents in fresh-cut melon during storage. The statistical result describes that both edible coatings and storage intervals exhibited significant ($P<0.01$) effect on the TSS of melon dices. The interactive effect of treatments and storage intervals showed significant ($P>0.01$) results with respect to acidity of fresh-cut melon. The maximum content of TSS was observed in T_o followed by T_4 and T_1 whereas the minimum TSS was found in T_3 followed by T_6 and T_2, respectively as disclosed in Graph 3. Similarly, Dang *et al.* (2010) reached with conclusion that controlled atmosphere storage for chitosan acetate treated berries and prunes led to a mild increase in total soluble solids. They delineated that edible coatings effectively maintained quality attributes and extended postharvest life of the sweet cherries.

It is obvious from the Graph 3 that TSS of treated melon dices showed gradual increase during whole storage interval. Maximum TSS was observed at the end of study 12^{th} day of storage while minimum was observed at initiation of study. The current findings are in harmony with the Nongtaodum and Jangchud (2009), they explained that total soluble solids of fresh cut mango slices of both uncoated and chitosan coated increased with storage.

The interaction between treatment and storage intervals also found significantly different in TSS of melon dices as observed in Graph 3. The lowest TSS contents were observed in T_o at storage interval of zero day followed by T_3 and T_2 with the TSS, respectively, on same day of storage. However, T_3 showed minimum increase in TSS on 3rd day of storage followed by T_6 whereas the maximum increase in TSS was record in T_o on 12 day of storage.

Effect on reducing sugars: Enzymes present in fruits may cause effect on reducing sugars. It has also been observed that starch accumulation is due to sucrose synthase and it also involve in conversion of starch to sugar.

The maximum content of reducing sugars was observed in T_o followed by T_4 and T_1 whereas the minimum reducing sugars was found in T_3 followed by T_6 and $T_{2,}$ respectively as presented in Graph 4. Similarly, Tanda-Palmu and Grosso (2005) investigated biochemical changes during storage of strawberry fruit coated with gluten film. They found that fruit coating slows down the over ripening process which is responsible for increasing the level of reducing sugars in fruit.

It is obvious from the Graph 4 that reducing sugars of treated melon dices showed persistent increase during whole storage interval. Where maximum reducing sugars was observed at the end of this study12th day of storage while minimum was observed at preclusion of study. The current findings are in harmony with the work of Medlicot and Thompson (2006) they explained that the reducing sugars of mango pulp were increased during storage.

Effect on Acidity: It has been found that with the increase of acidity decreases in fruits and vegetables quality during storage period. Olivas and Barbosa-Canovas (2005) demonstrated that the acidity is often used as an indicator of maturity. The result indicated that both edible coatings and storage intervals exhibited significant ($P < 0.01$) effect on the acidity of melon dices. The interactive effect of treatments and storage intervals showed non-significant ($P > 0.05$) results with respect to acidity of fresh-cut melon.

The lowest acidity was observed in T_o followed by T_4 0.47±0.01% and T_1 whereas the maximum acidity was found in T_3 followed by T_6 and T_2 as it is revealed in Graph 5. These results are in accordance with the study of Chien *et al.* (2007), who found higher decrease trend in acidity of control then treated mango slices with chitosan till 7th day of storage.

It is obvious from the Graph 5 that decreasing trend in acidity of melon dices was observed in between the storage interval of 0 to 12th day. Higher acidity in melon dices were observed at 0 day while the lowest acidity was observed on 12th day of storage. Similarly Perez-Gago *et al*. (2006) found decreasing trend in acidity of apple during their whole period.

Effect on ascorbic acid: Ascorbic acid contents in different fruits decrease with the advancement of storage life. Ascorbic acid is most likely to convert into dehydroascorbic acid and then further degraded to 2, 3 diketo-gluconic acid. In present experiment, selective concentrations of chitosan and alginate were used in different combinations to reduce the loss of ascorbic acid from melon dices. The result indicated that treatments, storage intervals along with their interaction showed significant ($P<0.01$) results on the ascorbic acid contents of melon dices.

The lowest ascorbic acid content (mg/100g) was observed in T_o while maximum ascorbic acid content was observed in T_3 followed by T_6 as presented in Graph 6. These results are in accordance with the study of Olivas *et al*. (2007), who found that edible coatings are helpful to reduce the loss of weight and ascorbic acid in strawberry. Similarly, Gorny *et al.* (2002) observed significantly higher contents of ascorbic acid in treated fresh-cut pear slices than control.

It is obvious from the Graph 6 that ascorbic acid content of treated melon dices showed gradual decline during storage interval. Where quite lower loss was observed on zero day while the highest loss was observed at the last day (12th) of storage. Similarly, Olivas *et al*. (2007) who observed alginate and chitosan coatings on apple slices proved to work effectively as compared to soy protein coating as ascorbic acid barriers during the entire storage period. Huang *et al.* (2011) found that higher ascorbic acid loss was observed in untreated fruits than treated with protein isolates during whole storage time.

The interaction between treatment and storage intervals also causes highly significant difference in ascorbic acid content of melon dices. The lowest ascorbic acid loss was observed in T_o at storage interval of zero day followed by T_6, T_2 and T_1 on same day of storage. However, T3 showed higher stability with minimum ascorbic acid loss on 3rd day of storage followed by T_6 whereas the highest ascorbic acid loss was observed in T_o on 12 day of storage. Moreover, Chien *et al*. (2007) explicated that ascorbic acid content of mango dices treated with chitosan decreased after seven days of storage. However, chitosan treated slices have greater value of ascorbic acid as compared to control.

CONCLUSION

Edible coatings have become a promising tool to reduce alarming post-harvest losses of fruits and vegetables. Traditionally, these coatings were used to enhance food appearance of different fruits and vegetables. Over the years, edible coatings have become an encouraging method to maintain the shelf life and improve quality of fruits and vegetables. Coated items can easily be exported and transportation losses will also be curtailed. In the nutshell, edible coating is an innovative technique to be adopted in Pakistan for multifarious objectives which not only increases the value of fruits and vegetables in the foreign market but also attracts the local market. Future perspectives of the present research includes the application of chitosan coatings on minimally processed mango, papaya and apples to meet the escalating demand of ready to eat fresh fruits and vegetables. These coatings can also be used as a fortification tool for various commodities to combat with various iron and zinc deficiencies.

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