EFFECT OF EDIBLE FILM COATING ON POST STORAGE QUALITIES OF TOMATOES DURING REFRIGERATED STORAGE

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ABSTRACT

Mature green tomatoes were subjected to investigation on the effect of pectin as an edible coating on the storage quality and the shelf life during refrigerated at 15°C. Fruits were tested for physiological weight loss, ascorbic acid, titratable acidity and total sugars during storage and ripening. Coated tomatoes at Red stage were subjected to statistical analysis at 5% significant level. Fruits coated with 5% pectin solution were found to be the most effective in minimizing the weight loss by 1.56% at red stage. Tomatoes coated with 3% of pectin showed greater retention of titratable acidity and total sugars of 0.39% and 20.2% and reduced the ascorbic acid loss by 2.39 mg% respectively, during the storage and ripening. The ripening of tomato fruits was delayed by the coating and the tomatoes coated in 3% pectin solution were kept for 24 days without decay. In sensory analysis, the highest overall acceptability was observed in the tomatoes coated with 3% pectin solution compared to other treatments. Based on these results, tomatoes coated with 3% of pectin solution stored at 15°C were selected as the best treatment to maintain the post storage qualities during ripening.

Key words: Fruit quality, refrigeration, shelf life, skin coating, tomatoes

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a popular vegetable in the tropics which are important sources of vitamins A and C. In Sri Lanka, tomato is grown widely in many parts of the wet and intermediate zones where the environmental conditions are favourable for its cultivation and it is also grown most of the year in some parts of the dry zone. However, the postharvest losses of tomato in Sri Lanka are estimated to be 40%, which contribute to high market prices. Reduction in postharvest losses could reduce unit cost of production. Therefore, many storage techniques have been developed to extend the useful marketing distances and holding periods for fresh horticultural commodities after harvest. They are generally based on refrigeration with or without control of composition of the atmosphere (Watada *et al.,* 1996).

Refrigeration can serve to slow metabolic reactions including respiration, transpiration and enzymatic activity which may deteriorate the produce. The temperature and relative humidity of a commodity which is stored is usually very specific to that particular product. Perishable fruit and vegetable products should be maintained at RH levels of 90-95%. If storage temperatures are too low, chilling injury may result and the humidity levels which exceed 95% enhance the growth of microorganisms of the product. (Salunkhe *et al.,* 1991).

Tomatoes are chilling sensitive at temperatures below 10°C if held for longer than 2 weeks or at 5°C for longer than 6-8 days. (Suslow and Cantwell, 2006) Consequences of chilling injury are failure to ripe and develop full colour and flavour, irregular (blotchy) colour development, premature softening, surface pitting, browning of fruits and increased decay especially Black mould caused by *Alternaria alternata lycorpersici*.

Edible skin coating is another technique used to extend the postharvest shelf life of the fruits nowadays. Edible coatings are thin layers of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings and provide a barrier to moisture, oxygen and solute movement for the food (McHugh and Senesi, 2000). An ideal coating is defined as one that can extend storage life of fresh fruit without causing anaerobiosis and reduces decay without affecting the quality of the fruit. (Guilbert *et al.,* 1996). Today, coatings are used for fresh fruits and vegetables to retard moisture loss, improve appearance by imparting shine to the surface and create a barrier for gas exchange between the commodity and the external atmosphere.

This study was conducted to select the suitable concentration of pectin solution to extend the shelf life and to evaluate the effect of coating on post storage qualities of tomatoes during refrigeration.

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METHODOLOGY

2.1. Material Collection and Sample Preparation

Tomatoes (cv. KC-1) harvested at mature green stage were obtained from a commercial grower in the Batticaloa District. After purchase, each fruit was washed with cold water and with 0.5% sodium hypochlorite solution for disinfection. After rinsing, the fruit were blotted dry with paper towels and allowed to dry at ambient temperature. Commercially available pectin (Food Ingredient Suppliers, Sri Lanka) was prepared into solutions by dispersing it in 100 mL mild warm water whilst stirring with a magnetic stirrer at room temperature at the concentrations of 1, 3 and 5% (w/v) and allowed to homogenize, with moderate stirring until complete dissolution. After homogenization, the whole mature green tomato fruits were dipped separately for 5 minutes into the pectin gels. Excess gel was allowed to drain off and the fruits were allowed to dry and stored at 15°C along with uncoated fruit samples which consisted 15 fruits per each sample.

The treatments are listed as follows:

Tomatoes without coating stored at 15°C - Control	T_1
Tomatoes coated with 1% pectin solution stored at 15°C	T_2
Tomatoes coated with 3% pectin solution stored at 15°C	T_3
Tomatoes coated with 5% pectin solution stored at 15°C	T_4

2.2. Nutritional,Shelf life and Sensory Evaluation of Tomatoes

The physiological weight loss, titratable acidity, ascorbic acid and total sugars were analyzed at different ripening stages such as breakers, turning, pink, light red and red by using the USDA colour chart. All the nutritional analyzes were carried out using the recommended AOAC (2000) methods. Three replicates were tested for each treatments. Number of days taken for ripening and shelf life were evaluated for the treated fruits along with the control. The sensory evaluation was carried out by a panel consisting of 20 trained people by using a nine-point hedonic scale. Organoleptic assessment was conducted for the colour, firmness, flavour, absence of off-flavour, and overall acceptability for the best treated pectin coated tomatoes which were based on the nutritional and shelf life studies.

2.3. Statistical Analysis

Nutritional and shelf life studies were analyzed by Analysis of Variance (ANOVA) and the difference between means was compared using Duncan's Multiple Range Test (DMRT), using Statistical Analysis System (SAS) software package while the Sensory parameters were analyzed by Friedman's Test using Minitab software.

RESULTS AND DISCUSSION

Weight change is related to storage temperature and duration. Postharvest weight changes in fruits are usually due to loss of water through transpiration (Ball, 1997). Weight loss of coated tomato fruits was relatively smaller than the uncoated tomato fruits. The highest weight loss 1.78% was observed in the tomatoes without coating whereas the lowest 0.22% was observed in the tomatoes which were coated with 5% pectin solution at Red stage (Table 1).

Treatments	Physiological Weight Loss (%)
T_1	1.78 ± 0.003^a
T_2	0.58 ± 0.006^b
T_3	0.33 ± 0.015^c
T_4	0.22 ± 0.006^d

The values are means of triplicates ± standard error

The differences of physiological weight loss between coated and uncoated tomatoes is supported by Lin and Zhao (2007) where edible coatings provide an effective barrier to oxygen and carbon dioxide transmission and help to alleviate the problem of moisture loss and low temperature also plays a role in preventing the weight loss.

The ascorbic acid content increased at progressive stages during ripening of tomatoes. The retention of ascorbic acid is higher in coated fruits than the uncoated fruits at the Red stage. Tomatoes coated with 3% pectin solution stored at 15°C showed the highest value of ascorbic acid among other treatments at Red stage (10.39 mg%) where the uncoated fruits showed 8.00mg% (Figure 1). This is due to low oxygen availability in coated tomatoes which reduced the loss of ascorbic acid by oxidative deterioration. Sumnu and Bayindirli (1994) also supports that the retention of ascorbic acid is due to coating related to the reduction of respiration of the fruits.

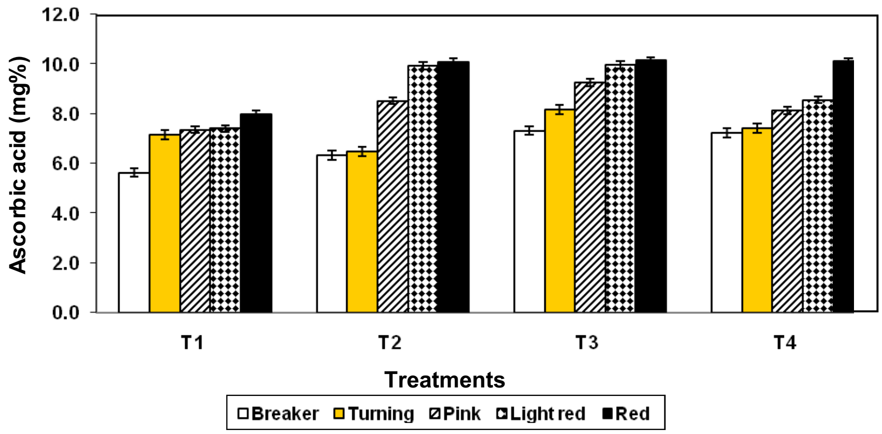

Figure 1: Changes in Ascorbic Acid of Pectin Coated Tomatoes at Different Ripening Stages

The study showed that the ascorbic acid increased significantly ($p<0.05$) between the treatments at ripe stage except in the treatment T_4, where the tomatoes coated in 5% pectin solution compared to control (T_1). This is due to the hydrophilic nature of polysaccharide films which exhibits only a limited moisture barrier at low temperature. Therefore, it provides a viscous nature and increases the respiration rate and oxidation of ascorbic acid in the fruits.

In this study, titratable acidity showed a significant change during storage. The rate of reduction in acidity in coated fruits compared to uncoated fruits is low due to restriction of oxygen availability which is minimizing the usage of acidity in the ripening process (Bayindirli *et al.,* 1995) (Figure 2).

ripening in climacteric fruits. Titratable acidity of the tomatoes coated with 3% pectin had the least mean value of 0.3% but significantly not differed from the other treatments which is supported by Dragan and Tomaz (2006) that there were no significant differences among acidity at the end of ripening period.

Sugars, acids and their interactions are important to sweetness, sourness and overall acceptability in tomatoes. The percentage of total sugar in tomato fruits increased initially and then decreased in all coated and uncoated tomato fruits, due to the ripening and respiration of the fruits takes place simultaneously. At the Red stage, coated fruits showed higher amount of total sugars than the uncoated fruits which is shown in table 2. But at the same time the total sugar

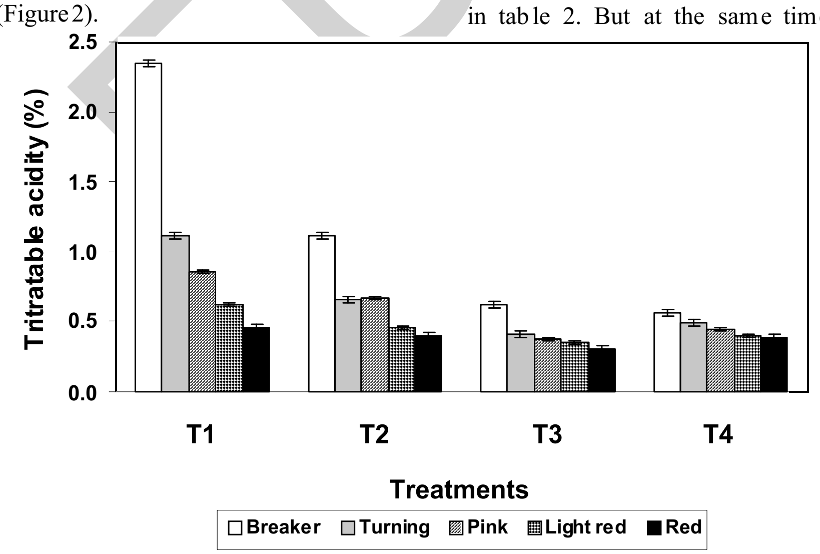

Figure 2: Changes in % Titratable acidity of Pectin Coated Tomatoes at Different Ripening Stages

The thickness of coating conjunction with low temperature made the rate of change of titratable acidity relatively small in T_3 and T_4 due to the retardation of

percentage declined between treatments T_3 and T_4 due to limited hydrophilic nature of polysaccharide coatings which is supported by Baldwin (2003).

Table 2: The Total Sugar of Pectin Coated Tomatoes at Red Stage

Treatments	Total Sugars (%)
T_1	11.59 ± 0.003^{d}
T_2	18.62 ± 0.006^{b}
T_3	20.25 ± 0.003^{a}
T_4	17.28 ± 0.003^{c}

The values are means of triplicates ± standard error

The number of days taken for the coated tomatoes to attain the Red stage is shown in table 3. Significant differences have obtained between the treatments stored at 15°C from T_1 to T_4 to attain the Red stage. There is no significant difference between the treatments T_3 and T_4 which had the highest mean value of 18 days to ripe. Studies pointed out that coating create a modified atmosphere inside the fruits and vegetables that delays ripening and senescence (Lin and Zhao, 2007). Therefore, the coated tomatoes at 3 and 5% pectin solution took 18 days to ripe at the storage temperature of 15°C.

Table 3: Number of Days taken for Ripening and Shelf Life of Pectin Coated Tomatoes

Treatment	Number of Days taken for Ripening	Shelf Life
T_1	10 ± 0.58^{c}	22 ± 1.00^{b}
T_2	12 ± 1.53^{bc}	22 ± 1.00^{b}
T_3	18 ± 1.16^{a}	24 ± 1.16^{b}
T_4	18 ± 0.58^{a}	20 ± 1.16^{b}

The values are means of triplicates ± standard error

The shelf life of tomatoes was determined in terms of days until the peel of fruits turned to sunken and began to decay. The uncoated tomato fruits perished by the end of 22 days. Tomatoes coated with 3% pectin coatings extended the shelf life of tomato fruits up to 24 days (Table 3). Studies showed that coatings provide sufficient gas barrier in controlling gas exchange between the fresh produce and its surrounding atmosphere, which would slow down respiration and delay deterioration (Lin and Zhao, 2007). However, tomatoes coated with 5% pectin solution showed lower shelf life and higher decay percentage than those with other treatments. Dragan and Tomas (2006) stated that the refrigeration temperature increases the hydrophilic nature of coating and thereby increases the viscosity of pectin which leads to high perishability.

Sensory analysis showed (Table 4) that there were significant differences between the treatments for the organoleptic characters. Retention of firmness and flavour were higher in coated fruits than the uncoated fruits due to the decrease in water loss and the restriction of the exchange of volatile compounds between the fresh produce and its surrounding environment.

The sample coated with 3% pectin solution (T_3) had the highest mean value which showed no significant difference with the treatment where the tomatoes coated with 1% of pectin solution (T_2) in colour, firmness and flavor. McDonald *et al.,* (1999) revealed that storage under lower temperature reduces the enzymatic activities and the loss of luminance, resulting from normal ripening and storage process as well as the cold storage also tends to limit the development of aroma volatiles in the ripening of fruits and also convert the sugars to starch. The absence of off-flavour showed a non-significant difference among all the treatments where the treatment T_3 had the highest mean value which is also supported by Zhao and McDaniel (2005) where edible coatings can retard ethylene production and delay the ripening process, thus preventing the development of off-flavours and odours. Tomatoes coated in 3% of pectin solution (T_3) had the highest mean value among the treatments in overall acceptability which is significantly not differed from other treatments.

CONCLUSION

The concept of using an edible film or active packaging to extend the shelf life of fresh products and protect

Table 4: Sensory Evaluation of Pectin Coated Tomatoes Stored at 15°C.

Treatments	Colour	Firmness	Flavour	Absence of Off-flavour	Overall Acceptability
T_1	5.85 ± 0.27^{b}	6.50 ± 0.26^{bc}	6.75 ± 0.31^{c}	7.65 ± 0.21^{a}	5.65 ± 0.22^{b}
T_2	6.05 ± 0.17^{b}	6.80 ± 0.35^{bc}	7.15 ± 0.27^{bc}	7.30 ± 0.23^{a}	5.80 ± 0.32^{b}
T_3	6.15 ± 0.15^{b}	7.00 ± 0.29^{ab}	7.20 ± 0.22^{abc}	7.65 ± 0.18^{a}	6.30 ± 0.22^{b}

The values are means of 20 replicates ± standard error them from harmful environmental effects is a widely practiced technique nowadays. In fact, the idea is derived from the natural protective coating on some foods such as the skin of fruits and vegetables. So the main reason the fresh produce industry uses coatings is to improve appearance, reduce water loss, delay ripening and reduce disorders.

This research was designed to delay the ripening and to extend the shelf life of mature green tomatoes with edible skin coating of pectin and to find out its effect on the quality of ripe tomatoes. The findings of the study showed that the tomatoes coated in the 3% pectin solution which were stored at 15°C was the best treatment in nutritional, organoleptic and shelf life's point of view compared to other treatments. The results of physiological weight loss revealed that the tomatoes coated in 5% pectin solution showed the lowest weight reduction during the storage period. Based on the nutritional analysis, at the end of ripening tomatoes stored with 3% of pectin solution showed better results in the retention of ascorbic acid, titratable acidity and total sugars. The shelf life study revealed that the tomatoes coated with 3% pectin solution were the best treatment which can be kept for 24 days without decay. The sensory analysis showed that the highest overall acceptability was observed in the tomatoes coated with 3% pectin solution. Therefore, 3% Pectin solution was selected as the most effective and desirable edible coating for the commercial application of mature green tomatoes which reduced the moisture loss, maintained the nutritional qualities, colour, fruit firmness and freshness.

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