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Active Packaging of Green Mature Tomatoes with Pectin Coating to Extend the Shelf Life

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Abstract

A study was conducted to investigate the effect of pectin as an active packaging on the storage quality and the shelf life of mature green tomatoes (cv. KC-1). The tomatoes were dipped into the concentrations of 1, 3 and 5% (w/v) pectin solutions for 5 minutes and stored at 30°C. Fruits were tested for physiological weight loss, ascorbic acid, titratable acidity and total sugars at different ripening stages such as breaker, turning, pink, light red and red. Fruits were also evaluated to determine the number of days taken for ripening and shelf life. Based on the quality parameters the best treatments were assessed for sensory characteristics using nine-point hedonic test. Fruits coated with 5% pectin solution showed most effective result in minimizing weight loss at red stage and tomatoes coated with 3% of pectin showed greater retention of ascorbic acid, titratable acidity and total sugars during storage. The ripening of tomato fruits was delayed by the pectin coating and the tomatoes coated with 3% pectin solution were kept for 28 days without decay. In the sensory analysis, highest overall acceptability was observed in the tomatoes coated with 3% pectin solution. Based on these results, tomatoes coated with 3% of pectin solution stored at 30°C was found to be the best treatment to extend the shelf life of the tomatoes.

Key words: *Active packaging, pectin, quality, shelf life, tomatoes*

INTRODUCTION

Fruit perishability is a main problem faced by the farmers during their marketing of the commodity. Tomato is a delicate fruit which contributes 40 - 60% of postharvest losses in Sri Lanka. Reduction in postharvest losses could reduce unit cost of production. Many techniques such as low temperature, high relative humidity control, controlled and modified atmosphere packaging have been studied in order to overcome these problems and to extend the shelf life of tomatoes. However, the maintenance of the quality of fresh produce is still a major challenge for the food industry. At present, active packaging such as edible skin coatings have many advantages over other techniques, but only when the coated products are stored at proper temperatures. Such coatings are made of edible materials which provide a semi permeable barrier to gases and water vapor. 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 [1].

Skin coatings are applied directly on the food surface by dipping, spraying or brushing to create a modified atmosphere. Previously, edible coatings have been used to reduce water loss, but recent developments of formulated edible coatings with a wider range of permeability characteristics extended the potential for fresh produce application [2]. The effect of coatings on fruits and vegetables depends greatly on temperature, pH, thickness, type of coating, variety and ripening stages of the fruit [3]. Edible coatings may be composed of polysaccharides, proteins, lipids or a blend of these compounds. Their presence and abundance determine the barrier properties of material with regard to water vapor, oxygen, carbon dioxide and lipid transfer in food systems [4].

Generally, the potential benefits of edible coatings and films for lightly processed produce are to stabilize the product and thereby extend product shelf life. More specifically, coatings have the potential to reduce moisture loss, firmness loss, provide moisture and oxygen barrier properties, retard respiration rates, retard ethylene production, seal in flavour volatiles and improve the appearance. The major benefit of edible coatings is that they can be consumed along with food, provide additional nutrients, enhance sensory characteristics and include quality enhancing antimicrobials [4].

In this research study, green mature tomatoes were dipped in different concentrations of pectin solution and stored at room temperature in order to extend shelf life and maintain the quality by using polysaccharide edible coating. Therefore, 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 nutritional and sensory qualities during storage and ripening of tomatoes.

METHODOLOGY

Material Collection and Sample Preparation

Tomatoes 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 in ambient temperature of 30°C. Commercially available pectin (Food Ingredient Suppliers, Sri Lanka) was used in this study. The solutions were prepared by dispersing pectin 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 in 30°C along with uncoated fruit samples. The treatments are listed as follows:

Tomatoes without coating stored at room temperature (30°C) - Control	T_1
Tomatoes coated with 1% pectin coating stored at room temperature (30°C)	T_2
Tomatoes coated with 3% pectin coating stored at room temperature (30°C)	T_3
Tomatoes coated with 5% pectin coating stored at room temperature (30°C)	T_4

Nutritional Analysis of Tomato during Storage and Ripening

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 nutritional analyzes were carried out using the recommended AOAC (2000) methods.

Shelf life Evaluation

The treated fruits along with the control were subjected to shelf life evaluation. The samples were tested daily and observations were made to evaluate the number of days taken for ripening, spoilage, off-flavour development and decay percentage.

Sensory Evaluation

The sensory evaluation was carried out by a panel consisting of 20 trained people. Organoleptic evaluation was carried out 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. Panelists were asked to rate the samples using a nine-point hedonic scale in 1 is denoted as "dislike extremely" and 9 denoted as "like extremely".

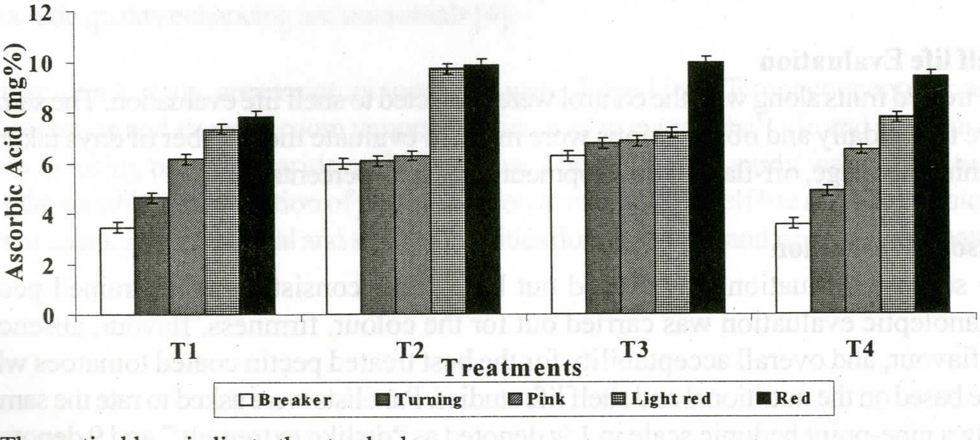
Statistical Analysis

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

A number of physico-chemical changes take place in fruits during storage. Weight loss of coated tomato fruits was relatively smaller than the uncoated tomato fruits. The highest weight loss (17.8% ± 0.003) was observed in the tomatoes without coating whereas the lowest (0.87% ± 0.006) was observed in the tomatoes which were coated with 5% pectin solution. The differences of physiological weight loss between coated and uncoated tomatoes is supported by [5] where edible coatings provide an effective barrier to oxygen and carbon dioxide transmission and help to alleviate the problem of moisture loss. The physiological weight loss of coated tomatoes fell significantly ($p<0.05$) between the treatments at Red stage compared to control T_1 [5].

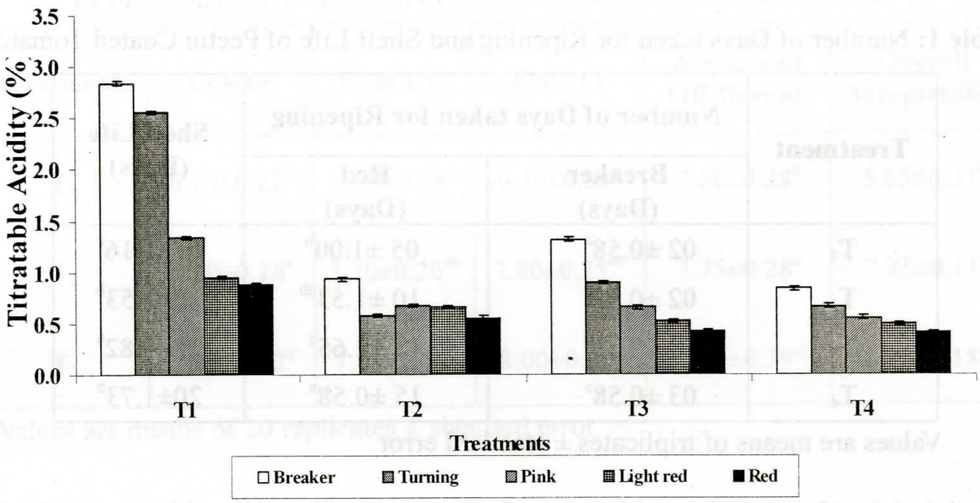
The ascorbic acid of mature green tomato was 3.0 mg%. The ascorbic acid content increased at progressive stages during ripening of tomatoes. The retention of ascorbic acid is higher in coated fruits than the uncoated fruits at the Red stage. Tomatoes coated with 3% pectin solution showed the highest retention of ascorbic acid among the tested treatments at Red stage (9.96 mg%) whereas the uncoated fruits had the lowest value of 7.72 mg%, respectively as shown in Fig 1.



The vertical bars indicate the standard errors.

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

This is supported by [6] where the retention of ascorbic acid which is due to coating is related to the reduction of respiration of the fruits and [7] stated that low oxygen permeability of coating reduces the ascorbic acid oxidation. The study showed that the ascorbic acid increased significantly ($p<0.05$) between the treatments at Red 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. Therefore, it provides a viscous nature and increases the respiration rate and oxidation of ascorbic acid. The prominent titratable acidity in tomato is citric acid which was 2.95% in mature green tomatoes. In this study, titratable acidity showed a significant change during storage. It declined over the ripening stages due to the climacteric rise in respiration over the degree of ripeness and with maturity evolution which is supported by [8]. The rate of reduction in acidity in coated fruits compared to uncoated fruits is low due to restriction of oxygen availability which leads to reduced respiration rate and thus use of acid as substrate in respiration is minimized [7] (Fig 2).



The vertical bars indicate the standard errors.

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

Titratable acidity showed a significant difference between the treatments where the tomatoes coated in 5% pectin stored had the value of 0.41% but significantly not differed from the treatment where the tomatoes coated with 3% pectin solution (T_3). This is supported by [9] that there were no significant differences among acidity during ripening.

The percentage of total sugars in tomato fruits increased initially and then decreased in all coated and uncoated tomato fruits, due to the ripening and respiration of the fruits simultaneously. At the Red stage, coated fruits showed higher amount of total sugars than the uncoated fruits. The changes are due to the modified atmosphere created by the fruit that delay ripening [10], but at the same time the total sugar percentage declined between treatments T_3 and T_4 due to limited hydrophilic nature of polysaccharide coatings which is supported by [11]. The total sugar content significantly ($p<0.05$) differed among all treatments at red stage. This shows that coatings create a modified atmosphere and act as gas barrier that delays ripening and reduces respiration that retains the total sugars in the fruit which is also supported by [12].

The number of days taken for the coated tomatoes to attain the Breaker and Red stage is shown in Table 1. There was no significant difference between the treatments stored at 30°C from T_1 to T_4 to attain the Breaker stage. However, the number of days taken to attain Red stage showed much difference between coated and uncoated tomatoes.

Table 1: Number of Days taken for Ripening and Shelf Life of Pectin Coated Tomatoes

Treatment	**Number of Days taken for Ripening**		**Shelf Life (Days)**
	Breaker (Days)	**Red (Days)**	
T_1	02 ±0.58^a	05 ±1.00^b	08±1.16^c
T_2	02 ±0.33^a	10 ±1.53^{ab}	22±1.53^b
T_3	02 ±0.33^a	15 ±2.65^a	28±0.82^a
T_4	03 ±0.58^a	15 ±0.58^a	20±1.73^b

Values are means of triplicates ± standard error

There is no significant difference between the treatments T_3 and T_4 which got the highest mean value in the Red stage. Studies pointed out that coating create a modified atmosphere inside the fruits and vegetables that delays ripening and senescence [5]. The coated tomatoes took 15 days to ripe at the storage temperature of 30°C. The shelf life of tomatoes was determined in terms of days until the peel of fruits turned to pulp and began to decay. The uncoated tomato fruits perished by the end of 08 days. Tomatoes coated with 1 and 3% pectin coatings (T_2 and T_3) extended the shelf life of tomato fruits up to 22 and 28 days (Table 1) respectively. 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 [5]. However, tomatoes coated with

5% pectin solution showed lower shelf life and higher decay percentage than those with other treatments. Coatings exceeding a critical thickness can cause detrimental effects by reducing internal oxygen concentration and increasing anaerobic fermentation [13]. Therefore, the tomato coated in 3% pectin solution in the room temperature (T_3) which is significantly varied from other treatments can be kept for 28 days without decay.

Sensory analysis showed (Table 2) that there were significant differences between the treatments for the organoleptic characters. The samples of tomato selected for the sensory evaluation (T_1, T_2, and T_3) were based on the nutritional and shelf life studies. The sample coated in 1% of pectin solution (T_2) had the highest mean value which was not significantly differed from the treatment coated in 3% of pectin solution (T_3). 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 [5].

Table 2: Sensory Evaluation of Pectin Coated Tomatoes Stored at 30°C.

Treatments	Colour	Firmness	Flavour	Absence of Off-flavour	Overall Acceptability
T_1	6.15 ± 0.22^{b}	6.00 ± 0.28^{c}	6.70 ± 0.36^{c}	7.50 ± 0.28^{a}	5.65 ± 0.33^{b}
T_2	8.30 ± 0.18^{a}	7.20 ± 0.20^{ab}	7.80 ± 0.25^{ab}	7.75 ± 0.28^{a}	7.75 ± 0.14^{a}
T_3	7.85 ± 0.22^{a}	7.80 ± 0.22^{a}	8.00 ± 0.20^{a}	7.90 ± 0.39^{a}	8.35 ± 0.18^{a}

Values are means of 20 replicates ± standard error

The sample coated in 3% pectin solution (T_3) had the highest mean value which showed no significant difference with the treatment where the tomatoes coated in 1% of pectin solution (T_2) in both firmness and flavour. 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 [14] 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 only significantly differed from the control (T_1). Therefore, the treatment where the tomatoes coated in 3% of pectin solution had the highest overall acceptability among the other treatments.

CONCLUSIONS

This research was designed to delay the ripening and to extend the shelf life of mature green tomatoes with active packaging of pectin coating and to find out its effect on the quality on ripe tomatoes. The findings of the study showed that the tomatoes coated in the 3% pectin solution which were stored at 30°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 (Red Stage) tomatoes stored with 3% of pectin coating showed better results in the retention of ascorbic acid, titratable acidity and total sugars. The shelf life study revealed that the tomatoes coated in 3% pectin solution were the best treatment which can be kept for 28 days without decay. The sensory analysis showed that there were significant ($p<0.05$) differences for the organoleptic characters between the treatments. 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. It is also an economically feasible method compared to controlled and modified atmosphere storage and can also be used by the small holding farmers in the developing countries without the need of refrigeration.

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