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Effect of Chitosan Coating on the Physiochemical Characteristics of Guava (*Psidium guajava* L.) Fruits During Storage at Room Temperature

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Abstract

The effect of chitosan coating on the physico-chemical characteristics of guava cv. Allahabad Safeda fruits stored at room temperature (28-32°C and 32-41% RH) was investigated. The fruits were treated with chitosan (1% and 2%) to study its effect on the postharvest life and quality of guava. Various storage attributes were studied at successive intervals of storage. In general, Physiological Loss in Weight (PLW %), respiration rate and TSS increased while firmness and acidity decreased with storage duration. Among various treatments, 1% chitosan treatment was found effective in extending the shelf life upto7 days, as it delayed ripening and retained greater firmness with reduced PLW%. However, the fruits treated with 2% chitosan showed uneven ripening and didn't turn yellow even at the end of shelf life, attributed to CO_2 injury.

Keywords: Chitosan, Guava, Postharvest Quality, Respiration, Storage

1. Introduction

Guava is one of the most delicious and nutritious fruits, liked by the consumers for its refreshing taste and pleasant flavour. Due to its climacteric nature the fruit ripens rapidly and hence highly perishable, with a very short shelf life ranging from 2-3 days at room temperature[5]. The fruit ripening in guava is characterized by loss of green colour, softening, shrinkage, loss of brightness and rot development[2]. Retailing of guava fruits in India is usually carried out under non-refrigerated conditions. Therefore preservation of fruits under ambient conditions is highly desirable in order to increase their shelf-life to facilitate long distance transportation, increase marketable period and thereby improving its commercialization.

Among edible coatings, chitosan, which has a chemical structure close to that of cellulose, has long been known to protect perishable produce from deterioration by reducing transpiration, respiration and maintaining the textural quality. Chitosan (poly β-(1-4)*N*-acetyl-d-glucosamine), a deacetylated form of chitin, is a natural compound obtained from crustacean shells (crabs, shrimp and crayfishes) either by chemical or microbiological processes and can be produced by some fungi too viz., *Aspergillus niger*, *Mucorrouxii*, *Penecillium notatum*[17]. Chitosan has been successfully tried and recommended for enhancing the shelf life of several fruits such as litchi[7], strawberry[9], mango[6], peaches, Japanese pears, and kiwi-fruit[8]. Indeed, chitosan is often considered to be the ideal preservative coating for fresh fruits because of its excellent film-forming and biochemical properties[10]. Keeping all these in view, the present investigation was undertaken to study the effect of different concentrations of chitosan as edible coating on ripening behavior and post-harvest quality of guava fruits under ambient condition.

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2. Materials and Methods

2.1 Sample Preparation

Physiologically mature green fruits of guava cv. Allahabad Safeda were harvested manually from nearby orchards of IIHR during early hours (8.00-9.00 am) of March 2013. The fruits were transported to the laboratory in plastic crates, where they were sorted out to remove immature, misshaped, bruised, diseased and insect infested fruits if any. These fruits were graded as floaters (≤ 1) and sinkers (>1) based on their specific gravity among which floaters (mature) were taken for the experiment. The fruits were then washed, air-dried and treated with chitosan.

2.2 Sample Treatment

Acetic acid (1%) solution was used to dissolve and prepare 1 and 2% chitosan. The solution was stirred for sufficient time using mechanical stirrer for complete dissolution of chitosan. Fruits were dipped in these chitosan solutions for 1-2 minutes, drained and surface dried. Acetic acid (1%) is also taken as one of the treatment since the same is used in dissolving and preparing the chitosan solutions. These fruits were then packed in three non-ventilated CFB boxes, each with 20 fruits and stored under ambient conditions (28-32°C and 32-41% RH).Various attributes were studied at specified intervals of storage.

2.3 Surface Colour

The surface colour of the fruit was measured with colour difference meter (Model: Color Reader, CR-10, Konica Minolta, Japan) in terms of (L, a, b) values.

2.4 Physiological Loss in Weight

The weight of 15 individual fruits were recorded periodically using electronic balance (Model: AND, FX-2000, Japan) from which the cumulative physiological loss in weight (CPLW) was estimated.

2.5 Fruit Firmness

Fruit firmness, as the force required to puncture the fruit, was measured using an Instron-Universal testing machine (Model 4201, USA) and expressed as kg/cm^2.

2.6 Rate of Respiration

Six individual fruits from were enclosed separately in air-tight containers for specified time and the concentrations of O_2 and CO_2 were recorded in the head-space of these containers using a three gas analyzer (Model Checkmate 9900, PBI Dansensor, Denmark). The rate of respiration was calculated and expressed as mg CO_2 kg^{-1} h^{-1}.

2.7 TSS and Titratable Acidity

Quality components like Total Soluble Solids (TSS) and titratable acidity were estimated according to standard methods[13].

2.8 Statistical Analysis

Data were recorded periodically and analysed statistically following completely randomized design[16].

3. Results and Discussion

3.1 Respiration Rate

The respiration rate of guava fruits decreased initially for one day immediately after harvest and then increased with the progression of storage/ripening period irrespective of the treatment. The respiration rate was low in chitosan (both 1% and 2%) treated fruits than control and acetic acid 1% treated fruits throughout the storage period. The control and 1% acetic acid treated fruits have shown a respiratory peak on 4th day, while such climacteric peak was not seen in chitosan (1% and 2%) treated fruits (Figure 1). Among the treatments, 1% chitosan treated fruits have shown lower rate of respiration with suppressed climacteric peak followed by 2% chitosan treated fruits till 5th day. This might be due to the formation of a protective barrier on the surface of fresh fruit, which in turn lead to partial gas exchange, thereby

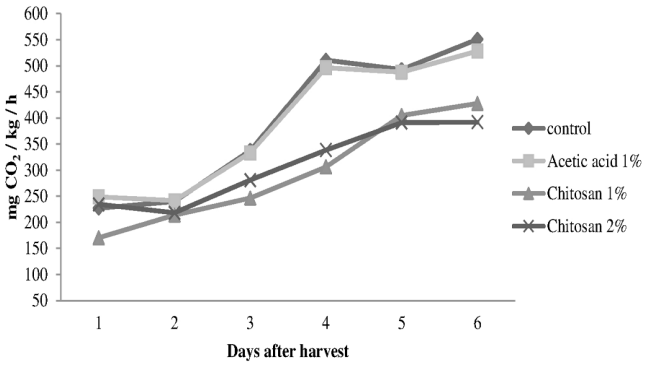

Figure 1. Influence of pre-treatments on the respiration rate (mg CO_2 kg^{-1} h$^{-1)}$ of the guava fruits during storage at Room Temperature (RT).

reducing respiration rate. The suppression of respiratory rates of Indian jujube fruits in response to chitosan treatment has been reported previously[18].

3.2 Surface Colour

Surface colour is indicated by L, a, b and the values are given in Table 1. L-value indicating brightness has increased gradually during storage from the day of harvest till the end of storage life. Untreated (control) and acetic acid treated fruits had shown significantly high values than chitosan (both 1% and 2%) treated fruits.

The negative a-value indicates greenness and positive a-indicates red colour. The gradual decrease of the negative value during storage indicates loss of greenness of fruit. The negative a-value decreased from date of harvest till the end of their storage life irrespective of the treatment. However, the untreated and acetic acid treated fruits lost their greenness in 3 days of storage. The 1% chitosan treated fruits lost greenness in 5 days, while 2% chitosan treated fruits had retained greenness even after 7 days of storage.

The positive b-value indicates yellowness and it increased from the day of harvest till the end of their storage life. The b-value increased from the day of harvest in both untreated and treated fruits, but chitosan 2% treated fruits had less b-value compared to other treatments. The colour change is a consequence of chlorophyll breakdown and formation of carotenoid pigments. The rate of loss of greenness and development of yellowness was slow in chitosan (both 1% and 2%) treated fruits compared to control and acetic acid treated fruits. This may be due to the reduction of respiration rate as reported in Figure 1 and lower metabolic activity in chitosan treated fruits. But fruits treated with 2% chitosan did not turn yellow at all which may be due to the accumulation of high CO_2 in fruit tissue that retarded the carotenoid pigment development. Green mosaic patches were also observed on these fruits, attributed to CO_2 injury. Similar results were confirmed in papaya fruits treated with 2% chitosan[3].

3.3 Physiological Loss in Weight

Cumulative Physiological Loss in Weight (CPLW) increased gradually in all the treatments with advancement of storage period. However, per cent increase in weight loss was recorded significantly low in 1% chitosan treated fruits followed by 2% chitosan and significantly high in control and acetic acid treated fruits (Figure 2). The reduction in weight loss in chitosan treated fruits may be attributed to reduction in respiration, transpiration and delay in ripening rates[1] and maintenance of tissue rigidity of the fruits. The favourable effects of chitosan coating in reducing the PLW have also been reported in Indian jujube[18].

3.4 Fruit Firmness

A considerable decrease in the fruit firmness was observed during ripening of guava fruit irrespective of

Table 1. Influence of different treatments on surface colour of guava cv. Allahabad Safeda fruits

Storage period (days)	Control	Acetic acid 1%	Chitosan 1%	Chitosan 2%	CD @ 1%
			L		
At harvest	51.22	51.22	51.22	51.22	
3	69.46	67.89	65.65	57.77	0.176
5	66.72	65.89	64.54	59.43	0.176
7	FS	FS	64.59	59.58	-
			a		
At harvest	-14.48	-14.48	-14.48	-14.48	
3	2.31	0.02	-3.4	-10.39	0.184
5	5.16	6.64	0.45	-5.21	0.104
7	FS	FS	9.67	-5.05	-
			b		
At harvest	35.58	35.58	35.58	35.58	
3	46.93	48.15	44.41	37.90	0.057
5	47.84	48.92	44.90	39.62	0.060
7	FS	FS	44.07	39.78	-

FS - Fruit Spoiled

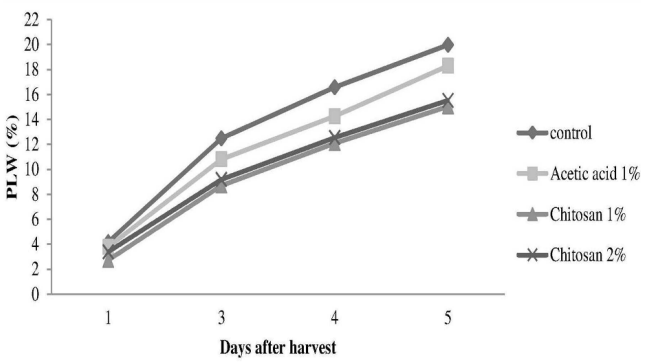

Figure 2. Influence of pre-treatments on the physiological loss in weight (%) of the guava fruits during storage at room temperature (RT).

the treatment[14]. Softening of the fruits is caused either by breakdown of insoluble proto-pectins into soluble pectin or by hydrolysis of starch. In the present investigation, chitosan treatments delayed fruit softening and exhibited significant differences during storage. Significantly greater fruit firmness was retained by 2% chitosan treated fruits followed by 1% chitosan treated fruits and least retention by control followed by acetic acid treated fruits (Table 2). The maintenance of firmness in the fruits treated with 1% and 2% chitosan coatings could be due to covering of the cuticle and lenticels and their higher antifungal activity thereby reducing respiration, other ripening processes and infection during storage. The retardation of fruit softening in response to chitosan treatment has been reported in fruits such as Indian jujube fruit[18] and papaya[1].

3.5 TSS

The Total Soluble Solid (TSS) content of guava fruit increased significantly till 3rd day of storage irrespective of treatments and decreased thereafter (Table 2). However, the TSS at full ripe stage was high in 1% chitosan treated fruits which might be due to lower rate of respiration coupled with reduced metabolism. The initial increase in TSS was mainly due to conversion of starch into soluble forms of sugars and subsequent decrease in TSS was due to rapid utilization of reducing sugar and other organic metabolites. Similar results of initial rise and then decline in the TSS contents was reported in guava fruits[15] and Mango[12].

3.6 Titratable Acidity

The titratable acidity was relatively high at harvest and then it decreased during ripening which is a natural phenomenon (Table 2). This might be due to rapid utilization of acids in guava fruits during the respiration process as a substrate[11]. However, there was no significant difference in titratable acidity among treatments throughout the storage which are in favour with titratable acidity in the guava fruits which did not change significantly throughout the storage period[4].

Table 2. Postharvest changes in quality of guava fruits during storage as influenced by different treatments

Storage period (days)	Control	Acetic acid 1%	Chitosan 1%	Chitosan 2%	CD @ 1%
			Firmness (Kg/cm²)		
At harvest	34.94	34.94	34.94	34.94	
3	3.70	5.23	6.65	9.93	0.03
5	3.56	3.81	5.97	8.50	0.09
7	FS	FS	3.74	7.28	-
			Total Soluble Solids (°B)		
At harvest	11.10	11.10	11.10	11.10	
3	14.90	12.53	14.53	14.70	1.27
5	10.13	10.80	12.26	10.96	0.69
7	FS	FS	11.32	10.78	-
			Titratable acidity (%)		
At harvest	1.25	1.25	1.25	1.25	
3	0.46	0.55	0.55	0.58	0.05
5	0.50	0.48	0.50	0.50	0.02
7	FS	FS	0.45	0.54	-

FS - Fruit Spoiled

The above observations on the effect of surface coatings on the quality also indicate that acetic acid used in the preparation of chitosan coatings does not have any positive effect on the quality retention. All the positive effects of coatings are purely due to chitosan alone.

4. Conclusion

Post-harvest treatment of Allahabad Safeda guava fruits with 1% chitosan delayed the ripening process and prolonged storage life up to 7 days at ambient conditions (28-32°C and 32 - 41% RH). The fruits retained desirable texture and post harvest quality till the end of their storage life. Thus, chitosan 1% can be integrated into the supply chain management of guava fruit to extend storage life, marketability and maintain quality during transport and storage under ambient conditions.

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