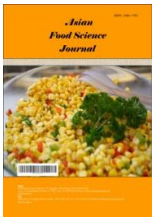

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Effect of Wax Coating on Post Harvest Quality Parameters and Sensory Characteristics of Oranges

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Authors' contributions

This work was carried out in collaboration between both authors. Author VCW designed the experiment, supervised the research work and authored the manuscript. Author WCC carried out the research work and performed the statistical analysis. Both authors read and approved the final manuscript.

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ABSTRACT

Various wax preservatives (Aloe vera gel, polyethene film, Candle wax, and Control) were evaluated to determine their effect on sensory characteristics (color, texture, and overall acceptability) of sweet oranges (*Citrus sinensis*) preserved at ambient temperature for 21 days. The goal of this study is to extend the shelf life of harvested oranges by the application of Aloe Vera wax, paraffin wax and polyethylene film to evaluate the treatment that will enhance physico-chemical parameters as well sensory characteristics. Other parameters examined were weight loss, pH, Total sugar (brix), Total solid, ash, moisture and vitamin C content. Results indicated that weight loss was observed across samples, however the weight loss was least with Aloe vera coated oranges which showed a significantly higher weight value (170.57 gm) after 3 weeks of storage. Sensory profile results showed that Aloe vera coated oranges had higher color and overall acceptability scores of 6.65 and 7.20 respectively. Also, the aloes vera coated oranges showed higher vitamin C content (24.15 mg/100 ml), indicating that oranges coated with Aloe vera gel prevented the deterioration of vitamin C during the period of storage.

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Keywords: Aloe vera gel; candle wax; polyethene film; fruit ripening; vitamin C; total sugar (brix); total solid.

1. INTRODUCTION

Fresh fruits and vegetables are highly perishable and during the process of distribution and marketing substantial losses are incurred which range from a slight loss in quality to total spoilage. Post-harvest losses may occur at any point in the marketing process from initial harvest through assembly and distribution to the final consumer. The losses may occur due to physical damage, physiological decay arising from inappropriate temperature of storage, microbiological activity, water loss etc. Investigations [1] have revealed that global citrus acreage in 2009 was nine million hectares with a production of 122.3 million tons for oranges. Sweet orange is a major source of vitamin C and contains sufficient amounts of folacin, calcium, potassium, thiamine, niacin and magnesium [2].

Consumers buy oranges primarily for their size but are attracted to repeat purchases by flavor and quality. The nutritional importance of oranges is due to the presence of functional food ingredients and antioxidant nutraceuticals or phytochemicals. Phytochemical present in edible fruits, when consumed modulate human metabolism in a favorable manner, thereby prevent chronic and degenerative diseases [3]. High dietary intake of biologically active compounds, soluble and insoluble dietary fibers, flavonoids have been shown to constitute health benefits such as reducing the risk of cancer, cardio-vascular diseases and obesity [4]. Transpiration is one of the major processes that affect commercial and physical deterioration of fruits and vegetables, which induces wilting, shriveling, and loss of firmness, crispness and succulence which are components of freshness. In developing countries these food losses may be as high as 30-50% of production levels where adequate storage facilities are not available thus contributing to weight losses and vitamin C degradation [5]. Fruit ripening is a complex, genetically programmed process that culminates in dramatic changes in color, texture, flavor and aroma of the fruit. A high quality orange is mature with good color intensity that is uniformly distributed over the surface. Fruit must be firm with fairly smooth texture and shape that is characteristic of the variety [6].

Waxing have been used in preventing moisture loss in fruits and vegetables and several raw materials have been used in formulating food grade waxes. The most commonly used materials are paraffin, carnauba, shellac and polyethylene [7]. Less frequently used wax bases include beeswax and candelilla wax. Each of these raw materials has unique and different properties which determine its shine, firmness, gas exchange and other physical characteristics.

Research have shown [8] that Aloe-Vera based coating have been shown to prevent loss of moisture and firmness, control of respiration rate and maturation development, delay oxidative browning and reduce microbial proliferation in fruits such as cherry. Aloe Vera is a tropical plant that has been used for its therapeutic and medicinal properties and the two major liquid sources of Aloe Vera are a yellow latex (exudates) and a clear gel (mucilage), which proceeds from the large leaf parenchymatic cells [9,10].

Other food grade waxes used to extend shelf life of fruits are paraffin wax which have been used in post-harvest preservation of yam, potato, breadfruit, as well as polyethylene material. Other coating material used in preservation of fruits are edible films which enhance shelf life, and acts as a barrier against bacterial invasion as well as carriers of anti- oxidants, assist in creating modified atmosphere by acting as barrier to gas and moisture [11,12].

The goal of this study is to extend the shelf life of harvest oranges by the application of Aloe Vera wax, paraffin wax and polyethylene film and to evaluate the treatment that will enhance physico-chemical parameters as well sensory characteristics.

2. MATERIALS AND METHODS

2.1 Location of Study

The experiment was carried out in the Department of Crop and Soil laboratory, University of Port-Harcourt, Nigeria.

2.2 Surface Preparation of Fruits

The selected Orange (*Citrus sinensis*) fruits, matured but unripe was washed under flowing water to remove all contaminants that would hinder proper coating adhesion, after which they

were wiped dry completely using a soft absorbent cloth before coating.

2.3 Preparation of Aloe Vera Coating

Matured leaves of Aloe-Vera were harvested and washed with 25% chlorine solution. Aloe Vera matrix were separated from the outer cortex of the leaves and the hypoperechyma was homogenized (homogenizer model L5M - A). The resulting mixture was filtered to remove the fibres and fresh Aloe Vera gel obtained. The gel matrix was pasteurized at 70^0C for 45min and allowed to cool to ambient temperature. Ascorbic acid (2.0 g/l) and citric acid (4.5 g/l) were added to maintain pH at 4. The viscosity of the Aloe Vera gel and its coating efficiency were improved by adding 1% commercial gelling agent (methy cellulose) and stored in a brown bottle to prevent oxidation [13].

2.4 Preparation and Coating of Candle Wax

Solidified candle wax was placed in stainless bowl and placed in a Bunsen burner where it is allowed to melt. After melting the prepared oranges were coated with the wax manually by the use of soft fine bristle brush. Before the coating, the surface of the fruit is completely dried to prevent the wax from dropping off the surface.

2.5 Determination of Physico-Chemical Properties

The following parameters were measured; weight loss, pH, ascorbic acid content, total sugar brix, total solid, total ash and product acceptability through sensory evaluation

2.5.1 Determination of weight loss

The weight of the oranges was determined using an analytical weighing balance (model Rs. 6000) to measure the difference between initial and final weight of oranges after duration of storage and the percentage weight loss calculated:

$$\text{Weight loss (\%)} = \frac{Initial\ wt - final\ wt}{Initial\ wt} \times 100$$

2.5.2 Determination of ascorbic acid content

Ascorbic acid content of the samples was determined by titration using the standard indophenol solution. The standard solution was prepared by dissolving 0.05 g of 2,6, dichlorophenolindophenol in water and diluting to 100 ml. Thereafter, 0.05 g of ascorbic acid is dissolved in 60ml of 20% metaphosphoric and diluted with 250 ml of distilled water. Sample determination was carried out using 50 ml of unconcentrated juice pipetted into a 100 ml volumetric flask and twenty-five milliliters of 20% metaphosphoric acid added, then made up with distilled water, and Ten milliliters(10 ml) pipetted into a small flask. A known volume (2.5 ml) acetone was added to the small flask and titrated against the indophenol solution until a faint pink color persists for 15 secs. The vitamin C content calculated as mg/100 ml of sample.

2.5.3 Determination of total sugar (Brix)

The hand held refractometer was in total sugar determination. The prism of the refractometer was cleaned and a drop of the juice extract placed on the prism and the total soluble solid read on the scale of the refractometer.

2.5.4 Determination of pH

The pH of the samples was determined using the digital pH meter (model -PHS-2F). The pH meter was calibrated using buffer solutions of pH 4 and 7. Samples were cut into smaller pieces and homogenized in a blender with 2500 rpm and filtered. The pH of the orange juice was then determined.

2.5.5 Determination of total solids

Total solid was determined using the A.O.A.C [14] method of determination. An aluminium dish with cover was cleaned and dried at 105°C for 15min and cooled in a dessicator for 10min and weighed (W_1). Five grams of sample was then weighed into the dish (W_2), and the dish with the content dried at 105°C in an air oven (Shang Hang) until a constant weight was obtained. The dish with its contents were removed from oven, cooled in a dessicator and weighed again (W3). The weight of the solid was then calculated using the formula:

$$\text{\% moisture content} = \frac{W_3 - W2}{W_2 - W1} \times 100$$

$$\text{\% Total solid} = 100 - \text{\% moisture content.}$$

2.5.6 Determination of ash

Total ash determination was carried out using the A.O.A.C. [14] method.

One gram (1 gm) of sample was weighed into a previously ignited and cooled porcelain with lid. The crucible and sample were heated on a heating mantle in a fumed cupboard until smoking ceased. The crucible and its content were then transferred to a preheated muffle furnace and allowed to ash for 3 hours at 500^0C. Upon completion of heating process, the crucible along with its content were removed from the furnace and cooled in a dessicator and then weighed again. The percentage ash of the sample was calculated as follows:

$$\text{Ash (\%)} = \frac{wt\ of\ ash}{wt\ of\ sample} \times 100$$

2.6 Sensory Evaluation

Sensory quality of colour, texture, flavor and overall acceptability of preserved oranges were determined using a nine-point hedonic scale [15]. Samples were evaluated by panelists for acceptability scores, Liked extremely = 9, Liked very much =8, liked moderately=7, Liked slightly = 6, Liked or dislike = 5, Disliked slightly = 4, Disliked very much = 3, Disliked moderately = 2 and Disliked very much = 1.

2.7 Statistical Analysis

The experiment was carried out in a Complete Randomized Design (CRD). Mean values of results were obtained from triplicate samples and analyzed using Gensat 20.0. The means were separated by Least Significant Difference (LSD).

3. RESULTS AND DISCUSSION

The results of weight loss of samples are presented in Table 1. The result obtained showed that there was no significant difference across the treatment (Aloe vera). However, all samples demonstrated a gradual weight loss from the first to the third week during storage. Also, the fruits coated with Candle wax had a significantly higher weight loss than that of Aloe vera coated fruit, polyethene film and uncoated control. This is in line with the observation by Ahmed [8] who found that coating with Aloe vera prevent moisture loss, control transpiration rate, reduce oxidative browning and reduce microorganism proliferation in fruits such as sweet cherry and grapes. Other researchers [16] also reported that weight loss in fruits occurs mainly due to water loss by transpiration, and loss of carbon reserves due to respiration. The rate of water loss is dependent on the shape and structure of the fruit, available tissue moisture and the surrounding atmosphere.

Color attributes of the oranges were evaluated at the end of week 1 as presented in Table 2. showed that there was no significant difference between the various treatments of Aloe vera, Polyethene film and control. However, the fruits coated with Candle wax had a significantly lower value of 5.35. The results obtained is in agreement with [17] who observed a greater retention of bright green color in papaya fruits coated with Aloe vera , improvement in quality parameters have also been reported by [18] who observed an attractive natural looking sheen in grape fruits. Textural characteristics of the results obtained showed that there was no significant difference between the samples coated with Aloe vera and the control, while samples coated with polyethene film showed higher acceptability values of 7.75.

Color, texture and overall acceptability values of week 2(after 14 days storage) are shown in Table 3 with no significant difference in Aloe vera, polyethene film and uncoated control samples with candle wax samples being significantly different. The sensory profile of the stored fruits for week 3 are shown in Table 4. with no significant difference existing between Aloe vera, polyethene film and control treatment. Textural values showed that polythene film coated produce were significantly higher 7.15 and overall acceptability scores indicated that Aloe vera coating and polyethene coated fruits were most preferred with significantly higher acceptability scores.

Results of the effect of wax coating on pH, Total sugar (brix), Total solid and vitamin C is shown in Table 5. There was significant difference across samples for pH, however Total solid values showed no significant difference in fruits coated with candle wax and polyethene film. Vitamin C content of coated fruits showed that there was no significant difference in Aloe vera, candle wax and control during week 1 storage period, with polyethene having a value of 27.31 mg/100 ml. Results at the end of week 2 are presented in Table 6 which showed that the pH of the orange juice gradually increased during storage. Total solid content of the fruits showed no significant differences between Aloe vera, polyethene and Control samples with values of 7.21, 8.25 and 7.89 respectively. The vitamin C content of the coated oranges were found to be higher than control at the end of week 2. Fruits are a major

source of vitamin C and minerals which are sensitive to breakdown due to oxidation [19]. Total solids which determine the amount of solids to be dissolved which are carbohydrates, protein and fats and Total sugar shows the amount of reducing sugar which are mainly glucose and fructose.

Results of the effects of various treatments (wax coating, polyethene coating and uncoated) on chemical parameters such as pH, Total sugar, Total solids, moisture content, Ash content and vitamin C after 3 weeks of storage at ambient temperature are shown in Table 7. The results indicated that there were significant differences between the various treatment with Aloe vera coating being significantly higher at 4.01.

The Total sugar contributes to the characteristic flavor of citrus. Prior to ripening, the sugar to acid ratio is low because of low sugar content and high fruit acid content which makes the fruit taste sour. Once ripening process begins, the acids contained in the fruits are broken down, the sugar content increases resulting in the breakdown of starch into water, soluble sugars, sucrose and glucose. Aloe vera coated fruits were significantly lower than the control (uncoated) in total sugar content indicating a delay in the ripening process. The findings in this study were similar to the results obtained by [20] who reported decreasing trend in Hadden mango treated with wax coating and stored at different temperatures. Also, there were no significant difference observed in total solid content both in the second and third weeks. This result is in agreement with that reported by previous researchers [21], who worked on banana and mango coated with polysaccharide-based coating and similar results have been reported for strawberry coated with wheat-gluten based films [22].

The vitamin C content of the coated fruits (Aloe vera and polyethene film) were significantly higher (24.15 mg/100 ml) than control. The results showed decreased content of vitamin C, as the storage duration increases. Similar results were obtained showed [23] that ascorbic acid content of fresh fruits was highest prior to ripening and then decreased due to the action of the enzyme ascorbic acid oxidase.

Table 1. Weekly weight loss

Treatment	Week 1	Weight loss (%)	Week 2	Weight loss (%)	Week 3
Aloe vera	203.46^{a}	12.9%	177.23^{b}	3.8	170.57^{a}
Candle wax	195.53^{b}	30.88%	135.14^{c}	68.85	42.09^{c}
Polythene film	163.60^{c}	9.49%	148.07^{b}	4.78	140.98^{b}
Control	168.19^{c}	7.12%	156.47^{a}	20.9%	139.16^{a}
LSD (p<0.05)	12.60		20.26		19.95

Means of the same letter are not significantly different

Table 2. Effect of treatment methods on sensory qualities of citrus stored at week 1

Treatment	Colour	Texture	Overall acceptability
Aloe vera	7.60^{a}	7.15^{ab}	7.30^{ab}
Candle wax	5.35^{b}	6.20^{b}	6.50^{b}
Polythene film	7.50^{a}	7.75^{a}	7.65^{a}
Control	7.35^{a}	6.90^{ab}	7.25^{a}
LSD (P<0.05)	1.15	1.04	0.89

Means of the same letter are not significantly different

Table 3. Effect of treatment methods on sensory qualities of citrus stored at room temperature at week 2

Treatment	Colour	Texture	Overall acceptability
Aloe vera	7.55^{a}	6.85^{a}	7.20^{a}
Candle wax	4.15^{b}	4.05^{b}	3.80^{b}
Polythene film	7.20^{a}	7.40^{a}	7.45^{a}
Control	6.75^{b}	6.45^{a}	6.60^{a}
LSD (P<0.05)	1.02	1.15	1.03

Means of the same letter are not significant different

Table 4. Effect of treatment methods on sensory qualities of citrus stored at room temperature at week 3

Treatment	Colour	Texture	Overall acceptability
Aloe vera	6.45[a]	6.10[b]	7.20[a]
Candle wax	2.15[c]	2.30[c]	1.95[c]
Polythene film	6.95[a]	7.15[a]	7.20[a]
Control	6.15[a]	5.30[b]	5.65[b]
LSD (P<0.05)	0.79	1.00	0.96

Means of the same letter are not significantly different

Table 5. The effect of wax coating on pH, total sugar, total solid and vitamin C content of oranges stored at room temperature at week 1

Treatment	Moisture content	Total solid	Total sugar (Brix)	pH	Ash (%)	Vit. C (mg/100 ml)
Aloe vera	92.70[a]	7.30[b]	6.0[d]	3.81[b]	0.44[b]	29.33[b]
Candle wax	90.41[b]	9.59[a]	8.40[b]	3.20[d]	0.60[a]	25.44[b]
Polyethene film	92.13[ab]	9.43[a]	6.50[c]	3.66[c]	0.45[b]	27.31[ab]
Control	90.01[ab]	8.99[ab]	13.0[a]	3.83[a]	0.30[c]	25.78[b]
LSD (p<0.05)	1.70	1.74	0.00	0.00	0.09	3.09

Means of the same letter are not significant different

Table 6. The effect of wax coating on pH, total sugar, total solid and vitamin C content of oranges stored at room temperature at week 2

Treatment	Moisture content (%)	Total solid	Total sugar (Brix)	pH	Ash (%)	Vit. C (mg/100 ml)
Aloe vera	93.70[a]	7.21[a]	12.90[b]	93.70[b]	0.65[a]	25.84[a]
Candle wax	0.00[c]	0.00[b]	0.00[d]	0.00[a]	0.00[b]	0.00[c]
Polyethene film	90.57[b]	8.25[a]	8.90[c]	90.57[c]	0.48[a]	24.34[ab]
Control	92.16[ab]	7.89[a]	13.60[a]	92.16[ab]	0.64[a]	22.22[d]
LSD P<0.05)	1.83	1.07	0.00	0.00	0.24	2.15

Means of the same letter are not significantly different

Table 7. The effect of wax coating on pH, total sugar, total solid and vitamin C content of oranges stored at room temperature at week 3

Treatment	Moisture content	Total Solid	Total sugar (Brix)	pH	Ash (%)	Vit. C (mg/100 ml)
Aloe vera	92.80[a]	6.30[a]	12.90[c]	4.01[b]	0.74[a]	24.15[a]
Polyethene film	91.75[a]	8.04[a]	13.90[a]	3.75[c]	0.64[a]	24.15[a]
Control	92.12[a]	7.85[a]	13.80[b]	3.95[b]	0.76[a]	19.32[b]
LSD (P<0.05)	1.07	1.86	0.00	0.00	0.38	4.52

Means of the same letter are not significantly different

4. CONCLUSION

Aloe vera gel coated oranges delayed the deterioration of nutrients such as vitamin C over a 21 days period, while sensory evaluation on color and textural characteristics of polyethene coated oranges had the highest value over the same period. Aloe vera gel as a coating agent is effective in vitamin C retention in oranges.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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