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Effect of packaging and storage condition on the quality of sweet orange (*Citrus cinesis*)

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The effect of packaging and storage condition on the quality of sweet orange was studied. Sweet orange (*Citrus cinesis*) were harvested at green maturity stage and were divided into 60 fruits per packaging material (Sack bag, jute bag and basket) and stored at ambient condition (32 ± 1°C). Rate of ascorbic acid loss, titratable acidity (TTA), pH, total soluble solids (TSS), percentage weight loss, firmness and rot incidence were evaluated at 2 days interval for 17 days. At the end of the storage period, mass losses were 36.6, 39.6 and 20.8% in basket, jute bag and sack bag. Ascorbic acid losses were 54.2, 38.9 and 38.3% in basket, jute bag and sack bag respectively. Rot incidence of 55% was observed in fruits packed in sack bag, 10% rot incidence occurred in fruits packed in jute bag while no rot incident was noticed in fruits packed in basket. Firmness, TSS and TTA of all the samples decreased with storage days.

Key words: packing, storage, rots incidence, basket, sack bag, jute bag

Introduction

The Nigerian fruit market is faced with many challenges. Lack of adequate transport vehicles, rough roads, careless packing of fruits and poor storage facilities subjecting the fruits to both static and dynamic stress (Chukwu *et al*., 1996). In this way, the fruits are exposed to various physical, mechanical and physiological stresses that can lead to adverse changes in their visual quality and chemical profiles. Poor post harvest handling and storage conditions can impact on the content of major groups of fruits and vegetable antioxidants namely; Ascorbic acid (Wilhelmina, 2005).

Citrus fruits for example are known for their high ascorbic acid content. Compared with other major fruits and vegetable antioxidants, ascorbic acid is more susceptible to significant losses during post harvest handling and storage (Wilhelmina, 2005). Ascorbic acid content of harvested fruits had been used to

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monitor freshness and fruit spoilage has been associated with loss of functional compounds such as phenolics and ascorbic acid (Sanusi *et al*., 2008).

This research was designed to evaluate the effects of post harvest handling and storage practices on the quality of orange fruits. The common packaging system in Nigeria such as packing in sack bags, jute bags and baskets were studied.

Materials and methods

The principal materials for the study were sweet orange fruits. The orange were at green maturity stage. The packaging materials used were; Sack bag, Jute bag and Basket. The sweet orange fruits were harvested in January, 2010 from Tyomu a village near makurdi, the Capital of Bunue State and were transported to the food processing laboratory at University of Agriculture, Makurdi. Fruits were selected for similar size, good appearance and lack of defects. Fruits were then sample and packed for storage (60 fruit per each package).

Determination of pH

The pH of the juice was determined with an electronic digital pH meter, following the standard method outline in AOAC (1995).

Determination of total soluble solids (TSS)

Brix is a measure of the concentration of soluble solids in a solution and is based up on the relationship between the specific and W/W solids of a pure sucrose solution. Brix of the Juice was determined using Abbe refractmeter. Brix= sugar W/W (Weight by weight).

Determination of total titratable acidity (TTA)

The titratable acidity as percent citric acid of the Juice was determined, using the method described in AOAC (1995). Twenty five milliliters of the Juice was diluted with 250ml boiled water. One hundred milliliters from the diluted solution was poured into a conical flask. Three drops of phenolphthalein indicator was added and the solution was titrated with 0.1N NaOH solution to a pink end point which persisted for 30 seconds.

$$\% \text{ acidity} = \frac{\text{Volume of NaOH x O.IN x ml of Citric acid x 100}}{\text{Weight of Sample}}$$

N.B Weight of Sample = Weight of 25ml filtrate. 1ml of NaOH used react with 0.064 of Citric acid.

Determination of ascorbic acid

Ascorbic acid was determined using the method described by AOAC, 1990. Indolphenol blue solution was standardized using vitamin C by shaking 3.0ml of standard vitamin C solution (0.800 mg/ml) with 0.1% indolphenols blue solution in a graduated cylinder until the reaction mixture changed to a blue or purple colour. The final volume of the reaction mixture was recorded and used to calculate the molarity of indolphenol.

$$\text{Molarity of indolphenol} = \frac{\text{concentration of vitamin C x volume of vitamin C}}{\text{Volume of indolphenol}}$$

Then exactly 3.0ml of the sample was introduced into a graduated cylinder and while shaking, indolphenol solution was added until the reaction mixture changed to a blue or purple colour. The final volume was recorded and the concentration of vitamin C in the sample was calculated and expressed in mg/ml using the formula above.

Determination of firmness

Firmness was determined on intact fruit using a digital penetrometer (model PCE- PTR 200) with a 6-mm probe. Three fruits were used and five points per fruit were selected for puncture. Each firmness value was an average of the determinations and result expressed in kg.

Determination of % weight loss

Weight was determined by use of a penetrometer (model PCE- PTR 200) using the hanger component. Weight loss was calculated by standard procedure as mentioned in AOAC (1994).

$$\text{\% Weight Loss} = \text{wt. of first interval} - \text{wt. of } 2^{nd} \text{ interval} \times 100 \,/\, \text{wt. of first interval}$$

Rot incidence

Appearance of rot was determined by visual observations.

Determination of the constant rate for the loss of ascorbic acid

The constant rate of ascorbic acid loss was determine according to the method described by (Gordon, 2006) using

$$K = \frac{(\ln A_o - \ln_A)}{\Theta}$$

Where Ao = initial ascorbic acid concentration, A = final ascorbic acid concentration, Θ = Time, and K = rate constant.

Statistical analysis

Data were subjected to analysis of variance (ANOVA). Least significant differences were calculated at 5%.

Results and discussion

The effect of packaging material and storage condition on firmness, weight and rot incidence of sweet orange was shown in Table 1. The firmness of the stored samples decreased during storage in the three packaging materials and later increased. The decrease could be due to the degradation of protopectin by pectinatase. 0n the 12^{th} day of storage, fruits stored in basket had increased firmness. This could be due to hardening of the skin as a result of high water loss and the development of wrinkling. Similar trends were observed in fruits stored in sack and jute bags on the 15^{th} day of storage.

Orange fruits packed in sack bag had the highest rot incidence of about 55% followed by 10% rot incidence in fruits packed in jute bag during the 17 days storage. No rot incident occurred in the fruit stored in basket. This could be due to the large air space available for the exchange of air with the surrounding. When one mole of hexose sugar is oxidized during respiration, energy is formed; part of this energy is being dissipated as heat. Rapid remove of this heat is usually desirable and it is important that the packaging system assists rather than impedes this process (Gordon, 2006). The high number of rotten fruits in the sack bag could be as a result of condensation inside the packaging material due to poor or very low permeability of the package to air flow resulting to accumulation of heat.

The effect of packaging material and storage condition on total soluble solid, ascorbic acid, pH and total titratable acidity of sweet orange was shown in Table 2. The total soluble solids (TSS) of fruits stored in all the packaging materials was observed to increase from the first day of storage up to the 9^{th} day after which there was a gradual decline. This indicates that the fruits have attained a maximum TSS of 9.5^{o}Brix on the 9^{th} day of storage. It has been reported by Arthey and Ashurst (1996) that the Brix content of orange is within the range of 4 – 10^{o} Brix. During storage fruits in the jute bag maintained low

TSS concentration, though there was no significant difference ($p < 0.05$) in the TSS of all the fruits. Increase in TSS could be as a result of the breakdown of organic polymers into simple sugars. Consequently, the decrease in TSS is due to exhaustions of acids and the conversion of sugars to other organic products as substrate for respiration.

The percent of titratable acidity (TTA) of all the samples decreased during storage. The decrease which indicates the disappearance of astringency is due to the use of the acids present as respiratory materials. Fruits in the basket exhibited a high percent TTA decline though not significantly different from the other packaging materials ($p < 0.05$). Generally organic acids usually decline during ripening of fruits as they are used as substrates for respiration or converted into sugars. There was a general increase in the pH of the samples. Increase in pH would be caused by the breakup of acids with respiration during storage (Pesis *et al.*, 1999). Reduction in acidity may be due to the conversion of the acids into sugars and their further utilization in the metabolic process of the fruits.

Percent ascorbic acid loss increased in the three packaging materials with storage time (Fig. 1). The loss may be due to the inability of the packaging materials to act as effective barrier against light, oxygen, temperature and other environmental factors (Gordon, 2006). High loss of up to 54.2% ascorbic acid occurred in fruits packed in basket, 38.9% loss in fruits packed in jute bag and 38.3% loss in fruits packed in sack bag. The high loss in ascorbic acid in fruits packed in basket may be as a result of the high transpiration and respiration rates. Fruits packed in sack and jute bags retained more ascorbic acid during storage probably due to their ability to enhance reduced respiration and transpiration rates. This agrees with the observation of (Wilhelmina, 2005) that wrapping fruits with plastic film to reduce water loss helped retain ascorbic acid even more than optimal storage temperature.

Table 3 shows the predicted Rate of ascorbic acid loss in sweet orange and shelf-life to reach 20mg/100ml. Fruits stored in sack and jute bag had constant rate of 0.028 and 0.045 respectively with a predicted shelf – life of 32 days with respect to ascorbic acid. Fruits stored in basket had a rate constant of 0.054 and a predicted shelf – life of 23 days. The concentration of ascorbic acid would fall to 20mg/100ml after 32 days in orange fruits stored in sack and jute bag and 23 days in fruits stored in basket.

The percentage weight loss of sweet orange in different packaging materials stored under ambient condition is shown in Fig. 2. Weight loss increased during storage and was affected by package type. Fruits stored in basket and jute bag loss more weight (36.6% and 34.7%) than that stored in sack bag (20.8%). Transpiration is the major process leading to weight loss. The fruits packed in basket and jute bag were more affected than fruits packed in sack bag. It means fruits in basket and jute bag produced higher rates of transpiration which resulted in decreased weight due to loss of moisture. Low weight loss was noted in fruits packed in sack bag because of reduced levels of transpiration and evaporation within the package.

Fruits packed in sack bag had controlled ascorbic acid and weight loss but there was high rate of rot incidence after the 10th day of storage. High losses of ascorbic acid and weight were observed in fruits packed in basket. The common practice of packing oranges in baskets and open truck van for distance markets by distributors should be discouraged.

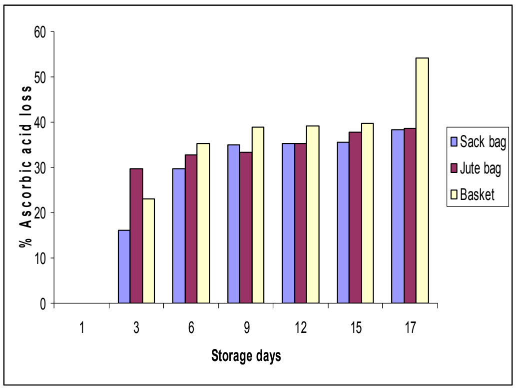

Fig. 1. Percent of ascorbic acid loss of sweet orange in different packaging materials stored under ambient condition (32±1^{0}C).

Table 1. Effect of packaging materials on firmness, weight and rot of sweet orange stored under ambient condition (32±1^{0}C).

Packaging Materials	Parameters	Storage period (days)						
		1	3	6	9	12	15	17
Sack	Firmness (Kg)	5.45 ± 48	4.38 ± 0.08	4.30 ± 0.5	4.20 ± 0.3	3.80 ± 0.06	5.26 ± 0.07	6.01 ± 0.
	Weight (g)	202 ± 0.01	198 ± 0.2	194 ± 0.2	192 ± 0.09	186± 0.08	162 ± 0.1	160 ± 0.1
	Rot (60/bag)	0	0	0	0	12	15	6
Jute	Firmness (kg)	5.45 ± 0.4	5.00 ± 0.02	4.84 ± 0.06	4.25 ± 0.07	4.09 ± 0.07	5.36 ± 0.04	5.78 ± 0.3
	Weight (g)	202± 0.1	182 ± 0.4	176 ± 0.6	164 ± 0.4	142 ± 0.2	132 ± 0.2	122 ± 0.4
	Rot (60/bag)	0	0	0	0	2	2	2
Basket	Firmness (kg)	5.45 ± 0.48	4.10 ± 0.03	3.43 ± 0.09	3.19 ± 0.6	4.18 ± 0.5	5.14 ± 0.3	6.64 ± 0.4
	Weight (g)	202 ± 0.10	186± 0.3	164 ±0.3	154± 0.5	146± 0.3	134 ± 0.2	128 ± 0.3
	Rot (60/bag)	0	0	0	0	0	0	0

Table 2. Effect of packaging materials on total soluble solid, ascorbic acid, pH and titratable acidity of sweet orange stored under ambient condition (32±1^{0}C).

Packaging Materials	Parameters	Storage period (days)						
		1	3	6	9	12	15	17
Sack	TSS (Brix)	5.0" ± 0.4	8.50± 0.01	8.50 ±0.1	9.50± 0.25	8.50 ± 0.27	8.50 ± 0.15	8.40 ± 0.
	Ascorbic acid (mg/100ml)	65.3 ± 1.96	54.6 ± 2.05	45.8 ± 0.32	43.1 ± 0.50	42.3 ± 0.22	42.1 ± 0.50	40.3±0.67
	pH	3.1 ± 0.05	3.26 ± 0.09	3.31 ± 0.01	3.44 ± 0.07	3.60 ± 0.02	3.66 ± 0.05	3.68±0.02
	TTA (%)	0.30 ± 0.02	0.29 ± 0.06	0.22 ± 0.03	0.19 ± 0.04	0.18 ± 0.08	0.08 ± 0.02	0.07±0.02
Jute	TSS (Brix)	5.0 ± 0.14	9.0 ± 0.50	9.0 ± 0.29	9.5 ± 0.50	7.5 ± 0.29	7.3 ± 0.11	7.0 ± 0.29
	Ascorbic acid (mg/100ml)	65.3 ± 1.96	45.8 ± 0.3	43.8. ± 03	43.5 ± 0.3	42.3 ± .03	40.5 ± 0.17	40.0±0.26
	pH	3.13 ± 0.05	3.28 ± 0.06	3.42 ± 0.03	3.58 ± 0.05	3.60 ± 0.01	3.62 ± 0.04	3.84±0.03
	TTA (%)	0.31 ± 0.02	0.28 ± 0.02	0.21 ± 0.04	0.19 ± 0.02	0.17 ± 0.05	0.07 ± 0.01	0.07±0.02
Basket	TSS (Brix)	5.0 ± 0.14	7.50 ±0.13	7.50± 0.25	9.50±0.19	8.50 ±0.11	8.5 ±0.13	8.0 ±0.24
	Ascorbic acid (mg/100ml)	65.3 ±1.96	50.2 ± 1.82	42.3 ± 0.2	39.8 ± 0.4	39.6 ± 0.7	39.4 ± 0.4	29.9 ± .02
	pH	3.13 ±0.05	3.28 ± 0.03	3.43 ± 0.01	3.47 ± 0.01	3.54 ± 0.05	3.66 ± 0.03	3.84± .01
	TTA (%)	0.30 ± 0.02	0.23 ± 0.04	0.20 ± 0.06	0.19 ± 0.04	0.17 ± 0.03	0.07 ± 0.01	0.06±..01

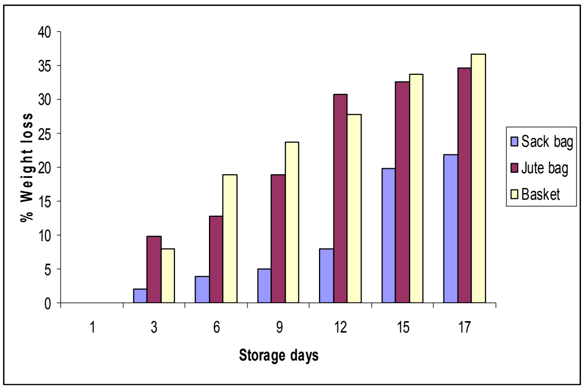

Fig. 2. Percent of weight loss of sweet orange in different packaging materials stored under ambient condition (32±1^{0}C).

Table 3. Rate of ascorbic acid Loss in sweet orange and shelf-life to reach 20mg/100ml.

Packaging Materials	Time (day)	Ascorbic (mg/100ml)	K/day	Predicted Shelf-life (days)
Sack	1	63.3	0.028	32
	9	43.1	0.045	
	17	40.3		
Jute	1	65.3	0.028	32
	9	43.5	0.044	
	17	40.0		
Basket	1	65.3	0.045	23
	9	39.8	0.054	
	17	29.9		

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