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EFFECTS OF EDIBLE COATINGS FROM XANTHUM GUM PRODUCED FROM *XANTHOMONAS CAMPESTRIS* PAMMEL ON THE SHELF LIFE OF *CARICA PAPAYA* LINN FRUITS

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ABSTRACT

Xanthan gum is an extracellular hetero polysaccharide produced by *Xanthomonas campestris* Pammel, 1895, a bacteria species that causes a variety of plant diseases. Due to its unique rheological behavior, xanthan gum is one of the major microbial polysaccharides employed in many industrial processes. The increase in *Carica papaya* L. fruit production requires new strategies to extend their storage life. Edible coatings when applied on the surface of fruits act as physical barriers which effectively change their internal atmosphere and delay the ripening process. In this study, effect of edible coatings from xanthan gum was investigated on the quality and storability of papaya fruits. A local isolate of the bacterium *X. campestris* was obtained from infected cabbage leaves and its identity was confirmed by standard microbiological and biochemical tests. Test fruits were surface sterilized with 100mg/$^{-1}$ sodium hypochlorite solution, coated with the gum and stored along with the control fruits for seven weeks at an average temperature of 27 ± 2 °C and relative humidity of 55-60 %. The parameters investigated in the fruits were, weight loss, ascorbic acid content, pH, firmness and total soluble solid. The results showed that xanthum gum was effective in extending the shelf-life of papaya fruits when compared to the control.

Keywords: Xanthum gum; Carica papaya L; edible coatings; storage period; Xanthomonas campestris

INTRODUCTION

Papaya *(Carica papaya L.)* is an important fruit that is common throughout tropical Africa. Over the years, Nigeria has recorded significant growth in its production figures of up to 765,000 metric tonnes and this has placed the country as the third largest producer of papaya globally (FAO, 2007). Papaya fruit is a rich source of nutrients such as vitamin A, carotenoids, vitamins C and B, lycopene, dietary minerals and dietary fibre. Papaya skin, pulp and seeds also contain a variety of phytochemicals (Echeverri et al., 1997). It is a climacteric fruit characterized by an increase in the respiratory rate, an autocatalytic production of ethylene, and sensory alterations such as color, flavor, and softening during ripening.

The perishable nature of papaya is a major setback for storage and transport of the fruits to distant places. Oluwalana (2006) has estimated that about 30-100 % of the fruits and vegetables are wasted in Nigeria, the losses being mainly due to decay, physiological damages, and mechanical injury, resulting from improper harvesting, storage and handling practices. Due to its thin skin, papaya is damaged very easily by handling and this can lead to infection by fungi such as *Colletotricum gloeosporioides* (Palhano et al. 2004).

Extension of fruit shelf life is an important goal to be attained in order to ensure food sufficiency. As such, many storage techniques have been developed to extend the marketing distances and holding periods for commodities after harvest. Different preservation methodologies have also been studied. One method of extending post-harvest shelf life of fruits is the use of edible coatings (Falcao-Rodrigues et al., 2007), as a modified atmosphere (MA). Edible coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping to retain volatile flavor compounds and reducing microbial growth (Debeaufort et al., 1998). Edible coating material for fruits and vegetables are driven by

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its antifungal activities, biodegradability and eco-friendliness (Martinez-Romero et al., 2006). An effort that will achieve these factors, shall enable the farmers, marketers and exporters of papaya fruit to earn maximum profits and capture a larger share of the world market. This is the main focus of the present study, with the objective to evaluate the effects of edible coatings from xanthum gum produced from *Xanthomonas campestris* on the shelf life of *Carica papaya* fruits.

MATERIALS AND METHODS

Preparation of *xanthan gum* gel (edible coatings):

A local isolate of *X. campestris* was obtained from infected cabbage leaves *(Brassica oleracea);* leaves showing the yellow necrotic lesion characteristic of *X. campestris* were collected randomly from a cabbage seller in Ipata market, Ilorin. The diseased leaf tissues were cut into small pieces, soaked in 5 ml sterile distilled water and kept at the laboratory for 24 h. The resulting suspension was streaked onto malt-yeast (MY) extract agar. The plates were incubated at 28 ± 1°C for 4 days. Single bacterial colonies displaying characteristics of *Xanthomonas* spp were selected and purified by re-streaking on MY agar. A yellow convex mucoid colony was submitted to standard microbiological and biochemical tests (AOAC, 1995). The cultures were maintained on MY agar slants at 4°C and were sub-cultured every two weeks.

Inoculation and culture media

The inocula were prepared by transferring cells from 72 h MY agar slants incubated at 28 ± 1°C to 250 ml Erlenmeyer flasks containing 50 ml of MY broth which consists of (g/l) glucose, 10; peptone, 5; yeast extract, 3; malt extract, 3. The pH was adjusted to 7.0 before autoclaving at 121°C for 20 min. Incubation was in shaker incubator at 150 rpm and 28 ± 1°C for 48 h. These cultures were used for seed production medium at 2%. The production basic medium composed of the following (g/l), K_2HPO_4, 5; $MgSO_4.7H_2O$, 0.1; yeast extract, 0.5 and urea, 0.4; glucose, was added as a carbon source unless otherwise stated and sterilized separately (Nitsche and Thomas, 1995). The pH was adjusted to 7.3 before sterilization. The medium was distributed into 250 ml Erlenmeyer flasks each with 50 ml and sterilized, after cooling; the flasks were seeded with the prepared inoculum of *X. campestris* and incubated in shaker incubator at 150 rpm and 28 ±1°C.

Preparation of xanthum gum

After incubation after 4days the bacterial culture was centrifuged and when necessary diluted with distilled water to decrease the viscosity. The centrifuged cells were washed twice with distilled water and centrifuged again. The precipitated cells were dried at 80°C for 24 h. The crude xanthan was precipitated from the supernatant by addition of two volumes of cold acetone, then the mixture was centrifuged and precipitate was collected and dried at 50°C until constant weight was achieved. The purified xanthan was obtained by repeatedly dissolving xanthan in distilled water and re-precipitation with two volumes of cold acetone. 100 mg of pure xanthan was hydrolysed with 10 ml of 2M trifluroacetic acid at 120°C for 2.5 h. The acid was removed by continuous evaporation at 50°C under reduced pressure. Pyruvic and acetic were extracted from the hydrolysate by ether. The water solution obtained was neutralized with $BaCO_3$. After removal of $BaCO_3$, the volume of the filtrate was concentrated to 1 ml by evaporation at 50°C under reduced pressure. The volume of ether portion was also concentrated to 1 ml by evaporation at 50°C. The purified Xanthum is then kept at 20^oC before usage.

Source of Fruits

From the fruits garden of the Nigeria Stored products Research Institute (NSPRI), Ilorin, Nigeria, fresh physiological mature papaya fruits were carefully hand-harvested to avoid scratching the skin The fruits were transported unhurt into the laboratory of the Institute where they were sorted on the basis of size, color and absence of external injuries.

Surface Preparation of the Fruits

All the fruits were cleaned with soap and rinsed under running water. Surface sterilization was then carried out by soaking them in $100mg/^{-1}$ sodium hypochlorite for 1 minutes. These were done primarily to remove all contaminants that would hinder proper coating adhesion and to render a sound clean substrate, suitable for firm bonding. The fruits were refrigerated after surface preparation.

Experimental Treatments

$T_{1:}$.Papaya without coating; T2:- Papaya coated with xanthum gum. The treated and untreated fruits were packed in plastic baskets of 60cm wide by 30cm height and each basket contained 8 Papaya fruits.

Application of edible coatings

Sterilized brush was used to apply purified xanthum gum on the Papaya fruit uniformly.

Determination of Some Fruit Parameters under Storage Conditions

Five parameters of the experimental and control papaya fruits were monitored over a period of seven weeks that the study lasted. These were total soluble solids (TSS), firmness, water content (i.e % water loss), pH and ascorbic acid content.TSS was measured using the method described by Dong et al., (2001). Individual pawpaw fruit from each of the treatments was ground in an electric juice extractor for fresh prepared juice. The TSS was then determined using T/C hand refractometer in Brix% (Model 10430 porx-reading 0.30 ranges Bausch and Lomb CO. Calif., USA. Fruit firmness was measured as the maximum penetration force (N) reached during tissue breakage, and determined with a 5 mm diameter flat probe. The penetration depth was 5 mm and the cross-head speed was 5 mm s^{-1} using a TA-XT2 Texture Analyzer (Stable Micro Systems, Godalming, UK), MA. Pawpaw was sliced into halves and each half was measured in the central zone. Water content of the fruits was determined using the following formula A.O.A.C (1994).

$$\text{Water content (\%)} = 100 \times \frac{M_1 - M_2}{M_1}$$

Where: M_1 = Mass of sample before drying in g.

M_2 = Mass of sample after drying, in g.

The pH of the fruit juice was determined using a digital pH meter while the ascorbic acid content was measured using 2, 5-6 dicholorophenol indophenols' method described by A.O.A.C (1994).

Statistical analysis:

Different trials were conducted in Completely Randomized Design (CRD) with three replications. Data obtained were subjected to Analysis of variance using statistical software MSTATC as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

Total Soluble Solids

The results of total soluble solids in the xanthum-coated and control pawpaw fruits are shown in Figure 1. The mean value ± SE of TSS in coated pawpaw was 8.11 ± 0.06 Brix while that in the uncoated pawpaw was 10.57 ± 0.52 Brix. In untreated fruit, the TSS increased as the storage period increased but a constant value was maintained in the xanthum-coated fruit throughout the storage period (Figure 1).

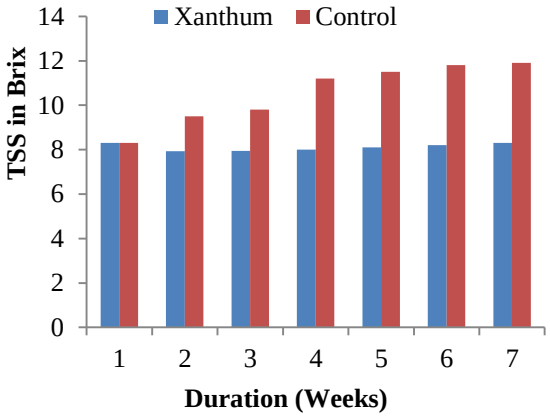

Figure 1: Effects of edible coatings from Xanthum gum on total soluble solids (TSS) in *Carica papaya* fruits stored at ambient temperature.

The effect of Xanthum gum in maintaining the TSS of papaya fruit was probably due to the slowing down of respiration and metabolic activity, thus retarding the ripening process. These results are in agreement with Park (1999) who concluded that coatings and/or films significantly affected TSS.

The loss of soluble solids during the storage period is natural, as sugars which are the primary constituent of the soluble solids content of a product, are consumed by respiration and used for the metabolic activities of the fruits (Özden & Bayindirli, 2002).

Water Loss

The mean ±SE value for weight loss of coated pawpaw was 10.45±1.83 while the mean ±SE value for the weight loss of uncoated pawpaw was 8.02±1.80.The weight loss appeared to be the major determinant of storage life and quality of papaya fruit. Figure 3 shows that Xanthum coatings significantly reduced the weight loss of the papaya fruit during storage compared to the control. In the papaya fruit, it

is believed that the major pathway for water loss is through the peel (Seymour et al., 1993). Our results are supported by Pérez-Gago et al. (2006), where water loss can be reduced by covering with a plastic film or coating. In this study, Xanthum gum applied formed a film on the fruit skin, reducing the water and weight loss. The application of Xanthum coatings reduced the weight loss compared to that of the control which is sufficient to maintain a good appearance and the quality of the papaya.

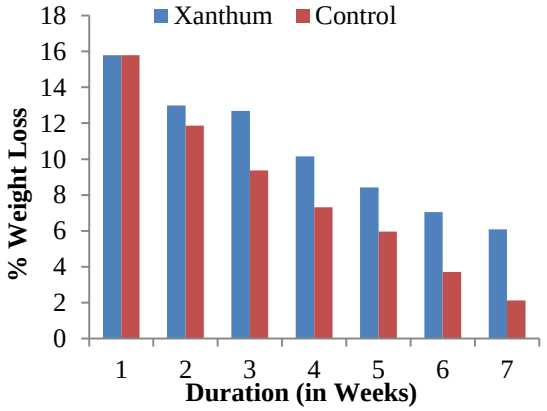

Figure 2: Effects of edible coatings from xanthum gum on water content of *Carica papaya* fruits stored at ambient temperature.

pH of Treated and Untreated Pawpaw Fruits

The mean ±SE value for pH of the coated pawpaw was 8.00±0.43 and while the mean of the uncoated was 5.83±0.03.This was probably because the semi-permeable Xanthum gel formed on the surface of the fruit might have modified the internal atmosphere, i.e., the endogenous CO_2 and O_2 concentration of the fruit, thus retarding ripening (Davila-Avina et al. 2011) .The pH increased along with increased storage time in coated fruits (Figure 4). These results agreed with those reported by El-Ghaouth et al., (1991) and Garcia *et al*., (1998) that the decrease of acidity during storage demonstrated fruit senescence. It was determined as a small change in pH represents a large change in hydrogen ion concentration (Ball, 1997).

The change in pH could be associated with a number of reasons; it might be due to the effect of treatment on the biochemical condition of the fruit and slower rate of respiration and metabolic activity (Jitareerat et al., 2007). Coatings slowed the changes on pH effectively delaying fruit senescence. This was probably because the semi-permeable Xanthum gel formed on the surface of the fruit might have modified the internal atmosphere i.e., the endogenous CO_2 and O_2 concentration of the fruit, thus retarding ripening (Davila-Avina et al. 2011). The increase in pH may be due to the breakup of acids with respiration during storage (Pesis et al., 1999).Increased or reduction in acidity during ripening may be due to their conversion into sugars and their further utilization in the metabolic processes of the fruit. Doreyappa & Huddar (2001) reported the similar pattern in different varieties of mango fruits stored at 18-34°C. They observed a series of physico chemical changes during ripening and the major changes were decrease in acidity. The acidity of the fruit is an important character to determine its quality and acceptability. Very high or very low values of the acidity are not recommended for good fruits.

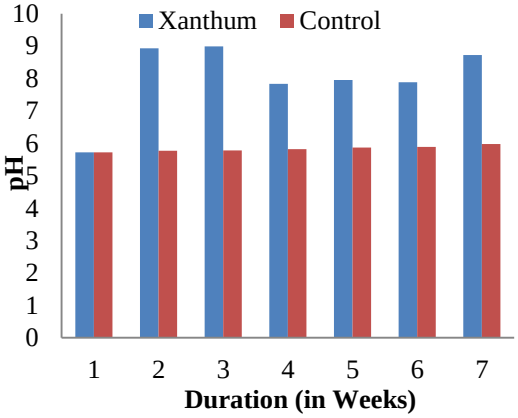

Figure 3: Effects of edible coatings from Xanthum gum on PH of *Carica papaya* fruits stored at ambient temperature.

Ascorbic Acid Content

The mean ± SE values for coated pawpaw for Vitamin C was 4.48 ± 0.16 and while the mean ± SE value for the uncoated pawpaw was 3.52 ± 0.32. Ascorbic acid was maintained and higher in the pawpaw coated with Xanthum gum. Ascorbic acid was higher than that obtained for the control treatments (Fig. 4). Ascorbic acid in papaya increases during ripening but decreases during senescence. It has been observed that once the fruits have ripened, the ascorbic acid contents start to decline. The fruit with Xanthum coatings did not show any significant changes in ascorbic acid during the

first four weeks of storage and with slight changes at the last three weeks of storage. This suggests that the Xanthum coatings slowed down (but did not cease altogether) the synthesis of ascorbic acid during ripening. Similar results have been reported with a high CO_2 storage atmosphere for tomatoes (Mathooko, 1995), where a slowing down of the increase in ascorbic acid during ripening was observed. Slowing down of the vitamin loss was attributed to the low O_2 permeability of the coatings. Keeping oxygen away from the food delays the deteriorative oxidation reaction of vitamin C (Ayranci & Tunc, 2004). The Xanthum coatings appeared to inhibit the metabolic processes to such an extent that ascorbic acid synthesis ceased. Hence, there was no increase in the ascorbic acid contents even during the ripening stage. It seems that the modified atmosphere created by xanthum coating suppresses the synthesis of ascorbic acid, but does not impair the fruit's capability to synthesize vitamin C.

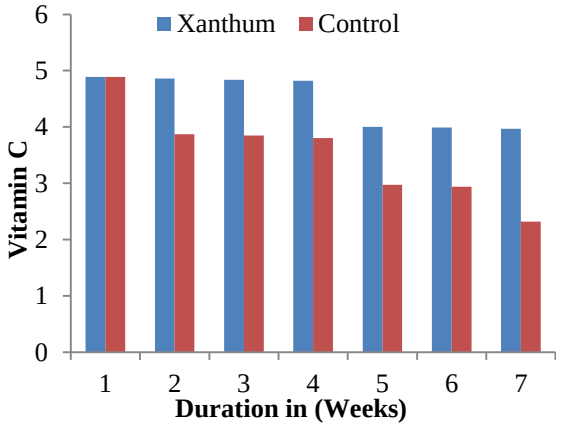

Figure 4: Effects of edible coatings from Xanthum gum on the Vitamin C content of *Carica papaya* fruits stored at ambient temperature

CONCLUSION

Xanthum gum, applied as edible coatings in pawpaw fruits, has beneficial effects in retarding the ripening process. This treatment was effective as a physical barrier and it reduced the weight loss of pawpaw fruits during postharvest storage. In addition, xanthum gum coating delayed softening of the fruit, Ascorbic acid and TSS losses and maintained the quality of pawpaw fruit.

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