Comparison of Polymeric Films and Plant Materials in the Preservation of Mango *(Mangifera indica)* Fruits

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Abstract
The use of plant materials in the preservation of food is less toxic to humans and animals than synthetic or chemical preservatives. These attributes enhance the economic value of such foods. The objective of this study was to investigate the effect of plant materials in comparison with polymeric films on the preservation of mango (Mangifera indica) fruits. Moringa and neem leaves, aloe vera, polyvinyl chloride (PVC) and cling film (CLF) were used in the experiment as fruit coats. The experiment was laid out in a completely randomized design (CRD) replicated six times. Data on percentage weight loss, firmness and skin colour of the fruits after treatments were collected daily. Results showed that there was significant (P<0.05) changes in colour, firmness and weight loss from 5 – 9 days after treatment. All the treatments had positive effect on the colour and firmness of the fruits. The effect of the plant materials on weight loss did not differ significantly (P>0.05) from the control. In general, the use of PVC and CLF significantly (P>0.05) preserved the mango fruits better than the plant materials and the control.

***Key Words**: mango, fruit rot, PVC, CLF, plant materials.*

Introduction

Mango (*Mangifera indica*), is one of the most important and widely cultivated fruits grown in the tropical and subtropical regions of the world. After harvest, the ripening process in mature green mango takes few days (Hoque et al., 2017). Depending on storage conditions, their shelf life varies, ranging from 4 to 8 days at room temperature and 2 to 3 weeks in cold storage (Carrillo et al., 2000). Several factors affect mango production with postharvest rotting of the fruits being among the major constraints. Softening caused by enzymatic degradation of carbohydrates and cell wall components is one of the principal contributors of postharvest losses in fresh mango fruits (Lohani et al., 2004). Several methods have been used to preserve mangoes, which include canning, freezing and the use of several materials to extend their shelf life. Other methods include heat treatment, edible coating and nano packaging (Cushen et al., 2012). Polymeric films have been widely used to package and preserve fresh products over the years (Ščetar et al., 2010). Although a wide range of other packaging materials are available, most packs are made from four basic polymers: polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP) and polyethylene (PE), for packaging of fruits and vegetables (Marsh and Bugusu, 2007 and Mangaraj et al., 2009). However, most of these materials are expensive and time-consuming. In recent years, concern has shifted to using plant materials as preservative for food due to their potential to reduce fruit rot with little or no health implication and their environmental friendliness. It has been demonstrated that the efficacy of the extracts from these plant materials depend on the nature of the solvent used in extraction,

the active ingredients present in the plant materials as well as the rot causing organisms (Ali, 1999 and Jasso de Rodríguez, 2011).

These plant materials are easy to access, thus making it easy to be adopted by the local farmers. Because of the importance of mangoes to the local population and the general acceptability of this product to Nigerians, there is need to evaluate the effectiveness of some locally sourced plant materials on the preservation of mango fruits especially during transportation from northern Nigeria where they are produced, to southern Nigeria where they are widely consumed. Success in this area will ensure all year availability of mangoes in our local markets and supermarkets, which will not only boost mineral and vitamin sufficiency intake but also help to grow the economy of the nation.

Materials and Methods

Experimental Site

Mango sampling was carried out at the fruit garden market in Port Harcourt, Nigeria and the laboratory experiment carried out at the Crop Protection Laboratory of the Department of Crop and Soil Science, University of Port Harcourt, Port Harcourt, Nigeria.

Experimental Materials

Materials used in the experiment included mangoes (John Peter variety), a popular mango variety grown in Benue State, Nigeria which has little fibre and excellent eating quality. Moringa *(Moringa oleifera*), Neem (*Azadirachta indica)* and Aloe vera (*Aloe barbadensis*) were sourced locally. Fresh leaves of moringa and neem were air dried at room temperature before being ground into powder using a milling machine, while fresh and mature aloe vera leaves were well washed and blended to obtain a jelly-like substance. The cling film (CLF) and polyvinyl chloride (PVC) were also sourced from the local stores in Port Harcourt, Nigeria.

Treatment application

200 g of the ground moringa and neem leaf powder was dissolved in 100 ml of water to form a paste and used to coat each of the mangoes, while aloe vera leaves were ground in a blender to obtain a good quality juice which was used to coat each of the mangoes. The other treatments involved mangoes individually wrapped in one layer of either PVC or CLF film. Control had no treatment applied to the mango fruits. The individual mango fruits were weighed before treatment. All treatments were placed in shallow plastic plates and kept on the laboratory bench at 25 ± 2^{o}C for 9 days.

Isolation and identification of fungal pathogens

Infected mango were randomly selected and collected in sterile polythene bags and labelled. Fungi species were isolated using Potato Dextrose Agar (PDA). The isolation and identification of the causal agents were performed for every single rotting fruit. Sub-cultures were made from emerging colonies repeatedly until pure cultures were obtained. The fungi were identified using Illustrated Genera of Imperfect Fungi by Benneth and Hunter, (1987). The pathogenicity of the isolated fungal species was confirmed by inoculating them to healthy mangoes to induce the rotting symptoms.

Data Collection

Daily data were collected on weight of fruit, firmness and fruit color throughout the experiment.

The Weight loss was evaluated using the following expression;

Weight loss (%) = [(A-B)/A] x 100

Where, A indicates the initial fruit weight before treatment application

B indicates the fruit weight after treatment application (A.O.A.C., 2000) The firmness was determined by applying hand pressure on the fruits to feel the softness of the tissue and using the Hedonic Scale ranking system of 1-6, where;

1. Hard
2. Fairly Hard
3. Medium
4. Fairly Soft
5. Soft
6. Bad

The colour was determined by observing the color change from the outer skin (mesocarp), using the Hedonic Ranking system of 1- 4, where;

1. Fresh (Very Green)
2. Good (Green)
3. Half Ripe (Yellow Green)
4. Ripe (yellow or Red)

Experimental design and data analysis

Data obtained were subjected to analysis of variance (ANOVA) using Genstat (Genstat 13th Edition, VSN International Ltd, UK) and means separated using the least significance difference (LSD) at 5% level of probability.

Results and Discussion

Fungal species

The fungi species isolated from the infected mangoes were; *Botryodiolodia theobromae, Colletotrichum gloeosporioides* and *Aspergillus niger* (Table 01). *Fusarium* sp, *Aspergillus flavus* and *Phoma* sp. were also isolated but could not prove pathogenicity when inoculated into healthy mango fruits. *Botryodiplodia theobromae* caused stem rot of the mangoes and affected the entire fruit within days after initiation. *Colletotrichum gloeosporioides* caused dark-brown to black spots, while fruits infected by *Aspergillus niger* had brown round shaped spots showing a depression. From the current study, *C. gloeosporioides and B. theobromae* were the major cause of the mango rots. Anthracnose caused by *C. gloeosporioides* has been reported widely wherever mangoes were produced or marketed (Jaiswal et al., 2013).

Table 01: Fungi species isolated from the mango fruits

Fungi species	Occurrence (%)
Botryodiolodia theobromae	47.8
Colletotrichum gloeosporioides	47.2
Aspergillus niger	2.5
Fusarium sp	1.2
Aspergillus flavus	1.0
Phoma sp	0.3

Fruit weight loss (%)

Weight loss showed no significant effect ($P>0.05$) effect of postharvest treatments for the first 3 days, but from the 4th day, PVC and CLF were significantly ($P<0.001$) better preservatives than the plant materials (Fig.01). Percentage weight loss increased with increase in storage duration throughout the experiment and this agrees with (Carrillo et al., 2000) who observed that coated or uncoated Haden mangoes in Mexico had increasing weight loss with the passage of storage time. Higher weight differences were observed in the fruits treated with plant

materials and control compared with the fruits treated with PVC and CLF. Control fruits were statistically same with the fruits treated with the plant materials.

Changes in weight loss are one of the important indicators for maintaining the quality of fruits. The reduction in weight loss in the film wrapped samples or treatments are attributable to the modified atmosphere storage conditions created within the wraps. As the fruits were sealed in plastic films such as cling film and polyvinyl chloride, the respiration process consumed oxygen and caused carbon dioxide to accumulate within the film covering. The plastic bag, in this case coatings of different types and plastic films, served as a modified atmosphere compartment and retained water vapour while allowing slow entry of oxygen, unlike the coating with plant materials. This drastically reduce the physiological loss in weight due to respiration and transpiration of water through peel tissue, and other organic changes taking place in the fruit. The use PVC and CLF may have resulted in the reduction of these processes thus preserving the mango fruits longer.

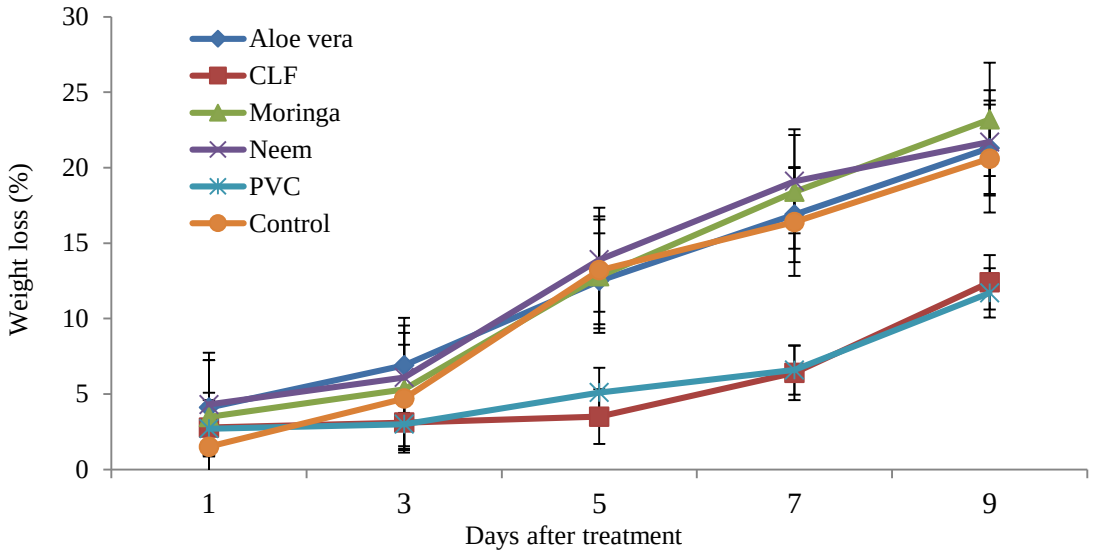

Figure 01: Effect of Aloe vera gel, neem leaves, moringa leaves, PVC and cling film on weight loss (%) of mango fruits.

Fruit colour

No significant (P>0.05) colour effect was observed in the first 4 days after treatment (Table 02). The postharvest treatments applied showed a significant difference from days 5 - 9 of storage. From the 5th day, as was observed in the weight loss, highly significant (P<0.001) colour changes were observed in fruits treated with plant materials when compared with the fruits treated with PVC and CLF. The rate of colour deterioration progressed faster in fruits treated with the plant materials ranging from 1.5 – 2.5 and 2.0 – 3.8 in aloe vera and neem treated fruits, respectively, from the 5th to 9th day of storage. This is compared to 1.0 – 1.7 in fruits treated with CLF and 1.2 – 2.0 in fruits treated with PVC under the same period. Control fruits progressed from 1.6 at the 5th day of storage to 3.2 at the 9th day and this was statistically same with the fruits treated with the plant materials. Colour is one of the most important criteria for fruits and peel colour of mango indicates stage of maturity and ripening. The fresh green colour of the fruit was preserved longer by PVC and CLF compared with the plant materials but eventually the fruit turned yellow and eventually red as their pulp got softer. During colour changes, the pulp of the fruit became softer and sweeter as the ratio of sugars to starch increased and the characteristic aromas are produced (Robinson, 1996). It has also be reported that the

green colour of mature varieties of mango turned from light green or green or dark green to light yellow or yellow or orange yellow due to the breakdown of chlorophyll due to a series of physico-chemical changes during ripening, leading to the disappearance of the green colour (Vijayanand et al., 2017). The use of plant materials may have aided ripening of the fruits thus resulting in faster disappearance of the green colour of the fruits.

Fruit firmness

Table 03 shows that firmness changes occurred faster in fruits treated with neem, Aloe vera and the control whereas the rates were slower in those fruits treated with PVC and CLF. At 8 days of storage, mango had a firmness score of 4.0 in neem which was significantly (P=0.05) different from fruits treated with CLF, PVC and moringa. According to Olmo et al., (2000) firmness is widely used as a ripeness test for many fruits and values of firmness are effective for evaluating fruit maturity as the fruit ripens The quality of mango also depended on firmness of tissue during storage. Firmness changes were affected by postharvest treatments and fruit treated with neem reached the highest score 4 during the 9 day period of storage.

Table 02: Effect of Aloe vera gel, neem and moringa leaves, PVC and Cling film on colour of mango fruits

	Days after treatment							
Treatment	1	2	3	4	5	6	7	8
Aloe vera	1.0	1.0	1.0	1.5	1.7	1.7	2.0	2.5
CLF	1.0	1.0	1.0	1.0	1.0	1.2	1.3	1.7
Moringa	1.0	1.0	1.0	1.7	1.8	2.0	2.8	3.2
Neem	1.0	1.0	1.0	1.5	2.0	2.2	3.0	3.8
PVC	1.0	1.0	1.0	1.2	1.2	1.3	1.5	2.0
Control	1.0	1.0	1.0	1.4	1.6	2.2	3.0	3.2
LSD	nil	nil	nil	0.56	0.45	0.55	0.59	0.79
P. value	nil	nil	nil	0.18^{ns}	<0.001***	<0.001***	<0.001***	<0.001***

**** Highly significant; ns = not significant

Table 03: Effect of aloe vera gel, neem and moringa leaves, PVC and Cling film on firmness of mango fruit

	Days after treatment							
Treatment	1	2	3	4	5	6	7	8
Aloe	1.0	1.2	1.5	1.5	2.2	2.7	3.5	3.5
CLF	1.0	1.0	1.0	1.0	1.2	1.3	1.8	2.0
Moringa	1.0	1.0	1.2	1.5	1.7	2.0	2.7	2.8
Neem	1,0	1.2	1.3	2.2	2.5	3.0	4.0	4.0
PVC	1.0	1.0	1.2	1.5	1.7	2.0	2.2	2.3
Control	1.0	1.2	1.6	1.8	2.2	2.6	3.0	3.5
LSD	nil	0.35	0.53	0.83	0.96	1.21	1.26	1.20
P value	nil	0.66^{ns}	0.23^{ns}	0.14^{ns}	0.08^{ns}	0.12^{ns}	0.03*	0.04*

* Significant; ns = not significant.

Conclusion

The greatest challenge in fruit production is the short shelf life of these products, mostly as a result of oxidation reactions such as degradation and enzymatic browning as well as microbial deterioration. One approach to reduce fruit deterioration is the use of films and coatings using plant materials. The result from the current study reveals that the use of polymeric films potentially preserved mango fruits better than the plant materials. The effectiveness of plant materials might depend on plant materials used, the fungus evaluated and nature of the skin of fruits. The results obtained showed that plant materials used in the current study mainly promoted quick ripening. This presents an opportunity for further investigations on the use of these plant materials as ripening agents. Also the use of these plant materials on fruits with harder skin is recommended.

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