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Full Length Research Paper

Edible sheabutter and palm kernel cream coatings extend the postharvest shelf life of white yam (*Dioscorea rotundata,* Poir)

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ABSTRACT

A significant quantity of white yam (*Dioscorea rotundata,* Poir) gets deteriorated soon after harvest through sprouting, weight loss and development of soft spots; a major concern to farmers and other actors within the yam value chain in West Africa. We studied the effect of using shea butter and palm kernel cream as postharvest coatings to improve the keeping qualities of white yam. Variety (*Puna, Asana* and *Punjo*) and tuber size (surface factor 1.1, 1.4 and 1.7) were the other variables. Parameters monitored during the 5-month storage period were the physiological weight loss, rate of sprouting, and development of soft spots. Additional parameters monitored were changes in reducing sugars and moisture of the stored yam as well as the sensory of the roasted yam. Postharvest shelf life indices were significantly improved for first three months of storage as evidenced by reductions in the rate of weight loss, sprouting and development of soft spots. All these parameters were also influenced by variety and size of the tuber and the treatments but the treatment with shea butter and palm kernel creams did not affect the sensory parameters of the baked yam. Sheabutter and palm kernel cream coatings can therefore potentially help several yam value chain actors to improve upon the keeping qualities of white yam.

KeyWords: Shea-butter; palm kernel cream coatings; white yam; post- harvest shelf life;

INTRODUCTION

White yam (*Dioscorea rotundata* Poir) is a major food security crop in the diet of many in the tropical world. Being a perishable crop, its high postharvest loss is major challenge to farmers and other yam value chain actors (Osunde, 2008). Yam cultivation is very intensive in the Forest-Savanna and the Guinea Savanna zones of the Northern Region of Ghana. Studies have shown up to 18% postharvest loss in yam could be between the range of 18 to 60%during a typical storage period of 4 months mainly through postharvest physiological and pathological causes (Osunde, 2008 and IITA, 2012). The physiological causes lead to tuber weight loss through sprouting and respiration (Ravi and Aked, 1996) while pathological causes lead to soft spots formation (decay) due to the actions of fungi, bacteria and parasitic nematode (Aidoo, 2007).

Though some methods and treatments such as irradiation and use of refrigerated temperatures below 13 ^{o}C (Gyamfi, 2002) have been developed to help extend the postharvest life of yam tubers, they are however too expensive. The potential of using low-cost postharvest treatment such as waxing has been documented. Cooke *et al* (1988) waxed yam tubers with epolene (E10) but unfortunately found inconsistencies in weight loss reduction. Hardenburg *et. al.*, (1959) found that waxed potato developed decay especially from lenticel type of infection. However, Sugri *et. al.* (2010) and Kumahor and Johnson (2015) have effectively used shea butter waxing to extend the shelf life of plantain (from 5 to 21 days) and cassava (2 to 30 days), respectively.Shea butter and palm kernel cream have lauric acids, which by nature prevent excessive moisture loss and therefore have anti-weight loss and anti-oxidative properties (Emenike, 2010).Palm kernel creamalso has anti-microbial properties known to be active against *Escherichia coli*, alpha and beta hemolytic streptococci, *Aspergillus fumigate*, *Staphylococcus aureus and Asperigillus niger* some of which cause serious yam tuber rot (Aidoo, 2007). This paper therefore concerns a study carried out on the effect of using shea butter and palm kernel cream as post-harvest waxing materials on the keeping qualities of *Puna, Asana* and *Punjo* varieties of white yam (*Dioscorea rotundata* Poir).

MATERIALS AND METHODS

Yam samples and method of storage

Three varieties of white yam (*Puna, Asana* and *Punjo*) were used for the study. These were obtained from commercial yam farmers at Appiakrom near Tapa Abotoase (7°28'02.3"N 0°21'06.2"E) located in Biakoye District in the northern part of Volta Region of Ghana. The yam tubers used for the study were carefully selected. These were freshly harvested tubers and were without disease or physical bruises. The soil particles on the selected tubers were removed by gently brushing the surfaces using soft bristle brush to minimize bruises on the skin. In all there were 4 replications and each replicate consisted of 27 tubers. The experiment was carried out on-farm using the farmers' own yam storage structures which consisted of well-ventilated wooden barns on raised platforms (Osunde, 2008). The ambient temperature and relative humidity around the barns were monitored and found to average 30±1^{o}C and 72 ±1 %, respectively; over the 5-month storage period; whilst the average air speed around the storage barns was found to be 9 km/h using a handheld anemometer (Flus: MT-905/905C).

Research design

A 3x3x3 factorial experiment in a randomized complete block design (RCBD) with 4 replications as shown in Table 1 was used. These treatment combinations were represented in each of four (4) blocks with each block representing a yam barn of each of the four yam farmers selected.

Procedure of waxing

For each treatment 500ml of each wax (shea butter and palm kernel cream)was used to achieve uniform wax cover. Flat soft brushes were used to apply wax on the selected tubers. The brush was dipped into the cream and smeared uniformly on the surface of the yam samples. Different brushes were used for each wax to avoid contamination.

Physical parameters measured

Physical parameters measured were the surface factors, rates of physiological weight loss, rates of sprouting, and rotting. The surface factor was determined using the methods by Ezeike (1984) with the formula below:

$$\mathrm{SF} = \frac{\mathrm{L}}{\sqrt[3]{(\mathrm{D_1 D_2 D_3})}}$$

where L= length of tuber, D_1 = diameter of the proximal part, D_2= diameter of the mid portion, and D_3= diameter of the distal part of the tuber. The proximal diameter (D_1), was calculated using the formula below:

$$D_1 = \frac{C_1}{\pi}$$

where 'C_1' = the circumference of the proximal part, while π = 3.14. These measurements were taken at the start of the storage period , using a tailor's tape measure. This resulted in the following three sizes of yam tubers:small tuber size (with SF = 1.1), medium tuber size (with SF = 1.4), and large tuber size (with SF = 1.7).

The Physiological weight loss (PWL) during storage was determined at 2-week intervals using the method of Ezeike (1984).The rate of sprouting of the treated yam was also monitored fortnightly during the 5-month storage period. At the 2 -week intervals, the number of shoots on the yam, representing the occurrence of sprouts, that had developed were counted and the number obtained added to the previous counts. The rate of sprouting was thus estimated using the formula:

$$\text{Rate of sprouting} = \frac{\text{Weekly total number of sprouted tubers per each type of waxing}}{\text{Initial total number of tubers per each type of waxing}} \times 100\%$$

The rate of rotting was also monitored using the same principle as explained for the rate of sprouting.

Chemical parameters measured: changes in moisture and reducing sugars

Changes in moisture content and reducing sugars were monitored during the storage at 6-week interval using standard AOAC methods (AOAC, 1994).

Table 1 Factors and levels

Factors and Levels		
A = Variety	B = Waxing treatment	C = Tuber Size
V_0 - Puna	T_0 – No waxing (control)	S_0 – Smaller size tuber (surface factor 1.1)
V_1 – Asana	T_1 – Waxing with shea butter (SBO)	S_1 – Medium tuber size (surface factor 1.4)
V_2 - Punjo	T_2 – Waxing with Palm Kernel Cream (PKO)	S_2 – Larger tuber size (surface factor 1.7)

Table 2. Effect of waxing, tuber size and yam variety on physiological weight loss of tubers in storage

Yam Variety	Tuber size	Rate of physiological weight loss(%) as affected by type of waxing used			Means for variety
		Shea butter	**Palm kernel Cream**	**Control**	
Puna	**Small size**	6.82 (0.38)	8.70 (0.34)	18.09 (0.24)	**11.57 (0.29^c)**
	Medium size	9.47 (0.33)	9.69 (0.32)	19.49 (0.23)	
	Bigger size	10.74(0.31)	11.80(0.29)	20.64 (0.22)	
Asana	**Small size**	6.17 (0.40)	7.67 (0.36)	17.20 (0.24)	**10.28 (0.31^b)**
	Medium size	7.69 (0.36)	8.32 (0.35)	17.83 (0.24)	
	Bigger size	10.29(0.31)	10.27(0.31)	18.14 (0.24)	
Punjo	**Small size**	6.00 (0.41)	6.55 (0.39)	16.95 (0.24)	**9.89 (0.32^a)**
	Medium size	7.12 (0.38)	9.35 (0.33)	17.54 (0.24)	
	Bigger size	9.62 (0.32)	9.66 (0.32)	18.11 (0.24)	
Mean for waxing		**7.94 (0.36^a)**	**8.94 (0.34^b)**	**18.17(0.24^c)**	

***LSD ($p < 0.05$) for both waxing and variety = 0.0026. *Data in parenthesis are transformed values**

Sensory evaluation of the baked yam

The effect of using the shea butter and palm kernel waxes on the sensory properties of baked yam samples was investigated at the end of the 5-month storage. Baked yam was used because the process does not involve addition of water or any other ingredient that can interfere or influence the actual sensory qualities of the yam tubers. Samples of the three yam varieties at the end of 5-month storage period were peeled, sliced into 3 cm thick cylinders (average diameter =6.7 cm) and roasted on an average charcoal fire for 20-30 minutes until ready for consumption as is normally done in street food vending situation in Ghana. Flavour, texture, taste, appearance, and overall acceptability were the sensory attributes that were evaluated by trained panel of twenty using the 9-point hedonic scale.

Statistical analysis of data

The data obtained were first transformed into their reciprocal square roots (Osborne, 2002) and then statistically analyzed using the Analysis of Variance (ANOVA) using the statistical package GenStat (9th edition).

RESULTS AND DISCUSSION

Effect on physiological weight loss (PWL) and changes in moisture content

Table 2 shows that significant ($p<0.05$) reduction in PWL was achieved using both palm kernel cream(8.94%)and shea butter waxing (7.94%)compared to the control (18.17%). The *Puna* yam variety recorded the highest significant ($p<0.05$) PWL of 11.57% compared to 10.28% in *Asana* and 9.89% in *Punjo*. Smaller-sized tubers (SF: 1.1) were found to lose less weight compared to medium-sized (SF: 1.4) and larger-sized tubers (SF: 1.7). The average weight loss of smaller-sized tubers was 8.97% compared to 10.65% in medium-size tubers and 12.42% in larger-sized tubers. The reduction in PWL could have been as a result of the slowing down of the respiration rate when the yam was waxed with either the shea butter or the palm kernel cream (Lopez-Castaneda *et. al*., 2010). The slowing of the respiration may have come about because both shea butter and palm kernel coatings may have created a modified atmosphere between them and yam skin such that there was an overall reduction in the amount of available oxygen during storage (Revathy *et. al*., 2002). This will result in the slowing down of respiration as well as the rate of moisture loss (Lopez-Castaneda *et. al*., 2010). This argument is ably supported

Table 3. Effect of shea butter and palm kernel cream waxing on moisture content of yam samples over 5 months during storage

Type of waxing	Tuber Moisture content (%) (Months after storage)				
	1st month	2nd month	3rd month	4th month	5th month
Shea butter waxed yam	74.1 (1.87)	71.1 (1.85[a])	68.7 (1.84[a1])	64.7 (1.81[a2])	63.2 (1.80[a3])
Palm kernel cream waxed yam	72.6 (1.86)	66.7 (1.83[b])	64.3 (1.81[b1])	59.3 (1.77[b2])	57.8 (1.76[b3])
Non waxed yam (control)	72.1 (1.86)	66.7 (1.82[c])	61.7 (1.79[c1])	55.2 (1.74[c2])	53.7 (1.73[c3])
LSD (p < 0.05)	**NS**	**0.0088**	**0.0093**	**0.0101**	**0.0104**

*NS = not significant   *Data in parenthesis are transformed values

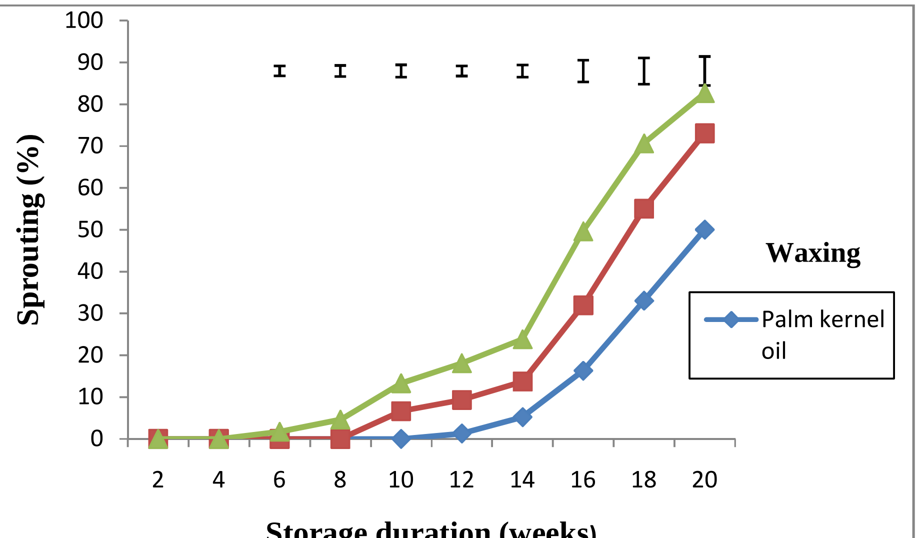

Fig. 1: Effect of shea butter and palm kernel cream waxing on sprouting in either Puna, Asana or Punjo variety of white yam stored at 30±1 ^{0}C and 72±1 % RH
*vertical bars indicate LSD values at 5% level of significance

by results obtained for the moisture content profile over the 5-month period as shown in Table 3, where it was found that tubers waxed with shea butter had significantly (p<0.05) higher moisture content, followed by palm kernel cream–coated yam and the control group.

Effect on rate of sprouting and development of soft spots

Figure 1 shows that waxing with palm kernel cream and shea butter reduced the rate of sprouting significantly(p< 0.05).At 20th week of storage, sprouting in the control group was 82.6% compared to 60.1% in shea butter and 45% in palm kernel cream waxed tubers (Figure 1). First sprouting was noticed at 4th week of storage in the control group, 8th week in shea butter waxed tubers and 10th week in palm kernel waxed tubers. The slowing down of the rate of sprouting can be attributed to the slowing down of the respiration as explained earlier (Tortoe *et al*, 2015).

In Table 4, tubers treated with palm kernel cream significantly (p < 0.05) developed less soft spots compared with shea butter and the control group. Early soft spot incidence was noticed in the control at 4th week, and in shea butter waxed tuber at 6th week of storage. Generally, soft spots did not occur in yam tubers waxed with palm kernel cream until the 8th week of storage. After 5 months of storage, the rate of soft spot formation in tubers treated with palm kernel cream was low (9.8%) compared to 14.8% in shea butter and 18.9% in the control. It was also observed that tubers of *Puna* variety were significantly (p < 0.05) susceptible to soft spots compared to *Asana* and *Punjo* varieties. In general there are two soft spots formation; the bacterial soft spots and lenticels spot in yam tubers during storage (Osunde, 2008 and IITA, 2012). The bacterial soft spot caused by the action of fungi, bacteria and parasitic nematode (Ravi and Aked, 1996) have remained the critical challenge in the postharvest handling of yam (Aidoo, 2007). In general, the bacteria that cause soft rot are referred to as

Table 5. Effect of shea butter and palm kernel cream waxing on reducing sugar Contents of yam samples during the 5-month storage

Storage Duration	**Tuber Variety**	**Levels of Reducing Sugars (in mg.g^{-1} dry weight)**		
		Palm kernel cream waxing	**Sheabutter waxing**	**Control**
1st month after storage	Puna	3.85	3.87	4.36
	Asana	3.83	3.84	4.01
	Punjo	3.82	3.82	4.03
3rd month after storage	Puna	3.98	4.27	6.63
	Asana	3.97	4.25	6.44
	Punjo	3.95	4.23	6.46
5th month after storage	Puna	4.21	6.55	8.34
	Asana	4.19	6.52	8.31
	Punjo	4.18	6.49	8.30

pectolytic bacteria because they produce enzymes that decompose the pectin in plant cell walls, leading to tissue deterioration. The soft rot bacteria are assigned to several species in the genera *Pectobacterium* and *Dickeya* (both were formerly in the genus *Erwinia*), and include *P. atrosepticum*, *P. carotovorum* subsp. *carotovorum* and subsp. *brasiliensis*, *P. wasabiae*, and *D. dianthicola*(Aboakye-Nuamah, *et al*., 2005, Aidoo, 2007 and Ravi and Aked, 1996). Lenticel spot can also be caused by one or more species of *Pectobacterium*. However, other bacteria such as species of *Bacillus*, *Clostridium* and *Pseudomonas* are also suspected to cause symptoms of lenticel spot (Aboagye-Nuamah, *et al*, 2005 and Aidoo, 2007).

Wet fields and warm temperatures before harvest, plus a film of moisture on the tuber surface either in storage or transit, greatly favor development of both diseases (Ravi and Aked, 1996). The lenticel spot is a manifestation of bacterial soft rot, initiated in tuber lenticels. The results revealed that shea butter and palm kernel cream were effective in reducing the formation of the soft spots because of the anti-microbial properties. Additionally, the presence of the lauric acid, beta-carotene and tocopherols (vitamin E), which have anti-moisture loss and anti-oxidation properties (Aidoo, 2007) further helped to reduce the development of soft spots and thus the PWL. We also noted that the palm kernel cream appears to be more effective in reducing the occurrence of soft spots in yam than the shea butter and without any adverse influence.

Perhaps this could be attributed to the higher content of anti-microbial property (Emenike, 2010), which probably is lethal to the yam buds. We however noticed that excessive application of palm kernel cream on the yam tubers killed the periderm of the tubers. It is therefore advisable to mop up the excess cream on the tubers after waxing. It was also observed that yam varietal differences affected the rate of physiological weight loss, soft spots and sprout formation.For example, the *Puna* variety was most susceptible compared to *Asana* or *Punjo*. We believe this might be due to differences in the physico-chemical properties of the yam tubers as a result of varietal differences. We also considered the fact that apart from lignin, other yam constituents such as cellulose and hemicellulose are affected by tuber variety (Ravi and Aked, 1996) and therefore may have influenced what we observed. Furthermore, Ravi and Aked (1996) further reported that during prolonged storage of yam the increase in fibre depends on the variety.

Effect on reducing sugars at 5 months after storage

Table 5 shows that the level of reducing sugars content increased gradually with prolonged storage. The increase was higher in the control tubers compared to those waxed with shea butter or palm kernel cream. In addition, tubers waxed with shea butter produced higher level of reducing sugars than those that were waxed with palm kernel cream.The level of reducing sugars was high in sprouting tubers compared to dormant tubers. There were also varietal influences in the levels of reducing sugars in the stored tubers, indicating different rates of breakdown of the starch of the three yam varieties (Osunde, 2008).

Effect on sensory parameters

Table 6 clearly shows that the use of either shea butter or palm kernel cream as coatings did not significantly affect the quality of the sensory parameters. This finding is consistent with the general observation that the use of edible postharvest waxes to increase the shelf –life of fruits and vegetables does not affect the eating qualities (MFCL, 2004).

Table 6. Effect of shea butter and palm kernel cream waxing on sensory qualities of roasted yam samples at the end of 5-month storage

Type of waxing	Scores of Waxed Yam Tuber for Sensory Qualities				
	Taste	**Texture**	**Flavour**	**Appearance**	**Overall Acceptability**
Shea butter	9.00	8.67[b]	8.33[b1]	9.33	8.33
Palm kernel oil	9.00	8.67[b]	8.08[b1]	9.33	8.33
Control	9.00	9.00[a]	9.00[a1]	9.33	8.33
LSD ($p < 0.05$)	NS	0.2549	0.332	NS	NS

***NS= not significant**

CONCLUSIONS

Overall, this study has shown that shea butter and palm kernel cream waxing inhibited excessive weight loss across the varieties evaluated. In addition, palm kernel cream waxing inhibited sprouting and soft spots formation. Bigger tubers recorded higher weight losses compared with tubers of smaller size of the same variety. It was however found that the *Puna* yam variety was more susceptible to weight loss and soft spot formation than *Asana* and *Punjo* yam varieties. This study reveals the potential of using shea buter and palm kernel cream, both food-grade oils to prolong the shelf-life of white yam (*Dioscorea rotundata,* Poir)and would therefore be of tremendous assistance to the yam value chain actors.

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