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Effect of different drying methods on the physicochemical characteristics of cassava flour ("pupuru")

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ABSTRACT

The effects of smoking, toasting and oven drying methods on the physical and chemical characteristics of "*pupuru*", a fermented cassava product, were studied. Cassava tubers were manually peeled, washed and steeped in water for four days after which the water was decanted; the soft wet mash was packed into Hessian sack and pressed. One portion was moulded into small-sized (500 g) ball shape and smoked on wood fire for 72 hours (Traditional method). The second portion was moulded into 500 g size ball and dried in the hot air oven at 60 °C for 14 hours. The two products were pulverized and sieved with 60 mesh size into fine *pupuru* flour. The third wet meal was sifted and toasted on an aluminum pan over fire and then milled into fine toasted *pupuru* flour. The flours were subjected to physicochemical evaluations. There was reduction in drying time when *pupuru* was toasted compared to the tradition smoking method. The range of final moisture content achieved was 7.14- 8.40% (db). Despite the shortness in the drying time, the toasted samples had the lowest moisture content. Irrespective of the drying methods, there were significant differences ($p < 0.05$) in the proximate composition. The crude fibre content was highest in smoked dried with 3.17% compared to the toasted and oven dried samples with 2.12% and 2.53% respectively. The titratable acidity increased by about 78% from 0.09 to 0.16 with corresponding decrease in pH from 5.34 to 4.18. The toasted product had the lowest pH value of 4.18 while smoked and oven dried had 4.67 and 4.63 respectively. The bulk densities for both loosed and packed \ were higher for toasted product with values of 0.54 and 0.62 g/ml respectively, while smoked dried had the least value of 0.21 and 0.40 g/ml. The swelling power was highest in the toasted *pupuru* with value 0.38 ml/g and water holding capacity was 259.42 ml/g. The cyanide content of the smoked, oven dried and toasted product were 0.42, 0.48 and 0.47 mg/100g respectively. The toasting method gave the best sample in terms of drying time, moisture content, physical properties and sensory qualities. It can be concluded that toasting drying method is a better alternative method of producing *pupuru.*

Keywords: Cassava, *pupuru*, physicochemical, sensory, processing.

INTRODUCTION

Food preservation is as important as food processing itself because methods of food preservation are expected to improve the shelf life of food products. Cassava (*Manihot esculenta Crantz*) roots are widely used as food in Nigeria. It is one of the most important root crops in most tropical countries and it is estimated that foods processed from cassava roots are staple for over 800 million

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people in the tropics (Nagib et al., 2005). Utilization of cassava roots as food has been in the increase in many countries in the tropic in the past decade (Oduro et al., 2000). *Pupuru* is a staple starchy food popular in Nigeria, especially in the western part of the country. *Pupuru* is traditionally prepared by soaking cassava in water for about 3-5 days to become soft. After fermentation, the wet mash is packed into sack and dewatered using a mechanical press. The fibres are handpicked from the mash and the mash are molded into ball or circular shape and placed over fire to smoke dry. The resulting products are spherical-like material with brown appealing appearance. The outer covering is then scraped off with knife and the inner white component is milled and sieved into *pupuru* flour. This is then reconstituted by stirring in hot water and pounded into a smooth solid food called "*pupuru*".

The control and monitoring of conditions in the traditional processing methods are difficult. Another major constraint in the traditional processing of *pupuru* is the unduly time (24-72 h), as a result of ineffective heat transfer mechanism using the traditional dryer and probably due to the irregular and large sizes (1.2- 1.8 kg) of the ball dried. Therefore, proper drying is not achieved and dried balls have the high moisture content, thus the product is susceptible to mold attack as well as developing some off flavor on storage. Also, prolonged drying may institute some changes that could negatively affect some functional properties of the product (Shittu et al., 2001)

The objective of this work was to provide an alternative method of producing *pupuru* using oven dried and toasted dried samples of *pupuru* and to discern the effect of the two drying methods.

MATERIALS AND METHODS

Preparation of *pupuru*

Cassava tubers were manually peeled, washed and steeped in water for four days until they were softened. The flow chart for samples production is shown in Figure 1. At every 24 hours, the water was decanted and replaced with fresh water in order to reduce the odour. After the fourth day the water was decanted, the soft wet mash was packed into Hessian sack and the water allowed draining off (Odetokun, et al., 1998) by pressing in Federal University of Technology's mechanical press. The fibres were manually removed and the wet meal was divided into three portions. The first part was prepared into *pupuru* as it is done traditionally. It was moulded into small-sized (500 g) balls shape. The moulded balls were arranged on mat of palm fronds and smoked to dryness using fire wood as a source of smoke for 72 hours. The resulting products were spherical-like materials with brown appearance. The outer covering was scraped off with knife and the inner white component was pulverized and sieved into *pupuru* flour using Endecolt laboratory Test Sieve with 60 mesh size.

The second portion of the dewatered meal was moulded into 500 g size ball and dried in the hot air oven (Gallenkamp Model Oven- 160) at a set temperature of 60 ^{o}C for 14 h (Osundahunsi, 2005). The product was pulverized and sieved with 60 mesh size to have oven dried *pupuru* flour. The third portion of the wet cassava meal was sifted with a mesh of pore size wider than that of gari to remove shafts. The meal was toasted in wide aluminium pot with constant stirring for some minutes to prevent burning and formation of lumps. It was then milled into fine toasted *pupuru* flour.

Analyses

Chemical characteristics

Proximate analyses of the *pupuru* flours were carried out using the standard procedure of Association of Official Analytical Chemist (AOAC, 1990) and carbohydrate by difference. The energy values were calculated by Atwater factor of 4, 9 and 4 for protein, fat and carbohydrate contents respectively. Total titratable acidity (TTA, as % lactic acid) was determined using the method of Pearson (1976). The pH was determined on a standardised digital pH meter. Hydrogen cyanide content of *pupuru* flour samples was determined using AOAC

(1990). Gravimetric determination of tannin was done according to the method of Marker and Good Child (1999). Phytate was determined according to the method of Young and Greaves (1990). The oxalate content determination was done according to Day and Underwood (1986). The following mineral contents sodium, potassium, calcium, magnesium, iron, copper, zinc, and lead were determined by wet ashing of *pupuru* samples as described by Osborn and Voogt (1978).

Physical characteristics

The swelling power was determined according to Ukpabi and Ndimele (1990). Twenty-five grams of each samples was weighed into 250 measuring cylinder. Cold distilled water (150 ml) was added and cylinder was allowed to stand for four hours before observing the level of swelling. The water absorption capacity was determined by using the method of Sathe et al. (1982). One gram of sample was added to 10 ml of distilled water and stirred with a magnetic stirrer for five minutes. The mixture was centrifuged at 3500 rpm for 30 minutes and the volume of supernatant was noted that is measured by using 10ml measuring cylinder for each of the sample. The density of water was assumed to be 1 g/ml.The bulk density of the flour was determined as described by Fashina and Sokhansaj (1993). The values were calculated as the amount in gram that filled up 50 cm^3 of a glass cylinder. Brabender amylograph was used on flour-water mixture 10% (w/v) to determine the pasting properties. The samples were reconstituted into paste and assessed for colour (appearance), taste, aroma, texture (mouldability) and overall acceptability of the samples by a twenty member semi-trained panellists using nine-point hedonic scale; 1= dislike extremely, 9 = like extremely (IFT, 1981**;** Larmond, 1982).

Statistical analysis

Means and standard errors of the mean (SEM) of replicate scores were determined and subjected to analysis of variance (ANOVA). Means were separated using the Duncan's New Multiple Range Test (Steel et al., 1997).

RESULTS

The proximate compositions of *pupuru* obtained from different drying methods are presented in Table 1. The moisture content of *pupuru* flour ranged from 7.19 to 8.40% dry basis. *Pupuru* dried with smoke have moisture content of 8.40% while oven dried and toasted have 7.94% and 7.19% respectively.

The protein content of oven dried product is 1.34% while smoke dried and toasted products were 1.91% and 1.88% respectively. The crude fibre content was high in smoked dried with 3.17% compared to the toasted and oven dried sample with 2.12% and 2.53% respectively. The smoke dried and oven dried are almost the same 1.05 and 1.06%, while toasted was 0.91% for ash content. The carbohydrates content was highest in oven dried with 86.36% compare to other methods. The energy content is 358.03 kJ in smoked dried while oven dried and toasted has 358.22 kJ and 359.32 kJ respectively.

The pH; toasted *pupuru* has 4.18, it was much lower than the smoke and oven dried *pupuru* that has 4.67 and 4.63 respectively compare to the fresh root with value of 5.34. Thus, there was no significant difference between the pH of the smoked dried and oven dried. Meanwhile there was significant difference ($p>0.05$) among the titratable acidity of the three drying methods. The smoke dried and oven dried with value 0.13 and 0.14% respectively while the toasted has 0.16%. Table 2 shows the water absorption capacity (WAC); there was significant difference ($P\leq 0.05$) in the drying methods, the toasted *pupuru* was 259 ml/g higher than both smoke and oven dried *pupuru* with 166 and 187 ml/g respectively all compared to 115 ml/g for fresh roots. The swelling power has 1.09 g/ml for smoked dried *pupuru* while oven dried and toasted *pupuru* has 0.38 and 3.78 g/ml respectively. The oven dried *pupuru* was significantly lower in swelling power than the smoked dried and toasted *pupuru*. The loose bulk density for the smoked and oven dried had 0.21 and 0.33 g/ml respectively while toasted had the highest value of 0.54 g/ml. while the packed bulk density ranged between 0.40 to 0.62 g/ml. The anti-nutritional factors determined are shown in Table 3. There was reduction in the cyanide content of *pupuru* during processing from 14.6 mg/100 g to 0.47 mg/100 g with smoked dried having the lowest cyanide content. Thus there was significant difference in the *pupuru* obtained from the different methods. There was no significant difference in oxalate content for the smoked dried and the oven dried *pupuru* the values are 0.36 mg/g and 0.35 mg/g respectively. The phytate contents are significant different in the *pupuru* dried using different methods. The value of phytate ranged from 957.56 to 1071.90 mg/100 g.

The mineral analysis is presented in Table 4. The values of the potassium, lead and iron are not significantly different in smoked and oven dried samples. In the calcium content, the toasted *pupuru* has the highest value of 167.33 mg/100 g while smoked and oven dried *pupuru* had 160.8 mg/100g and 144.1 mg/100g respectively. The magnesium contents are significantly different with toasted having the highest value of 226.85 mg/100 g, the smoked dried had 108.95 mg/100g and oven dried had 100.3mg/100g. Zinc, Lead, Iron and copper were significantly lowest in the oven dried samples (1.9, 0.15, 0.05 and 0.05 mg/100g) respectively; while Lead, Iron and copper were significantly highest in toasted samples (0.36, 0.19 and 0.19 mg/100g) respectively. There was no significant difference in the Zinc content of smoked and toasted samples. Table 5 shows the result of sensory attribute of *pupuru* with different drying methods. The smoke dried *pupuru* was scored highest in terms of colour and taste with 6.69 and 6.62 respectively; while the toasted *pupuru* was scored highest in mouldability, aroma and overall acceptability with 6.63, 7.06 and 6.63 respectively. The oven dried *pupuru* was scored lowest in almost all the sensory parameters.

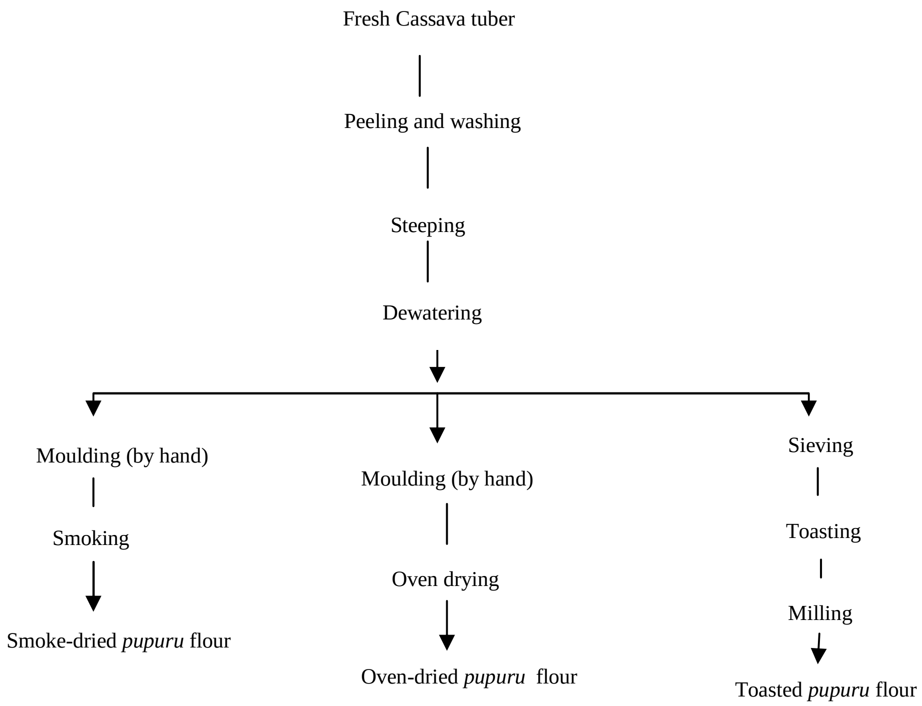

Figure 1: Flow Chart for the production of *pupuru* flour using different drying methods.

Table1: Chemical composition of *pupuru* dried by different methods.

Parameter	Smoked- dried	Oven- dried	Toasted
Moisture (%)	8.40^{a}	7.94^{b}	7.19^{c}
Ash (%)	1.06^{a}	1.05^{a}	0.91^{b}
Fat (%)	0.87	0.86	0.88
Crude protein (%)	1.91^{a}	1.34^{b}	1.88^{a}
Crude fibre (%)	3.17^{a}	2.53^{b}	2.12^{c}
Carbohydrate (%)	85.64^{b}	86.28^{b}	85.97^{b}
pH	4.67^{a}	4.63^{a}	4.1^{b}
Titratable acidity (%)	0.13^{c}	0.14^{b}	0.16^{a}
Energy(kcal)	358^{b}	358^{b}	359^{a}

Values are means of triplicate readings; values with different superscript in the row are significantly different ($p \leq 0.05$).

Table 2: Physical properties of *pupuru* dried by different methods.

Parameter	Smoked- dried	Oven- dried	Toasted
Water absorption capacity (ml/g)	165.52^{c}	187.67^{b}	259.42^{a}
Swelling index (w/v)	1.09^{b}	0.38^{c}	3.78^{a}
Bulk density (loosed) g/ml	0.21^{c}	0.33^{b}	0.54^{a}
Bulk density (packed) g/ml	0.40^{b}	0.42^{b}	0.62^{a}

Values are means of triplicate readings; values with different superscript in the row are significantly different ($p \leq 0.05$).

Table 3: Anti-nutritional factors in *pupuru* dried using different methods.

Parameter	Smoked- dried	Oven- dried	Toasted
Cyanide content (mg/100g)	0.42^{c}	0.49^{a}	0.47^{b}
Oxalate (mg/g)	0.36^{a}	0.38^{a}	0.27^{b}
Phytate (mg/100g)	1071.90^{b}	1240.05^{a}	957.56^{c}
Tannin (mg/100g)	0.000	0.0000	0.0000

Values are means of triplicate reading; value with different superscript in the row are significantly different ($p \leq 0.05$).

Table 4: Mineral content of *pupuru* flour.

Element(mg/100g)	Smoked- dried	Oven- dried	Toasted
Sodium	5.45^{a}	4.95^{b}	4.45^{c}
Calcium	160.8^{b}	144.1^{c}	167.33^{a}
Potassium	259.15^{b}	260.5^{a}	$160c^{a}$
Magnesium	108.95^{b}	100.3^{c}	226.85^{a}
Zinc	2.8^{a}	1.9^{c}	2.7^{b}
Iron	0.18^{b}	0.15^{b}	0.36^{a}
Lead	0.1^{b}	0.05^{c}	0.19^{a}
Copper	0.7^{b}	0.05^{c}	0.19^{a}

Values are means of triplicate readings; values with different superscript in the row are significantly different ($p \leq 0.05$).

Table 5: Sensory analysis.

Parameter	Smoke – dried	Oven- dried	Toasted
Colour	6.69[a]	6.64[b]	6.25[b]
Taste	6.63[a]	6.44[c]	6.56[b]
Modability	6.50[b]	6.44[c]	6.63[a]
Aroma	6.69[b]	6.38[c]	7.06[a]
Overall acceptance	6.56[b]	6.44[b]	6.63[a]

Values are means of triplicate reading with different superscript in the row are significantly different ($p<0.05$).

DISCUSSION

The rate of drying was influenced by the drying method. Drying time for oven drying was 14 hrs, the toasted 4 hrs and 24 hrs for the traditional smoking method. Osundahunsi (2005) reported that the moisture content as 12.21 and 12.90% for both smoked and oven dried while Odetokun et al. (1998) reported 9.86 and 10.20% for traditional prepared *pupuru*. Onayemi and Oluwamukomi (1987) reported that optimum stability of cassava and yam lies between 6.5% and 8.0%. The toasted sample has the lowest moisture content; this may be attributed to high heat process during toasting. . This is in agreement with Aboua (1995) who reported that moist cassava products have short shelf-life. The traditional smoke drying usually takes a long time (24-72 hr) which is the major constraint in the traditional processing of *pupuru* and probably due to the irregular and large sizes of the balls to be dried. As a result, proper drying is not achieved and dried balls have high moisture content, thus the product is susceptible to mould attack as well as developing some off flavour. However, such problem was eliminated by toasting method The protein content is low; however, cassava as a stable food has the problem of protein deficiency but they are indispensable food in many homes in Nigeria. The crude fibre was high in smoke dried due to the fact that it was not milled unlike toasted that has the lowest value of crude fibre because it was milled. The samples are within the nutritionally maximum level of 3.0% as reported by Ibe (1981) for processed gari. There was no significant difference ($p > 0.05$) in fat content of the samples of the three drying methods; the oven dried has 0.86%, smoked dried has 0.87% and toasted has 0.88%. There was significant difference ($p < 0.05$) among the titratable acidity of the three drying methods. The fresh roots was 0.09% while there was no significant difference between the smoke dried and oven dried with value 0.13 and 0.14% respectively, the toasted has 0.16% . The titratable acidity increased with corresponding decrease in pH revealing increase in acidity, which could be as a result of acid produced during fermentation. Similar result has been reported by Osundahunsi (2005). The toasted *pupuru* has the highest value for packed bulk density while there was no difference between the smoked dried *pupuru* and oven dried *pupuru*. The differences could be as a result of further processes involved in toasted *pupuru*. These values increased with the decrease in moisture contents of the flour. Faborode et al. (1992) and Fashina and Sokhansaj (1993) similarly observed increase in the bulk density of the particulate foods produced from maize, cassava and alfalfa as their moisture contents increased. The bulk density of solid food material determines the ease of packing during handling, processing and storage. The smoke dried sample had the lowest hydrocyanic acid (HCN) while the oven dries had the highest. This reduction in smoke dried product must have been due to the prolonged exposure to heat leading to volatilization of more HCN. These values were lower than the recommended standard value of 2.0 mg/100g (Ingram, 1975; NIS 181, 2004). *Pupuru* made from any of the methods used in this study would be safe for consumption since values recorded (0.42-0.49 mg/100g) were far below these reported values. The reduction in cyanide content could be attributed to synergistic effect of loss by hydrolysis into the steeping water during fermentation (Opadokun and Ikeorah, 1984) and evaporation during drying (Sanni et al., 1994 and Okpokiri, 1995). The wood used for smoking did not deposit high phenol content in the product which is confirmed by absent of tannin.

In terms of sensory qualities, the panelist most preferred the colour and the taste of the smoked sample. This might have been due to the fact the back was scraped off before milling and the smoking did not have any deleterious effect on the colour and the taste. During smoking, there is deposition of organic components like phenols, which impacts flavor and antimicrobial effect on the product. This could have enhanced acceptability in term of colour and taste, more so, panelists are more familiar with the smoke dried product. They however most preferred the toasted sample in terms of mouldability, aroma and overall acceptability. the aroma. The aroma of smoked dried was similar to the toasted sample but significantly different from oven dried.

Conclusion

From this study, it could be concluded that the toasting method produced the best *pupuru* in terms of lower moisture content, physical properties and more acceptable sensory qualities. Toasting method has shown to be a better alternative to the traditional smoking method of producing *pupuru.*

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