Environmental Influence on the Functional and Pasting Properties of Sun Dried and Oven Dried Bitter Yam (*Dioscorea dumetorum*) Flour

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Abstract: **This research work was carried out to investigate the effect of drying methods on functional properties and pasting behaviour of bitter yam (*Dioscorea dumetorum*) flour. Flour processed from bitter yam tubers was subjected to sun drying and oven drying methods at 4% moisture contents level, under the temperature of 32.3 ± 0.2^{0}C and 61.8 ± 0.2^{0}C at 6% respectively. The results showed that the oven-dried bitter yam flour had higher water absorption capacity (173g/g) and oil absorption capacity (341g/g) compare with lower values of 165g/g, water absorption and 298g/g, oil absorption capacity for sun dried bitter yam flour. It was also observed that oven dried flour had lower foaming capacity and foaming stability of 5.3% and 3.5% respectively compared with sun dried flour with the values of 5.9% and3.9% for foaming capacity and foaming stability respectively. Furthermore, Sun-dried bitter yam flour showed greater pasting characteristics for peak viscosity (73.18 RVU) and breakdown (19.63 RVU) compared to that of oven-dried flour of peak viscosity (65.96 RVU) and breakdown (3.71 RVU). On the other hand, it was observed that oven dried flour possessed higher holding strength, final viscosity and setback pasting characteristic compared to sun dried flour. While the sun-dried flour produced higher peak viscosity and breakdown pasting characteristics compared to oven-dried flour, the peak time is insignificantly different. This study showed that a low temperature dry method (sun drying) could be employed for processing bitter yam into flour for considerable application in food formulations especially when flour with high functional characteristics for foaming capacity, foaming stability, emulsion capacity and emulsion stability is to be considered. Oven dried bitter yam flour should be considered when high water absorption capacity, high oil absorption capacity and high reconstitution index are of high priority.**

Keywords**: Absorption, Bitter yam, Emulsion, Formulations, Flour, Oven-dried, Temperature**

I. INTRODUCTION

The challenges of post-harvest losses have been and are still a global issue for a long time especially in the African countries that rely solely on agriculture as the mainstream of the economies. In Nigeria, there is the need to promote efforts and programmes that will enhance progressive increase in food production at levels higher than the present state in order to meet the need of the ever increasing massive population growth. The diversification of products is extremely important in effort of an economy to become self-reliant. However, it should be noted that a major step toward achieving a greater level of food sovereignty, availability, diversities and security is to prevent losses between the times of harvest and end- use by ensuring adequate drying.

Drying is the removal of moisture from a certain material by evaporation as a result of heat, which have several effects on the physical properties of the material such as colour, odour/aroma, appearance and bulk density. Drying processing methods have been found to have significant effect on thermal properties of materials, such as thermal diffusion, moisture content, thermal conductivity and specific heat capacity. Similarly, drying as a function of temperature also has impact on functional properties and pasting characteristics of materials such as holding strength, final viscosity, elasticity, peak viscosity etc. Drying is a major tool of processing of quality food through the traditional, mechanical or solar drying methods.(Zantoph and Schuster, 2004 and Maxwell and Zantoph, 2002)

The *Dioscoreadumetorum*is a specie of yam that is traditionally known as "Esuru" in the Southern part of Nigeria. It is known for its slight bitter taste because it contains high alkaloid, hence it is called bitter yam (Martins *et al*, 1984.). Bitter yam being a perishable crop could be processed into a more stable and acceptable form such as chips, flour, starch, glues and glucose, to increase its shelf life; reduce tuber losses due to deterioration, sprouting, insect damage, rodent attack and reduce transportation costs. It is required that value is added to the commodity by creating "form utility", making the product more acceptable to the consumer in various forms and ensures the availability of the commodity over time and space (Orkwor, 1998).

Flour is a powder made by processing of crop which is obtained either by milling the dried crop or chips. The flour obtained from *Dioscorea dumetorum* is achieved by milling and it contains starch which can be substituted for rice starch. The bitter yam in spite of its bitter taste and long period of boiling before consumption can be processed into flour which may find applications in confectionery as thickening agents, gluing. agents e.t.c, especially when the functional properties and pasting behavior are ascertained. The specific objective of this research is to determine the functional characteristics and pasting properties of bitter yam under two drying methods in order to ascertain its food application and utility.

II. MATERIALS AND METHODS

4 kg of white variety bitter yam (*Dioscorea dumetorum)* tubers were obtained from Sabo Market, Ikorodu Lagos State. The tubers were thoroughly washed with clean water. The tubers were put into two batches of 2kg each and boiled for 45 minutes to soften the skin and prevent enzymatic reaction as carried out by Martins *et al* (1984). The thin skins were peeled off after boiling and cut into thin slices of 5mm. The batch for sun drying was spread thinly on trays and left for drying under the sun for 72 hours to ensure effective sun drying at an average temperature of 32.3 ± 0.2.

The batch for oven drying was thinly spread on trays and dried using a cabinet dryer (Corcair model). Thorough drying was ensured for 48 hours at an average temperature of 61.8 ± 0.2^0C. The two batches of dried yam chips were separately milled using a plate mill in order to obtain a fine powder, sifted through 0.5mm sieve and weighed. The fine flours obtained from the two batches were then packaged in polyethylene containers as sun dried flour (SDF) and oven dried flour (ODF) for further laboratory analysis.

III. FUNCTIONAL PROPERTIES OF FLOUR

Water and Oil Absorption Capacity (WAC/OAC) Determination

This was determined according to Sathe*et al*, (1982), and Eke and Akobundu, (1998).0.5g of each samplesflour was mixed with 5ml of distilled water or Salvon oil in a10ml graduated centrifugal tubes. Each mixture was stirred with glass rod to disperse the sample in distilled water and Salvon oil respectively. After allowing it stand for a period of 30 minutes, it was centrifuged for 30 minutes at 3500 rpm. The excess water/oil absorbed by each example was expressed as the percentage water or oil bound by 100g sample. The density of the oil was determined using the specific gravity bottle while density of water was taken as 1g/ml. The absorption capacity was calculated using the formula.

WAC (%) or OAC (%) =

$$\frac{\text{volume of bound water or oil}}{\text{Weight of sample}} \times \frac{100}{1} \quad (1)$$

The determinations were carried out in triplicate at room temperature.

Dispersibility or Reconstitution Index

10g of flour sample was weighed into a 100ml measuring cylinder. 100ml of distilled water added, stirred vigorously and allowed to settle for 3 hours. The volume of settled particles is recorded and subtracted from 100 to give percentage Dispersiblity. Measurements were made in triplicate and averaged (Banigo and Akpapunam, 1987).

% Dispersibility = 100 - volume of settled particle

Foaming Capacity / Stability

This was determined according to the method of Coffman and Garcia, (1977). 1g of sample was whipped with 50ml of distilled water for 3 minutes in Kenwood blender at speed 'soft' and 'max', and was later poured into a 100ml graduated measuring cylinder to measure the volume. Foaming capacity was calculated as follows:

Foaming Capacity (%) =

$$\frac{\text{volume after whipping} - \text{volume before whipping}}{\text{Volume before whipping}} \times \frac{100}{1} \quad (2)$$

Foaming stability was measured by measuring the foam value after standing for intervals of 5 – 120 minutes until a stable volume was obtained. This volume was expressed as percent of the initial foam volume. Measurements were carried out in triplicate and the average is made.

Emulsion Capacity

1g of sample was made into slurry in 20ml distilled water in an Erlenmerger flask by stirring 1000rpm for 15 minutes with a magnetic stirrer. 5ml of Salvon oil was added and stirring was continued for another 1 min. The system was then transferred to centrifuge tube and finally centrifuged at 3500rpm until the volume of oil separated from emulsion was constant. The measurements were triplicated and averaged.

Emulsion capacity (%) =

$$\frac{\text{Height of emulsified layer}}{\text{Height of the whole layer}} \times \frac{100}{1} \quad (3)$$

Emulsion Stability

1g of sample was blended in a Kenwood blender with 50ml of distilled water for 30 seconds at high speed. Oil was added continuously from burette at the rate of 5ml per minute while blending was continued. When the nature of emulsion changed as marked by decreasing homogeneity, oil addition was stopped. The emulsion so prepared was allowed to stand in a graduated cylinder and volume of water separated at time intervals of 0, 0.5, 1, 2, 3, 4, 5, 6 and 24 hours was noted in each case.

Emulsion Stability (%) =

$$\frac{\text{Height of the remaining emulsified layer}}{\text{Height of the whole emulsion layer in a tube}} \times \frac{100}{1} \quad \ldots \quad (4)$$

Pasting Properties of Flour

The pasting characteristics of the flour sample were studied using computerized Rapid Visio Analyzer (RVA) model RVA- 3D as described by Delcour *et. al* (2000). A slurry containing 3g of sample was mixed with 25ml distilled water in the RVA cup and stirred. The RVA machine was loaded and set at 40^0C to run for 20 minutes. During the test, the flour gelatinized with consequent rise in viscosity, subjected to high temperature and controlled shear which revealed its stability and was then cooled to provide an indication of setback during gelation. The sample was assessed for peak viscosity, final viscosity, setback, trough, breakdown, pasting temperature and peak time. Analyses were duplicated and averaged.

IV. RESULTS AND DISCUSSIONS

The results obtained from the determination of the functional and pasting characteristics of the sun-dried and oven-dried flour of bitter yam, *Dioscorea dumetorum* are as follows:

Table 1: Mean Values of Functional Properties of Bitter Yam Flour Subjected To Sun and Oven Drying Methods

Sample	WAC(g/g)	OAC(g/)	RI(%)	FC(%)	FS(%)	EC(%)	ES(%)
SDF	165±1.6	298±2.4	77±1.6	5.9±0.2	3.9±0.2	23.51±0.02	5.98±0.06
ODF	(173±1.3]	341±2.6	81±2.0	5.3±0.2	3.5±0.3	21.91±0.02	4.96±0.09

Means of triplicate determination ± S.D

WAC= Water Absorption Capacity, RI= Reconstitution Index, FC= Foaming Capacity, OAC=Oil Absorption Capacity, FS=Foaming Stability,EC= Emulsion Capacity, ES=Emulsion Stability.

The results in Table 1 show that the water absorption capacity of sun-dried flour (165 ± 1.6g/g) was found to be significantly lower than the value of 173 ± 1.3g/g obtained for the oven-dried flour. These results show that the type of heat method applied in processing affected the water absorption capacity of the native protein of bitter yam flour. Heat processing has been reported by Eke and Akobundu (1993) to have an increase effect on the water absorption capacity of African yam bean flour. While Jimoh et al. (2007) also reported similar effect on the processed yam flour from *Dioscorea rotundata* and *Dioscore aalata*

The oven-dried flour has a higher oil absorption capacity of 341 ± 2.6% than the sun-dried flour of 298 ± 2.4% (Table 1). Giami (1993) and Odoemelam (2005) reported that heat applied in processing increases the oil absorption capacity of cowpea flour and jackfruit flour respectively. Narayana and Narasinga (1982) also attributed the increased oil absorption of heat processed flours to the denaturation and dissociation of the constituent proteins that may occur on heating which unmasks the non-polar residues from the interior of the protein molecules. The oil absorption capacity attribute of bitter yam flour suggests that it can find useful application in food production systems as ground meal formulations

The applied heat in processing decreased the foaming capacity and stability of the oven-dried bitter yam flour compared to sun-dried yam flour (Table 1). A similar effect of heat processing on foaming capacity and stability of winged bean flour and of cowpea flour has been reported by Narayana and Narasinga, (1982) and Giami,(1993). The foamability of flour has been shown to be related to the amount of native protein. Lin *et al*. (1974) also reported that native protein gives higher foam stability than the denatured protein. Reduction in the foam capacity and stability of the oven-dried flour can be explained on the basis of protein denaturation due to application of heat, since proteins are heat labile.

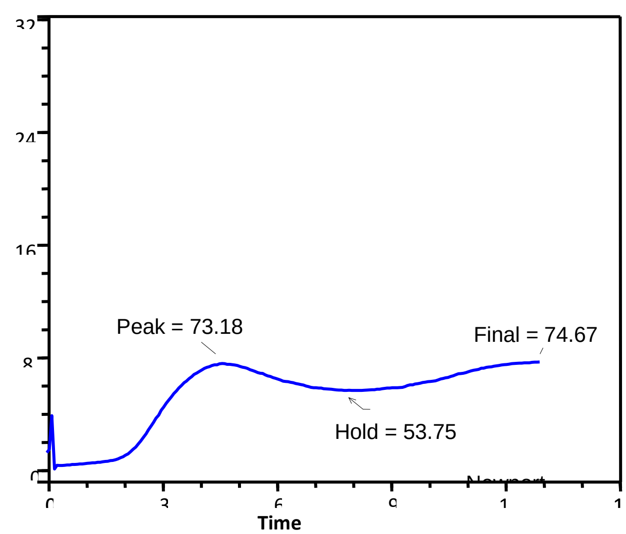

Fig. 1 Viscosity RVU (y-axis) against time, min (x-axis) during the heating cycle of oven-dried flour.

The sun-dried bitter yam flour has a higher emulsion capacity (23.51 ± 0.02%) and emulsion stability (5.98 ± 0.06%) than the oven-dried bitter yam flour of emulsion capacity (21.91 ± 0.02%) and emulsion stability (4.96 ± 0.09%). The observed reduction in the values of the oven-dried flour could be attributed to thermal denaturation of protein caused by heating. A similar observation has been reported for experiment on raw and heat-processed winged bean flour, (Narayana and Narasinga, 1982).

Reconstitution Index values for bitter yam flour which are measures of how the flour readily scatters in water as shown in Table 1 revealed that the value for oven-dried bitter yam flour (81 ± 2.0%) is higher than that of sun-dried bitter yam flour (77 ± 1.6%).This may be due to the influence of heat during processing

The result obtained after the analyses carried out on the pasting properties of the flour samples as shown in Table 2 are discussed below:

Table 2: Results of the Pasting Properties Of Sun – Dried And Oven Dried Bitter Yam Flour

PARAMETERS	SUN-DRIED FLOUR	OVEN-DRIED FLOUR
PEAK VISCOUSITY (RVU)	73.18 ± 2.3	65.96 ± 1.5
TROUGH (RVU)	53.75 ± 2.0	62.25 ± 1.3
BREAKDOWN (RVU)	19.63 ± 0.5	3.71 ± 0.2
FINAL VISCOUSITY (RVU)	74.67 ± 2.7	102.30 ± 2.2
SETBACK (RVU)	20.92 ± 0.7	40.00 ± 0.8
PEAK TIME (MIN)	4.90 ± 0.03	4.70 ± 0.05
PASTING TEMPERATURE (^{0}C)	61.90 ± 0.05	61.40 ± 0.08

(Mean ± SD. of duplicate determinations)

The measure of the ability of starch to form a paste as shown by the peak viscosity values in Table 2 revealed that the sun-dried flour possessed 73.18 ± 1.5RVU while the oven-dried flour value was found to be 65.96 ± 1.5 RVU). These are much lower than the average values reported by Jimoh *et al* (2010) for sun-dried (389.86RVU) and oven-dried (311.83RVU) flour made from *Dioscorea rotundata* and *Dioscorea alata* respectively. This showed that the bitter yam flour will have considerably less pasting ability during processing and may be used as weaning food for infants when fortified with milk and egg which enhances its utilization as a functional ingredient in certain food formulations.

The paste produced from sun-dried flour has higher breakdown point (19-63±0.5RVU) than oven-dried flour (3.71 ± 0.2RVU) as shown in Table 2. Oduro *et al.* (2000) reported that starches with low pasting stability or breakdown have very weak cross-linking within the granules. This therefore reveals that there is stronger cross-linking within the granules of sun-dried bitter yam flour, probably due to the lower temperature drying.

The final viscosity of oven-dried paste (102.3 ± 2.2RVU) is higher than that of sun-dried paste (74.67 ± 2.7RVU). It was observed as shown in Figures generated from the Computerized Rapid Visio Analyser (Fig 1and.2) that there was no significant change inthe final viscosity of the oven-dried paste as the temperature decreased with time on cooling This insignificant change in the final viscousity value of the oven-dried paste during cooling is an indication of formation of a firm gel after cooking and cooling, rather than effect of a viscous paste characteristic as in the case of sun-dried flour sample. The sun-dried flour exhibited a pasting characteristic values which decreased progressively as the temperature of paste decreased during cooling the process. It was also observed that the holding capacity value obtained for oven-dried paste (62.25 ± 1.3RVU) is higher than that of sun-dried pate (53.75 ± 2.0RVU). This may be due to greater interaction between the constituent of oven dried paste as a result of the method of the applied heat during processing (Fig 1and.2). Therefore, it can be inferred that drying method has a significant effect on the final viscosity of reconstituted yam flour paste as observed by *Jimoh et al* (2007).

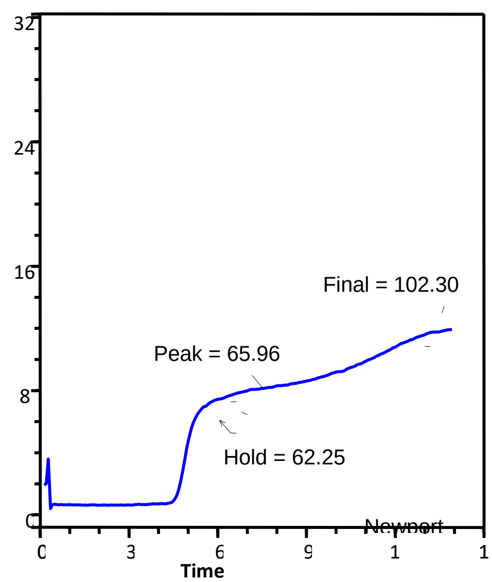

Fig. 2 Viscosity RVU (y-axis) against time, min (x-axis) during the heating cycle of sun-dried flour.

The measure of the cohesiveness of the resulting paste as indicated by the setback point show that the value of oven-dried paste (40 ± 0.8RVU) characteristic is higher when compared to sun-dried paste (20.92 ± 0.7RVU). Kin *et al.* (1995) had earlier reported that a high setback value is associated with a cohesive paste while a low value is an indication that the paste is not cohesive. Hence, the paste made from oven-dried bitter yam flour is more cohesive than that made from sun-dried bitter yam flour. Jimoh and Olatidoye (2009) also reported that flour with low setback and breakdown would make paste that will have high stability against retrogradation due to processing methods.

There is no significant influence of the drying methods employed on the peak time and peak temperature of processed material, as shown in the data obtained for both pastes made from sun-dried and oven-dried bitter yam flour (Table 2).This is also in agreement with the findings of Jimoh *et al* (2007).

V. CONCLUSION

This study showed that a low temperature dry method (sun drying) could be considered for processing bitter yam into flour when flour with high foaming capacity, foaming stability, emulsion capacity and emulsion stability is to be considered for appropriate food formulations. However, when high water absorption capacity, high oil absorption capacity and high reconstitution index are priority oven dried bitter yam flour is preferred. It was also observed that the sun-dried bitter yam flour when compared with oven-dried flour produced a paste of higher peak viscosity and breakdown characteristics while the oven dried flour produced higher pasting characteristics for holding strength, setback and final viscosity.

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