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Physical Properties of Nine Nigerian Staple Food Flours Related to Bulk Handling and Processing

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***Abstract*—**The physical properties of nine Nigerian staple food flours related to bulk handling and processing were investigated following standard procedures. The results showed that the moisture content, bulk density, angle of repose, water absorption capacity, swelling index, dispersability, pH and wettability of the flours ranged from 9.95 to 11.98%, 0.44 to 0.66 g/cm^3, 31.43 to 39.65^o, 198.3 to 291.7 g of water/100 g of sample, 5.53 to 7.63, 60.3 to 73.8%, 4.43 to 6.70, and 11 to 150 s. The particle size analysis of the flour samples indicated significant differences ($p<0.05$). The least gelation concentration of the flour samples ranged from 6 to 14%. The colour of the flours fell between light and saturated, with the exception of cassava, millet and maize flours which appear dark and dull. The properties of food flours depend largely on the inherent property of the food material and may influence their functional behaviour as food materials.

***Keywords*—**Properties, staple food flours, Nigeria, cereals, tuber, root crops, fruits.

I. Practical Application

CONSIDERING the role that staple foods play in human nutrition and the economic interests that the food items considered in this study attract in international trade, an understanding of their physical properties related to bulk handling and processing will promote standardization of products and their utilization in food systems.

II. Introduction

A staple food is that which is routinely eaten in such quantity that it constitutes a dominant portion of standard diets in a given population. It supplies a large fraction of the energy needs of that population and a significant proportion of recommended daily nutrients intake. Staple food items are typically inexpensive, readily available and an important part of human diets all over the world. They are largely derived from cereals such as wheat, barley, rye, maize and rice, or starchy tubers and root vegetables such as potatoes, yams, cocoyam and cassava. In some regions of the world, they may also be derived from pulses and fruits such as breadfruit and plantains. Tchango-Tchango [1] observed that grain cereals are known globally as major food materials for man and livestock. Baked food products which are largely eaten all over the world have one staple food flour or a composite as base ingredient, constituting the major source of carbohydrates, energy and other vital nutrients for millions of people, especially in Africa, the Caribbean, Latin America, Asia and the Pacific [1], [2]. In some communities, staple foods are eaten everyday or at every meal by adults, babies and the aged. However, the rapid increase in the food requirements of most developing countries places serious pressure on agriculture and the need for the year-round supply of food. The short postharvest shelf life of most crops makes it essential that processing techniques be with the view to maximize utilization and acceptability [2]. Food processors are therefore increasingly aware of the important role of traditional staple food flours in modern classical food products development. In many cases, staple food crops are processed into flours or granules to extend their season of availability, promote utilization and enhance functionality. In this form, the food material is easier to transport and stores longer than it would in its original state [3]. The delivery of modern food products in an acceptable form requires a good understanding of the properties and behaviour of the base material in relation to handling and processing.

In south western Nigeria, cassava and yam in the form of fermented cassava flour (*lafun*) and yam, plantain, breadfruit flours or their composites (*elubo*), are the most important food items in terms of dietary carbohydrates for many households [4]–[8]. They are usually processed into dough known as *amala* and eaten with vegetables and draw soup in the local food system. Although edible aroids (taro) are less important than other tropical root crops such as yam, cassava, and sweet potato, they are major staple food items in some tropical and subtropical regions of the world; especially the southern Pacific. In southeastern Nigeria, taro flour is used mainly as a soup thickener; whereas, in the southwestern part, it is processed and consumed as adulterated *elubo* [2]. However, in the north, grain cereals such as wheat, millet, sorghum and maize are the most eaten staple food items. These cereal flours are also processed into a dough called *tuwo* and eaten with different kinds of soup. In addition, cassava flour and many grain cereal/legume flours have gained prominence as base materials for various enriched baked, roasted and fried food products in different localities. Processing generally extends shelf life and improves the biological stability of food crops, ease of handling, transportation and delivery of products in the desired form. The behaviour of food powders at different processing and food systems interface is based on their physicochemical and functional properties [9]. At this juncture, it suffices to remark that basic information regarding

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the properties of most staple food flours in the form in which they are consumed in Nigeria is rarely available in literature, yet they are largely traded in neighbouring African countries and other parts of the world where Nigerians have migrated. On the basis of the foregoing, this paper reports some physical properties of nine important staple food flours in Nigeria. This valuable information is relevant in bulk handling, value addition, product standardization and overall acceptability of these food products by the end users. Figs. 1 and 2 show the physical appearances of the staple food items of interest in this study and their flours.

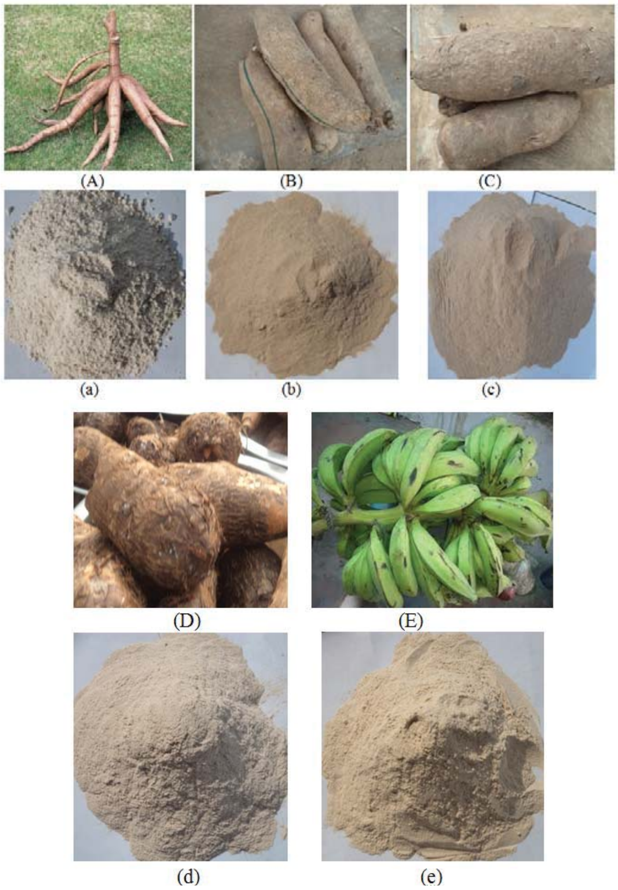

Fig. 1 Some staple food crops and their respective flours (A) cassava, (B) white yam, (C) water yam, (D) cocoyam, (E) plantain; (a) cassava flour, (b) white yam flour, (c) water yam flour, (d) cocoyam flour, (e) plantain flour

III. Materials and Methods

About 20 kg each of two different species of yam tubers (*Dioscorea rotundata* and *Dioscorea alata*) were obtained from a local market in Saki, Oyo State, Nigeria. The yam tubers were processed into yam flour (*elubo*) as shown in Fig. 3 following the traditional method documented earlier by [10]-[12]. The yam tubers were washed with clean water to remove adhering soil particles and other earth materials. The yams were peeled using kitchen knives and sliced into discs of 30 mm average thickness. The yam slices were subjected to blanching at 55±5 ^{o}C for 2 h and the slices were left to ferment for 24 h; afterwards, they were removed from water and sun-dried.

Fig. 2 Some staple food grain cereals and their respective flours (F) wheat, (G) maize, (H) sorghum, (I) millet, (f) wheat flour, (g) maize flour, (h) sorghum flour, (i) millet flour

Cassava roots were processed into fermented cassava flour (*lafun*) according to Fig. 4 as documented by [13]. Freshly harvested cassava roots (*Manihot esculenta*) obtained from a local market in Ile-Ife were peeled, sliced, soaked in water and allowed to ferment for 96 h. The fermented product was dewatered and sun-dried [14], [15].

For cocoyam flour, freshly harvested cocoyam (taro) roots (*Colocasia esculenta)* purchased from sabo market in Ile Ife were processed as shown in Fig. 5. The roots were washed, peeled, re-washed and sliced into discs, about 30 mm average thickness. Similarly, the slices were subjected to thin layer sun-drying [16], [17], [19].

African plantain (*Musa parasidiaca*), landrace cultivar (*Ogẹdẹ agbagba*) were obtained from sabo market in Ile Ife. They were peeled manually with knife and the fruit pulp was cut into discs of about 30 mm diameter and sun-dried in thin layer on clean polythene sheet to a constant weight [18], [20], [21].

For each of all the food items, sun-drying was carried out in thin layers on a clean polythene sheet until the weight was constant between two weighing successions. This experiment was carried out during the dry season when daily sunshine was constant enough to dry the product properly. The crisp dry products were milled differently into flour using a hammer mill ensuring thorough cleaning between successive milling of different products. The flours were packed differently, sealed in polyethylene bags and refrigerated until the time of use. Flow charts describing the processing of the afore-mentioned products into flours are shown in Figs. 3-6.

Four grains cereals: wheat *(Triticum aestivum)*, millet (*Pennisetum* spp.), sorghum (*Sorghum bicolor)*, maize (*Zea mays*) obtained from sabo market in Ile Ife were sun-dried. Each was dry-milled differently in a hammer mill as applicable in the preparation of traditional foods in Nigeria. The particle size reduction parts of the hammer mill were thoroughly cleaned between successive milling of different products. The flours were stored differently in sealed polythene bags inside a refrigerator until the time of use.

Moisture contents of the samples were determined according to standard AOAC methods [22]. Particle size analysis was carried out by weighing 100 g of each flour sample and sieved through sieves of mesh sizes 600, 500, 425, 300, 212 and 150 µm using a mechanical sieve shaker. The particle size distribution was recorded in percentages of the powder sample retained on each mesh [22].

$$\text{PSD} = \frac{W_{sr}}{W_f} \times 100 \tag{1}$$

where, PSD = Particle size distribution; W_{sr} = weight of sample retained; W_f=Total weight of flour sample.

For pH measurement, 5 g of each flour sample was weighed into a beaker containing 25 ml of distilled water and stirred continuously for 30 mins. The pH of the samples was then obtained using a pH meter [23].

The Munsel system of colour notation was used to determine the colours of the flour samples. Flour samples were grouped into two categories using the Munsel colour chart. Cassava, white yam, water yam, cocoyam, plantain, sorghum, maize and wheat flours were in one group while only millet flour stood as another group. Five paper discs of different colours (white, grey, green, yellow-green and yellow) were selected for the first group and three paper discs of different colour were selected for the second group. Each set of paper discs were combined in certain proportion such that they form only one disc. The disc was illuminated and allowed to rotate under a colorimeter. The single colour given by the rotating disc was compared to the colour of each of the flour sample and adjustment was made until a perfect colour was obtained for each sample. The space occupied by each of the discs that formed the singular disc was then measured by placing it on a graduated circular disc. The readings gathered were used to obtain the hue, value and chroma of each sample from the Munsel standard tables and graphs.

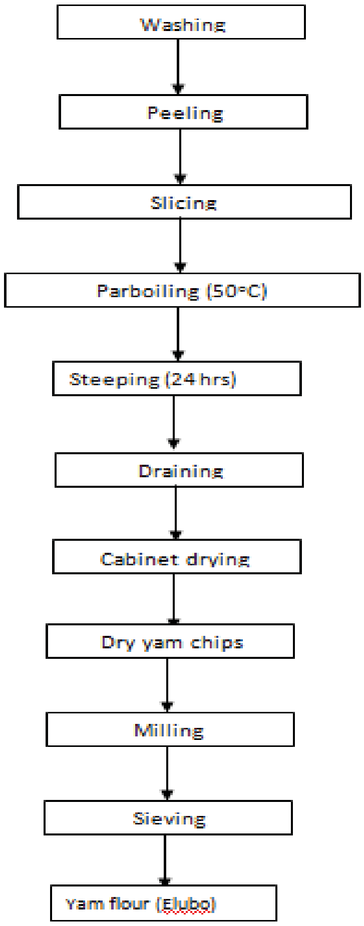

Fig. 3 Production of yam flour *'elubo'* [11]

Bulk density was determined using method [24]. Sample of known weight was put inside a 50 ml graduated measuring cylinder which was tapped gently on a table top 10 times from a height of about 5 cm and the volume occupied by the sample was measured. Bulk density (g/cm^3) was calculated as a ratio of the weight to the volume occupied.

Angle of repose was determined using an open ended cylinder of known dimension [25]. The cylinder was placed at the centre of a raised circular plate and filled with the flour sample. Afterwards, the cylinder was raised slowly until it formed a cone on the circular plate. The height (H) and the diameter (D) of the cone were determined and angle of repose (α) was calculated as:

$$\alpha = tan^{-1}\left(\frac{2\text{H}}{\text{D}}\right) \tag{2}$$

Dispersability was determined using the method described by [26]. For each flour sample, 10 g was weighed into a 100 ml measuring cylinder, water was added to make the volume up to 100 ml; the set up was stirred vigorously and allowed to stand for three hours. The volume of settled particles was recorded and the percent difference was expressed as dispersibility.

Water absorption capacity was determined by weighing 1 g of each flour samples into dry centrifuge tubes. Distilled water was added to make up 10 ml dispersion and the mixture was centrifuged at 3500 rpm for 15 min. The supernatant was then discarded while the tube with its content was reweighed. The gain in mass was the water absorption capacity of the flour sample [27].

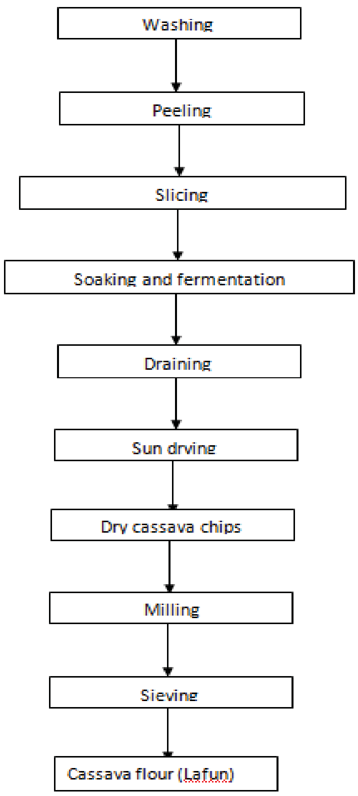

Fig. 4 Flow chart for cassava processing into high quality cassava flour [15]

In order to determine the swelling indices of the flours, about 3 g of each sample was weighed into clean, dry and graduated 50 ml cylinders. The sample was gently levelled and the volume was noted; afterwards, 30 ml of distilled water was added under ambient conditions (28±2^{o}C). The solution was stirred properly for few seconds and allowed to stand for 1 h after which the change in volume (swelling) was recorded. The swelling index of each flour sample was calculated as a ratio of the final volume of the sample to the initial volume of sample in the cylinder [27].

The least gelation concentration (LGC) of each flour sample was determined by the method of [24]. Test tubes containing suspensions of 6, 8, 10, 12, 14 and 16 (w/v) of material in 5 ml distilled water will be heated for 1 h in boiling water bath, followed by rapid cooling under running tap water. The tubes were further cooled at 4^{o}C for 2 h in a thermostat controlled cooling device. LGC was measured as the concentration above which the sample will not fall down or slip when the test tube was inverted.

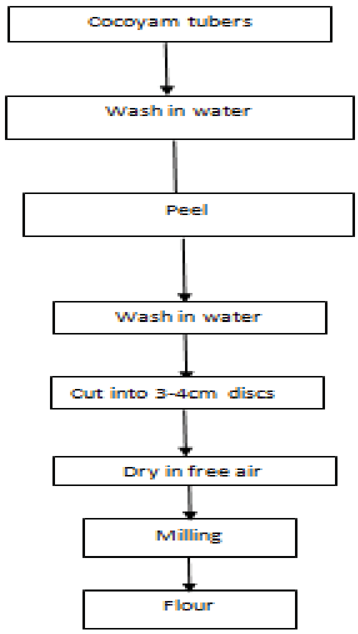

Fig. 5 Flow chart for the preparation of Cocoyam flour [17]

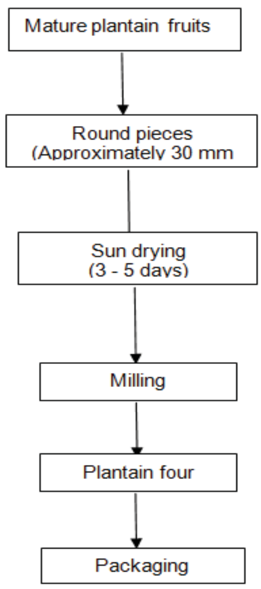

Fig. 6 Production of plantain flour [18]

Wettability was determined by pouring 1g of each sample in measuring cylinder containing 10 ml of water. The value is measured as the time (usually in seconds) taken by the flour sample to disperse in water [24].

Data obtained were subjected to statistical analysis using statistical analytical software [28].

IV. Results and Discussion

Table I shows the particle size distribution of the nine flour samples. It was observed that the fractions retained on each sieve were significantly different ($p<0.05$). Under the same treatment, the least and the highest fraction of particles retained on sieve 600 µm were 0.54 and 18.44% for cocoyam and maize flours respectively. For the flours, the fractions retained on sieves 500 and 425 µm ranged from 0.6 to 9.41% and 1.11 to 11.82% respectively. These fractions were minimal and significantly different ($p<0.05$) when compared with values retained on the other sieves. For all the flour samples, the highest fractions were retained on sieve 150 µm. Particle size distribution affects the swelling index, taste, appearance, stability, pasting characteristics and functional properties of food flours to a very large extent in their utilization as materials for dough preparations [29]. Properties such as bulk density, compressability and flowability depend largely on particle size and shape.

TABLE I
Percent Particle Size Distribution of Nine Nigerian Staple Food Flours

Flour Samples	SA	SB	SC	SD	SE	SF
Cassava	4.55^{e} (0.05)	3.36^{f} (0.0)	4.79^{d} (0.03)	14.54^{d} (0.03)	30.84^{bc} (0.03)	41.96^{f} (0.12)
White Yam	2.17^{d} (0.15)	1.47^{c} (0.03)	2.83^{c} (0.08)	14.56^{d} (0.04)	40.77^{e} (0.20)	38.67^{cd}(0.20)
Water Yam	1.42^{b} (0.09)	1.18^{b} (0.02)	2.20^{b} (0.11)	12.01^{c} (0.02)	33.71^{c} (0.07)	49.26^{g} (0.07)
Cocoyam	0.54^{a} (0.06)	0.60^{a} (0.02)	1.11^{a} (0.08)	10.04^{b} (0.05)	37.44^{d} (0.05)	50.37^{h} (0.05)
Plantain	1.42^{b} (0.02)	1.10^{b} (0.10)	2.18^{b} (0.01)	6.52^{a} (0.08)	32.09^{c} (0.17)	56.50^{i} (0.17)
Millet	2.16^{d} (0.14)	3.19^{e} (0.05)	5.39^{e} (0.02)	15.36^{d} (0.27)	33.22^{c} (0.07)	40.71^{d} (0.27)
Sorghum	1.57^{c} (0.02)	2.51^{d} (0.02)	4.77^{d} (0.07)	16.93^{e} (0.07)	33.80^{c} (0.09)	40.48^{d} (0.09)
Maize	18.44^{g} (0.08)	6.94^{g} (0.07)	11.82^{f} (0.10)	13.37^{c} (0.51)	24.57^{a} (0.51)	25.48^{a} (0.03)
Wheat	8.39^{f} (0.03)	9.41^{h} (0.15)	5.35^{e} (0.09)	18.65^{f} (0.12)	28.34^{b} (0.57)	30.61^{b} (0.57)

Each value represents the mean (standard deviation) of three replicates; Means followed by the same superscript on a column are not significantly different ($p<0.05$); SA -% retained on sieve 600 µm; SB - % retained on sieve 500 µm; SC - % retained on sieve 425 µm; SD - % retained on sieve 300µm; SE - % retained on sieve 212 µm; SF - % Flour retained on sieve 150 µm.

Table II shows the colours of the flour samples as indicated by the Munsel colour notation. The flour samples exhibited significant colour differences. White yam, water yam cocoyam, plantain and wheat were in the yellow-red colour group; while, sorghum and maize were in the green-yellow group. Generally, the rate at which each sample approached the indicated colour ranged from 5 to 8.5 as shown by the hue readings. Lightness ranged from 6.23 to 9.26 as depicted by the value readings. Many of the flour samples appeared and saturated, except cassava, millet and maize flours, which appeared slightly dull.

TABLE II
Colour of Nine Nigerian Staple Food Flours

Flour Samples	Colour notation	Name	Description
Cassava	Neutral 9.21/0.5	White-Grey	very light/weak
White Yam	8.5YR 8.23/2.5	Yellow-red	light/saturated
Water Yam	8.0YR 8.04/3.5	Yellow-red	light/saturated
Cocoyam	7.25YR 8.33/3.5	Yellow-red	light/saturated
Plantain	6.25YR 8.64/5.9	Yellow-red	light/saturated
Millet	7.5R 6.23/1.0	Red	slightly dark/weak
Sorghum	6.25GY 8.15/2.5	Green-Yellow	light/saturated
Maize	5.25GY 9.26/1.25	Green-Yellow	very light/weak
Wheat	5YR 8.23/2.5	Yellow-red	light/saturated

In Table III, the flour samples indicated significant differences ($p<0.05$) in their moisture contents; except water yam and plantain flour for which no significant differences were observed. The moisture contents of millet and maize flours were to be quite close in value. White yam flour had the highest moisture content (11.98%), while the lowest value was obtained for sorghum (9.95%). Moisture content is a key factor that influences microbial growth in stored food products; it affects the cohesive strength and arching ability of bulk materials [30]. Moreyra and Peleg [31] established a linear relationship between the moisture content of flour and the cohesive force between flour particles; in addition, moisture content affects many other physical properties of flours [32]. There were significant differences ($p<0.05$) in the bulk densities of the flour samples (Table III). The values ranged between 0.44 g/cm3 and 0.66 g/cm3. Bulk density is not only affected by the chemistry of the powder, the particle size distribution and moisture content, but also by the processing and handling history. This property finds great relevance in mixing (as obtains in dough formation), sorting, packaging as well as transportation of particulate food products [33]. Thus, for food flours, bulk density is a physical attribute of serious concern to the food industry [34]. Lewis [35] remarked that bulk density is influenced by the structure of the starch polymer. The angles of repose of the flour samples (Table III) may be grouped under three significantly different ($p<0.05$) categories. Cassava, white yam, water yam and cocoyam flour had values in the range of 31.43-32.94o which were not significantly different. Similar values obtained for plantain and millet were 36.89o and 36.86o; and for sorghum and wheat, 39.65o and 38.83o while 35.23o was obtained for maize. All these values indicate significant differences ($p<0.05$). The root and tuber flour samples were observed to have low values of the angles of repose, the cereal grains and plantain flours had relatively higher values. Angle of repose, apart from being one of the simplest parameters that gives a rough estimate of the cohesive behaviour of flours and bulk solids [37], provides useful information for the design of conveyors and other flour unloading devices. This property has been widely used to characterize the flow behaviour of powders and granular materials with respect to flowability, avalanching, stratification and segregation [36].

TABLE III
PHYSICAL PROPERTIES OF NINE NIGERIAN STAPLE FOOD FLOURS

Flour samples	MC (%)	Bulk density (g/cm^3)	Angle of Repose (°)	Water Absorption index (g of H2O per 100 g of sample)	Swelling Index	Dispersability	pH	Wettability (secs)
Cassava	10.97^{e}(0.07)	0.44^{a}(0.01)	31.43^{a}(1.18)	228.3^{da} (2.90)	5.87^{c}(0.06)	69.0^{c}(0.11)	4.43^{a}(0.06)	29^{c}(1)
White Yam	11.56^{f}(0.07)	0.60^{d}(0.0)	31.99^{a}(1.76)	296.7^{i}(1.70)	7.28^{f}(0.08)	64.2^{b}(0.31)	5.5^{b} (0.0)	70^{f}(1)
Water Yam	11.97^{g}(0.03)	0.60^{d}(0.01)	33.13^{a}(0.61)	286.7^{g}(2.10)	6.53^{e}(0.06)	65.0^{b}(1.01)	5.57^{b}(0.06)	32^{d}(1)
Cocoyam	10.70^{d}(0.05)	0.55^{c}(0.02)	32.94^{a}(0.21)	213.3^{b}(0.91)	5.53^{a}(0.15)	60.3^{a}(0.91)	6.70^{g} (0.0)	149^{g}(2)
Plantain	11.98^{g}(0.02)	0.51^{b}(0.02)	36.89^{b}±0.03	223.3^{c}(1.82)	6.43^{d}(0.15)	72.3^{e}(0.32)	5.93^{e}(0.06)	150^{g}(1)
Millet	10.50^{c}(0.04)	0.63^{e}(0.02)	36.86^{b}(0.38)	253.3^{f}(2.50)	5.70^{b}(0.10)	73.8^{f}(0.81)	6.07^{f}(0.06)	33^{d}(1)
Sorghum	9.95^{a}(0.12)	0.60^{d}(0.02)	39.65^{d}(1.23)	235.0^{e}(0.0)	6.33^{d}(0.06	74.3^{f}(0.92)	5.90^{de}(0.0)	24^{b}(1)
Maize	10.51^{c}(0.04)	0.66^{f}(0.02)	35.23^{c}(1.15)	291.7^{h}(1.51)	7.63^{g}(0.06)	68.1^{c}(0.12)	5.67^{c}(0.06)	11^{a}(0)
Wheat	10.07^{b}(0.05)	0.51^{b}(0.01)	38.83^{d}(0.50)	198.3^{a}(2.82)	5.72^{b}(0.03)	71.1^{d}(0.70)	5.83^{d}(0.06)	52^{e}(1)

Values are expressed as mean (standard deviation) of three replicates); Mean with different superscripts on a column are significantly different ($p<0.05$).

The water absorption index of the flour samples (Table III) differed significantly ($p<0.05$) with white yam indicated the highest value (296.7); and wheat flour, the least (198.3). Water absorption index represents the quantity of water required to gelatinize a particular food flour completely. Largely influenced by the degree of disintegration of native starch granules in the food flour, water absorption index helps processors to know how much water to add to a food material during processing. Low water absorption capacity is a desirable quality characteristic when making thin gruels in food formulation [32]. The swelling indices of the flour samples were significantly different ($p<0.05$); but for plantain and sorghum flours, and millet and wheat flours, each pair showing no significant differences in their values (Table III). Maize flour had the highest swelling index (7.63), followed by white yam flour (7.28), while cocoyam flour indicated the least value (5.53) among the samples. Swelling index generally describes the extent of interaction between water and starch molecules. For guinea corn flour, [37] submitted that swelling index indicates the presence of amylase and influences the concentration of amylose and amylopectin. The dispersibility of the flour samples ranged between 60.3 and 74.3%; all showing significant differences ($p<0.05$). Sorghum flour indicated the highest value (74.3%); while cocoyam flour indicated the lowest (60.3%). However, there no significant difference was observed in the values obtained for white yam and water yam flours. This also applies to cassava and maize flours, as well as millet and sorghum flours (Table III).

The pH of flour samples (Table III) ranged from 4.43 to 6.7; with cassava flour showing the lowest value (4.43) and cocoyam, the highest (6.7). The rate at which starch gets converted to dextrin is determined by acid value; which in turn is determined by pH. For all the flour samples, pH values fell within the low acid value range, which may support spoilage by a wide range of microorganisms. Therefore, the extension of shelf life of such food item may necessitate the use of chemical anti-microbial agents and anti-oxidants [33].

Wettability (Table III) for the different flour samples were significantly different ($p<0.05$) ranging from 11 to 150 s; except cocoyam and plantain flours for which the values were 149 and 150 s respectively. While maize flour got wet within 11 s, it took plantain 150 s. Wettability describes how readily a dry flour sample absorbs moisture. For instance, the inter-molecular moisture exchange which occurs during the preparation of bread dough is responsible for the physicochemical properties of the aqueous phase and other systemic changes that the dough undergoes [38].

TABLE VI
LEAST GELATION CONCENTRATION OF NINE NIGERIAN STAPLE FOOD FLOURS

Food flour samples	6	8	10	12	14	16
Cassava	-	-	±	±	±	+
White Yam	-	-	±	±	+	+
Water Yam	-	±	±	±	+	+
Cocoyam	-	-	+	+	+	+
Plantain	-	-	±	±	±	+
Millet	+	+	+	+	+	+
Sorghum	±	±	±	+	+	+
Maize	+	+	+	+	+	+
Wheat	-	-	±	±	+	+

(-) no gel formed; (+) gel formed; (±) sample did not completely form gel.

Table IV shows the least gel concentration of the flour samples. The least gel concentrations of cassava, white yam, water yam, cocoyam, plantain, millet, sorghum, maize and wheat flours were 16, 14, 14, 12, 16, 6, 12, 6 and 14% (w⁄v), respectively. However, cassava, white yam, water yam, plantain, sorghum and wheat flours were observed to gel slightly and show evidence of slipping at 10, 10, 8, 10, 6 and 10%, respectively. Gelation has been linked to the structured aggregation of denatured molecules and this provides the required structural matrix for holding water, flavours, sugars and food ingredients and enhances the functional properties of flours in food products development [24].

V. CONCLUSIONS

Some physical properties of cassava, white yam, water yam, cocoyam, plantain, millet, sorghum, maize and wheat flours have been investigated and the following conclusions may be drawn. The particle size distribution of the samples was significantly different at $p<0.05$ and the amount of sample retained on the sieve increased as the diameter of the sieve decreased with the exception of maize flour for some variation was observed. The colour of the flour samples was light and saturated except for cassava flour, millet flour and maize flours which appear dull or weak. A significant difference was noticed in the moisture content of the sample except for water yam and plantain flours; and maize and millet flours each pair which showed no significant difference in moisture content. A significant difference ($p<0.05$) was generally shown by the flour samples for all the properties measured. These findings provide basic information that may be useful in the standardization of these food flours and their utilization as food.

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