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EVALUATION OF THE CHEMICAL COMPOSITION, FUNCTIONAL AND PASTING PROPERTIES OF FOUR VARIETIES OF NIGERIAN SWEET POTATO [*Ipomoea batatas* L. (Lam.)] FLOUR

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ABSTRACT

Data on nutritional composition, functional and pasting properties of food ingredients are of importance in food formulations. In this work, flours were prepared from four varieties of Nigerian sweet potato. Chemical composition, functional and pasting properties of the flours were determined using standard procedures. The moisture contents ranged between 6.5% and 10%, which are below 15% specified for flour samples. This study showed that Orange Fleshed Sweet Potato (OFSP) had the highest protein (2.9%) and Yellow Fleshed Sweet Potato (YFSP) had the least (2.3%). This study also showed that OFSP flour had the highest β-carotene content and YFSP had the least indicating that pro-vitamin A is more concentrated in OFSP than other varieties. The amylose content ranged between 21% and 21.7%. The values obtained for OFSP, YFSP, and White Fleshed Sweet Potato (WFSP) are not significantly different from each other but significantly higher than the value obtained for Purple Fleshed Sweet Potato (PFSP). The bulk density ranged between 0.8g/ml and 0.9g/ml indicating easy sinkability and dispersibility. Water absorption capacity ranged between 58% and 83%. The oil absorption capacity ranged between 31% and 51%. The solubility and swelling capacities ranged from 7% to 11%, and 1.2% to 1.7%, respectively. The pasting temperature/ time ranged between 78^0C (3.9 min.) and 83^0C (4.8 min.) indicating that the flours have easy to cook properties. The peak viscosity of the sweet potato flours ranged between 46.9RVU and 86 RVU and it indicates that WFSP will form paste easily than OFSP. The setback values ranged between 3.8 RVU and 21 RVU. The WFSP have the highest tendency to retrograde and the OFSP having the least tendency. The final viscosity ranged between 13 RVU and 82.2 RVU. Results indicate that the WFSP will form a better gel than OFSP. The above results indicate that the flours have good functional and pasting properties that make them useful for application in food products formulations.

Key words: Sweetpotato, flour, nutritional, composition, functional, pasting, properties, food, formulation

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INTRODUCTION

Sweet potato, *Ipomoea batatas* belongs to the family Convolvulaceae. The common varieties are usually identified by the colour of their skin: yellow, purple, pink, white, and orange varieties. There is little awareness on other characteristics for differentiating varieties besides skin and flesh colour[1]. There are large variations among the cultivars regarding the skin and flesh colour, shape and size of the tubers, the morphological characters, the depth and period of rooting [2].

Orange Fleshed Sweet Potato (OFSP) clones contain β (beta) carotene which is a precursor of vitamin A [3,4,5]. Beta-carotene content of sweet potato varies with the varieties up to 20 mg/ 100g fresh weight [3,4]. It has four times United States Recommended Dietary Allowance (USRDA) for beta-carotene when eaten with the skin [6]. Anthocyanins are found in the greatest quantities in purple and red potatoes while carotenoids are found largely in yellow and red potatoes; although, small amounts are also found in white potatoes [7].

Sweet potato often called “almost perfect nourishing food” contains vitamins, minerals, and many other nutrients in favourable ratios [8]. Therefore, promoting the utilization of sweet potato in various food preparations could provide affordable source of nutrients that can improve malnutrition.

Sweet potato storage roots cannot be stored for more than a few weeks. Traditionally it could be boiled, fried, roasted, baked, or included in a wide range of tasty and famous recipes, nutritive first courses, delicious soups, main dishes and desserts [9].

Recent assessments conducted in developing countries suggest that processing sweet potato roots into flour offers a unique opportunity of presenting the commodity in a more stable form [10].

The success of utilizing food ingredients in food manufacture depends on their contributions to the overall beneficial qualities which they impact to the manufactured food and this depends to a large extent on their functional and pasting properties. These are the properties that determine how suitable will the ingredient be for the intended purpose. Information on the functional and pasting properties of these improved sweet potato varieties are unavailable. It is, therefore, quite clear that there is a need to know the functional and pasting properties of these varieties for product formulation and industrial applications of flours from the various sweet potato varieties. Therefore, the objective of this study was to determine the nutritional, functional and pasting properties of flours from four Nigerian popular sweet potato varieties.

MATERIALSAND METHODS

Sample collection and preparation

Four months old, matured and freshly harvested improved varieties of sweet potatoes namely Orange-fleshed (Umuspo 3), purple-fleshed (Ex Kwara), yellow-fleshed (TIS80/0140), and white-fleshed (TIS1499) sweet potatoes were obtained from an

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experimental farm of the Nigerian Root Crops Research Institute (NRCRI), Agbamu village, Kwara State. These were selected due to their possession of β-carotene. The sweet potato varieties were represented as Umuspo 3 (OFSP). Ex Kwara (PFSP), TIS80/0140 (YFSP) and TIS1499 (WFSP).

The crop was sorted to remove diseased and damaged produce, cleaned with water to remove soil and peeled using manually operated peelers. The peeled roots were sliced into pieces of about 2mm thick, dried using cabinet drier at 60^{o}C for 8 hours and milled through a 210 µm sieve in an attrition mill (Franky DM-WP 200 Electric Cereal Mill) to obtain the flour and immediately packaged in high density polyethylene bags. They were then packed in a plastic bucket and stored in a freezer at -10^{0}C.

Determination of chemical composition

The proximate analyses of the flours from the four varieties of the sweet potato were carried out using the official methods of AOAC [11]. Beta- carotene contents were estimated using the method of Rodriguez-Amaya and Kimura [12]. Amylose and amylopectin were determined using the method of Juliano [13]. The reported values are means of three determinations.

Determination of functional properties

The bulk density of flour samples was determined using the methods of Narayana and Narasinga [14] and Okaka and Potte [15]. The experiment was conducted in triplicate. The water absorption capacities were determined using the method of Sathe and Salunkhe [16].

The oil absorption capacity was determined as follow. To 1.0 g of the samples, 5 ml of refined vegetable oil was added in a 25 ml centrifuge tube and agitated on a vortex mixer for 2 minutes. It was then centrifuged at 4000 rpm for 20 minutes. The supernatant was decanted and discarded. The adhering oil were removed and the tube reweighed again.

$$OAC = \frac{Weight\ tube + sediment - Weight\ of\ empty\ tube}{Weight\ of\ sample}$$

The swelling capacities of all flour samples were determined by the method described by Takashi and Sieb [17].

A modified method of Coffman and Gracia was used to determine the least gelation capacity [18].

Determination of pasting properties

The pasting profiles of the flours were studied using a Rapid Visco-Analyzer (RVA) of Newport Scientific Pty. Ltd, Warriewood, Australia (perten Instrument), Model RVA Super 4 at the Multipurpose Laboratory, University of Ibadan, with the aid of a thermocline for windows version 1.1 software (1998). The RVA was connected to a PC where the pasting properties were recorded directly.

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Statistical analysis
All the data obtained were analyzed statistically using the SPSS version 17.0 software package for windows. Data were analyzed using ANOVA at $\alpha_{0.05}$.

RESULTS AND DISCUSSION

Chemical composition
The chemical composition of sweet potato flours is shown in Table 1. The moisture content ranged from 6.5% to 9.9%. The value for YFSP is significantly lower than those for all other samples. The values for OFSP and WFSP were not significantly different, but significantly lower than that of PFSP. The moisture content range obtained in this study was below the 15.5% maximum specified for wheat flour by CAC [19]. In a research study a range between 7.9 and 9.7% were reported by Amajor *et al.* for five different varieties of sweet potato [20]. A moisture range of 4 – 8% was reported for OFSP by Fana *et al*. [21], while a range of 7.6 to 10% was obtained for 12 varieties of Ghanian sweet potato by Tortoe *et al*. [22]. The low moisture content reported in this study is favourable for storability.

The protein content of the flours ranged between 2.3% and 2.9%. The value for OFSP was significantly higher($P \leq 0.05$) than the value for all other samples, followed by the value for PFSP, WFSP and lastly by YFSP. The value for the highest protein content obtained (OFSP, 2.85%) was found to be within the range 2.8% and 3.3% reported for two varieties in a study by Sanoussi *et al.* [23].Crude protein content of between 1.2 and 3.3% were reported by Suraji *et al*. [24].This is within the same range as reported in this research work. The protein content (4 – 8%) reported by Fana *et al*. [21] is far higher than the values obtained in this study.

The fat contents were in the range 0.7% to 1.0%. Orange fleshed sweet potato (OFSP) had the highest while PFSP had the least value. The values for OFSP, YFSP and WFSP were not significantly ($P \leq 0.05$) different from each other but significantly ($P \leq 0.05$) higher than the value for PFSP flour. In a similar study a range of between 0.72% and 1.3% fat contents were reported by Sanoussi *et al.* [23]. This range is similar to the results obtained in this work, but a higher range of 0.9 – 2.5% was documented by Fana *et al.* [21].

The ash content for the flours ranged between 1.8% and 2.8%. OFSP had the highest value, followed by YFSP, PFSP and lastly by WFSP. The ash content for the flours obtained in this study were higher than 0.7% and 1.3%reported for the two varieties tested by Sanoussi *et al.* [23]. The fiber contents range from 2.2% and 3.4%, the highest being OFSP and lowest being YFSP. The value for OFSP is significantly ($P \leq 0.05$) higher than all other samples. The values for YFSP and WFSP were not significantly ($P \leq 0.05$) different from each other but significantly lower than the value for PFSP.

The carbohydrate contents range from 82.3% to 86.5%. All the values obtained were significantly ($P \leq 0.05$) different from each other, YFSP having highest and PFSP having the lowest. The carbohydrate contents range obtained in this work is in consonance with the range 80 – 84% recorded by Fana *et al.* [21] but lower than 89.4% reported by Sanoussi *et al*. [23]

The β-carotene contents ranged between 2.0 mg/100g and 6.3 mg/100g. All values obtained were significantly (P≤0.05) different from one another, the OFSP being significantly (P≤0.05) higher and YFSP being significantly (P≤0.05) lower than other values. Beta-carotene is a precursor of vitamin A and from this study it is noted to be higher in OFSP than all other varieties studied.

The amylose contents ranged between 21.1% and 21.5%. The values obtained for OFSP, YFSP, and WFSP are not significantly (P≤0.05) different from each other but significantly (P≤0.05) higher than the value obtained for PFSP. The amylopectin contents ranged between 78.3% and 78.9%. The value obtained for PFSP is significantly (P≤0.05) higher than all other samples studied. The values for OFSP, YFSP and WFSP are not significantly (P≤0.05) different from each other.

Functional properties

The functional properties of sweet potato flours studied are presented in Table 2. The water absorption capacity (WAC) for the flours ranged between 58% and 83%. The WAC for OFSP was significantly higher than all other samples at P≤0.05, but the WAC for YFSP, PFSP and WFSP were not significantly (P≤0.05) different from each other. The WAC of 60% was reported for the red variety and 95% for the white variety in a similar study by Onuh*et al.* [25]. The value recorded for the OFSP in this study (83%) is higher than the value reported for the red variety while the value reported for the WFSP recorded in this study is lower than that reported by these researchers for the white variety. High water absorption capacity is an indication of loose association of the starch polymer in the native granules. Water absorption capacity is reflective of protein-water interaction in food systems and is therefore influenced greatly by protein content [22]. The differences observed may be attributed to differences in water binding sites available in the various flours according to Wootton and Bamunuarachchi [26]. The high water absorption capacity obtained for OFSP (83%) is indicative of the possession of large number of water-binding sites by this flour due to the availability of hydrophilic and hydrophobic sites in the starch molecules as compared to YFSP flour (58%), PFSP (61%) and WFSP (68%).

The oil absorption capacity (OAC) for the flours ranged between 31% and 51%. The value obtained for OFSP is significantly higher than the rest at P≤0.05, followed by that for PFSP, then WFSP and lastly by YFSP. The values for PFSP and WFSP are not significantly (P≤0.05) different from each other but significantly higher than the value obtained for YFSP. The OAC of 21%was reported for the red variety and 18% for the white variety by Onuh *et al.* [25]. The values of OAC obtained by Onuh *et al.* [25] are lower than the values obtained in this present study.

The least gelation capacity for the flours ranged between 2% and 4%. The value obtained for OFSP was significantly lower at P≤0.05 than the values for the rest samples. The values for YFSP, PFSP and WFSP were not significantly (P≤0.05) different from each other.

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The least gelation concentration (LGC) which is defined as the lowest protein concentration at which gel remained in the inverted tube was used as index of gelation capacity Chandra *et al.* [27]. Samples formed gel quickly at very low concentration (2 – 4g/100ml). According to Akintayo *et al*. [28] the lower the LGC, the better the gelatin ability of the protein ingredient. Further, the lower the LGC the better the swelling ability of the flour as observed by Kaushal *et al*. [29]. The low gelation concentration of OFSP flour may be an added asset for the formation of curd or as an additive to other gel forming materials in food products, Chandra *et al*. [27].

The swelling capacities ranged between 1.2% and 1.7%. The value obtained for OFSP is significantly higher (P≤0.05) than the values for the rest samples, followed by the value for WFSP, then PFSP and lastly by YFSP. The values for WFSP and PFSP were not significantly different from each other. The swelling capacities range obtained in this work is lower than the range between 2.4% and 4.6%obtained for three varieties studied in a similar study by Ali *et al.* [30]. The swelling power is classified as a measure of the hydration capacity of starches and is used to provide evidence for associative binding forces within starch granules [22]. The differences in swelling and solubility may be attributed to differences in starch structure and morphology, amylose and amylopectin composition, the presence of dissolved salts, proteins and other components brought about by differences in genetic makeup of the different varieties [22].

The solubility for the flours ranged between 7% and 11%. The values for YFSP and WFSP are not significantly different from each other but are significantly higher than the values for OFSP and PFSP which were not significantly different from one another. The values for solubility obtained by Ali *et al.* [30] are in the range 0.11 and 0.32. This range is found to be far lower than all the values obtained in this study.

The bulk densities for the flours ranged between 0.8g/ml and 0.9g/ml. The bulk densities for OFSP, PFSP and WFSP are not significantly different (P≤0.05) from each other but are significantly lower than the value for YFSP. The values of the bulk density obtained in this study imply that the sinkability of YFSP flour and ability to disperse during mixing is higher than those of the other flours. A value of 0.96g/ml was obtained for the red variety and 0.9g/ml for the yellow variety by Onuh *et al.* [25]. This is similar to the value for YFSP in this study. A range between 0.6g/ml and 0.8g/ml was reported for spray-dried sweet potato powders by Grabowski *et al.* [31]. This is similar to the range recorded in this experiment.

Pasting properties

The pasting properties of the sweet potato varieties studied are presented in Table 3. The peak viscosity of the flours studied ranged between 46.9 RVU and 86 RVU. The value obtained for the WFSP was significantly higher than the values for all other samples. The peak viscosity for the PFSP was also significantly higher than those for YFSP and OFSP. The value for OFSP is significantly lower (P≤0.05) than the values for the rest samples. The performance of flours in food systems depends on the cooking behaviour of their starches, and it provides beneficial information in new food product development. Peak viscosity indicates the highest viscosity value attained in a heating cycle and it is a

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measure of the ability to form pastes. The values of peak viscosity obtained in this study are lower than the values 103.9 and 120 RVU reported for orange and purple flesh sweet potato flour by Jangchud *et al.* [32].

The values for the trough ranged between 9.5 RVU and 61.3 RVU. The value for WFSP is significantly higher ($P \leq 0.05$) than the value for all other samples, followed by that of YFSP, then PFSP and lastly OFSP.

The breakdown values ranged between 24.6 RVU and 62.4 RVU. All the values obtained were found to be significantly different at $P \leq 0.05$. The value obtained for PFSP is significantly higher ($P \leq 0.05$) than the values for all other samples evaluated, followed by YFSP, then OFSP and lastly by WFSP. Breakdown viscosity of cooked pastes indicates their stability to shearing during cooking [33]. The WFSP had the highest stability ratio (trough/ peak viscosity) of 0.71 and is therefore expected to withstand shear better at high temperatures according to Sefa-Dedeh and Sackey [34], compared to PFSP (0.18), OFSP (0.20) and YFSP (0.40).

The values for final viscosity for the flours ranged between 13.3 RVU and 82.2 RVU. All the values obtained were found to be significantly different from each other at $P \leq 0.05$. The value for WFSP is significantly higher ($P \leq 0.05$) than all other samples, followed by that of YFSP, then PFSP and lastly by OFSP. A high final viscosity gives an indication of the ability of the flour to form firm gel or viscous pastes and this is a useful tool in the prediction of the texture of food products. Therefore, the WFSP flour will form a better gel than other flours followed by YFSP.

The setback viscosities for the flours ranged between 3.8 RVU and 21 RVU. All the values obtained were found to be significantly different from each other. The value for WFSP is significantly higher, followed by YFSP, PFSP and lastly by OFSP. High setback gives an indication of higher tendency to undergo retrogradation after heating and cooling of pastes. This phenomenon is characterized by gelling and increase in firmness and rigidity of pastes, loss of paste clarity and occurs as a result of the reordering of amylose and a reversible crystallization of amylopectin molecules [35]. Setback was highest in WFSP and lowest in OFSP. This implies that OFSP has the least tendency to retrograde.

The pasting times ranged between 4 minutes and 5 minutes. The pasting times for all the samples were found to be significantly different from each other at $P \leq 0.05$. The pasting time for WFSP is significantly higher than pasting time for all other samples, followed by that of YFSP, then PFSP and lastly by that of OFSP. The values for OFSP and PFSP were not significantly different from each other.

The pasting temperatures vary from 78^0C to 83^0C.Pasting temperatures for all samples are significantly different from one another at $P \leq 0.05$. Pasting temperature for OFSP is significantly higher ($P \leq 0.05$) than all other samples, followed by that of YFSP, WFSP and lastly the PFSP. The pasting temperatures obtained in this study indicates that flour from OFSP is expected to begin gelatinization at 78^0C and that of WFSP at 83^0C. This

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implies that OFSP will be easier to cook compared to WFSP. It means that the WFSP with the highest pasting temperature would require more energy to cook.

CONCLUSION

This study revealed some chemical composition, functional and pasting properties of four popular Nigerian sweet potato flours which are useful information for product development. The flours showed good water solubility and absorption capacity. With the exception of WFSP all samples are not likely to undergo retrogradation easily having a setback range of 3.8RVU and 9.5 RVU. Their pasting temperatures range 78^{o}C and 83^{o}C and pasting times 4 and 5 minutes showed that they will require less energy and short time for cooking or processing.

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Table 1: Chemical composition of sweet potato flours (g/100g)

Parameter	OFSP	YFSP	PFSP	WFSP
Moisture	8.8^{a}	6.5^{b}	9.9^{c}	8.4^{a}
Protein	2.9^{a}	2.3^{b}	2.5^{c}	2.4^{d}
Fat	1.0^{a}	1.0^{a}	0.7^{b}	0.9^{a}
Ash	2.8^{a}	2.5^{a}	1.9^{b}	1.8^{b}
Fiber	3.4^{a}	2.2^{b}	2.4^{c}	2.3^{b}
Carbohydrate	82.3^{a}	86.5^{b}	83.6^{c}	85.2^{d}
β-Carotene mg/100g	6.3^{a}	2.0^{b}	4.0^{c}	2.7^{d}
Amylose	21.5^{a}	21.7^{a}	21.1^{b}	21.5^{a}
Amylopectin	78.5^{a}	78.3^{a}	78.9^{b}	78.5^{a}

Values with the same superscript along rows are not significantly different at $P \leq 0.05$
OFSP=Orange Fleshed Sweet Potato, YFSP=Yellow Fleshed Sweet Potato
PFSP=Purple Fleshed Sweet Potato, WFSP=White Fleshed Sweet Potato

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Table 2: Functional properties of sweet potato flours (%)

Parameter	OFSP	YFSP	PFSP	WFSP
WAC	82.7[a]	57.7[b]	60.7[b]	68.0[b]
OAC	51.0[a]	31.0[b]	39.3[c]	36.3[bc]
LGC	2.0[a]	4.0[b]	4.0[b]	4.0[b]
Swelling Capacity	1.7[a]	1.2[b]	1.2[bc]	1.4[bc]
Solubility	7.0[a]	11.0[b]	8.3[a]	10.3[b]
Bulk Density (g/ml)	0.8[a]	0.9[b]	0.8[a]	0.8[a]

Values with the same superscript along rows are not significantly different at $P \leq 0.05$
WAC=Water Absorption Capacity, OAC=Oil Absorption Capacity, LGC=Least Gelation Capacity
OFSP=Orange Fleshed Sweet Potato, YFSP=Yellow Fleshed Sweet Potato
PFSP=Purple Fleshed Sweet Potato, WFSP=White Fleshed Sweet Potato

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Table 3: Pasting Properties of Processed Flour from sweet potato varieties (RVU)

Parameter	OFSP	YFSP	PFSP	WFSP
Peak Viscosity	46.9[a]	73.2[b]	76.4[c]	86.0[d]
Trough	9.5[a]	29.5[b]	13.5[c]	61.3[d]
Breakdown	36.9[a]	44.0[b]	62.4[c]	24.6[d]
Final Viscosity	13.3[a]	38.8[b]	18.4[c]	82.2[d]
Setback	3.8[a]	9.5[b]	5.0[c]	21[d]
Pasting Time (min.)	4[a]	4[b]	4[a]	5[c]
Pasting Temp. (^{o}C)	78[a]	82[b]	79[c]	83[d]

Values with the same superscript along rows are not significantly different at $P \leq 0.05$
OFSP=Orange Fleshed Sweet Potato, YFSP=Yellow Fleshed Sweet Potato
PFSP=Purple Fleshed Sweet Potato, WFSP=White Fleshed Sweet Potato

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