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Study of the Nutritional Characteristics and Technological Properties of *Xanthosoma sagittifolium* Tubers (Tabouchi) from Burkina Faso

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A B S T R A C T

In the present study, flour from tabouchi or *Xanthosoma sagitifolium* tuber was analyzed for biochemical composition, physico-chemical, gelatinization and pasting property. It appears that the tuber is nutritious and the results showed that tabouchi is essentially a carbohydrate food (83% dry weight (dw)). Furthermore tabouchi contains protein, fat, ash, fiber and vitamin C to the respective mean contents of 7.61, 0.99, 4.21, 3.76, and 0.013 g/100 g dw. Our study showed that 100 g (dw) of tabouchi flour contains 217.88 mg of phosphorous (P), 109.15 mg of Calcium (Ca), 45.79 mg of sodium (Na), 2208 mg of potassium (K) and 3.43 mg of iron (Fe). The second part of our study focused on the physicochemical properties of the flour from tabouchi. Water absorption capacity, Oil absorption capacity and Solubility of tabouchi flour were 2.10 mL/g dw, 0.85 mL/g dw and 89 mg/ 100 g dw respectively. Swelling of tabouchi flour increased with temperature. Pasting temperature (79°C), Peak viscosity (66.70 cP) and setback (40 cP) obtained during the study of the gelatinization and the pasting profiles suggested that tabouchi flour could be subject to its possible use in food technology. Interestingly, tabouchi could help reducing proteino-energetic malnutrition and some micronutrient deficiencies in our country.

Keywords

Tabouchi flour, proximate and mineral composition, gelatinization, pasting profiles.

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Introduction

Xanthosoma sagittifolium tuber is an important source of carbohydrate in Tropical Africa including Burkina Faso. The tubers can also be processed in several ways to produce food and feed products. Among the processes, the tubers can be subjected to boiling, roasting, frying, milling and conversion to soup thickeners, flour for baking, chips, beverage powder, porridge, and speciality food for gastro- intestinal disorders (Onwueme, 1978). In Burkina Faso where diet is characterized by a predominance of grain, the corms of *X. sagittifolium* are usually eaten boiled.

Several studies evaluated the chemical composition of *X. sagittifolium* tubers in Cameroon (Agbor-Egbe and Rickard, 1990), in Ivory Coast (Amani *et al*., 1993), in Nigeria (Yahaya *et al*., 2013), in Ghana (Sefa-Dedeh and Agyir-Sackey, 2004), in Venezuela (Perez *et al*., 2007), showing thattubers from *X. sagittifolium* contain digestible starch, protein of good quality, vitamin C, thiamin, riboflavin, niacin and high scores of amino acids.

However, the tubers have a short shelf life because of their high moisture content which can lead to damage during harvest and storage. One of the best ways to preserve them may be by processing them to obtain flour and/or starches. Flour obtained from theses tubers have never been commercialized in Burkina Faso because their properties are unknown.

In order to collect data that could help to promote tabouchi in our country, we began determining its biochemical composition and the study of its technological properties. The objective was to contribute to the fight against hunger and malnutrition on the one hand, and improving tabouchi processing technology in Burkina Faso.

Materials and Methods

Materials

Fresh tuberous roots of *Xanthosoma sagittifolium* were harvested in N'Dorola located in South -West region of Burkina Faso. The samples were transported to the laboratory where they were selected, washed with water, peeled and cut into small slices with a knife to promote drying in an oven at 60 °C. The dried fragments were then ground using a mortar. The flour obtained after sieving through at 0.5 mm mesh sieve was collected in a polyethylene bag and stored in the refrigerator for different analyzes. Analyzes were performed in triplicate.

Chemical composition

Standard Association of Official Analytical Chemistry (AOAC) methods (1996) were adopted for estimating moisture, ash, crude fibre, protein and fat contents. Total carbohydrates were determined by using the orcinol (3, 5-dihydroxytoluène)/sulfuric and the absorbance was measured at 510 nm according to the method of Tollier and Robin (1979). Starch content was determined using the spectrometric method described by Jarvis and Walker (1993).

Determination of mineral composition

Phosphorus was determined by a colorimetric method described by Stuffins (1967). 1 g of flour was digested with a mixture of HClO4 70%, HNO3 65% and H2SO4 98% in a kjedahl digestion tube. Digestion was initially at low heat until the brown fumes had escaped and heating continued until the appearance of white fumes emerge. After cooling, the digest is transferred into 100 mL volumetric flask and made up to the mark with distilled water.

1 mL of the digested solution was mixed with 5mL H2O and 4 mL of mixture composed of H_2SO_4 0.1N, molybdic ammonium 1% and ascorbic acid 1%. The mixture was vortexed and allowed to stand for 30 min and absorbance at 820 nm was read against blank solution which was prepared as appropriate.

Two (2) mL of the digested solution were used to determine Na and K contents using a Flame Photometer (model 410) and absorbance at 589 nm (Na) and 768 nm (K) were read.

The method using Ethylene Diamine Tetraacetic Acid (EDTA) was applied to determine Ca content in 5 mL of the digested solution (Bouguerra, 1988).

Fe content was determined using the method described by Bandemer and Schaible (1944).

Physico-chemical property of flour from *X. sagittifolium*

Determination of water absorption capacity

Water absorption capacity was determined using methods described by Beuchat (1977). 1 g of sample was weighed into 25 mL graduated conical centrifuge tubes; both weight noted, then 10 mL of water added. The suspensions were allowed to stand at room temperature (30°C) for 1 h. The suspension was centrifuged at 6000 rpm for 20 min. The supernatant was decanted and then the sample was reweighed. The change in weight was expressed as percent water absorption based on the original sample weight. Analysis was conducted in triplicate.

Determination of oil absorption capacity

The method described by Beuchat (1977), was adopted in determining the oil absorption capacity. 1 g of sample was weighed into a dry, clean centrifuge tube and both weight noted. Peanut oil (10 mL) with density of 0.85 g/ml was poured into the tube and properly mixed with the samples using a stainless steel spatula; the suspension was centrifuged at 6000 rpm for 20 min, then, the supernatant was discarded and the tube with its content reweighed. The gain in mass expressed as a percentage of oil bound is the oil absorption capacity of the sample. Analysis was conducted in triplicate.

Swelling power determination of the flour

The method described by Subramanian *et al* (1986) was adopted to determine swelling power of flour from tabouchi. 0.5 g of flour were dispersed in 5 mL of distilled water in a pre-weighed centrifuge tubes. The slurries were heated in a thermostatically controlled water bath at 95^{o}C for 60 min with constant stirring. The same experiment was carried out at 70, 75, 80, 85 and 90^{o}C. The heated slurries were then cooled to room temperature and centrifuged at 5000 rpm for 10 min to separate gel and supernatant. The supernatant was decanted carefully and poured into dish. Weight of swollen flour was determined and swelling power was determined as the ratio of the weight of the swollen flour to the weight of the initial flour sample.

Solubility determination of the flour

The method described by Subramanian *et al* (1986) was adopted to determine solubility of flour from tabouchi. 0.5 g of flour were dispersed in 15 mL of distilled water in a pre-weighed centrifuge tubes. The slurries were heated in a thermostatically controlled water bath at 90^{o}C for 60 min with constant stirring. The heated slurries were then cooled to room temperature and centrifuged at 7000 rpm for 15 min to separate gel and supernatant. The supernatant was decanted carefully and poured into a weighed evaporating dish and dried at 110^{o}C for 20 min. The difference in weight of the evaporating dish was used to calculate flour solubility.

Determination of pasting properties

Pasting properties of flour from *X. sagittifolium* tubers were determined in duplicate using a Brookfield viscosimeter (HBDVII, version 2, model LVT, USA) according to the method described by Faladé and Okafor (2013).A suspension of 10 g of tabouchi flourin 100 mL distilled water was heated from 37°C to95°Cwith constant stirring. The sample was held at 95°C for15 min (breakdown) and then cooled to 50°C (setback). Pasting curve was obtained for the flour. Viscoamylograph profiles were determined as follows: the pasting temperature was defined as the temperature at which an increase in viscosity was first detected by the instrument; peak viscosity was defined as the equilibrium point between swelling and polymer leaching; trough was defined as the lowest viscosity; final viscosity was defined as the viscosity of the sample at the end of the cycle period; setback was defined as the difference between final viscosity and peak viscosity; peak time was defined as the time the peak viscosity occurred.

Statistical analysis

The parameters evaluated in the present study were assessed in triplicate (n=3) and reported as average ± standard deviation.

Results and Discussion

Proximate composition of flour from *Tabouchi* (*X. sagittifolium*) tubers

Table.1 presents the proximate composition of tabouchi flour.

Moisture content obtained (72.91% on fresh weight basis) was lower than those reported by Onwueme in 1978 (77.50% dw) but higher than those reported by Perez *et al*. in 2007 (67.01% dw) and Agbor-Egbe and Rickard in 1990. (68.40% dw). Moisture content is a quality factor for preservation, convenience in packaging and transport.

Fiber content from Tabouchi flour (3.76% dw) was lower than those obtained byPerez *et al* (2007) but higher than the value of Onwueme (1978).

Starch is a major component of plant foods and an important raw material for industry. Our study showed that the starch content in tabouchi is 68.66% dw, that is similar to the value obtained by Perez *et al* (2007) but lower than those reported Agbor-Egbe and Rickard (1990).

Total carbohydrates content from tabouchi flour is 82.63% dw. Similar results were obtained by Treche and Guion (1980) and Onwueme (1978).

Concerning the protein content, tabouchi contains 7.61% dw. Onwueme (1978) showed high value 11.11% dw) whereas low value (6.37% dw) was found by Perez *et al.* (2007).

The ash content from Tabouchi (4.21 dw) was lower than those reported 5.50%, by Abdulrashid and Agwunobi in 2012 (5.50% dw) but our value was higher than those found by Onwueme (1978). Perez *et al*. (2007) found similar ash content (4.25% dw). Ash content could be explained by botanical source, different seasons and soil conditions.

Tabouchi was found to contain 0.99% dw of fat that is higher than the value (0.88% dw) reported by Perez *et al*. (2007) and Onwueme (1978). But the fat content was lower than those reported by Abdulrashid and Agwunobi in 2012 (1.50% dw).

The mineral content of tubers from *X. sagittifolium* was investigated. Our study showed that 100 g (dw) of Tabouchi flour contains 217.88 mg of phosphorous (P), 109.15 mg of Calcium (Ca), 45.79 mg of sodium (Na), 2208 mg of potassium (K) and 3.43 mg of iron (Fe). P, K and Na contents were lower than those reported by Agbor-Egbe and Rickard (1990). The content of Fe in tabouchi flour was similar to those found by Onwueme (1978) but high than those reported by Agbor-Egbe and Rickard (1990).

The mineral content is dependent on the botanical source and soil conditions.

Physico-chemical property of Tabouchi flour

The Water absorption capacity(2.10 mL/g dw) was 2.5 times higher than the Oil absorption capacity (0.85 mL/g dw). This result lends credence to observations of Iwuoha and Kalu (1994).The water absorption found in our study is lower than the value obtained by Perez *et al*, in 2007 (2.84 mL/g dw). Our sample showed higher oil absorption capacity when compared to the flour samples described by Faladé and Okafor (2013) ranging from 25.0% to 33.5%. Oil absorption capacity reflects the emulsifying capacity, a highly desirable characteristic in products such as mayonnaise, denoting the amount of oil that can be picked up by a sample during processing, for instances how samples will react during frying (Faladé and Okafor, 2013).

Solubility of tabouchi flour was 89 mg/ 100 g dw. This value was higher than those found by Subramanian *et al.* (1986) for pearl millet flour. This result suggests that tabouchi flour could be used to produce zoom-kom, a local juice from Burkina Faso made from millet grains.

Fig.1 shows the effect of temperature on flour swelling capacity. The flours swelling capacity increased from 3 to 8 between 70°c – 85°c but decreased to about 6.8 at 95°C. This property is similar to those observe by Amani *et al.* (1993) and Rasper (1969). However it was found that oxidation and acid-thinning reduced the swelling power (Lawal , 2004).

Viscosity

Fig. 2shows the viscosity of *Xanthosoma sagittifolium* flour as a function of temperatures. This figure is similar to that obtained by Rasper (1969).

Indeed, it was first detected an increase in viscosity at 79°C (pasting temperature) corresponding to the gelatinization of the starch. Four (04) min later (Peak time), the value of the viscosity was maximum corresponding to 66.70 cP (Peak viscosity). During the constant temperature (15 min at 95°C), the viscosity breakdown to 53.3 cP(Trough) corresponding to a loss of 13.7 cP (20.08%).

Table.1 Proximate composition of tabouchi flour

Component	Values
Moisture (% fresh weight basis)	72,91±2.04
Fat (% dw)	0,99±0.1
Crude Protein (% dw)	7,61±0.11
Totalcarbohydrates (% dw)	82,63±1.6
Starch (% dw)	68,66±2.03
CrudeFiber (% dw)	3,76±0.44
Ash (% dw)	4,21±0.4
P (mg /100 g)	217,88±5.6
Ca (mg /100 g dw)	109,15±3.4
K (mg /100 g dw)	2208±8.3
Na (mg /100 g dw)	45,79±4.42
Fe (mg /100 g dw)	3,43±3.43

Values are Mean±SD of triplicate determination

Table.2 Gelatinization and pasting profile of Tabouchi flour

Profiles	**Values**
Pasting temperature (Initial gelatinization temperature)	79°C
Peak viscosity	66,70 cP
Peak time	4 min
Trough (Breakdown) (A)	53.3 cP
Final viscosity (B)	106.7 cP
Setback: B-A	53.4

Fig.1 Effect of temperature on flour swelling capacity

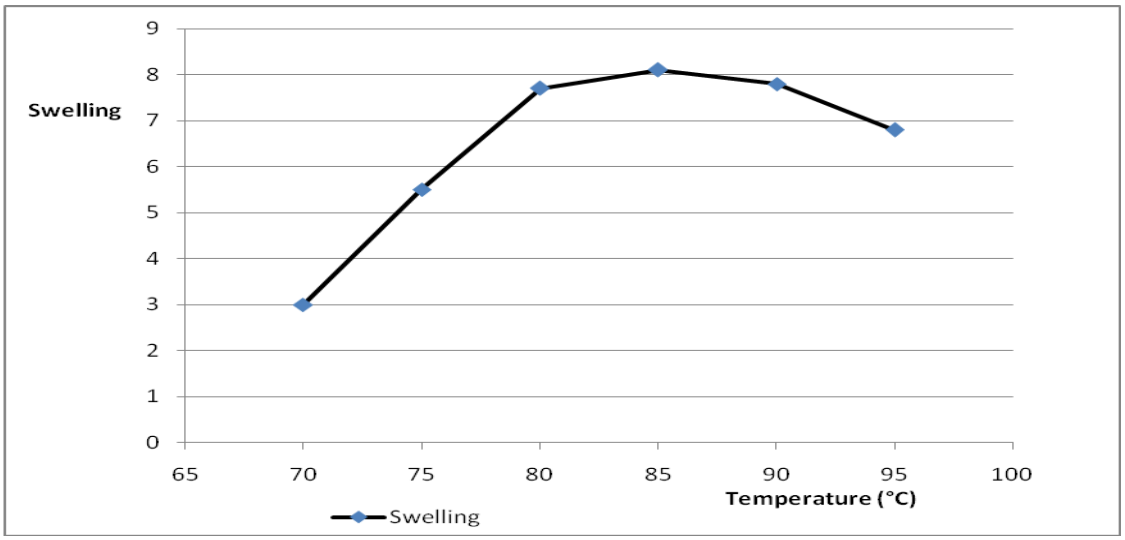
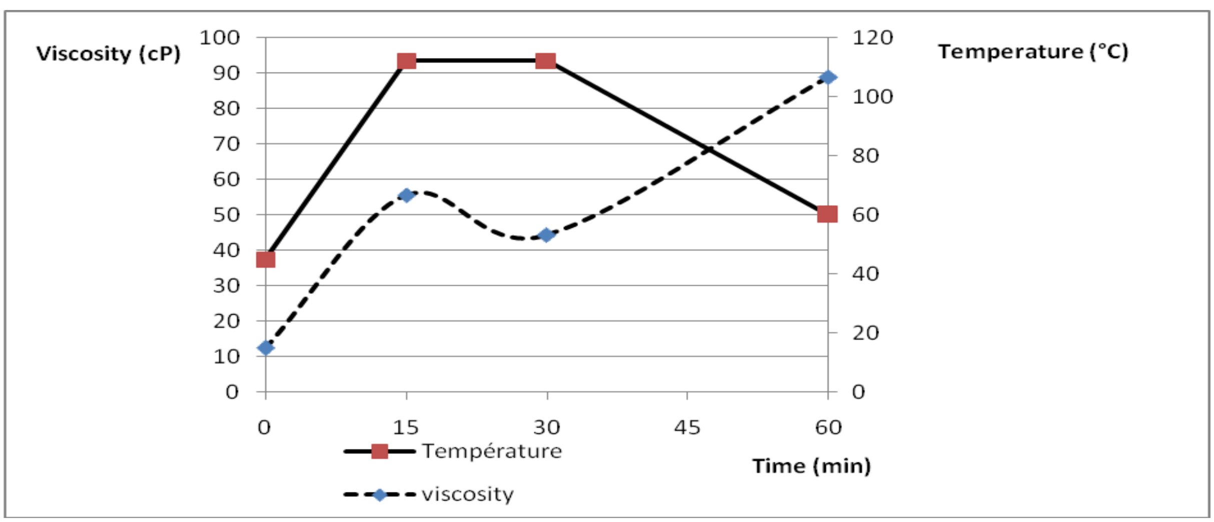


Fig.2 Viscosity of *Xanthosoma sagittifolium* flour



During cooling, the viscosity increased to 106.7 cP (final viscosity) and the setback was estimated to 53.4.Table2 summarizes the gelatinization and the pasting profiles of Tabouchi flour. Pasting temperature influence the ability of flour to imbibe water and swell. The pasting temperature found in the present study does not correspond with range of 84.53-88.75°C for *Colocasiaes culenta* and *Xanthosoma sagittifolium* (Falade and Okafor, 2013). But our pasting temperature is close to that obtained by Lawal in 2004 (76°C).

The peak viscosity, the breakdown as well as the final viscosity of tabouchi flour were lower than those obtained by Lu *et al*. (2005). This is interesting because it is well known that Flour with a lower peak viscosity has a lower thickening power than flour with a higher peak viscosity. Setback, defined as the difference between the breakdown viscosity and the viscosity at 50°C and determining the tendency of starch to retrogradation, was found to be lower than the value reported by Lu *et al*. (2005). The peak time found in the present study is lower than those observed by Falade and Okafor (2013) who reported peak time of the cocoyam starches ranging from 4.55 min to 4.97 min. The authors expected these results as high peak times characterize low swelling starch granules in the flour.

In conclusion, our study suggested that the flour from tabouchi could be considered of potential nutritional quality and good physico-chemical property and may contribute to new product development by local food industries. The information provided by flour gelatinization profiles illustrates that Tabouchi may be useful for the use of its flour as ingredients in food formulation and processing. Wheat flours are usually suggested for bread making and also for the manufacture of baked goods, snack, pasta, and noodles. Tabouchi flour could be proposed if wheat flour use is to be reduced. In such a case, it might be interesting that the amylose content be quantified for food processing and quality.

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