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Research Article

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Characterizations of *Ipomoea batatas* (L.) Flour with White Bark and Yellow Pulp

Randrianantenaina Antoni[1]*, Aly salma[2], Razafindrasoa Honoria[3], Razafimahefa[4]

[1,2,3]Food Biochemistry and Valorization of Natural Resources, Faculty of Science, University of Antsiranana, Greenmadag laboratory of the Faculty of Sciences of Antsiranana University, BP 0-Antsiranana (201), Madagascar
[4]Biochemistry, Microbiology and Biotechnology Applied, Faculty of Science, Technology and Environment, University of Mahajanga, BP 652-Mahajanga (401), Madagascar
*antoni73randria@gmail.com

Abstract The sweet potato (Ipomea batatas (L.) Lamarck) is azan important crop for its production and its contribution to food security in Madagascar. This study made it possible to evaluate the physical-chemical and nutritional characteristics of sweet potato flour with white peel and yellow pulp. The results of the analysis show that this flour has a water content of 8.82±0.09%; the ash rate is 2.00±0.28% with a pH equal to 5.98±0.06. The starch content in g per 100g of dry matter is 71.76±0.81. The amylose rate is 14.49±0.47%. It has a very low protein and fat content of 2.36±0.61g/100g of dry matter and 0.89±0.13g/100g of dry matter, respectively. The simple sugar in g per 100g of dry matter is 11.68±0.99. This flour contains mineral salts like potassium, sodium, phosphorus, magnesium, calcium, iron, zinc, manganese and copper. Their value in mg per 100g is respectively 579.40±0.12; 303.31±0.17; 116.13±1.02; 60.02±0.54; 44.10±0.46; 6.82±0.31; 0.74±0.11; 0.66±0.64 and 0.41±0.71. The value of the potential renal acid load is negative at -11.97 meq/100g. It is very energetic with a value of 360.31kcal/100g of flour. This flour is very important for nutrients and minerals. It can be used to prepare modern foods like cookies, bread and also to prepare baby food.

Keywords Edible, modern food, tuber, cuttings, alkalizing

1. Introduction

The sweet potato is a perennial from of the Convolvulaceae family [1]. It is widely grown in tropical and subtropical regions for its tubers and edible leaves for humans and livestock [2]. In industry, tubers are used for starch [3], fuel, alcohol and acetic acid [4]. It is native to South America and is grown from cuttings [5]. It is a very flexible plant considering climate change [6], cultivable even on poor soils, but it prefers deep, fresh soil rich in humus matter [7] and grows better on sandy soils aerated with pH between 5 to 7.80 [8]. Currently, these agronomic characteristics of the sweet potato represent major assets to face the challenge of food security in the context of global climate change [9].

According to Karna [10], the sweet potato tuber contains polyphenols such as anthocyanins (cyanidin rather than peonidin) and phenolic acids (caffeic acid, monocaffeoylquinic acid (chlorogenic acid), dicaffeoylquinic acid and tricafféoylquinic acid). These molecules have important therapeutic activities.

Compared to the 18 largest producers of sweet potato in Africa, Madagascar was ranked fifth after Kenya in 2013 [11]. It is eaten in boiled or fried form and is only slightly processed. It is used especially during the lean season.

The main objective of this study is to determine the physical-chemical and nutritional characteristics of sweet potato flour with white peel and yellow flesh in order to highlight its nutritional value, to optimize the transformation processes of sweet potato into flour.

2. Materials and methods

2.1. Plant material

In this study, we will use sweet potato flour with white peel and yellow pulp. The tubers were harvested at maturity and during the dry season, the month of September 2018 in the DIANA Region of Madagascar. It is in this season that the leaves and lines are dry. All the important nutrients are concentrated in the tubers.

2.2. Transformation of sweet potato tubers into flour

The transformation of sweet potato tubers begins with sorting followed by peeling and washing. The peeled and clean tubers are cut into very fine crisps to allow very rapid water removal. The crisps thus obtained were dried in full sun. The dry chips were pounded and sieved into a low porosity sieve to obtain flour of uniform sizes. The flours thus obtained were packed in a dry, tightly closed box while waiting for us.

2.3. Determination of the physic-chemical and nutritional properties of flour

- ***Water content and dry matter rate***

The water content and the dry matter content were determined according to the method described by the AOAC "*Association Official Analytical Chemists*" [12]. The principle of this method is to eliminate the water by evaporation until obtaining the constant mass. The water content and the dry matter content are determined respectively, according to formula number 1 and 2.

$$\%H = \frac{M_1 - M_2}{M_2 - M_0} x100 \quad (1)$$

$$\%DM = 100 - \%H \quad (2)$$

With: M_0, the mass in grams of the empty vessel; M_1, the mass in grams of the vase with the test sample before drying and M_2, the mass in grams of the vase with the test sample after drying.

- ***Crude ash rate***

The crude ash rate was determined according to the AOAC method in [13] by incineration of 5g of the sample at 550 ºC for 6h. Maintain at this temperature until white, light gray or reddish ash is obtained, apparently free of carbonaceous particles. It is calculated according to formula number 3.

$$\%CB(DM) = \frac{(M_2 - M_0).10^4}{\%DM\ x\ M_1} x100 \quad (3)$$

With: M_0, the mass in grams of the empty incineration capsule; M_1, the mass in grams of the fresh sample analyzed; M_2, the mass in grams of the capsule containing cooled ash and %DM, the dry matter content of the sample analyzed.

- ***pH and acidity***

The pH and the acidity were determined according to the method of Vasconcelos *et al*. [14] and Oyewole [15]. The total acidity (At) of the sample was determined by formula number 4.

$$At = \frac{9xNx\,V_2xV_0}{\%DMx\,V_1xm} x100 \quad (4)$$

With: N, the normality of the sodium hydroxide solution (0.1N); V_0, the volume in ml of the prepared extract (equivalent to that of the solvent used =20ml); V_1, the volume in ml of the titrated extract (10ml); V_2, the volume of the sodium hydroxide poured to bring the pH of the analyzed extract to 8.30; m, the mass in g of the flour sample analyzed and %DM, the dry matter content of the sample analyzed.

2.4. Determination of nutritional values of flour

- Starch rate

The starch content was determined according to the Ewers method in [16] modified and described by BIPEA [17]. The starch content was calculated according to formula number 5.

$$\Delta m = \frac{\propto x13.587}{me} - \frac{\propto' x27.174}{me'} \quad (5)$$

With: me', the test sample (g) of the sample for substances soluble in alcohol 40%; me, the mass (g) of the test sample in grams; 27.173 being the constant of substances soluble in ethanol 40% or conversion factor; 13.587 being the constant of total sugars or conversion factor; α, the average of the angles (right and left) for the first test sample (sample); α ', the average of the angles for the second test sample and Δm, the starch level.

- Amylose and Amylopectin content

The amylose and amylopectin content was determined by spectrophotometer assay according to the method of Juliano [18], Nri [19] and Williams *et al*. [20]. The content of amylose and amylopectin was calculated respectively, according to formula number 6 and 7.

$$\%\ \text{Amylose(DM)} = \frac{\text{Ts x \%DM x Ab}}{\text{As x \%DM}'} \quad (6)$$

$$\%\ \text{Amylopectin(DM)} = 100 - \%\ \text{Amylose(DM)} \quad (7)$$

With: Ab, absorbance at 620nm of the colored solution and prepared from the analyzed extract; %DM', the dry matter content of the flour analyzed; Ts, the amylose content (based on fresh matter) of the standard flour used; %DM, the dry matter content of the standard flour used; As, the absorbance at 620nm of the colored solution for the standard flour extract used.

- Protein content

The total protein content of the flour was determined according to the Kjeldahl method. It is calculated according to formula number 8.

$$\%P = \frac{(V_e - V_b)xNx\ 14x6.25}{\%DMxm} \quad (8)$$

With: Ve, the volume (ml) of the sulfuric acid solution used for the titration of the sample; Vb, the volume (ml) of the sulfuric acid solution used for the blank titration; N, the normality of the sulfuric acid used for the determination (0.10N); m, the mass (g) of the test portion and 6.25, the nitrogen to protein conversion factor used for cassava flour proposed by Favier [21].

- Fat content

The fat content was determined according to the methods of the AOAC [22] and Joslyn [23]. The fats were extracted using hexane. The fat content was calculated according to formula number 9.

$$\%MG = \frac{(M_2 - M_0).10^4}{\%DMx\ M_1} \quad (9)$$

With: M_0, the mass (g) of the empty balloon intended to receive the fat; M_1, the mass (g) of the fresh sample analyzed; M_2, the mass (g) of the cooled flask containing the fat after baking and %DM, the dry matter content.

- Total carbohydrate levels

The carbohydrate content was estimated by the difference method. According to Bertrand and Thomas [24] and AOAC [25], it was calculated by subtracting from 100 the sum of humidity (H), fat (MG), proteins (P) and ashes (CB) contained in the sample according to formula number 10.

$$\%\ \text{Carbohydrate levels} = 100 - (\%H + \%MG + \%P + \%GB) \quad (10)$$

- Mineral and Phosphorus content

The mineral content was determined using atomic absorption spectrophotometer. And the phosphorus was measured by a UV spectrophotometer; the optical density was measured at 430nm. The maximum wavelength for determining the contents of mineral elements is: calcium (422.70nm), potassium (768.00nm), sodium (589.00nm), magnesium (285.20nm), iron (248.30nm), copper (324.80nm), manganese (279.50nm), zinc

(213.80nm) and phosphorus (430.00nm). The contents of minerals and phosphate elements were calculated according to formula number 11.

$$Te(mg/100g) = \frac{C.10^{-6}xdilxV}{me}x100 \qquad (11)$$

With: C, Concentration of the solution in µg.ml^{-1} (This value is determined from the calibration curve); dil, inverse of the dilution factor; V, Volume of the solution in the filtrate and me, initial test taking.

2.5. Determination of the Potential Renal Acid Load (PRAL)

The value of the acid load (PRAL) of food is obtained from its composition of proteins and various minerals by formula number 12 [26], [27].

PRAL = [0.490 x protein (g)] + [0,037 x phosphors (mg)]-[0.021 x potassium (mg)]-
[0.026 x magnesium (mg)] - [0.013 x calcium (mg)] (12)

The value is expressed in meq/100g (mill equivalents per 100g of food).

2.6. Determination of energy value

The value of the metabolized energy of yellow pulp sweet potato flour is calculated using the calorific coefficients of Atwater and by summing the metabolized energies provided by each energy nutrient contained in the sample, formula number 13 [21].

$$EM(Kcal) = (\%\ P\ x\ CcPr) + (\%\ MG\ x\ CcLi) + (\%\ Glu\ x\ CcGlu) \qquad (13)$$

With: %P, the protein content; %MG, fat content; %Glu, the content of total Carbohydrate; CcPr, Atwater calorific coefficient in kcal/g of protein; CcLi, calorific coefficient of Atwater in kcal/g of lipid and CcGlu, calorific coefficient of Atwater in kcal/g of Carbohydrate.

3. Results

The results of the physical-chemical, nutritional properties and the value of the potential renal acid load (PRAL) of the flour are presented in the table 1 below.

Table 1: Physic-chemical, nutritional properties and the value of the renal acid load of flour

Parameters	Values
Energetic value (kcal/100 g)	360.31
Water content (%)	8.82±0.09
Dry matter content (%)	91.18±0.08
Ash rate (%)	2.00±0.28
pH	5.98±0.06
Total acidity (%)	0.35±0.02
Starch level (%)	71.76±0.81
Amylose level (%)	14.49±0.47
Amylopectin level (%)	85.51±0.47
Protein level (%)	2.36±0.61
Fat content (%)	0.89±0.13
Total carbohydrate levels (%)	85.93±1.02
Simple sugar (%)	11.68±0.99
Potassium (mg/100g)	579.40±0.12
Sodium (mg/100g)	303.31±0.17
Phosphorus (mg/100g)	116.13±1.02
Magnesium (mg/100g)	60.02±0.54
Calcium (mg/100g)	44.10±0.46
Iron (mg/100g)	6.82±0.31
Zinc (mg/100g)	0.74±0.11
Manganese (mg/100g)	0.66±0.64
Copper (mg/100g)	0.41±0.71
PRAL (meq/100g)	-8.84

Each result represents the mean ± standard deviation of 3 independent determinations (n = 3).
The difference between the means is significant ($p \leq 0.05$).

The sweet potato is a starchy plant. The flour of this plant contains a significant amount of starch, but low amounts of protein and fat. This flour can be used to prepare modern foods by fortifying with foods rich in protein and fat.

Sweet potato flour contains significant amounts of macro elements like Potassium, sodium, Phosphorus, Magnesium and Calcium. It also contains significant amounts of trace elements such as Iron, Zinc, Manganese and copper.

The PRAL (Potential Renal Acid Load) index is a way of indicating the potential renal acid load of a food and thus allows knowing its acidifying or alkalizing effect on the organism. It is in the urine that we obtain the measurement. It depends on its protein and mineral content, but also on its absorption rate and its metabolism [28]. Sweet potato flour is used to balance the acid-base of the body. It is an alkalizing plant with a negative PRAL index. It is able to rebalance the biochemical reaction within the body, especially in the kidney.

4. Discussion

The water content is similar to that reported by Dangui [29]. The water content above 12% promotes the development of microorganisms. In our studies, the water content is less than 10%, could thus allow good texture resistance, nutrients in the flour during storage.

The fat content is similar by the results reported by Soares *et al*. [30] between 0.20 and 0.80%. The very low fat content is an advantage for having a long conservation of the flour during storage.

The protein content in our results is close to that of the results of the work of Djinet *et al.* [31] of the ten sweet potato varieties between 1.01% and 2.54%. The difference can be explained by the genotype of the species, the cultivation conditions and the nature of the soils [32], [33]. In general, the protein content in tuber flour is very low.

The starch rate is higher than the result of work carried out by Dangui [29], of flour from the unprotected sweet potato slice which is equal to 64.80±0.20%. According to Owori *et al*. [2], the chemical composition of sweet potato flour depends on the variety, soil type and the period of cultivation and harvest.

The mineral content varied from variety to soil type and harvest period [34], [35]. Indeed, the potassium content is greater than that obtained by Chuang *et al*. [36] on sweet potato tubers from 18.50µg/100g to 25.20µg/100g (1.85 mg/100g to 2.52mg/100g). An amount of 431.50g of flour is sufficient to fill the recommended daily requirement of Potassium (2.50g per day). The sodium content is higher than that obtained by Badila *et al*. [37] 0.008g/100g (8mg/100g) sweet potato. 494.54g of flour is sufficient to meet the recommended daily requirement for sodium (1.50g per day). The Phosphorus is higher than those obtained by Libra *et al*. [38] sweet potato varieties from 65.98 to 66.18mg/100g. A quantity of 688.90g of flour is sufficient to fill the minimum daily requirement of Phosphorus (0.80g per day). The magnesium content is higher than that of the results obtained by Dangui [29] of sweet potato flour of 38.30mg/100g. A quantity of 582.04g of flour is sufficient to fill the daily need for Magnesium (0.35g per day). Calcium is superior to the results obtained by Unifesp [39] which is 22mg/100g. A quantity of 1814.06g of flour is necessary to fill the recommended daily requirement of calcium (800mg per day). The iron content is very large than that obtained from Scott *et al*. [40] sweet potato varieties from 0.19 to 0.65mg/100g. An amount of 14.70g of flour is sufficient to meet the minimum daily requirement of iron (1mg per day). Zinc is lower than those of the results obtained by Djinet *et al*. [31] sweet potato varieties from 1.94 to 2.32mg/100g. An amount of 810.81g of flour is necessary to fill the minimum daily requirement of Zinc (6mg per day). The Manganese content is higher than that obtained by Nepa [41] by 0.20mg/100g. An amount of 487.80g of Manganese is important to fill a sufficient daily amount of Manganese (2mg per day). Copper is superior to Nepa [41] sweet potato results of 0.11mg/100g. A quantity of 243.90g of Copper is important to fill a sufficient quantity of Cook (1mg per day).

5. Conclusion

In conclusion, the water and fat content can highlight the shelf life of this flour. The yellow flesh sweet potato flour is very energy dense. It contains a large amount of starch. Sweet potato flour is not a health hazard, except for people with chronic kidney failure; they are required to decrease its consumption due to the high potassium level. It can be used by athletes and pregnant women to benefit from its nutritional contribution, the elderly and even children.

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