



PHYSICO-CHEMICAL COMPOSITION OF EARLY AND LATE HARVESTED IMPROVED AND LOCAL SWEET POTATO (*Ipomoea batatas* (L) Lam) CULTIVARS ON THE JOS PLATEAU.

Sila-Gyang, M.D., Nyam, D.D., Wuyep, P.A., Ogbonna, A.I., Itelima. J. U, and Ogbonna, C.I.C.

Department of Plant Science and Biotechnology, Faculty of Natural Sciences, University of Jos.

Corresponding Email: michaeldavoul@gmail.com

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ABSTRACT

The physicochemical composition and the energy values of the flours of both identified improved sweet potato (*Ipomoea batatas* (L) Lam) cultivars: CIP4400168, Ex-Igbariam, Tanzania, TIS 8164 and TIS 87/0087 and three local varieties (Land-races) of sweet potato were investigated. The cultivars were harvested after 4 months (early harvest) and 6 months (late harvest) to determine their suitability for the formulation of sweet potato secondary products. The root of each harvest was weighed, washed, scrubbed, chipped to 1 x 1 x 6mm dimension, dried, milled into powder, sieved through 250µm mesh size sieve to obtain sweet potato flour. The flour was proximately analysed for moisture content (MC), Protein, Lipid, Fibre, Ash, Starch, Calorific value and pH using standard methods. The late harvest differed significantly in the parameters examined. The flour had low percentage moisture content ranging between 5 and 7.04% for late and early harvests respectively, indicative of long shelf life characteristics and low chances of attack by microorganisms. The crude protein values were higher (7.04%) in the flours of the early harvest but low (0.77%) for late harvest. The lipid concentration of the cultivars was low, 0.24 and 1.67% for the flours of 4 and 6 months harvests respectively. The fibre mean values of the flours were high (3.80%) in the 6 months harvest but low (1.24%) in the 4 months harvest. The ash content of the samples ranged between 0.83 and 2.56% for the flours of 6 and 4 months harvest respectively. The mean percentage values for starch of the flours were high ranging between 79.43 and 89.76% for 4 and 6 months harvested cultivars. The calorific values ranged between 313.11 to 336.01 Kcal/100g for 6 and 4 months harvests respectively. The pH data 5.5 to 6.55 for the flours of the 4 and 6 months harvests were slightly acidic. The study has clearly indicated that only early harvested cultivars percentage compositional values were most stable in Moisture content, Protein, Lipid, Fibre, Ash, Starch, pH and Calorific value (energy) than late harvest. Therefore early harvested sweet potato cultivars will be most appropriate for the formulation of secondary sweet potato products.

Keywords: *Cultivars, Proximate analysis, Early harvest, Late harvest, Calorific values, Secondary products.*

INTRODUCTION

Food is a basic necessity of life and a food crop that is highly productive even under marginal conditions deserves great attention. Sweet potato (*Ipomoea batatas* (L) Lam) is an example of such local food crop commonly produced on the Jos Plateau. The nutritional contents of Sweet potato root tubers are overwhelm high with valuable nutrients composed of protein, ash, carbohydrates and are a fair source of lipid and fibre (Oyenuga, 1968; Dufour *et al.*, 2000; Antonio *et al.*, 2011; Eleazu and Ironua, 2013; Sanoussi *et al.*, 2016). The carbohydrate of sweet potato is highly digestible and soluble containing 4-7% sugars: fructose, glucose, maltose and sucrose (Baba *et al.*, 1987; Koji and Osamu, 2000; Cust *et al.*, 2009). The starch is made up of amylopectin and amylose molecules (Lewthwaite *et al.*, 2010; Mohammad *et al.*, 2016). Pectin, hemicellulose and cellulose substances are classed as dietary fibre and play a significant role in the nutritional value of sweet potato (Reddy and Sistrunk, 1980; Woolfe, 1993; Ukom *et al.*, 2009; Olatunde *et al.*, 2015). Sweet potato competes favourably with cassava, cocoyam, taro and yam in caloric content. The proteins of the tuber are of high biological value and contain many essential amino acids some of which may be sub-optimal in certain cereals and pulses (FAO/WHO/UNU 1985; Kordylas, 1990; Habib and Fazil 2007; Eke-Ejiofor, 2013; Etong *et al.*, 2014; Ganiyat *et al.*, 2016). A globulin named ipomoein has been analyzed in sweet potato. A large percentage of true soluble protein including the essential amino acids is found in a large concentration in fresh roots especially the yellow varieties. It contains a variety of minerals and trace elements (Makki *et al.*, 1986; Woolfe, 1992; Iwuoha and Nwakanwa, 2002; Liu *et al.*, 2009). The root tubers are rich in carotene, ascorbic acid, vitamins A and B complex (Low *et al.*, 2007; Gebremedhin *et al.*, 2013; Ellong *et al.*, 2014).

The major role sweet potato plays in diets is that of energy provider but they have negligible lipid content, therefore their energy values are not as high as those foods with greater lipid concentration. Although sweet potato supplies less energy than cassava, the root tuber with about 111 Kcal/100g on fresh weight basis, has an energy value similar to those of yam, taro and plantain and nearly one and a half times that of potatoes (Woolfe, 1992, Ojeniyi and Tewe, 2003; Oke and Workneh, 2013; Sanoussi *et al.*, 2016).

Oyeyipo (2012) stated that the high moisture content and nutrients of the fresh root tubers and handling make them highly susceptible to microbial

colonization and insect infestation and their eventual decay. If the tubers are not processed to less perishable products, the microbial activities could lead to huge economic losses for a sweet potato producing State like Plateau State of Nigeria.

The potentials identified with the sweet potato cultivars are still underexploited despite its abundant production on the Jos Plateau. The root tubers get glutted in the local markets especially during the raining season the peak of production. Development of secondary products such as sweet potato chips, flour and starch from the cultivars with extensive shelf life could be a way of ameliorating the glutting of the commodity and to expand utilization among the peasant farmers and consumers (industrialists). In many food-deficit countries, the need to fully utilize all existing foodstuffs with a view to alleviating poverty and hunger is now receiving considerable attention (FAO, 2013). One way of minimizing post-harvest losses and increasing the utilization of sweet potato on the Jos Plateau is through processing it into secondary products. Therefore the objective of this study was to proximately determine the compositional and energy values of both the early and late harvested cultivars commonly found in the field of farmers and commercially sold in Jos and major towns of Plateau State with the hind motive of processing the commodity into secondary products.

MATERIALS AND METHODS

A plot of land measuring 45m×25m was carved out at Rayfield an environ of Jos town; 9.20 North Latitude, 8.90 East Longitude and 1208 meters elevation above sea level, located on the North and East hemisphere with a cool temperature fluctuating between 34.50 – 13°C (GPS Coordinates of Jos and environs, April 2017). The weather encourages the production of both temperate and tropical crops like sweet potato (*Ipomoea batatas* (L) Lam). The plot is composed of soil that is adequately drained, pH of 5, organic content of 4%, and moisture content of 50%, receives adequate rays of sunshine both in the wet and dry seasons of the year. Five identified improved cultivars: CIP4400168, Ex-Igbariam, Tanzania, TIS 8164 and TIS 87/0087 commonly cultivated on the Jos Plateau and three local varieties (Land-racers): Jandankali I, Jandankali II, Jandankali III, also popular on the Jos Plateau, were collected from sweet potato farmers and cultivated on the farm. The cultivars were harvested after 4 and 6 months to determine the suitability of early and late harvests for the formulation of sweet potato secondary products.

Four hundred grams (400.00g) of each cultivar

harvested within 48h without blemish was weighed out, washed, scrubbed with a spongy wire brush to remove the leathery coloured skin and damaged surfaces. A Chinese made shredder of 7 x 5 x 15cm dimension was modified to produce chips of 1 x 1 x 6mm dimension, dried with Air oven drier MODEL: N75CF, milled into powder in a hammer mill; sieved first through 180µm mesh size sieve (Odaga, 1992; Iwuoha and Nwakanwa, 2002) and thereafter through 250µm mesh size sieve (Oduro *et al.*, 2003), to obtain good grade quality of sweet potato flour. The flour was then proximately analysed to determine its Moisture content (MC), pH, Protein, Lipid, Fibre, Ash, Starch and Calorific value using the Official Methods of Analytical Chemist (AOAC, 2010).

Two grams (2g) of each of the cultivar's flours was weighed out into evaporating dish; put into hot air oven for 12 hours at 100°C+5°C and was removed; cooled in a desiccator then reweighed; dried for 1 hour; cooled for 10 minutes; reweighed until a constant weight was obtained. The experiment was replicated 5 times for each sample and the values were converted to percentages and analyzed statistically.

$$\% \text{ MC} = \frac{\text{Wt. of Sample} - \text{Wt. of Sample after drying}}{\text{Wt. of sample}} \times 100$$

Ten grams (10g) of each of the sample flour was weighed out using Mettler Analytical Balance, Model AE 100; put into Silica dish, dried in hot air oven to constant weight; removed and cooled in a desiccator. The protein in the sample was converted to ammonium sulphate after digestion with concentrated sulphuric acid, 20mg of the powder was placed in Kjeldahl flask and 20mg of kjeldahl catalyst was then added into the mixture. Ten cubic centimetres (10cm³) of concentrated sulphuric acid was also added into the contents of the flask and heated gently for few minutes until frothing ceased; the heat was increased for 3 hours in order to achieve complete digestion; then allowed to cool, volume was made up to 100cm³ with distilled water. A volume of 10cm³ aliquot of the digest was distilled by pipetting the volume into distillation chamber of microkjeldahl apparatus, 10cm³ of 40% Sodium hydroxide solution was added and the content was steam distilled into 10cm³ of 2% boric acid containing mixed indicator (Methyl red/bromo-cresol green). A colour change from red to green was noted then titrated with standard 0.01N hydrochloric acid to grey end point. The experiment was replicated 5 times for each sample and the values were converted to percentages and analyzed statistically.

$$\% \text{ CP} = \frac{(a - b) \times 0.01 \times 14.0057 \times c \times 100 \times 100 \times 6.25}{i \times d \times c}$$

Where: a = Titre value for the sample
 b = Titre value for blank
 c = Volume to which digest is made up with distilled Water
 d = Aliquot taken for distillation
 e = Weight of dried sample.

Five grams (5g) of each the sample flour was weighed out using Mettler Analytical Balance, Model AE100; put into a silica dish, labelled then dried in the oven to constant weight and cooled in a desiccator. A soxhlet extractor was fitted up with a reflux condenser and a small flask which had been previously dried and weighed; 2g of the flour was transferred to a "fat-free extractor thimble" plugged lightly with cotton wool then placed in the extractor while 150cm³ of the petroleum ether (B.P. 60°C) was dispensed into the flask and was left to siphon over once. The soxhlet apparatus was disassembled to allow for the addition of the petroleum ether until the barrel of the 300ml extractor was half full. The whole apparatus was assembled then put onto electro-thermal heating mantle with a regulated temperature so that the ether boiled gently. The extraction was allowed to last for 8 hours then disassembled again and the ether in the flask was distilled back into the extractor, the remaining content of the flask was dried in the oven to obtain the lipid. The experiment was replicated 5 times for each sample and the values were converted to percentage and analyzed statistically.

$$\% \text{ Lipid} = \frac{\text{Wt of flask + fat} - \text{Wt. Of flask}}{\text{Wt. of Sample}} \times 100$$

Five hundred cubic centimetres (500cm³) of glacial acid, 450cm³ of water and 50cm³ of con. nitric acid were mixed well, 20g of trichoroacetic acid (TCA) was dissolved in the mixture. The residue of the defatted sample was put into a 250ml conical flask, 100cm³ of the TCA mixture was added to it, the mixture was refluxed for about 40 min, counting from the time heating commenced. Three feet (3ft) long air condenser was used to prevent the loss of liquid. The flask was disconnected and allowed to cool the content was filtered through 15cm No.4 whatman filter paper previously dried and weighed. The residue in the filter paper was washed 5 times with hot distilled water and once with industrial methylated spirit, the filter paper containing the residue was dried in the oven at 105°C overnight and was cooled in the desiccator.

The residue was removed and was transferred into a previously weighed crucible then ashed in muffle furnace at 500°C overnight. The weight of the crucible and the ashed material were noted. The experiment was replicated 5 times for each sample and the values were converted to percentage and analyzed statistically.

$$\%CF = \frac{\text{Wt of Ash} \times 100}{\text{Wt. of sample}}$$

Ash content determination of the cultivars flour was determined by weighing five grams (5g) of each flour using Mettler Analytical Balance, Model AE100, put into a silica dish which had been dried and weighed then charred for 12 hours in muffle furnace at 500°C until each was nearly white. The ashes were allowed to cool and then reweighed.

The experiment was replicated 5 times for each sample and the values were converted to percentage and analyzed statistically.

$$\% \text{ Ash} = \frac{\text{Wt. of Ash} \times 100}{\text{Wt of sample}}$$

The starch, nitrogen free extract (NFE) of each sample was determined by the proximate indirect method (PIM). This was calculated by the subtraction of the sum of the percentage moisture, protein, lipid, crude fibre and ash content from 100 (Fetuga *et al.*, 2013). The starch of each sample was replicated 5 times and the result was recorded as was determined for protein, lipid, crude fibre and ash content. Each sample's starch percentage value was carried out by applying the following formular:

$$\% \text{ CHO} = 100 - (\% \text{ moisture} + \% \text{ protein} + \% \text{ lipid} + \% \text{ fibre} + \% \text{ ash})$$

The calorific value (Energy Values) of each sample was determined by using the percentage values of the flour's compositions obtained for crude protein, lipid and digestible starch (NFE). The energy value of each sample was calculated by applying the following formular:

$$\text{Energy value (kcal)} = (P \times p) + (F \times f) + (C + c)$$

Where: P, F and C are the values expressing the % of Protein, Fat and Carbohydrate respectively in the samples; p(4), f(9) and c(3.75) denoting the respective energy conversion factor (Okoye, 1992).

The filtrate pH was determined with LABTECH DIGITAL pH meter which was first

standardized with a buffer pH 7, the electrode was then employed to determine the pH of the flours filtrate.

Ten grams (10g) of each of the flours was homogenized in 100ml of distilled water in a beaker. The homogenized mixture was filtered using Whatman's No 1 filter paper. Each pH determination was replicated 5 times and the values were recorded and analyzed statistically.

The data obtained from the experiments were statistically analysed using Two-Way Analysis of Variance (ANOVA) and were computed with Statistical Package for Social Science (SPSS) version 8. Duncan's New Multiple Range Test (DMRT) was specifically preferred to check for significant difference ($p \leq 0.05$) between means.

RESULTS AND DISCUSSION

There were high significant differences ($p < 0.05$) in the moisture content (MC) of the flours of the cultivarsharvested after 4 and 6 months. The flour of cultivars harvested after 4 months varied in their MC than those harvested after 6months. The mean percentage (MC) of the floursof the cultivarsharvested after 4months were higher than those harvested after 6 months. The values ranged between 5.00 – 7.04% for CIP 440168, Jan II and III harvested after 6months and Ex-Igbariam harvested after 4months respectively (Table 1). However, both 4 and 6 months harvested roots flours had MC below the expected safe storage moisture content of 12% recommended for sweet potato flours(Cock, 1985).

The flours crude protein (CP) of the cultivarsharvested after 4 and 6 monthswere significantly different ($p < 0.05$).The flours of the cultivars harvested after 6 months varied in their crude protein than those harvested after 4months. The mean percentage crude protein analysed in the flours of the cultivars harvested after 4months were much higher than those harvested after 6months. The values ranged between 0.77-7.84% for CIP 4400168 harvested after 6months and Ex-Igbariam harvested after 4months respectively (Table 1).

The lipid content (LP) of the flours of both the cultivars harvested after 4 and 6 months was very low but significantly different ($p < 0.05$). The flours of the cultivars harvested after 6monthsdiffered more in lipid content than those harvested after 4months. The values ranged between 0.24-1.67% for CIP 4400168 harvested after 6months and TIS 87/0087 harvested after 4months (Table 1).

There were high significant differences ($p < 0.01$) in the flours fibre content (FC) of the cultivars

harvested 4MAP and 6 MAP. The flours of the cultivars harvested 6MAP varied more in their lipid content than those harvested 4MAP and the mean values ranged between 1.24-4.84% for CIP 4400168 harvested 4MAP and Jan 11I harvested 6 MAP respectively (Table 1)

There were high significance differences ($p < 0.01$) in the flours ash content (AC) of the cultivars harvested after 4 and 6 months. Ash content variation was more in the flours of the cultivars harvested after 6 than those harvested after 4 months. The mean percentage AC analysed in the flours of the cultivars harvested after 4 months were higher than those harvested after 6 months. The values ranged between 0.81-2.56% for Jan 11I harvested after 6 months and Tanzania harvested after 4 months respectively (Table 1).

There were high significant differences ($p < 0.01$) in the flours Starch (NFE) content of the

cultivars both harvested after 4 and 6 months. Starch content variation was more in the flours of the cultivars harvested after 6 months than those harvested after 4 months. The NFE value of the flours of the cultivars harvested after 6 months were higher than those harvested after 4 months. The values ranged between 79.43-89.78% for Ex-igbariam harvested after 4 months and Jan II harvested after 6 months respectively (Table 1).

There were also differences in the flours calorific (energy) mean percentage values of the root tubers both harvested after 4 and 6 months. The mean percentage calorific values of the flours were high although the flours of the cultivars harvested after 4 months were higher than those harvested after 6 months. The calorific values ranged between 313.11-336.01 Kcal/100g for Tanzania and TIS 8164, both harvested after 6 months and CIP 4400/68 harvested after 4 months respectively (Table 1).

Table 1: The Proximate Compositions of the Root Tubers Harvested 4 and 6 Months after Planting (MAP)

Cultivars	Moisture Content (9%)		Crude Protein (%)		Lipid (%)		Fibre (%)		Ash (%)		Starch, NFE (%)		Calorific Value kcal/100g	
	4MAP	6MAP	4MAP	6MAP	4MAP	6MAP	4MAP	6MAP	4MAP	6MAP	4MAP	6MAP	4MAP	6MAP
CIP 4400168	5.11e	5.00d	5.27c	0.77f	1.23e	0.24g	1.24e	3.33d	1.42d	0.86d	85.70a	89.76a	336.01	319.28
Ex-Igbariam	7.04a	6.35a	7.84a	2.46a	1.52b	0.98a	1.63b	2.87e	2.53a	1.27b	79.43f	87.07f	330.27	323.41
Jan I	6.14c	5.15bc	6.28bc	1.56d	1.22e	0.27f	1.43c	3.80c	1.61b	0.96c	83.31d	88.24d	327.69	317.51
Jan II	5.33d	5.00d	5.31c	1.27e	1.34d	0.35d	1.37d	2.62f	1.53c	0.87d	85.11b	89.78a	331.19	322.81
Jan III	5.07e	5.00d	5.24c	1.83c	1.44c	0.42c	1.44c	4.84a	1.47d	0.81f	85.93a	88.07e	332.58	319.75
Tanzania	6.93b	5.55a	6.95ab	1.85c	1.35d	0.36d	1.37d	4.47b	2.56a	1.35a	80.85e	86.42g	322.93	313.11
TIS 8164	5.25d	5.06cd	5.44c	2.25b	1.25e	0.29e	1.63b	2.21g	1.54c	0.84e		89.46b	330.16	313.11
TIS 87/0087	5.06e	5.02d	5.25c	2.17b	1.67a	0.68b	1.86a	2.22g	1.43d	0.83e	84.69c	89.08c	332.45	321.18

*Means with the same letter(s) are not significantly different at 5% level of probability (Duncan's New Multiple Range Test)

Key 4MAP = 4 Months After Planting, 6MAP = 6 Months After Planting.

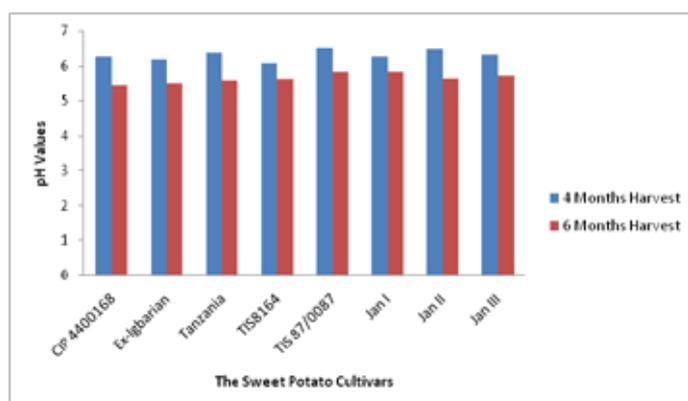


FIGURE 1: The pH values of the Sweet Potato Cultivar's Flours

The flours of the cultivars moisture content were very low and ranged between 5 and 7.04% from cultivars harvested after 4 and 6 months respectively. The low moisture content of the flours is expected to be an

advantage towards increasing their shelf life stability. In general the lower the moisture contents of a product the longer the potential shelf life. Cock (1985) reported that sweet potato quality flour is expected to have moisture level of below 12% thus all the flours had moisture content lower than this, an indication of good quality flour which could be employed in the formulation of different sweet potato secondary products. The crude protein values were higher in the flours of the cultivars harvested after 4 months than for those harvested after 6 months (Kordylas 1990; Akoroda 2000; Ojeniyi and Tewe 2003). The crude protein content of the samples ranged between 0.77 and 7.84% from harvests of 6 and 4 months respectively. Maeshima *et al.*, (1985) identified protein to be in high concentration in fresh tubers but was almost absent in tubers stored for one year and above. This also indicated that only fresh root tubers

should be utilized in the formulation of sweet potato products. The protein content of sweet potato as a crop is highly impressive, yielding on average 189 kg protein/ha, comparing favourably with the estimated average yields for wheat (200kg/ha) and rice (9168kg/ha) (Walter *et al.*, 1984). The authors also reported that sweetpotato has the potential to provide about 2 million tone of protein world-wide. The lipid concentration of the cultivars was low because the crop is purely a carbohydrate source. The samples lipid mean value ranged between 0.24 and 1.67% similar with the values obtained by Haytowitz and Matthews (1975). It has been reported by various authors that fibre in food composition table ranged between 0.1 – 0.8% in raw roots. The fibre mean values of the flours ranged between 1.24 and 3.80% similar with the report of Reddy and Sistrunk (1980) and Makki *et al.*, (1986). The high fibre values of the cultivars harvested after 6 months might be attributed to their prolonged storage on the farm. The fibre values obtained in this study vary with those of Bradbury *et al.*, (1984) which ranged between 1.2% and 2.62% fresh weight basis (fwb). The variation can be attributed to differences in methods of analysis, genetical or environmental differences. However, small root tubers have been shown to possess significant high content of pectin, hemicellulose and cellulose substances, the main constituents of fibre, than large tubers (Reddy and Sistrunk, 1980). Pectin, hemicellulose and cellulose substances are classed as dietary fibre and play a significant role in the nutritional value of sweet potato. Ash the non-volatile inorganic residue content of sweet potato is much higher in the peels than in the flesh of the root tuber Makki *et al.*, (1986) reported that the average ash concentration in the peel and flesh of two Egyptian cultivars were 14.1% and 4.6 dry weight basis (dwb) respectively. The ash content of the samples ranged between 0.83 and 2.56% lower than those reported by these researchers. The differences may also be attributed to varietal effect, environmental conditions, genetical difference and method of analysis. The

mean percentage values for starch of the flours were high ranging between 79.43 and 89.76% for 4 and 6 months harvested cultivars giving credence to the approximated values 80 – 90% obtained by Woolfe (1992). However, the values were higher in the samples of the cultivars harvested after 6 months possibly due to the conversion of the root tubers sugars to starches because of prolonged in-ground storage in the farm. Flours of such cultivars will be poor grade and would not be suitable for the formulations of sweet potato secondary products. Sweet potato dry matter (24-27%, fwb) is made up of carbohydrates, consisting mainly of starch and sugars used in the food industry as an ingredient of bread, biscuits, cakes, juices, ice-creams and noodles (Sakamoto and Bouwkamp, 1985). The other commodities produced by fermentative processes using the starch include lactic acid, acetone and butanol (Azhar and Hamdy, 1981a, 1981b). The calorific values analysed in the samples of the root tubers were , ranging between 313.11 kcal/100g (dwb) and 336.01 kcal/100g (dwb) for 6 and 4 months harvest. The values for the flours of the 6 months harvested cultivars were low because protein, lipid and starch main components might have been converted to other constituents (Kim and Hamdy, 1987). The major role the root tubers of sweet potato play in diets is that of energy provider which is also observed in this study. All roots and tubers have negligible lipid content, therefore their energy values are not as high as crops with greater lipid concentration. Although sweet potato supplies less energy than cassava, the cultivars with about 111 kcal/100g fwb has an energy value similar to those of yam, taro and plantain, and nearly one and a half times that of potatoes (Woolfe, 1992). The pH data revealed little differences between the 4 and 6 months harvested cultivars. The flours were slightly acidic ranging from 5.5 to 6.55. Tsakama *et al.* (2010) reported that the pH of flour suspension is important since some functional properties such as solubility, emulsifying activity and foaming properties were affected by it.

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