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Nutrient Composition and Physical Properties of Local and Improved Pearlmillet Cultivars (*Pennisetum Glaucum)* Flour

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Abstract

Good nutrition is a basic human right. However, most nutrients from commonly consumed foods are lost due to the processing methods used. Thus, the relationship between food, nutrition and health should be reinforced through improvement in the processing methods. The cultivars used were *Zango*, *Ex-bornu* and *Supper-sosat*. Proximate composition, carbohydrate fractions, energy values, vitamins, minerals, functional properties, dietary fibre, antinutrient were analysed using standard methods. *Super-sosat* cultivar flour significantly ($p<0.05$) had a high ash (1.6±0.00%), protein (14.03±0.01%), amylose (16.54±0.34%), total sugars (2.75±0.01%), sodium (37.50±0.01%) and bulk density (0.91±0.01%) when compared with *Zango* and *Ex-bornu* cultivars. *Supper-sosat* flour was higher significantly ($p<0.05$) in vitamin B_1 (0.46±0.00%) and vitamin B_3 (3.29±0.01%) but significantly ($p<0.05$) lower in energy value (373.32±0.56%), Tannins (0.60±0.00%), soluble dietary fibre (7.47±0.05) and insoluble dietary fibre (2.36±0.08). This study has shown that the new cultivar could be a potential source of protein where plant is the main source of protein. The low tannin content is an indicator of nutrients bioavailability and high B-group vitamin for energy metabolism. Low energy value and high fibre respectively makes it a good vehicle for satiety in adult with overweight. The new cultivar (*Super-sosat*)

flour with high protein content may be of advantage where animal protein is scares.

Keywords: *Pennisetum glaucum*, *Super-sosat*, *Ex-bornu*, *Zango*, Local cultivars and Improved-cultivar.

Introduction

Millet is a small seeded grain with varietal differences like pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), kodo millet (*Setara italic*), little millet (*Panicum sumatrense*), and barnyard millet (*Echinochlo autilis*). Pearl millet is widely used for food thence recorded for about half of total millet production (Taylor *et al*., 2010).

EX-bornu (*Sosat* C88) popularly called *Dandighli* is an improved cultivar of pearl millet that has been consumed locally through processed foods like *tuwo*, *fura*, pap (*koko*), *masa* or boiled and consumed directly or as a complementary food (Ayo *et al*., 2010). *Ex-bornu* has a yield potential of 2000 – 3000 kg/ha (Ojediran *et al*., 2010).

Zango is a local pearl millet cultivar that has been cultivated mainly for food because of its high draught resistant.

It has a maturity time of 100 days and above. It was used for animal feed by the nomads who migrated into Nigeria. It is consumed locally as pap, *Fura*, *Tuwo*, *Bula*, Masa etc.

Super-sosat also known as *soso* is a recently improved cultivar that was jointly submitted for release by Lake Chad Research Institute (LCRI) and International Crop Research Institute for Sub-arid Tropics (ICRISAT). The project for this development provided the poor dry land households with the needed technologies, linkages, and developmental impetus to harness the attraction of the growing markets. In partnership with LCRI Maiduguri, Institute of Agriculture Research (IAR) Zaria, IFAD-CBARDP, Community based organizations (CBOs), Nongovernmental organizations (NGOs) and private companies, this project was implemented in eight states – Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe and Borno. Millets are comparable nutritionally and are even

superior to major cereals in terms of macronutrients and minerals (Anu and Kwatra, 2006). However, due to the presence of anti-nutrients like phytate, polyphenols, oxalates and tannins, bioavailability of mineral is affected. Nutritional data are lacking for local foods to check the rapid improvement in food cultivars to meet the growing population for food security

Materials and Methods

The pearl millet grains for this study *Zango*, *Ex-bornu* and *Super-sosat* were collected from Lake Chad Research Institute (LRI) through the Zamfara State Agricultural Development Project (ZADP), Zamfara State.

Reagents and Chemicals

All chemicals and reagents were of analytical standard as obtained from Sigma Chemical Company St Louis U.S.A. Potassium iodide (KI). Anhydrous D-Glucose, Maltose, Sucrose, Buffer solutions: Acetate buffer 0.1M, pH6.6, pH 4.6 and Buffer Tris 0.5M pH 7. Ethanol, phosphate buffer, □-amylase (Fungamyl 800L) (Novo Nordisk, Copenhagen, Denmark),□-Glycosidase 240 U/ml (Sigma-Aldrich), Invertase 150 U/mg (Sigma-Aldrich), Glucose oxidase/peroxidase protease, amyloglucosidase, hydrochloric acid (Hcl), sodium hydroxide (NaOH), ferric chloride, Copper sulphate ($CuSO_4$) etc.
Each sample was measured out in 2kg after sorting and cleaning, milled into flour (0.8mm).

Determination of Proximate Composition (AOAC, 2010)

Determination of energy value (Nnwabueze, 2007)
The energy calculation equation using general Atwater factors shows: Energy (kcal) = (4 kcal/g protein -1g protein), (9 kcal/g fat -1g fat), (4 kcal/g carbohydrate -1g carbohydrate), (7 kcal/g alcohol -1g alcohol).

Determination of Carbohydrate Fractions

Procedure

The method is all about the determination of glucose concentrations after series of hydrolysis. The concentration of glucose was evaluated from each sample that contained maltose by using □-glucosidase and sucrose using invertase.

The background concentration of glucose was determined by an initial glucose readings (Bjorn *et al*., 2006).

Standard curve

Fifty milligrams (50mg) of anhydrous D-glucose was dissolved in 1000ml of ethanol (48%). A standard curve was obtained from a prepared dilution ranging from 0.01-0.05mg/ml. Four milliliters of glucose oxidase/peroxidase enzyme solution was added and incubated at room temperature (20^{o}c) for one hour and the absorbance was measured at 450nm wave length (Bjorn *et al*., 2006).

Sample preparation

A total of 1g of each cultivar flour sample (0.08mm) was suspended in ethanol (48%) to make 1000ml of suspension, alcohol treatment helped to precipitate starch and proteins in the sample. The system was extracted in the shaker at room temperature for 40minutes, thereafter the suspension was filtered with filter paper 0.22µm (Bjorn *et al*., 2006).

Determination of glucose content (Holm, 1986).

One milliliter (1ml) of the filtrate was mixed with 1ml of acetate buffer (pH 6) and 4ml of glucose oxidase/peroxidase (6g/100ml). The mixture was incubated for 1 hour at room temperature followed by absorbance reading at 450nm for determination of the concentration of glucose using standard curve.

Determination of maltose (Gutmann and Wahlefeld, 1974).

One milliliter of the filtrate was mixed with 1ml of acetate buffer pH 6.6 and 0.2ml of α-glucosidase (240U/ml), the mixture was incubated at room temperature for one hour afterwards, 0.1ml of the filtrate was mixed with 1.9ml distilled water and 4ml glucose oxidase/peroxidase (5.6g/100ml). it was incubated for 1 hour at 25^{o}c. The absorbance was measured at 450nm for determination of the concentration of glucose using standard curve.

Determination of sucrose content (Holm, 1986)

One gram (1g) of sample was measured into a volumetric flask (100ml). Then 50ml (80%) ethanol was added and gently boiled for 15min. Standard was prepared after a blank was run. Fifteen grams of sucrose was dissolved to 100ml with distilled water and allowed to cool at 20^{o}C, dilute to 100ml with 80%

ethanol, filtered and 1ml of filtrate was added to 9ml of Fehlings solution in test tube and heated in a water bath within 15minutes. To 1ml of this solution, 10ml of Anthrone was added and hold for 30min. at 40ºC. Absorbance was taken at 610nm for determination of the concentration of glucose using standard curve.

Determination of starch content (Ojiako and Akubugwo, 1998)
Sugars were removed using 0.5g of sample with 80% ethanol, this was done by centrifugation, the filtride obtained was rinsed several times with hot 80% ethanol until the washing produced a colourless reaction with Anthrone reagent, resultant residue was dried on a water bath. Five milliliters of water (5.0ml) and perchloric acid (6.5ml) were added to the residue at 0ºC for 20 minutes, and the supernatant was obtained by centrifugation. Fresh perchloric acid was used for further extraction and the supernatants were collected and made up to 100ml. The supernatant (0.2ml) was transferred into a volumetric flask using a pipette and made up to 1.0ml using distilled water. A standard curve was prepared and absorbance read at 630nm. Glucose × 0.9 = starch.

Determination of Amylose Content (Ojiako and Akubugwo, 1997)
One gram (1g) of iodine and 10g of potassium iodide (KI) were disintegrated in distilled water and made to 500ml. Then 100mg amylase was dissolved in 10ml NaOH, made up to 100ml with distilled water. One milliliter (1ml) of distilled ethanol was added to 100mg of the sample. Then 10ml of 1M NaOH was added and allowed overnight. The volume was added up to 100ml, and 2.5ml of the extract was taken and 20ml of distilled water was added, then 3 drops of phenolphthalein, 0.1M Hcl drop after drop were added until the pink colour disappears. One milliliter of iodine reagent was added and the volume brought to 50ml. The absorbance was read at 590nm. A standard curve was obtained using 0.2, 0.4, 0.6, 0.8 and 1ml. Dilute 1ml of iodine reagent with 50ml distilled water for blank reading.

$$\%\ Amylose\ content = \frac{x}{25} \times 100$$

Sugars determination (Ojiako and Akubugwo, 1997)
One gram (1g) of the sample was boiled in 10ml of 1M Hcl solution until it was negative to iodine starch test. It was centrifuged and the supernatant was used for the analysis. Five (5) ml of the supernatant was mixed with 4ml of Anthrone

reagent and boiled in a water bath at 50°C for 10min, filtered and diluted with distilled water. The absorbance was obtained at 620nm.

$$Total\ sugars = \frac{An \times C \times VF \times 100}{As \times VX \times W}$$

Where: An - Absorbance of sample, As - Absorbance of standard
VF- total volume of extract, VX- volume of sample
W- Weight of sample

Determination of Starchyose (Black and Bagley, 1978**)**

Procedure

To prepare a sample for analysis, 1g of the ground defatted millet flour was weighed into a 50ml polythene centrifuge tube (100x26mm). The sample was thoroughly mixed with 10ml of ethanol-water (80:20 v/v) using a glass stirring rod. The sample was heated in a water bath at 80°C for 30 minutes with frequent stirring (a vortex mixer was used) and centrifuged. The precipitate was washed with 3ml of the ethanol solution and recentrifuged. Washed and extracts were combined. The extract was evaporated to 20ml on a steam plate. Excess lead was precipitated with 10% oxalic acid until the extract was free of lead. The extract was then centrifuged to remove the lead oxalate, and the clear extract was quantitatively transferred into a 25ml volumetric flask and brought to volume with water.

Separation by chromatographic

Liquid chromatograph (water associated model ALC 201) equipped with a differential refractometer was used. The separation was achieved on a µBONDAPAK/carbohydrate column (30cmx4mm 10 packed with 10µ silica with an amine functionality) water associates, Milford, MA. The elution solvent was acetonitrile-water (70:30v/v) with a pump rate of 2.0ml/minute. A 10µ sample of the extract was injected (using a 25µl pressure-lok micro-syringe, precision sampling corporation, Baton Rouge, LA) into a model U6K injector, which allows the sample to be bye passed through injection port (no pressure exists in the bypass state). The bypass valve was then switched to introduce the sample to the pressurized column. *Method of Quantification*

Repetitive injection method, exactly 10µl of standard starchyose solution containing 20mg/ml of starchyose that was weighed accurately and corrected to

a dry basis, was injected repeatedly into the chromatograph to obtain reproducible peak areas. Same steps were followed for samples. Between every 2-3 samples, a standard stachyose solution was injected. The average value obtained for peak area/mg of each standard stachyose was used to calculate the amount of the unknown stachyose using the following equation;

$$\% \text{ Starchyose} = \frac{ASt(S)(V)(100)}{(ASt')(W)}$$

Where: ASt- Peak area of unknown starchyose
S- mg starchyose (10µl standard)
V- Final volume (ml)
ASt'- Peak area of standard starchyose
W – Sample weight (g)

Determination of Dietary Fibre (AOAC, 2000).
Duplicate test portions of dried foods, fat extracted if >10% were gelatinized with heat stable α-amylase and then digested with protease and amyloglucosidase to remove protein and starch respectively. Insoluble dietary fibre was removed by filtering and washing the residue with water. Soluble dietary fibre in the filtrate was precipitated by adding 95% ethanol and acetone, dried and weighed. One duplicate was analysed for protein and ash. Therefore
Soluble dietary fibre= Weight of residue-Protein+Ash

Determination of Vitamins Content (Okwu and Joshiah, 2006)
Vitamin A content (RAE)
One gram (1g) of the sample was weighed and macerated with 20mls of petroleum ether. It was evaporated to dryness and chloroform acetic anhydride (0.2 ml) was added and 2ml of TCA chloroform were added and the absorbance was taken at 620nm. Then concentration of vitamin A was extrapolated from standard curve.

$$Vitamin\ A\left(\frac{mg}{100g}\right) RAE = \frac{100\ \times \text{Au}}{\text{W} - \text{As}} \times \text{C}$$

Where; Au= absorbance of test sample, As = absorbance of standard solution, C = concentration of the test sample, W= weight of sample
Vitamin B_1 (Thiamine) content
Five grams (5g) of sample were homogenized with ethanolic sodium hydroxide (50 ml). It was seperated into a 100 ml flask. Ten milliliter of the filtrate was

collected and the colour developed by addition of 10ml potassium dichromate and the absorbance read at 360nm. $Thiamin\ \left(\frac{mg}{100g}\right) = \frac{Au \times C \times Vf}{W \times As \times Va} \times 100$

Where:w= weight of sample, Au= absorbance of test sample, As= absorbance of standard solution, Vf= total volume of filtrate, Va=volume of filtrate analysed, C= concentration of the standard.

Vitamin B_2 (Riboflavin) content

Five grams (5g) of each sample was mixed with 100ml of 50% ethanol solution and shaken for 1 hour. This was filtered into 100ml flask, 10ml of the extract was collected into a 50ml volumetric flask. Ten milliliter of 5% potassium permanganate and 10 ml of 30% H_2O_2 were added and allowed to stand over a hot water bath 50ºC for 30 minutes and 2ml of 40% $NaSO_4$ was added. De-ionized water was used to make up to 50ml mark and absorbance of 510 nm was measured using spectrophotometer.

$$Riboflavin\ (mg/100g) = \frac{100 \times Au \times C \times Vf \times D}{W \times As \times Va}$$

Where; W=weight of analysed sample, Au=absorbance of the test sample
As=absorbance of standard solution, Vf=total volume of filtrate
Va=volume of filtrate analysed, C=concentration of the standard
D=dilution factor where applicable

Vitamin B_3 (Niacin) content

Five grams (5g) of the sample was treated with 50 ml of 1 N sulphuric acid, shaken for 30 minutes, 3 drops of ammonia solution (0.1N) were added to the sample and filtered. Filtrate (10ml) was collected into a 50 ml volumetric flask and 5ml potassium cyanide was added. This was acidified with 5ml of 0.02 N H_2SO_4 and absorbance was measured using spectrophotometer at 470nm wavelength.

$$Niacin\ \left(\frac{mg}{100g}\right) = \frac{Au \times C \times Vf \times D}{W \times As \times Va} \times 100$$

Where;
W= weight of sample, Au=absorbance of the test sample
As=absorbance of the standard solution, Vf=total volume of filtrate, Va=volume of filtrate analysed, C=concentration of the standard
D=Dilution factor where applicable

Vitamin E content

A gram (1g) of the sample was measred and macerated with ethanol (20ml). One milliliter (1ml) of 0.2% ferric chloride in ethanol was added, 1ml of 0.5% □-dipyridyl was added, it was diluted to 50ml with distilled water and absorbance was read at 520nm. Then vitamin E concentration was extrapolated from standard curve calculation.

$$Vitamin\ E\left(\frac{mg}{100g}\right) = \frac{\mathrm{Au} \times \mathrm{C}}{\mathrm{W} \times As} \times 100$$

Where Au=absorbance of test sample, As =absorbance of standard solution, C = concentration of the test sample, W= weight of sample

Determination of Mineral Contents

A gram of sample was digested using 15ml Hcl and 5ml of nitric acid (3:1). Mineral compositions of the digested samples were determined using Atomic Absorption Spectrophotometer (AAS) 6800, Shimadzu. (AOAC,1990). Different electrode lamps were used for each mineral. The equipment was run for standard solutions of each mineral, before and during determination to ensure it was accurate. Concentration of minerals was determined using the formula below:

$$X = \frac{\mathrm{A} \times \mathrm{V}}{\mathrm{W}}$$

X= Actual concentration
A= Machine reading
V= Volume of samples
W= Dry weight of sample

Sodium (Na) and Potassium (K) determination was done using flame photometry method. The same wet digested sample solutions used in AAS was used for the determination of Na and K. Standard solutions of 20, 40, 60, 80 and 100 milli-equivalent/L was used. The calculation for both minerals involved the same procedure as given in AAS.

Determination of phytic acid content (Lucas and Maskakas, 1975)

Sample (2g) was taken into 250ml flask; sample was soaked in 100ml of 2% concentrated hydrochloric acid for 3hours, 50ml of each filtrate was placed in

250ml beaker and 107ml of distilled water was added as indicator and was titrated with standard iron chloride solution that contained 0.00195 iron per ml.

$$\%\ Phytic\ acid\ \left(\frac{mg}{100g}\right) = \frac{\mathrm{Y} \times 1.19}{\mathrm{W}} \times 100$$

Where Y= Titre value x 0.00195, W= weight of sample

Determination of tannin content (Makkar and Goodchild, 1996)

Sample (2g) was measured into a 100ml borosilicate glass, dissolved in 50ml distilled water and was shaken for an hour using mechanical shaker. The filtrate was collected into a 50ml volumetric flask and made up to the mark. Five milliliter (5ml) of the filtrate was taken out into test tube and mixed with 2ml of 0.1M $FeCl_3$ in 0.1N HCl and 0.008 M potassium ferrocyanide. The absorbance was read at 620nm in 10 minutes.

$$\%Tannin\ content = \frac{\mathrm{An} \times \mathrm{C} \times 100 \times \mathrm{Vf}}{\mathrm{As} \times \mathrm{W} \times \mathrm{Va}}$$

Where An = Absorbance of test sample, As = Absorbance of standard solution C = Concentration of standard solution, W = Weight of used sample, Vf= Total extract volume

Determination of Functional Properties

Bulk density (Okaka and Potter, 1979)

Twenty grams (20g) of sample were measured into 100cm^3 cylinders and tapped ten times on palm of hand. The volume of the powder after tapping was recorded and the bulk density recorded in g/cm^3. The bulk density = Initial sample weight (g) / Sample Volume (cm^3) **Viscosity (**Mosha and Svaberg, 1983).

Result and Discussion

Malnutrition is of urgent public global health concern. The elements that contribute to poor nutrition outcomes are complex and changes across production to consumption context. Food security is said to be when all persons at all times, have access (economic and physical) to enough, safe and nutritious food to meet their dietary requirements and food preferences for an active healthy life (Barrett, 2010).

Table 1. Proximate Composition and Dietary Fibre Content of *Pennisetum glaucum* Flour.

Proximate Parameters	Unprocessed Flour		
	Zango sosat	***Ex-bornu***	***Super-***
MOISTURE (%)	8.00 ± 0.00^{a}	8.12 ± 0.03^{b}	8.07 ± 0.03^{ab}
ASH (%)	1.05 ± 0.00^{a}	1.13 ± 0.03^{b}	1.60 ± 0.00^{c}
LIPID (%)	3.10 ± 0.14^{b}	3.45 ± 0.06^{b}	2.40 ± 0.13^{a}
PROTEIN (%)	6.99 ± 0.01^{a}	10.52 ± 0.00^{b}	14.03 ± 0.01^{c}
CHO (%)	80.87 ± 0.15^{c}	76.79 ± 0.06^{b}	73.91 ± 0.10^{a}
CRUDE FIBRE (%)	2.58 ± 0.01^{c}	1.60 ± 0.00^{b}	1.23 ± 0.01^{a}
SDF (g/ml)	8.74 ± 0.19^{c}	7.88 ± 0.03^{b}	7.47 ± 0.05^{a}
IDF (g/ml)	3.05 ± 0.01^{c}	2.66 ± 0.01^{b}	2.36 ± 0.08^{a}

Results represent mean ± SD of three determinations. Values with different superscripts across each row differ significantly ($p < 0.05$).

The determination of proximate composition of *Pennisetum glaucum* flour provides substantive nutritional and functional qualities for effective guide on dietetics. The proximate composition of *P*ennisetum *glaucum* flour showed that moisture, ash, lipid, protein, carbohydrate, crude fibre, soluble-dietary fibre and insoluble-dietary fibre had values ranging from 8.00-8.12%, 1.05-1.60%, 2.40-3.45%, 6.99-14.03%, 73.91-80.87%, 1.23-2.58%, 7.478.74% and 2.36-3.05% respectively. Florence *et al*. (2014) recorded that semi-refined flour of two pearl millet varieties contained 10.8 and 9.5% moisture, 1.3 and 1.3% ash, 4.4 and 5.0% fat, 8.5 and 10.1% proteins, and 75.0 and 75.0%, carbohydrates respectively. Researchers like [Hulse *et al*., (1980); Jambunathan and Subramanian, (1988); Rooney and Serna-Saldivar,(1991)] have reported notable variations in the seed composition of pearl millet. Environmental and genetic factors play major role in determining grain composition.

The moisture content shows that *Zango* cultivar had the least while *Ex-bornu* cultivar had the highest. However, findings have shown that food samples with low moisture content is a desirable process, since the microbial activity is lowered (Oyenuga, 2013). Low moisture content in food samples enhance storageability of food products (Alozie *et al*, 2009), while food spoilage is inevitable in high moisture content foods as they support microbial growth (Temple *et al*., 2006). Previous study has shown higher moisture content

compared to the present study, the low moisture content of *Zango* cultivar may give these cultivar a better storage quality.

The ash content varied significantly, *Super-sosat* cultivar had the highest value. The ash content is an indication of a crude mineral elements content of food. The ash content in this study agrees with the findings of Florence *et al*., (2014) for semi refined flour of two pearl millet varieties. This ash content is within the range of 1.6-3.6%standard range for ash in whole millet flour (Taylor, 2004).

Lipid content varied significantly with *Ex-bornu* cultivar having the highest lipid content. Report shows that low fat content helps in extending shelf life of samples by reducing chances of rancidity. Low fat contribute to the low energy value of sample while high fat foods may get rancid quickly, but may have a high energy value. The lipid content in this present study is higher than 1.3% reported by Florence *et al*., (2014). The lipid content reported at ICRISAT for pearl millet ranges between 4.1-6.4%, the value in this study is very low. However, the lipid content observed in pearl millet in this study is higher than 31g/d recommended for growing infants (http://www.nationalacademies.org).

Protein content in this study also shows significant difference within the cultivars, with Z*ango* cultivar having the least while *Super-sosat* cultivar had the highest. Protein enhances absorption of Zn and Fe (Heaney, 2000). The present study showed lower protein content in the lower limit and a higher protein content in the higher limit than that reported by Florence *et al*., (2014). This high protein content in *Super-sosat* cultivar may be a supplementary source of protein where plant materials are the main source of protein.

The study shows a significant ($p < 0.05$) difference for carbohydrate contents among the cultivars. *Zango* cultivar had the highest carbohydrate content. From previous study it is clear that carbohydrate provides the body and brain with energy and adequate intake also spare protein and helps with fat metabolism. The present study showed a lower carbohydrate content at the lower limit and a higher carbohydrate content at the higher limit than that reported by Florence *et al*., (2014). The high carbohydrate in *Zango* cultivar may contribute greatly to textural properties of this cultivar.

Crude fibre, soluble-dietary fibre and insoluble-dietary fibre contents varied significantly with *Zango* having the highest values. Variety of health benefits and essentiality of fibre has been reported for reducing risk of chronic diseases like diabetes, obesity, cardiovascular diseases and diverticulitis (Salas-salvado

et al., 2006). Dietary fibre act to reduce the amount of low density lipoprotein cholesterol in the blood by binding with bile acids using lignin fraction as its possible binding agent. The present study showed a lower crude fibre and insoluble dietary fibre contents than 2.90% and 10.9-12.6g/100g reported by Zakari *et al*.,(2010); Flourence and Asna, (2011) respectively, however the soluble dietary fibre content in this study is higher than 0.70-1.05g/100g reported by Flourence and Asna, (2011).

Table 2. Carbohydrate Fractions and Energy Value of *Pennisetum glaucum* Flour

Carbohydrate Fractions	*Zango*	*Ex-bornu*	*Super-sosat*
Starch (mg/g)	57.72 ± 0.17^{a}	62.82 ± 0.11^{c}	59.81 ± 0.01^{b}
Amylose (%)	14.30 ± 0.00^{a}	13.69 ± 0.13^{a}	16.54 ± 0.34^{b}
Total sugars (mg/g)	2.32 ± 0.03^{b}	2.10 ± 0.01^{a}	2.75 ± 0.01^{c}
Sucrose (mg/g)	0.84 ± 0.02^{a}	0.86 ± 0.05^{a}	0.80 ± 0.01^{a}
Glucose (mg/g)	0.85 ± 0.04^{b}	0.82 ± 0.03^{a}	0.75 ± 0.00^{a}
Starchyose (%)	0.06 ± 0.00^{b}	0.05 ± 0.00^{a}	0.06 ± 0.00^{b}
Maltose (mg/g)	1.13 ± 0.00^{b}	1.07 ± 0.04^{a}	1.06 ± 0.00^{a}
Energy value (kcal)	379.33 ± 0.50^{b}	380.23 ± 0.23^{b}	373.32 ± 0.56^{a}

Results are mean ± SD of three determinations. Means with different alphabets (superscripts) across the rows are significantly different ($p < 0.05$).

The carbohydrate fractions and energy values of *Pennicetum glaucum* flour ranged for starch (57.72-62.82%), amylose (13.69-16.54%), sugars (2.10-2.75%), sucrose (0.80-0.86%) and glucose (0.75-0.82%), starchyose (0.050.06%), maltose (1.06-1.13%) and energy value (373.32-380.23%). The energy value in the three cultivars was found to be less than 386.46-397.68kcal reported by Kavitha and Parimalavalli,(2014). Carbohydrate fractions like starch remains a major nutritional component in cereals that provides energy to the body. The present study had a lower starch content compared to 63.2% for starch reported by Ali *et al*., (2003). Cultivar difference and variation of amylose to amylopectin ratio may be responsible. Usually energy giving diets depend on carbohydrate quality, consequently it is of nutritional importance to know the carbohydrate fractions present in food. Starch content of flour is

directly influenced by method of milling (Particle size). Starch content increases as the size of milling screen used decreases (Kerr *et al*., 2000). This may be that as mesh size decreases, more fibre is separated and finer flour of high starch content passes through the sieve. In this study *Ex-bornu* cultivar had a significantly higher starch and has the highest energy value. *Ex-bornu* cultivar may be a healthy replacement for most of the staple foods in our regular diet.

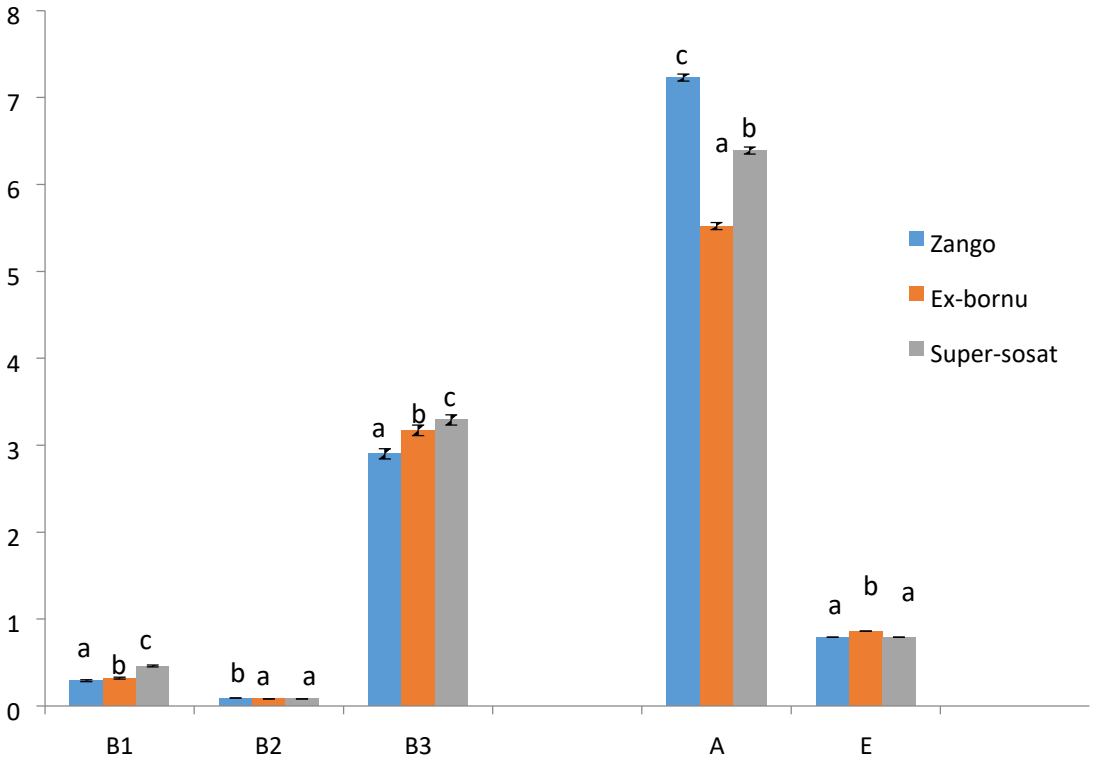

Figure 1. Vitamin Composition of *Pennisetum glaucum* Flour
Charts with different super-scripts are different significantly ($p < 0.05$).

The vitamin composition of *P*ennisetum *glaucum* showed vitamin A (5.52-7.23mg/100g), vitamin B_1 (0.290.46mg/100g), vitamin B_2 (0.08-0.09mg/100g), vitamin B_3 (2.90-3.29mg/100g), vitamin E (0.379-0.86mg/100g). *Zango* cultivars had the highest values for vitamins (A, B_2, B_3), *Super-sosat* cultivar was the highest in vitamin B_1. Vitamins are important in human nutrition and health, they possess antioxidants, serve as cofactors for several enzymes involved in energy metabolism and for maintaining healthy blood cell. The values of B_1, and B_3 in the study are within normal range while that for vitamin

B_2, A and E had a lower value than that reported by Taylor, (2004). Deficiency in B-group vitamins like niacin causes pellagra and this condition classically manifests as a triad of dermatitis, diarrhea, and dementia that can lead to death (Seal *et al*., 2007). Deficiency in fat soluble vitamin A and E can increase free radical and reduce immune system. The values of these vitamins reported in this work for vitamin E, K, B_3, B_2 are below 4mg, 2mg, 2mg, and 0.3mg/day respectively while vitamin A content is higher than 400µg/day a range recommended for growing infants (http://www.nationalacademies.org).

Table 3. Minerals and Antinutrients Composition of *Pennisetum glaucum* Flour

TABLE

Results represent mean ± SD of three determinations. Values with different superscripts across each row differ significantly ($p < 0.05$).

Minerals and antinutrients composition of *P*ennisetum *glaucum* flour ranged for zinc 1.16-3.33mg/100g, iron 21.3123.18mg/100g, sodium 29.50-37.50mg/100g, manganese 0.26-0.79mg/100g, potassium 20.50-34.50mg/100g, phytate 0.10-0.12mg/g and tannin 0.60-0.95mg/g. Minerals take part in all aspects of the cellular function. They are essential for normal growth, effective immune system, maintenance and cell damage prevention (Kassa and Hailay, 2014). *Zango* cultivars gave the highest value for manganese, zinc and potassium, *Super-sosat* cultivar gave the highest sodium while *Ex-bornu* cultivar gave the highest iron content. The values obtained for manganese, zinc, potassium and sodium are lower than the previously reported values for pearl millet flour of different varieties (Laminu *et al*., 2014; Shweta, 2015). However this study had a high iron content than 9.27mg/100g stated by Laminu *et al*., (2014) and 4.06 and 5.83 mg/100g iron by Florence *et al*. (2014) for mineral composition of semi-refined flour of two pearl millet varieties, this may be due to genetic and environmental factors. Iron helps to transport oxygen throughout the body. In this study the iron and zinc are lower than 40mg/d, 5mg/d respectively recommended for an infant (Lynch, 2001).

Antinutrients from this study showed that the lowest value of phytate and tannins were found in *Ex-bornu* cultivar and *Super-sosat* cultivar respectively. Phytate and tannins have been implicated nutritionally by impeding the bioavailability of some essential nutrients, inhibiting enzymes. Bran comprised a large amount of insoluble-dietary fibre and antinutrients like tannins and

phytate which can bind enzymes and proteins and lower their activity. This study had lower phytate values and tannins values compared to 0.80 mg/g and 1.75mg/g reported by Laminu *et al*., (2014). This low antinutrient content may give this millet advantage over other millets.

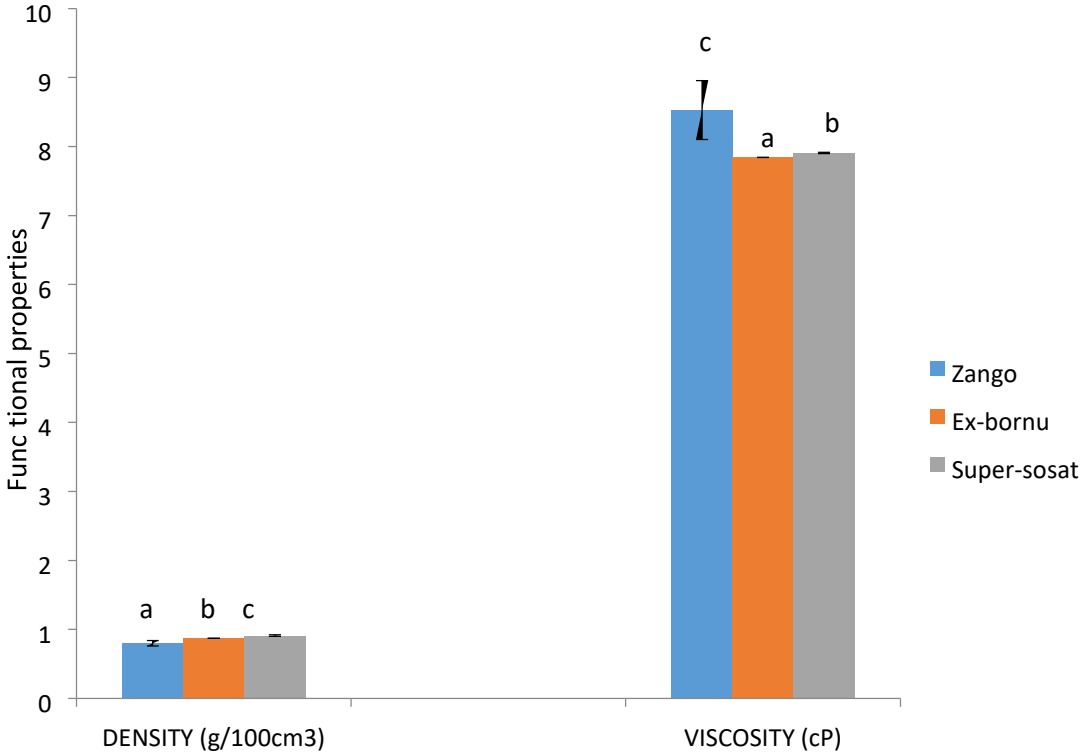

Figure 2. Functional Properties of *Pennisetum glaucum* Flour
Charts with different superscripts are significantly different
Note: 1g/100cm^3 =100cP

Functional properties of *P*ennisetum *glaucum* flour showed that bulk density ranged from 0.80-0.91g/ml and viscosity ranged from 784.30-852.67cP. *Zango* cultivar had the least while *Super-sosat* cultivar had the highest. Low bulk densities are nutritionally advantageous as more can be consume which results in high energy and nutrient densities. *Zango* cultivar may offer the beverage higher energy and nutrient because of its low bulk density. The present study showed a higher value compared to 0.44g/ml reported by Zakari *et al.*, 2010. Viscosity gives uniformity and rate of flow ability to foods. *Ex-bornu* cultivar had the least while *Zango* cultivar had the highest values. The present study had

a higher viscosity value compared to the 84.55cP reported by Zakari *et al*., (2010).

Conclusion and Recommendations

Super-sosat flour has ash, protein, amylase, sugars, sodium, bulk density, vitamin B1 and B3 higher than zango and ex-bornu.

Based on this study, new cultivar may be a good vehicle for infant supplementary food.

Further study should be carried out on these cultivars for storageability and sensory quality.

References

Ali, M.A.M., Tinay, A.H.E. and Abdalla, A.H. (2003). Effect of Fermentation on the In Vitro Protein Digestibility of Pearl Millet. *Food Chemistry*, 80: 51- 54.

Anu, S.S., and Kwatra, A. (2006). Nutritional Evaluation of Pearl Millet Based Sponge Cake. *Journal of Food and Technology*, 43 (3): 312-313.

Ayo, J.A., Onuoha, O.G., Ikuomola. D.S., Esan, Y.O., Ayo, V.A. and Oigiangbe, I.G.(2010). Nutritional Evaluation of Millet-beniseed Composite Based Kunun-Zaki. *Pakistan Journal of Nutrition* 9 (10):1034-1038.

AOAC (1990). Official Methods of Analysis of Association of Official Analytical Chemist (15th ed.), Washington D.C: AOAC.

AOAC (2010). Official Methods of Analysis. (18th edition). Washington, D.C Association of analytical chemists. AOAC (2000). Official Methods of Analysis. Association of Official Analytical Chemist,16th edition.

Alozie, Y., Akpanabiatu,M.I., Eyong,E.U., Umoh, I.B and Alozie, G.(2009). Amino Acid Composition of *Dioscorea dumetorum* Varieties. *Pakistan Journal of Nutrition*. 8:103-105.

Bjorn, B., Baboo, N., Adelina, H., Rojas, C. and Carola, C. (2006). Simultaneous Determination of Glucose, Maltose and Sucrose In Starch of Six Varieties of Cassava. *Bolivian Journal of Chemistry* 23 1:19-23.

Flourence Suma P, and Asna U. (2011) Pearl Millet Nutrients, Antinutrients and Minerals Bioaccessibility as Influence by Wet and Dry Heat Treatments. *International Journal of Biomedical Research Analysis* 2 (5): 31-36.

Florence-Suma, P., Urooj, A., Asha, M.R., and Rajiv, J. (2014). Sensory, Physical and Nutritional Qualities of Cookies Prepared from Pearl Millet (*Pennisetum typhoideum*) *Journal of Food Processing and Technology*, 5: 2-6.

Gutmann, I and Wahlefeld, A.W. (1974). L(+) – Lactate: Determination with Lactate Dehydrogenase and NAD. In HU Bergmeyer, ed, Methods in Enzymatic Analysis, English ed 2, vol. Academic Press, New York, 14641470.

Heaney, R.P. (2000). Dietary Protein and Phosphorus do not Affect Calcium Absorption. *American Journal of Clinical Nutrition.* 72 758–761.

Holm, J. (1986). A Rapid Method for the Analysis of Starch, *Starch*, 38:224-226

Hulse, J.H., Laing, E.M and Pearson, O.E (1980). Sorghum and the Millets: Their Composition and Nutritive Value. New York, Academic Press. 997.

Iwe, M.O. (2002) A Handbook in Sensory Methods and Analysis. First Edition Rejoints Communication Service Ltd, Uwani, Enugu: 2000. 71

Jambunathan, R. and Subramanian, V. (1988). Grain Quality and Utilization of Sorghum and Pearl Millet. In Biotechnology in Tropical Crop Improvement. Proceedings of the International Biotechnology Workshop, Patancheru, India, 12-15th January 1987. 133-139. Patancheru, ICRISAT.

Kavitha, S and Parimalavalli, R (2014).Effect of Processing Methods on Proximate Composition of Cereal and Legume Flour. *Journal of Human Nutrition and Food Science*, 2(4) 1051.

Kerr, W., Ward, C., McWatters, K., and Resurreccion, A. (2000). Effect of Milling and Particle Functionality and Physicochemical size on Properties of Cowpea Flour. *Cereal Chemistry*, 77, 213–219.

Laminu, H.H, Sheriff, M., Bintu, B.P and Muhammad, A.A (2014). Evaluation of the Protein Quality of Composite Meals produced from Selected Cereals and Legumes for Infants. *Journal of Agricultural Science*, 4 (11), pp. 536-542.

Lucas, G.M and Markakas, P. (1975). Phytic Acid and Other Phosphorus Compounds of Bean (*Phaseolus vulgaris*). *Journal of Agricultural Education Chemistry*, 23: 13-15.

Lynch, S (2001). The Effect of Calcium on Iron Absorption: *Nutrition Research Reviews*. 13:148-158. Doi: 10.1079/095442200108729043.

Makker, A.O.S and Goodchild, A.O (1996) Quantification of Tannin. A Laboratory Manual International Centre for Agricultural Research in Dry Areas (ICARDA) Aleppo, Syria IV-25.

Mosha A.C, Svanberg U. (1983). Preparation of Weaning Foods with High Nutrient Density Using Flour of Germinated Cereals. The United Nations University Food Nutrition Bulletin, 5(2): 110-114.

Ojediran J.O., Adamu M. A. and Jim-George D. L. (2010). Some Physical Properties of Pearl millets (*Pennisetum glaucum*) Seeds as a Function of Moisture Content. *African Journal of Genetic Agriculture.* 6 (1). Ojiako, O.A and Akubugwo, E.I. (1998). An Introduction Approach in Practical Biochemistry.CRC Publishers Owerri.

Okaka, J.C and Potter, N.N. (1979). Physico Chemical and Functional Properties of Cowpea Powders Processed to Reduce Beany Flavours. *Journal of Food Science*, 55: 1235- 1240.

Kassa, B. and Haillay, K (2014). Spectroscopic Determination of Trace Metals (Mn, Cu and Ni) Contents in Moringa Oleifera. *International Journal of Chemical and Natural Sciences.* 2(5) 141-144.

Okwu, D.E. and Josiah, C (2006). Evaluation of the Chemical Composition of Two Nigerian Medical Plants. *African Journal of Biotechnology*, 5(4):357-361.

Oyenuga, V.A. (2013). Nigeria's Foods and Feeding-stuffs; Their Chemistry and Nutritive value, Ibadan University Press, Ibadan. 47-49.

Rooney, L.W. and Serna-Saldivar, S.O. (1991). Sorghum. In Lorenz, K.J and Kulp, K. eds. Hand book of Cereal Science and Technology 2 33 269. New York, Marcel Dekker.

Salas-salvado, J., Bullo, M., Perez-heras, A., Ros, E., (2006). Dietary Fibre, Nuts and Cardiovascular Diseases. *The British Journal of Nutrition*, (2) 96: 46-51.

Seal, A.J., Creeke, P.I., Dibari, F., Cheung, E., Kyroussis, E., Semedo, P., and Van den Birel, T. (2007). Low and Deficient Niacin Status and Pellagra Are Endemic in Postwar Angola. *American Journal of Clinical Nutrition*, 85, 218-224.

Shweta, M. (2015). Pearl Millet-Nutritional Value and Medicinal Uses. *International Journal of Agriculture Research.* 1 (3), 414-418.

Taylor, J.R.N. (2004). Millet: Pearl. In: *Encyclopedia of Grain Science* (edited by Wrigley, C., Corke, H. and Walker, C.E.). 253- 263. London: Elsevier

Taylor, J.R.N., Barrion., S.C. and Rooney, L.W. (2010). Pearl millet—New Developments In Ancient Food Grain. *Cereal Foods World*, 55: 2-8.

Zakari U.M, Hassan A, and Abbo E.S. (2010). Physico-Chemical and Sensory Properties of "Agigi" from Pearl Millet (*Pennisetum glaucum*) and Bambara Groundnut (*Vigna subterranean*) Flour blends. *African Journal of Food Science*. 4:662-667.