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Chemical, Functional and Pasting Properties of Flour from Three Millet Varieties

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ABSTRACT

Flour samples were prepared from different millet varieties (pearl, finger and fonio millet) using standard methods and subjected to chemical, functional and pasting properties. The functional properties of the millet flour ranged between 0.49-0.59(g/ml) for bulk density, 1.55-1.64(g/g) for oil absorption capacity, 1.60-1.71(g/g) for water absorption capacity, 73-37.50(%) for dispersibility, 0.53-0.71(g/g) swelling power and 18.17-36.08(%) solubility respectively. The chemical composition of flour from different millet varieties ranged between 6.85-7.30% for moisture content, 0.35-2.14% ash, 1.99-3.45% fat, 6.63-11.80% protein, 1.98-3.48% fibre, 74.34-82.71% carbohydrate, 1.61-3.46% sugar, 69.76-78.47% starch, 21.70-23.43% amylose and 76.57-78.30 (%) amylopectin. The pasting properties of millet flours ranged between 45.13-191.34 RVU for peak viscosity, 71.92-190.75 RVU trough, 154.96-471.55 RVU final, 109.84-280.21(RVU) setback, 5.03-5.44(min) pasting time and 49.88-50.60oC, pasting temperature respectively. This property of the millet flour shows good nutrient composition that would provide better opportunity for their use in product development and value addition.

Keywords: *Flour, millet, chemical, functional, pasting*

INTRODUCTION

Cereals are important sources of the world's food supply and their role in human diet throughout the world is extremely vital such as rice, barley, maize, wheat, sorghum, oat, rye and millet contributes to diet in the world.

Millets are small-seeded grains, belonging to the *Poaceae (Graminaea*) family (Zhu, 2014). They are cultivated in diverse and adverse environments, mostly in the dry, semi-arid to sub-humid, drought prone agro- ecosystem (Obilana and Manyaga 2002). They are comparable or superior to some commonly consumed cereals like wheat and rice (Ragaee *et al*, 2006). Millets have different varieties, but of interest to this location include pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana)*, fonio (*Digitaria exilis*). Species of this crop are produced in large quantities in Borno, Yobe, Kano, Sokoto and Jigawa state in Nigeria (Ogunlela and Egharevaha 1981). It is the sixth cereal crop in terms of world agriculture production with an annual production of about 29million tonnes in 2013 (FAOSTAT, 2015).

Foods made of millet, specifically among the non affluent segments in their respective societies (Chandrasekara and Shahidi 2012) compared to major cereals (Devi *et al*, 2011).

Millet is superior in its nutritional qualities especially valuable amino acid, higher protein, quality macro and micronutrients (Shobana and Malleshi, 2007). It is found to be significantly rich in resistant starch, soluble and insoluble dietary fibers, minerals, and antioxidants (Ragaee *et al*, 2006). It is also a good source of nutraceutical and functional food ingredients in health promotion due to their anti-oxidant, antimicrobial, anti-inflammatory, antiviral and anticancer activities (Muthamilarasan *et al*, 2016). Millet has been termed as "nutri-cereals" because they are rich in vitamins and sulphur containing amino acids with a low glycemic index and gluten free, allergy friendly food which makes it an excellent choice for people suffering from celiac disease due to gluten intolerance (Taylor *et al*, 2006). Thus, the presence of all the required nutrients in the varieties of millet makes them suitable for large-scale utilization in the manufacture of flour.

Wheat production in Nigeria is limited due to climatic conditions and wheat is imported to meet local flour needs for baking. As a result of this, huge amount of foreign exchange is spent annually for wheat importation (Oberoi *et al*., 2007). Hence, the aim of the study is to produce flours from different varieties of millet and to evaluate their chemical, functional and pasting properties for domestic and industrial application.

MATERIALS AND METHODS

Collection of Sample

Millet varieties were purchased from Bori-camp market, Port-Harcourt. Rivers state, Nigeria.

Chemicals

Chemicals used for analysis were obtained from the biochemistry laboratory Department of Food Science and Technology, Rivers State University and were of analytical grade.

Methods

Processing of Millet Flour

The method of Olapade *et al*, 2011 was used. Millets were manually cleaned by washing in clean water using local calabash and decanted by sedimentation, draining and drying in cabinet drier at 50^{o}C for 6h. The resulted dried millets were milled into flour using hammer mill (2014 hot model PC 120) and sieved to pass through 0.2mm mesh.

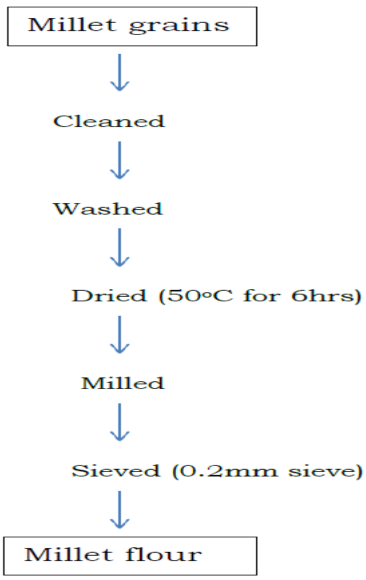

Fig1. *Production of Millet Flour*

Source: *Olapade et al, 2011.*

Formulation of Blends

Wheat flour was substituted with the different varieties of millet flour at levels of 0% -40% and 100% respectively. 100% wheat flour (sample A) was used as control. A kenwood mixer (model KMC011) was used for mixing flour samples for five minutes to achieve a homogenous mixture.

Chemical Analysis of Different Varieties of Millet Flour

Different millet flour samples produced were subjected to the following analysis. The moisture content of the sample was determined using moisture analyzer model AMB-ML-50 at 105^{0}C. Fat, protein, crude fibre and ash content of the samples were determined using AOAC (2012) and carbohydrate calculated by difference method. Starch and sugar were determined by the methods described by Dubois *et al*, (1956) as reported by Eke, (2006). Amylose content of samples was determination by the method of Williams *et al* (1970) and amylopectin content was calculated by the difference between starch and amylose content.

Pasting properties of the different flour samples were determined using a Rapid Visco Analyser (RVA, model 3C, Newport Scientific PTY Ltd, Syndney) according to Sanni *et al* (2004).

Functional Properties

The following functional properties were studied; Bulk density, Water absorption capacity, Solubility, Swelling power and dispersibility

Relative bulk density (RBD) of the flour samples were determined according to the method of Appiah *et al*, (2011), water absorption capacity (WAC) and oil absorption capacity (OAC) determined by the method of (Elkhalifa *et al*,2005). Swelling power and solubility of flour was determined by the method described by Takashi and Sieb (1988). Flour dispersibility was determined by the method described by Kulkarni *et al*, (1991) while Least Gelation Concentration (LGC) by the method of (Coffman and Garcia 1977).

STATISTICAL ANALYSIS

All experiments and analyses were carried out in duplicates and the mean calculated. Data were subjected to analysis of variance (ANOVA) using a general linear model Wahua (1999). Duncan multiple range test was used to separate means where significant difference existed (Duncan, 1955).

RESULTS

Chemical Compostion of Different Varieties of Millet Flour

Table 1 shows the chemical composition of flours produced from different varieties of millet.

The moisture content of varieties of millet flour ranged from 6.85-7.30% with sample A (pearl millet flour) recording the lowest and sample C (fonio millet flour) recording the highest. Result shows that sample A (pearl millet flour) was significantly different ($p<0.05$) from other samples, while sample B and C showed no significant differences from each other. The moisture content of these samples (A,B,C) were within the acceptable limit of not more than 10% for long term storage of flour (Onimawo and Akubor, 2012). The low moisture content of these millet flour would enhance its storage stability by avoiding mould growth and other biochemical reactions (Onimawo and Akubor, 2012).

Ash content of the millet flour ranged from 0.35-2.14% with sample B (finger millet flour) recording the highest and sample C (fonio millet flour) recorded the lowest. The samples did not differ significantly ($p<0.05$) from each other. The ash content (1.29%) for pearl millet in this study was lower than the 2.2% reported by Gomez and Gupta (2003). The ash content (2.13%) for finger millet flour in this research is close to 2.20% reported by (Amir *et al*,2015), while the ash content (0.34%) for fonio millet flour in this research was lower than the 1% reported by Vodouche *et al*,(2003). Ash content is an indication of mineral content of a food. This therefore suggests that finger millet flour could be important sources of minerals.

Fat content of millet flours ranged from 1.99-3.45% with sample A (pearl millet flour) recording the highest while sample C (fonio millet flour) the lowest. The samples (A, B and C) did not differ significantly ($p<0.05$) from each other. The fat content of 3.45% for pearl millet flour from this study was found to be lower than the report of 4.86% for pearl millet flour (Taylor *et al*, 2010). The fat content (2.15%) for finger millet flour is in an agreement with the report (2.73%) by Amir *et al*, 2015. The fat content (1.99%) for fonio millet flour is higher than the (1.1%) report by Vodouche *et al*, 2003. High fat flour is also good as flavor enhancers and useful in improving palatability of foods in which it is incorporated (Aiyesanmi and Oguntokun, 1996).

Protein content of millet flour ranged from 6.63-11.80% with sample A (pearl millet flour) recording the highest while sample C (fonio millet flour) the lowest. Result shows that sample A, B and C differed significantly ($p<0.05$) from each other. The protein content of 11.80% for pearl millet flour in this research was similar to 11.84% reported for same flour by Thilagavathi *et al*, (2015). The protein content of 7.42% for finger millet was close to 7.30% reported by Amir *et al*,201 5. The protein content of 6.63% for fonio millet flour was lower than the 9% reported by Vodouche *et al*, 2003. Proteins are increasingly being utilized to perform functional roles in food formulations. Therefore, the protein content of the flour in this study suggests that they may be useful in food formulation systems especially with the pearl millet flour which is comparable to wheat flour protein used in most food confections.

The fibre content ranged from 1.98-3.48% with sample B (finger millet flour) recording the highest while sample C (fonio millet flour) the lowest. The samples A, B and C did not differ significantly ($p<0.05$) from each other. Crude fibre content (2.14%) recorded for sample A (pearl millet flour) in this study was close to the 2.25% reported by Thilagavathi *et al*,(2015). The crude fibre content (3.48%) for sample B (finger millet flour) is in agreement with findings (3.60%) of Obadina (2018). The crude fibre content (1.98%) for fonio millet flour in this study is also in agreement with the findings (1.98%) of Voudouche *et al*, (2003).

Carbohydrate content of the millet flour varied from 74.34-82.71% with sample C (fonio millet flour) recording the highest and sample A (pearl millet flour) the lowest. Sample A, B and C were significantly different from each other. The carbohydrate content (73%) for pearl millet flour recorded in this study was lower than (75.6%) reported by Gomez and Gupta (2003) while the carbohydrate content of (74.46%) recorded for sample B (finger millet flour) in this study was higher than the (72.6%) reported by Hulse *et al*,(1980). The carbohydrate content (82.71%) for sample C (fonio millet flour) in this research was lower than 84% reported by Vodouche *et al*, (2003). It can be observed that the flour produced in this research had higher carbohydrate content.

Starch content of millet flour ranged from 69.76% with sample C (fonio millet flour) as the lowest, to 78.47% with sample B (finger millet flour) as the lowest. The starch recorded in this study is close to the range (64-79%) obtained for starch from (Geervani and Eggum1989).

Sugar content of millet flour ranged from 1.61% in sample C (fonio millet flour) as lowest to 3.46% in sample A (pearl millet flour) as highest. The amount of sugar in a diet should not be more than 10% of the daily total energy intake (Khazar *et al*, 2004). The amount of sugar in the flour produced could be said to be at a safe level.

Amylose content ranged from 21.70% (sample C) to 23.43% (sample B), while Amylopectin ranged from 48.07% (sample C) to 55.54% (sample A). The result obtained in this study falls within the range 26-30% for amylose and 69-74% for amylopectin as reported by Krishnakumari and Thayumanavan (1998). Amylose content is the linear structure while amylopectin is the branched structure of starch. Amylose positively influences the functioning of the digestive tract microbial flora, the blood cholesterol and glycemic index and assist in the control of diabetes (Fuentes-Zaragoza *et al*, 2010). Amylose decreased with increase in amylopectin meaning that one is a function of the other and both properties are important in food preparation and development (Fuentes-Zaragoza *et al*, 2010).

Functional Properties of Different Varieties of Millet Flour

Table 2 shows the functional properties of flour produced from different varieties of millet. The bulk density of millet flour ranged from 0.49-0.56 g/ml with sample B (finger millet) recording the highest while sample C (fonio millet) the lowest. The result of the present study is lower than that (0.54-0.72g/ml) reported by Eke-Ejiofor *et al* 2018 for acha/defatted soybean and groundnut flour blend. Bulk density is an indication of the porosity of a product which influences package design and could be used in determining the type of packaging material required, material handling and application in wet processing in the food industry (Appiah, 2011). Samples A, B and C did not differ significantly ($p<0.05$) from each other Akpata and Akubor (1999). Low bulk density would be an advantage in the formulation of complementary foods, This implies that sample C (fonio millet flour) will be the most suitable for formulation of complementary foods because of its low bulk density.

Oil absorption capacity ranged from 1.55-1.64g/g, sample A (pearl millet flour) recording the highest while sample C (fonio millet flour) the lowest. The samples did not differ significantly ($p<0.05$) from each other. Oil absorption capacity is attributed mainly to the physical entrapment of oils. It is an indication of the rate at which the protein binds to fat in food formulations (Onimawo and Akubor, 1999).The relatively high oil absorption capacity of sample A(pearl millet flour) suggests that it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products (Adejuyitan *et al*, 2009).

Water absorption capacity ranged from 1.60-1.71g/g sample A (pearl millet flour) recording the highest and sample C (fonio millet flour) the lowest. The water absorption capacity of flour is an indication of the amount of water available for gelatinization (Edema *et al*., 2005). It is a useful indication of whether protein can be incorporated into aqueous food formulations, especially those involving dough handling such as processed cheese, sausages and bread dough (Osungbaro *et al*., 2010). Sample A, B and C differed significantly ($p<0.05$) from each other. Adeleke and Odedeji (2010) reported water absorption capacity value of 2.45g/g for wheat flour, which was higher than the one reported for millet flour in this study. The result of this study suggests that sample A (pearl millet flour) would be useful in foods such as bakery products which require hydration to improve handling features (Akubor and Yusuf, 2013).

Dispersibility ranged between 73.00-75.50% with sample C (fonio millet) recording the highest while sample A (pearl millet) having the lowest. This result is higher than the findings of Eke-Ejiofor and Mbaka (2018) who reported 68-72% for acha/soybean/groundnut flour blends. Samples A, B and C did not differ significantly from each other.

Swelling power of millet flour ranged from 0.53-0.71g/g with sample A (pearl millet flour) recording the highest and sample C (fonio millet flour) the lowest. Sample A, B and C are significantly differently ($p<0.05$) from each other.

The solubility ranged from 18.17-36.08% with sample A (pearl millet flour) recording the highest while sample C (fonio millet flour) the lowest. Solubility is indicative of water penetration ability into starch granules (Ikegwu *et al* 2010). Sample A was significantly different($p<0.05$) from sample B and C. Adeleke and Odedeji (2010) reported solubility of 8.63% for wheat flour which is lower than the recorded values for different millet flours in this research. The high solubility of sample A (pearl millet flour) suggests that it was more digestible and therefore could be suitable for use as ingredient in infant food formulations.

Table1. *Chemical composition (%) of flour produced from different varieties of millet.*

SP	MC	Ash	Fat	Protein	Fibre	CHO	Sugar	Starch	Amylose	Amylo Pectin
A	$6.85^{b}\pm0.07$	$1.57^{ab}\pm0.53$	$3.45^{a}\pm0.25$	$11.80^{a}\pm0.0$	$2.14^{a}\pm0.24$	$74.34^{c}\pm0.7$	$3.64^{a}\pm0.05$	$76.5^{b}\pm0.02$	$22.90^{a}\pm0.1$	$77.10^{b}\pm0.02$
B	$7.30^{a}\pm0.14$	$2.14^{a}\pm0.22$	$2.16^{a}\pm0.22$	$7.43^{b}\pm0.01$	$3.48^{a}\pm0.26$	$77.51^{b}\pm0.4$	$2.14^{b}\pm0.03$	78.4a±0.09	$23.43^{a}\pm0.1$	$76.57^{a}\pm0.04$
C	$7.30^{a}\pm0.00$	$0.35^{b}\pm0.07$	$1.99^{a}\pm0.47$	6.63c±0.00	$1.98^{a}\pm0.47$	$82.71^{a}\pm0.6$	$1.61^{c}\pm0.06$	$69.77^{c}\pm0.0$	$21.70^{b}\pm0.0$	$78.30^{c}\pm0.01$
LSD	0.30	1.28	1.55	0.02	1.78	0.67	0.08	0.32	0.65	0.11

Means with different superscript in the same column are significantly ($p<0.05$) different

A = Pearl millet flour, B = Finger millet flour, C *= Fonio millet flour*

SP = Sample, CHO = Carbohydrate

Table2. *Functional properties of flour produced from different varieties of millet.*

Sample	Bulk Density (g/ml)	Oil abs (g/g)	Water Abs. (g/g)	Dispersibility (%)	Swelling power (g/g)	Solubility (%)
A	$0.52^{a}\pm0.01$	$1.64^{a}\pm0.16$	$1.71^{a}\pm0.12$	$73.00^{a}\pm4.24$	$0.71^{a}\pm0.00$	$36.08^{a}\pm0.42$
B	$0.56^{a}\pm0.07$	$1.55^{a}\pm0.15$	$1.65^{b}\pm0.16$	$74.00^{a}\pm4.24$	$0.59^{b}\pm0.00$	$23.90^{b}\pm0.07$
C	$0.49^{a}\pm0.03$	$1.61^{a}\pm0.02$	$1.60^{c}\pm0.12$	$75.50^{a}\pm4.95$	$0.53^{c}\pm0.00$	$18.17^{b}\pm2.87$
LSD	0.16	0.33	0.10	21.85	2.19	7.71

Means with different superscript in the same column are significant different ($p<0.05$)

Key: A = Pearl millet flour, B = Finger millet flour, C = Fonio millet flour

Pasting Properties (RVU) of Different Varieties of Millet Flour

When heat is applied to starch based foods in the presence of water, a series of changes occur, these changes are known as gelatinization properties. They influence the quality and aesthetic considerations in food industry such as the texture, digestibility and starch nature (Babajide and Olowe, 2013).

Table 3 shows the pasting properties (RVU) of different millet flour. The peak viscosity ranged from 117.04 in sample C (fonio millet) to 382.09 RVU in sample B (finger millet). The peak viscosity is the maximum viscosity developed during or soon after the heating portion of the samples. The Peak Viscosity (PV) indicates the water binding capacity of the starch or mixture in a product which correlates with final product quality and provides an indication of the viscous load likely to be encountered by a mixing cooker (Ingbian and Adegoke, 2007). It is also an indication of the ability of the products to swell freely before their physical breakdown.

Trough viscosity ranged from 45.13-191.34 RVU, while breakdown viscosity ranged from 71.92-190.75 RVU with sample B (finger millet) recording the highest and sample C (fonio millet) having the lowest respectively. Adebowale *et al*. (2008) reported that the higher the breakdown viscosity, the lower the ability of the sample to with stand heating and shear stress during cooking.

Final viscosity ranged from 154.96-471.55 RVU , while Set back viscosity ranged from 109.84-280.21 RVU with sample C recording the lowest and sample B the highest in both cases.

Pasting time ranged from 5.03-5.44 minutes with sample C recording the lowest time while sample A recorded the highest pasting time. Pasting time provides an indication of the minimum time required to cook flour. While pasting temperature ranged from 49.88-50.60°C with sample A recording the highest while sample B the lowest. There was a significant ($p<0.05$) difference amongst samples but pasting time and pasting temperature showed no significant ($p>0.05$) difference.

Table3. *Pasting properties (RVU) of different varieties of millet flour.*

Sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Pasting time (min)	Pasting temp (°C)
A	$263.00^{b}\pm0.76$	$157.00^{b}\pm0.24$	$106.96^{b}\pm0.53$	$289.42^{b}\pm3.42$b	$132.42^{b}\pm3.18$	$5.44^{a}\pm0.05$	$49.88^{a}\pm1.10$
B	$382.09^{a}\pm2.24$	$191.34^{a}\pm1.65$	$190.75^{a}\pm3.89$	$471.55^{a}\pm2.30$	$280.21^{a}\pm0.65$	$5.20^{a}\pm0.00$	$50.60^{a}\pm0.14$
C	$117.04^{a}\pm8.08$	$45.13^{a}\pm3.25$	$71.92^{c}\pm4.83$	$154.96^{c}\pm9.84$	$109.84^{c}\pm6.60$	$5.03^{a}\pm0.14$	$50.50^{a}\pm0.14$
LSD	23.83	7.45	18.78	28.40	21.05	0.42	3.05

Means with different superscript in the same column are significant different ($p<0.05$)

Key: A = Pearl millet flour, B = Finger millet flour, C = Fonio millet flour

Conclusion

Results of this study have shown that millet flour from (pearl, finger and fonio millets) have different characteristics under a given condition. Chemical and functional properties revealed higher preference for finger millet flour which had higher ash, fiber, amylose and starch as well as swelling power and solubility. All pasting properties were higher in the finger millet variety, meaning better potential for processing and value addition as well as improved consumer acceptability.

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