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ORIGINAL ARTICLE

PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF SPROUTED SORGHUM (*Sorghum Bicolor*) AND DEFATTED FLUTED PUMPKIN SEED (*Telfairia Occidentalis*) FLOUR BLENDS

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ABSTRACT

Introduction: Cereals and legumes play an important role in achieving the dietary pattern of many people in Africa as they solve protein-energy malnutrition by forming the major sources of proteins, carbohydrates, vitamins and mineral. **Objectives:** The study was aimed at evaluating the proximate composition and functional properties of the sprouted sorghum flour fortified with defatted fluted pumpkin seed flour. **Materials and Methods:** Sorghum grains (red variety) were purchased from Akpanandem market in Uyo Metropolis, Uyo while a pod containing fluted pumpkin seeds was purchased from Abak township market, Akwa Ibom State, Nigeria. Flour blends were formulated in a cereal-legume combination using sorghum and fluted pumpkin seed flours. Sorghum was sprouted to produce flour and fluted pumpkin seed was boiled and defatted to produce flour also. The flour blends were formulated as follow: SPA (100% Sprouted Sorghum Flour (SSF)), SPB (100% Defatted Fluted Pumpkin Seed Flour (DFPSF)), SPC (95% SSF/5% DFPSF), SPD (90% SSF/10% DFPSF), SPE (85% SSF/15% DFPSF) and SPF (80% SSF/20% DFPSF). SPA served as control. Proximate composition and functional properties were determined using standard methods. **Results:** Fortification of sprouted sorghum flour with defatted fluted pumpkin seed flour significantly ($p<0.05$) increased the moisture, crude protein, crude fat and ash contents of the flour blends while the crude fibre and carbohydrate contents were noted to be decreased. However, bulk density and swelling capacity decreased as the level of substitution increased while water absorption and oil absorption capacity were significantly increased ($p<0.05$). Least gelation of the fortified samples were not significantly ($p>0.05$) different from the control. **Conclusion:** This study has shown that fortified flours formulated from locally available food commodities contain nutrients needed by the children.
Keywords: *Legume, fortification, malnutrition, bulk density, infants.*

1. INTRODUCTION

Protein-energy malnutrition is one of the major public health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants, as well as very low resistance to disease [1]. In Nigeria, traditional weaning foods consists of cereal grains prepared from either sorghum, millet or maize referred to as *Ogi or Akamu*, which is of poor nutritional value due to deficiency in some of the essential amino acids such as lysine and tryptophan. Cereals and legumes play an important role in achieving the dietary pattern of many people in Africa and Asia and therefore form the major sources of proteins, carbohydrates, vitamins and mineral. They are the main sources of nutrients for weaning children in developing countries individually or as composites.

Sorghum (*Sorghum bicolor* L.) is considered as one of the most important food crops in the world. It provides the staple food of a large population and acts as a principal source of energy, proteins, vitamins and minerals for millions of the poorest people in Africa [2]. Unfortunately, sorghum grains contain low quality protein and considerable amounts of anti-nutritional factors [3]. However, efforts are directed to improve the nutritional value of the seeds. Processing methods, such as soaking, sprouting and cooking has been found to improve the nutritional value of plant grains. Sprouting is one of the processing methods that improve the nutritional properties (*in vitro* protein digestibility and minerals availability) by reducing the antinutritional factors [4] and bulk densities.

Due to high cost and unavailability of animal products such as milk, legumes are largely used as alternative sources of high quality protein [5]. Fluted pumpkin seed (*Telfairia occidentalis*) is widely consumed in Nigeria, especially in the South Eastern part. The seeds can be eaten cooked or ground into flour and used as a thickener or ingredient in some local foods [6]. It is known to be of high nutritional value in terms of protein and minerals [7]. Several studies have indicated the possibility of incorporating plants protein in cereal flour at various levels to produce composites but the fortification of sprouted sorghum flour with defatted pumpkin seed flour has not been explored. This type of blends should offer a good protein base complementary foods that will meet the nutritional requirement of infants. The objectives of the study were to evaluate the proximate composition and functional properties of the sprouted sorghum flour fortified with defatted fluted pumpkin seed flour.

2. MATERIALS AND METHODS

2.1. Procurement of raw materials: Sorghum (*Sorghum bicolor* (L.)) grains (red variety) were purchased from Akpanandem market in Uyo Metropolis, Uyo, Akwa Ibom State, Nigeria. A pod containing fluted pumpkin (*Telfairia occidentalis* Hook F.) seeds was purchased from Abak township market, Akwa Ibom State, Nigeria. All reagents used in this study were of analytical grade.

2.2. Preparation of Raw Materials (Sorghum Flour and Fluted Pumpkin Seed Flour)

The flow chart for the production of sprouted sorghum and fluted pumpkin seed flours are shown in Figure 1 and 2.

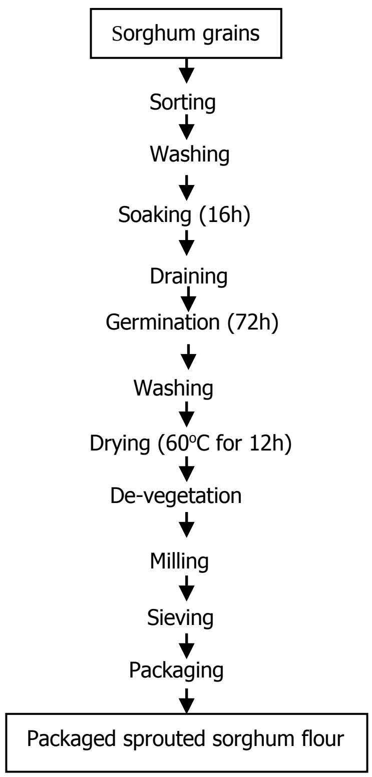

Figure1: Production of packaged sprouted sorghum flour

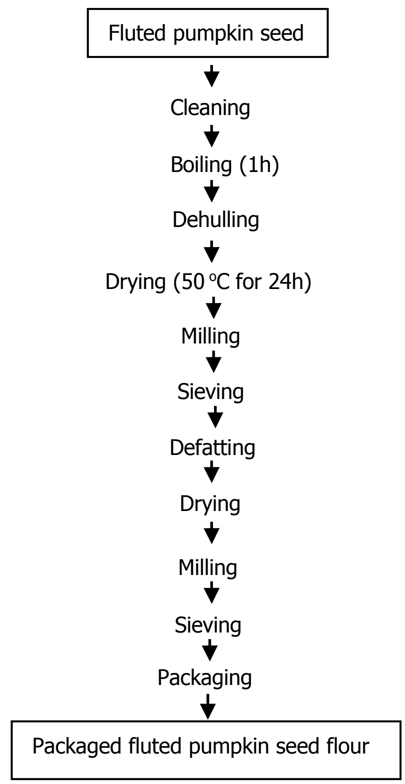

Figure 2: Production of packaged fluted pumpkin seed flour

2.2.1. Preparation of sorghum flour: Two (2) kg of sorghum grains was sorted to get rid of foreign matter and damages, washed and steeped in tap water (1:3 w/v) for 16 h at 30 °C. The water was changed after every 6 h interval to prevent fermentation. Steeped grains were drained and spread out about 1cm thick on a jute bag and covered with another sterilized jute bag. It was moistened and allowed to sprout for 72 h. The sprouted grains were washed and oven-dried at 60 °C for 12 h and cleaned to remove the vegetative parts (rootlets and shoots). The grains were milled using a manual laboratory mill. The flour was sieved through a 500 μm sieve to obtain sprouted sorghum flour. The flour was packaged in a polyethylene bag prior to analysis.

2.2.2. Preparation of fluted pumpkin seed flour: Seeds of fluted pumpkin were extracted from the pod. The seeds with hull were properly cleaned, washed and boiled for 1 h, after which they were drained, dehulled and cooled. The boiled seeds were transferred to an ovenable tray and oven-dried at 50 °C for 24 h in an oven. The processed seeds were then pulverized using a manual laboratory grinder, and sieved to pass through a 500 μm sieve. The seed flour was then defatted continuously for 8 h using petroleum ether and acetone as solvents. The defatted flour was allowed to dry at 50 °C until completely freed from the solvent(s). The flour was again pulverized and sieved to pass through a 500 µm mesh size to obtain the fine flour. The flour was then packaged airtight in polyethylene bags prior to analysis.

2.2.3. Formulation of sprouted sorghum-defatted fluted pumpkin seed flour blends: Sprouted sorghum and defatted fluted pumpkin seed flour blends were formulated in four different ratios and designated as SPA, SPB, SPC, SPD, SPE and SPF. The formulation of sprouted sorghum-defatted fluted pumpkin seed flour blends (composites) is shown in Table 1

Table 1: Sprouted sorghum and pumpkin Seed flour blends

Sample codes	Sprouted sorghum (%)	Pumpkin seed (%)
SPA	100	0
SPB	0	100
SPC	95	5
SPD	90	10
SPE	85	15
SPF	80	20

SPA=Sprouted sorghum flour, **SPB**= Pumpkin seed flour, **SP(C-F)**= Sprouted sorghum-pumpkin seed flour blends

2.3. Sample Analysis

2.3.1. Proximate composition determination: Triplicate samples of each blend were analysed for moisture content, crude protein (Kjeldahl method), crude fat (solvent extraction), crude fibre and ash using the standard procedures of [8]. The carbohydrate content was determined by difference method, that is, addition of moisture, fat, crude protein, ash and crude fibre, which was subtracted from 100%. This gave the amount of nitrogen free extract otherwise known as carbohydrate.

$$\% \text{ carbohydrate} = 100 - (\%\text{Moisture} + \%\text{Crude protein} + \%\text{Crude Fat} + \%\text{Crude fibre} + \%\text{Ash}) \quad \textbf{(1)}$$

2.3.2 Functional properties determination: Bulk densities of the flour samples were determined using the method described by [9], least gelation capacity was determined using the method described by [10], water absorption capacity (WAC) and oil absorption capacity (OAC) was determined using the procedure of [11] and swelling index was determined using the method of [12].

2.4. Statistical Analysis: Data generated from the study were evaluated by Analysis of Variance (ANOVA) at 5% level of significance. Means were separated by Duncan New Multiple Range Test using SPSS (20) software.

3. RESULTS

The proximate composition of the sprouted sorghum and defatted pumpkin seed flours and their composite blends is presented in Table 2. There were significant ($p<0.05$) differences in all the nutrients analysed. The moisture, crude protein, crude fat, crude fibre, ash and carbohydrate content of the flour samples ranged from 6.50-9.06%, 13.19-18.94%, 5.15-8.10%, 1.98-2.98%, 1.99-2.74% and 61.97-68.74%, respectively.

Table 3 shows the functional properties of the sprouted sorghum flour fortified with defatted fluted pumpkin seed flour. The bulk density of the flour samples ranged between 0.47 and 0.67 g/ml for 100% defatted pumpkin seed flour and the control sample (100% sprouted sorghum flour), respectively. Water and oil absorption capacity ranged between 5.46 and 7.03 ml/g, and 1.09 and 1.23 ml/g, respectively. Water absorption capacity was higher than the oil absorption capacity in all the flour samples. The highest and lowest water absorption capacity were seen in sample SPB (100% defatted fluted pumpkin seed flour) and SPA (100% sprouted sorghum flour), respectively. Significant ($p<0.05$) increase in water absorption capacity was observed in the fortified samples with sample SPF (80% sprouted sorghum flour fortified with 20% fluted pumpkin seed flour) had the highest value (6.07 g/ml). The least gelations of the flour samples were not significantly ($p>0.05$) different from the control (100% sprouted sorghum). No gelation was observed in the defatted fluted pumpkin seed flour. The fortified flour samples had the same least gelation (10.00%w/v). Swelling power ranged between 1.14 and 1.36 v/v for SPA and SPD, respectively.

Table 2: Proximate composition (%) of sprouted sorghum and defatted pumpkin seed flour blends

Sample codes	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
SPA	$8.02^{c}\pm0.02$	$13.19^{d}\pm0.04$	$5.15^{e}\pm0.06$	$2.95^{a}\pm0.03$	$1.99^{d}\pm0.08$	$68.70^{a}\pm0.01$
SPB	$6.50^{f}\pm0.50$	$18.94^{a}\pm0.06$	$8.10^{a}\pm0.04$	$1.98^{b}\pm0.58$	$2.51^{c}\pm0.49$	$61.97^{e}\pm0.06$
SPC	$7.05^{e}\pm0.05$	$13.45^{c}\pm0.04$	$5.21^{d}\pm0.10$	$2.98^{a}\pm0.04$	$2.57^{c}\pm0.03$	$68.74^{a}\pm0.01$
SPD	$7.43^{d}\pm0.05$	$13.55^{c}\pm0.11$	$5.28^{d}\pm0.02$	$2.82^{a}\pm0.29$	$2.68^{b}\pm0.04$	$68.24^{b}\pm0.01$
SPE	$8.70^{b}\pm0.01$	$13.92^{b}\pm0.02$	$5.37^{c}\pm0.03$	$1.68^{c}\pm0.32$	$2.71^{a}\pm0.03$	$67.62^{c}\pm0.02$
SPF	$9.06^{a}\pm0.02$	$13.97^{b}\pm1.03$	$6.05^{b}\pm0.02$	$1.55^{d}\pm0.05$	$2.74^{a}\pm0.04$	$66.63^{d}\pm0.02$

Values are means±SD, values with the same alphabet (superscript) in the same column do not differ significantly (p>0.05), a>b>c>d>e>f. Key: **SPA**=100% **SSF** (Control), **SPB**=100% **DFPSF**, SPC=95% **SSF**:5% **DFPSF**, **SPD**=90% **SSF**: 10% **DFPSF**, **SPE**=85%, **SSF**:15%, **DFPSF**, **SPF**=80% **SSF**:20% **DFPSF**. Where **SSF**=Sprouted Sorghum Flour, **DFPSF**=Defatted Fluted Pumpkin Seed Flour.

Table 3: Functional properties of sprouted sorghum and defatted pumpkin seed flour blends

Sample codes	Bulk Density (g/cm³)	Least Gelation Capacity (% w/v)	Water Absorption Capacity (ml/g)	Oil Absorption Capacity (ml/g)	Swelling Index (v/v)
SPA	$0.67^{a}\pm0.03$	$10.00^{a}\pm2.00$	$5.46^{e}\pm0.04$	$1.18^{b}\pm0.02$	$1.14^{d}\pm0.02$
SPB	$0.47^{d}\pm0.02$	No Gelation	$7.03^{a}\pm0.03$	$1.09^{d}\pm0.01$	$1.30^{b}\pm0.10$
SPC	$0.65^{ab}\pm0.02$	$10.00^{a}\pm1.00$	$5.63^{d}\pm0.03$	$1.14^{c}\pm0.02$	$1.41^{a}\pm0.02$
SPD	$0.65^{ab}\pm0.01$	$10.00^{a}\pm3.00$	$5.64^{d}\pm0.03$	$1.19^{b}\pm0.01$	$1.36^{ab}\pm0.02$
SPE	$0.64^{b}\pm0.02$	$10.00^{a}\pm0.00$	$5.83^{c}\pm0.04$	$1.22^{a}\pm0.01$	$1.30^{b}\pm0.03$
SPF	$0.62^{bc}\pm0.01$	$10.00^{a}\pm1.00$	$6.07^{b}\pm0.03$	$1.23^{a}\pm0.03$	$1.21^{c}\pm0.01$

Values are means±SD, values with the same alphabet (superscript) in the same column do not differ significantly (p>0.05), **a>b>c>d>e>f**. Key: **SPA**=100% **SSF** (Control), **SPB**=100% **DFPSF**, **SPC**=95% **SSF**:5% **DFPSF**, SPD=90% SSF: 10% **DFPSF**, SPE=85% **SSF**:15% DFPSF, SPF=80% SSF:20% DFPSF. Where **SSF**=Sprouted Sorghum Flour, **DFPSF**=Defatted Fluted Pumpkin Seed Flour

4. DISCUSSION

Moisture, crude protein, crude fat and ash content increased while crude fibre and carbohydrate content decreased as percentage defatted pumpkin seed flour in the composite blends increased. Moisture contents of the flour blends were less than the recommended 10% which is expected to keep for a reasonable time without remarkable negative change in the flour blends [13]. The result of the present study agrees with the findings of [14, 15]. Low moisture content in food samples increased the storage periods of the food products [16]; while high moisture content in foods encourage microbial growth which leads to food spoilage. The highest crude protein, fat and ash contents were observed in SPF (80% sprouted sorghum flour and 20% defatted fluted pumpkin seed flour). The higher content of these nutrients in defatted fluted pumpkin seed flour has obviously increased the crude protein, crude fat and ash content of the flour blends [5-17]. The result is in agreement with previous researchers [13-15-18].

Functional properties are referred to as those physical and chemical properties that influence the behaviour of proteins in food systems during processing, storage, cooking and consumption [19, 20]. There were significant ($p<0.05$) reduction in the bulk density of the flour blends as the fortification level increased. The reduction in the bulk density on malting was a reflection of the activity of alpha-amylase enzyme, which was activated during malting process [13]. Bulk density is usually affected by the particle size and density of the flour. Therefore, it is very important in determining the packaging requirement, materials handling and application of wet processing in the food industry [21]. The lower the bulk density, the lighter the flour, suggesting that sample SPF (80% sprouted sorghum and 20% defatted pumpkin seed flour) is lighter than other fortified samples. Diet of lower density is required for infants to allow them swallow it with ease without choking or suffocation [13]. Similar observation was reported by [20-22]. Gelation is an important property which affects the texture of different kinds of foods. This result is lower than result of the malted common maize and defatted fluted pumpkin flour (14.00%) reported by [13]. The increase observed in water absorption capacity of the flour blend composites might have been as a result of the production of compounds having good water holding capacity such as soluble sugars [23]. Besides, high water binding capacity will improve the reconstitution and texture obtainable from the sprouted sorghum and defatted pumpkin seed flour as a result of increased in protein content [24, 25]. Water absorption capacity is the ability of flour particles to entrap large amounts of water [26] and increase in water absorption of the flour will however increase product yield [27]. The observation in this present study is in agreement with [20] but lower than the report of [15] who enriched trifoliate yam flour with fluted pumpkin seed flour. Swelling power is an indication of the absorption index of the granules during heating [15]. Significant decrease in swelling index was observed as the level of substitution increased. These decreases could be as a result of increases in the particle size [28]. The retention of water in the swollen starch granules often connected food eating quality [29].

5. CONCLUSION

This study has shown that that fortified flours formulated from locally available food commodities contain nutrients needed by the children. The results from this study showed increased crude protein, crude fat and ash content and decreased in crude fibre and carbohydrate content as percentage defatted pumpkin seed flour in the composite blends increased. Some of the functional properties such as the bulk density, least gelation, water absorption, oil absorption and swelling index of the sprouted sorghum-defatted fluted pumpkin seed flour has industrial potential in the formulation of nutritious foods. These foods are suitable not only for weaning, but also for more cost effective diets for malnourished children.

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