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# NUTRITIONAL AND SENSORY EVALUATION OF SORGHUM OGI ENRICHED WITH *Basella alba* PROTEIN CONCENTRATE

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## ABSTRACT

In an attempt to use cheap, affordable and readily available sources of protein to enrich sorghum ogi flour**,** fresh *Basella alba* leaves obtained from Federal University Oye Ekiti farm were used to prepare protein concentrate. "Ogi" flour was prepared from sorghum grains by soaking, wet milling, sieving and drying. The leaf protein concentrate was later mixed with ogi flour at various proportions ranging from 0-20 %. Proximate composition, mineral content, functional properties and sensory attributes of ogi enriched with *Basella alba* leaf protein concentrate were determined using standard methods. The protein content increased with increase in level of enrichment with leaf protein concentrate. Protein ranged from 8.75 g/100g in 100 % soghum ogi to 47.30 g/100g in 100 % *Basella alba* leaf protein concentrate. The crude fibre ranged from 3.03 – 8.01 g/100g, while the ash content ranged from 0.4 to 4.75g/100g. The pH and bulk density of sorghum ogi enriched with *Basella alba* protein concentrate increases with the level of splemetation from 3.05 to 5.70 and 0.68 to 0.83 g/ml respectively. Water absorption capacity (115.30-126.57 %), emulsion capacity (114.39-119.73 %) and stability, and foaming capacity and stability (18.00-25.00 %) generally increased with increase in enrichment with *Basella alba* leaf protein concentrate, while gelation properties decreased. Zinc content of the samples increased with enrichment. Panelists generally accepted 100% sorghum ogi compared to other enriched samples in all the sensory attributes examined, however, *Basella alba* enriched sorghum ogi was generally accepted up to 10 % level of substitution. Sorghum ogi flour can be enriched with *Basella alba* leaf protein concentrate up to 10 %, this would help improve nutritional status of consumers.

**Keywords**: *Basella alba,* Ogi flour, Proximate , mineral content, functional properties, sensory attributes.

## INTRODUCTION

Protein deficiency is one of the major problems in the developing world (Ghaly and Alkoaik, 2010). This is most disastrous in children where protein malnutrition manifest in form of kwashiorkor. About 60% of the yearly death among children under age five in the developing world are attributed to malnutrition (WHO, 2000). Chronic under-nutrition affects about 215 million people in sub-Saharan Africa, representing 43% of the population. The demand for protein has tremendously increased particularly in many developing countries of the world.

The development of novel protein source such as leaf protein concentrate has made significant contributions toward the alleviation of protein deficiency. Agbede *et al*. (2012) reported that fractionation of some Nigerian edible vegetables to produce leaf protein concentrate could enhance the nutritive potentials of these vegetables and may be used as possible protein food alternatives. Leafy vegetables are important items of diet in many Nigerian homes. Apart from the variety which they add to the menu (Mepha *et al*., 2007), they are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibers and other nutrients which are usually in short supply in daily diets. Reports from literature (Agbede and Aletor, 2003 and 2004; Agbede *et al*., 2007) clearly stated that apart from lower methionine and cystine content, the amino acid profiles of leaf protein from most vegetables compared favourably with FAO/WHO (1973). The use of leafy vegetable in preparation of leaf protein concentrate for human consumption is however limited because of high fibre content, indigestible cellulose and presence of anti-nutrients (Kinsella, 1970). Processing of leaf into leaf protein concentrate reduces fibre content and some anti-nutrients. Concentrates have been defined as feedstuffs high in digestible nutrients and low in fibre (AERLS, 1987).

*Basella alba* is an extremely heat tolerant green leafy vegetable, fast growing perennial vine which belongs to family Basellaceae. It is commonly known as Malabar spinach, Indian spinach, Ceylon spinach, Vine spinach, Climbing spinach, East Indian spinach, Chinese spinach (Bamidele *et al*., 2010) and cyclone spinach. Due to easy *Basella alba* has very high adaptation to a variety of soils and climates, it grows all the year round especially in a moist environment. *Basella alba* has been reported to have high iron content (Majolagbe *et al*., 2013).

Overcoming food and nutritional insecurity in many developing countries in sub-Saharan Africa, where people's diets rely heavily on cereals, rice, potato and cassava, which are high in calories but deficient in protein and essential micronutrients; the nutrient content of some green leafy vegetables revealed that they have comparatively higher amounts of crude protein (Aletor *et al*., 2002). Extraction and incorporation of leaf protein concentrates into staple carbohydrate based foods would go a long way in alleviating the prevailing problem of protein and micronutrient insecurity in developing countries of the world. This work is aimed at the determination of nutritional, functional and sensory properties of sorghum ogi enriched with *Basella alba* protein concentrate.

## MATERIALS AND METHODS

### Collection of Materials

Fresh *Basella alba* leaves were obtained from Federal University Oye Ekiti farm. The leaves were immediately washed under tap water to remove adhering dirt and mud and the stalk were removed. The cleaned leaves were then dried in an oven at $60^0$C for 4-5 hours. The dried leaves were then milled into powder and sieved through 60-80 mesh sieves and kept in air tight container for future use. Sorghum was purchased from Kings Market in Ikole Ekiti, Nigeria.

### Preparation of Sorghum ogi Flour

Sorghum grains were cleaned and then soaked in cold water for 3days for fermentation to take place. The soaked grains were then rinsed, wet milled and wet sieved. It was then drained off in a clean cotton bag to get the wet sorghum ogi cake. The wet sorghum ogi was then dried in hot air oven at a temperature of $60^0$C. The dried sorghum ogi was then pulverized to fine particles using Brabender blender to obtain the sorghum ogi flour.

### Preparation of Protein Concentrate

A modified method described by Gbadamosi *et al.* (2012) was adopted for the preparation of protein concentrate from *Basella alba* leaves. A leaf meal to water ratio of 1:10 was dispersed in water and then stirred with a magnetic stirrer for 10min, and the pH of the medium was adjusted to 6 and stirred for 4 hours at a constant pH. The slurry was centrifuged at 3,500g for 10min at room temperature. The supernatant was discarded and the residue was collected and washed with distilled water, re-suspended in distilled water, neutralize and the pH was adjusted to 7.0 and then centrifuged at 3,500g for 10mins. The residue obtained after centrifugation was then dried at $50^0$C in a hot air oven and the concentrate obtained was then packaged in polyethylene bag for further analysis.

## Preparation of *Basella alba* Enriched Sorghum Ogi Blends

Blends of *Basella alba* enriched sorghum ogi were prepared by substituting sorghum ogi flour with 0, 5, 10, 15 and 20 % *Basella alba* protein concentrate and labeled as A, B, C, D and E respectively. One hundred percent (100 %) sorghum ogi flour (sample A) served as control, while 100% leaf protein concentrate is labeled LPC.

## Determination of Proximate Composition

*Basella alba* enriched sorghum ogi blends were analyzed for their proximate composition (crude fat, total ash, moisture and crude fibre) according to the standard method of AOAC (2005). The Nitrogen content was determined as described by Kirk and Sawyer (1991) and the Nitrogen content was converted to protein by multiplying by 6.25. Carbohydrate was obtained by difference.

## Determination of Physico-functional Properties

Bulk density of the blends was determined according to the method of Okezie and Bello (1988). pH was measured using Bench top pH meter (model pH-016A) (Ruck, 1969). Water absorption capacity of the blends was determined by a modification of the method described by Sathe and Salunkhe (1997). Oil absorption capacity was determined following the method described by Lin and Zayas (1987). Foaming capacity and foaming stability was determined by a modification of the method described by Chavan *et al.,* (2001). Gelation property was analysed using the method described by Coffman and Garcia (1977). The Emulsion capacity and stability were determined using the method described by Pearce and Kinsella (1978).

## Mineral Analysis

Minerals were extracted from the samples using acid digestion method (Umar, 2010). Atomic absorption spectrometer AAS (Alpha 4 model, Buck scientific Ltd USA) was used to estimate the mineral content.

## Sensory Evaluation

The blends were subjected to sensory evaluation by 10 semi-trained panelists who were selected on the basis of their consistency in scoring and familiarity with sorghum ogi. The samples were evaluated for taste, colour, aroma and overall acceptability using a five point Hedonic scale from like extremely (5) to dislike extremely.

## Statistical Analysis

All determinations were carried out in triplicates, errors were recorded as standard deviation from the mean. Data were subjected to analysis of variance using SPSS 17 computer programme, while means were separated using New Duncan Multiple Range Test (NDMRT). Significance was accepted at 5% level of probability.

## RESULTS

Table 1 shows the results of the proximate composition of sorghum ogi enriched with *Basella alba* leaf protein concentrate. The blends varied significantly in chemical composition. Supplementation of sorghum ogi flour with LPC significantly increased the protein content from 8.75% in control to 19.50 % in ogi enriched with 20% *Basella alba* protein concentrate. The moisture content of the samples ranged from 5.82 to 7.50 g/100g in 100 % sorghum ogi and leaf protein concentrate respectively. Table 2 shows the results of the pH and bulk density of *Basella alba* enriched sorghum ogi. The pH increases with addition of leaf protein concentrate and also increases with increase in the level of enrichment (from 5.03 to 5.70). There was however, no significant difference in the pH of 100% sorghum ogi and 5 to 15% LPC enriched sorghum ogi flours. The bulk density increases with increase in leaf protein concentrate supplementation, however no significant difference was observed in the bulk density with increased supplementation to 20% LPC.

The results of the functional properties is shown in Table 2. The functional properties varied significantly in all the samples. The water and oil absorption capacity, and foaming capacity and stability generally increased with increased level of *Basella alba* leaf protein concentrate supplementation. The gelation properties of the flour samples decreases with increased level of leaf protein concentrate supplementation. The emulsion activity index ranged from 16.87 to 21.13 $m^2/g$ in 5 % LPC enriched sorghum ogi flour and 100 % sorghum ogi flour respectively. Table 3 shows the mineral content of sorghum ogi enriched with *Basella alba* protein concentrate. Iron, zinc, magnesium and calcium determined ranged from 51.21- 62.31; 3.22-9.83; 118.21-131.26; and 127.91-147.90 mg/100g respectively. Calcium was the most abundant mineral element in the flour samples, followed by magnesium, iron and zinc.

The results of sensory evaluation of blends of sorghum ogi enriched with *Basella alba* protein concentrate is shown in Table 4. Addition of 5% *Basella alba* protein concentrate to sorghum ogi showed no significant difference from the control in all the sensory attributes examined. However at higher level of supplementation of ogi with LPC, there was generally noticeable difference from the control in all the sensory parameters. Sorghum ogi enriched with 15 and 20% *Basella alba* leaf protein concentrate were significantly inferior to other blends in all the sensory attributes examined.

## DISCUSSION

The increased in the protein content of sorghum ogi supplemented with leaf protein concentrate (Table 1) is in accordance with report of earlier researchers. Awadalkareem *et al*. (2008) reported that the protein content of sorghum meal increased significantly with the addition of soy protein concentrate. Adeparusi and Akinnuoye (2006) reported increased crude protein and crude fibre in diet of *Clarias gariepinus* fingerlings formulated with gliricida leaf protein concentrate. Olivera-Novoa et al. (2002) reported best growth and feeding efficiency in *Tilapia rendalli* fed with meals containing 10 and 20% sunflower protein concentrate. The moisture content of the samples ranging from 5.82 to 7.50 g/100g, compared favourably with 7.6% moisture content reported for *Amaranthus hybridus* and *Telfairia occidentalis* leaf protein concentrate (Adeyeye and Omotayo, 2011). The low moisture content of the samples may afford a good keeping quality and a longer shelf life. The protein content of *Basella alba* leaf protein concentrate (47.30g/100g) compared well with the average crude protein content of 47.20g/100g reported for four common leafy vegetable protein concentrates (Aletor *et al*., 2002).

The lack of significance difference in the bulk density of enriched sorghum ogi flour with increased level of supplementation up to 20 % may be an indication that addition of leaf protein concentrate may not unnecessarily increase the packing and hence transportation cost. The variation observed in the water and oil absorption capacity, and foaming capacity and stability of the enriched sorghum ogi may be due to increased protein content due to addition of LPC leading to greater interactions among the hydrophobic or lipophilic lipoproteins and oil thereby encouraging hydrophobicity (Vautsinas and Nakai, 1983). In addition the increase in the protein density of the enriched flours may enhance foaming (Ahschul and Wilcke, 1985). The improved water absorption capacity with increased LPC supplementation in sorghum ogi flour is in agreement with the report of Adebowale et al (2008). Least gelation concentration increased with increased supplementation from 14.00% in 100% sorghum ogi flour to 18.00% in 20% *Basella alba* protein concentrate enriched sorghum ogi flour.

The range of magnesium 118.21-131.26 mg/100g in the blends compared well with the range of values 1113-2032 mg/Kg reported for raw and processed fluted pumpkin flours (Fagbemi, 2007). Magnesium is important in the blood because it is an activator of many enzyme systems and maintains the electrical potential in nerves. Iron is important in blood formation and it is especially needed by pregnant and lactating mothers. The RDA (Recommended Daily Allowance) of iron for children, women and men are 10 - 15, 18 and 20mg respectively (NRC, 1989). These values can be met by consuming on the average 20 - 40g of the blend daily, which is not high.

Sorghum ogi flours substituted with 5-10 % *Basella alba* leaf protein concentrate generally compared favourably with control in all sensory attributes examined; this shows that sorghum ogi flour can be supplemented with LPC up to 10% to enhance the nutritional qualities without showing any adverse effect on the sensorial properties. Sorghum ogi enriched with 15 and 20% *Basella alba* leaf protein concentrate were significantly inferior to other blends in all the sensory attributes examined. This may be due to the objectionable change in the colour of ogi observed as the percentage leaf protein concentrate exceeds 10% level of supplementation.

## CONCLUSION

*Basella alba* leaf protein concentrate supplementation in sorghum ogi flour significantly improved the crude protein content, mineral composition and enhanced some desirably functional attributes. Addition of *Basella alba* leaf protein concentrate up to 10% is generally accepted in all the sensory properties evaluated. *Basella alba* leaf protein concentrate may find use in carbohydrate dense foods to alleviate the problem of protein deficiency especially in the developing nations of the world.

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**Table 1: Proximate Composition (g/100g) of Sorghum Ogi enriched with *Basella alba* protein concentrate.**

| Samples | Moisture | Ash | Protein | Crude fat | Crude fibre | Carbohydrates |
|---|---|---|---|---|---|---|
| **A** | 5.82±0.03$^{b}$ | 0.40±0.01$^{c}$ | 8.75±0.03$^{c}$ | 1.00±0.13$^{a}$ | 3.03±0.03$^{c}$ | 86.00±0.23$^{a}$ |
| **B** | 6.76±0.03$^{a}$ | 0.59±0.14$^{b}$ | 17.50±0.71$^{b}$ | 0.91±0.08$^{a}$ | 4.49±0.03$^{ac}$ | 74.45±0.00$^{b}$ |
| **C** | 6.84±0.03$^{a}$ | 0.67±0.10$^{a}$ | 17.50±0.42$^{b}$ | 0.93±0.04$^{a}$ | 5.15±0.07$^{b}$ | 73.91±0.66$^{b}$ |
| **D** | 6.97±0.01$^{a}$ | 0.70±0.28$^{a}$ | 19.50±0.28$^{a}$ | 0.97±0.03$^{a}$ | 7.09±1.41$^{a}$ | 69.77±2.02$^{c}$ |
| **E** | 6.99±0.01$^{a}$ | 0.73±0.03$^{a}$ | 19.50±0.71$^{a}$ | 0.98±0.01$^{a}$ | 8.01±0.01$^{a}$ | 68.79±0.78$^{c}$ |
| **LPC** | 7.50±0.14 | 4.75±0.45 | 47.30±0.42 | 0.97±0.05 | 16.75±0.08 | 22.73±0.32 |

Values reported are means ± Standard deviation. Values with different superscript within the same column are significant (P ≤ 0.05). LPC- *Basella alba* Leaf protein concentrate.

**Table 2: Physico-functional properties of Sorghum Ogi enriched with *Basella alba* protein concentrate.**

| Functional Property | A | B | C | D | E |
|---|---|---|---|---|---|
| **WAC (%)** | 115.30±0.28$^{d}$ | 117.30±0.42$^{c}$ | 121.40±1.41$^{b}$ | 123.40±0.01$^{b}$ | 126.57±0.04$^{a}$ |
| **OAC (%)** | 93.10±0.28$^{d}$ | 112.20±0.28$^{c}$ | 112.36±1.41$^{c}$ | 117.39±0.01$^{b}$ | 119.56±0.01$^{a}$ |
| **EAI ($m^2$/g)** | 21.13±0.03$^{d}$ | 16.87±0.04$^{c}$ | 17.38±0.54$^{abc}$ | 17.92±0.03$^{ab}$ | 19.38±1.41$^{a}$ |
| **ESI (%)** | 119.73±0.06$^{a}$ | 114.39±0.55$^{d}$ | 116.82±0.04$^{bc}$ | 117.23±0.04$^{bc}$ | 118.13±1.41$^{b}$ |
| **Foam capacity (%)** | 18.00±0.01$^{c}$ | 18.50±0.71$^{ab}$ | 19.50±0.00$^{ab}$ | 19.50±0.71$^{ab}$ | 20.30±0.42$^{a}$ |
| **Foam stability (%)** | 13.00±2.83$^{b}$ | 13.50±0.71$^{b}$ | 14.00±2.12$^{a}$ | 14.50±0.00$^{a}$ | 15.00±1.41$^{a}$ |
| **Least gelation Conc. (%)** | 14.00±1.00$^{c}$ | 16.00±2.00$^{b}$ | 16.00±2.00$^{b}$ | 17.00±1.00$^{ab}$ | 18.00±1.00$^{a}$ |
| **Bulk density (g/ml)** | 0.68±0.25$^{a}$ | 0.71±0.01$^{a}$ | 0.76±0.04$^{a}$ | 0.78±0.01$^{a}$ | 0.81±0.01$^{a}$ |
| **pH** | 5.03±0.01$^{a}$ | 5.11±0.03$^{a}$ | 5.23±0.04$^{a}$ | 5.40±0.14$^{a}$ | 5.70±0.14$^{b}$ |

Values reported are means ± Standard deviation. Values with different superscript within the same row are significant (P ≤ 0.05).

**Table 3: Mineral Analysis of Sorghum Ogi enriched with *Basella alba* protein concentrate (mg/100g).**

| Samples | Fe | Zn | Mg | Ca |
|---|---|---|---|---|
| **A** | 62.31±1.21[a] | 3.22±0.28[c] | 131.26±2.90[a] | 147.80±0.75[a] |
| **B** | 61.92±0.71[a] | 5.28±0.98[b] | 131.02±0.48[a] | 146.21±1.30[a] |
| **C** | 58.91±0.69[ab] | 5.96±0.76[b] | 122.81±0.64[c] | 133.82±0.90[b] |
| **D** | 51.21±1.36[c] | 8.51±0.49[a] | 118.21±0.98[d] | 127.91±1.26[c] |
| **E** | 59.48±0.73[ab] | 9.83±0.53[a] | 127.09±1.65[b] | 145.91±1.75[a] |

Values reported are means ± Standard deviation. Values with different superscript within the same column are significant ($P \leq 0.05$).

**Table 4: Sensory Evaluation of Blends of Sorghum Ogi enriched with *Basella alba* protein concentrate**

| Sample | Colour | Taste | Aroma | Overall acceptability |
|---|---|---|---|---|
| A | 4.40±0.69[a] | 4.70±0.65[a] | 4.60±0.70[a] | 4.80±0.67[a] |
| B | 3.80±0.95[ab] | 3.80±1.01[ab] | 4.10±0.85[ab] | 4.10±0.71[ab] |
| C | 3.40±1.09[ab] | 3.30±1.06[b] | 3.20±1.15[bc] | 3.30±1.12[b] |
| D | 2.30±1.23[c] | 2.30±1.22[c] | 2.50±1.18[c] | 2.30±1.20[bc] |
| E | 1.30±0.95[d] | 2.20±1.13[c] | 1.40±1.06[d] | 1.20±1.14[d] |

Values reported are means ± Standard deviation. Values with different superscript within the same column are significant ($P \leq 0.05$).