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QUALITY EVALUATION OF POWDERED *OGI* PRODUCED FROM MAIZE-SORGHUM AND SOYBEAN FLOUR BLENDS IN NIGERIA

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ABSTRACT

Ogi is a fermented cereal porridge usually made from single cereals such as maize (*Zea mays*). In traditional production, it is sometimes combined with other cereals such as sorghum or millet. It is usually in semi-solid form after production and has low shelf stability. This study was carried out to produce and evaluate the quality of *ogi* powder from mixtures of selected cereals (maize and sorghum), with soybean inclusion as advancement for improving the nutritive value of the product. *Ogi* flour was obtained from grains of maize and sorghum by weighing, sorting, soaking (for 72 hours), wet milling, sieving, dewatering, oven-drying, pulverizing and sieving through muslin cloth with maximum pore size of 20 mm. Optimal blend (70:30) for maize - sorghum *ogi* cumulating to 100% maize - sorghum mixture was obtained from a preliminary study; and fortified with soybean in the ratios of 90:10, 80:20, 70:30, 60:40, 50:50, and 100:0. The samples were analyzed for functional, proximate and micronutrient properties using standard methods. Results of water absorption and swelling capacity showed significant ($p<0.05$) differences among the samples. Proximate composition results showed significant ($p<0.05$) differences in all samples and ranged as follows: moisture (5.39 - 7.72%), protein (6.22 - 21. 46%), ash (2.66 - 3.64%), crude fibre (2.22 - 2.65%), crude fat (4.22 - 10.22%) and carbohydrate (51.31 - 79.14%). The micronutrient levels were improved and ranged from 166 - 360 mg/100g calcium, 1.15 - 3.22 mg/100g iron, 24.3 - 47.6 IU ß-carotene and 0.59 - 0.89 mg/100g thiamine. Soybean addition generally improved the quality of the samples. Protein increase was observed from 20% inclusion of soybean. The maximum inclusion level of 50% increased the protein content of the sample to 21.5%. Despite adding value and variety to *ogi* meal due to its powdered form, fortifying maize-sorghum *ogi* with soybean would reduce the problem of malnutrition especially among children who are usually fed *ogi* as infant formulae in developing countries.

Key words: *ogi*, maize, sorghum, soybean, proximate, functional, micronutrients, fortification

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INTRODUCTION

Ogi or pap is a local generic name for a fermented gruel or porridge made from cereals (commonly maize, sorghum or millet). It is a staple food in most African countries [1]. It is also known as *akamu* and *koko* in eastern and northern Nigeria, respectively. It is commonly used as complementary food for babies and young children and as standard breakfast cereals for many homes [2]. Those made specifically from sorghum are referred to as *ogi - baba*. The names are tribal names or according to the mode of its preparation. Apart from being used for human consumption, it serves as quick paper glue and free-range chicken feed supplements. It is often taken by nursing mothers because it may stimulate breast milk production, due to higher heat capacity than ordinary water while supplying energy and nutrients [3].

In developing countries, one of the greatest problems affecting millions of people, particularly children, is lack of adequate protein intake in terms of quality and quantity [4]. Cereals are generally low in protein, supplementation of cereals with locally available legumes high in protein increases protein content of cereal-legume blends [5]. Several traditional fermentations have been upgraded to high technology production systems and this has undoubtedly improved the general wellbeing of the people as well as the economy [6].

Ogi generally has been implicated for presence of kwashiorkor among infants due to its low protein quality [7]. This has led to many research attempts to fortify it in order to improve its nutritional value with plant protein sources such as melon, okara, cowpea [8], and animal protein sources. Fortification has been reported to improve protein in fortified preparations and increase lysine to more than 50% when cowpea is added [9].

Preparation of cereals and legumes by fermentation is of utmost importance in Africa especially as complementary foods. Microorganisms can ferment various substrates resulting in the generation of different end-products [10]. Fermentation of cereals is believed to increase protein and amino acid levels. Conventionally, microbes are used to prepare and preserve foods. Most foods including *ogi* contain enough moisture to permit chemical reactions by indigenous enzymes and microorganisms [10]. *Ogi* in the form currently available to the consumers cannot be stored at home for any length of time without spoilage [11]; hence the need for dehydration and pulverization to bring the product to powdered form to improve its shelf stability. Soybean as raw material in '*ogi*' production will help to improve the nutritional value of '*ogi*' and eradicate malnutrition associated with frequent consumption of '*ogi*' produced with only maize or other cereals. Blending of maize, sorghum, and soybean can yield nutritious, shelf-stable and acceptable complementary food when subjected to suitable processing techniques. The objectives of this study therefore, were to produce nutrient dense cereal gruel (*ogi*) from maize and sorghum fortified with soybean and modified into powdered infant formulae; and to evaluate the functional and chemical properties of the powdered (*ogi*).

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MATERIALS AND METHODS

Maize, sorghum and soybeans were purchased from *Ogi*ge market, in Nsukka, Enugu State, Nigeria. The samples were thoroughly cleaned and sorted by removing all broken kernels, stones and other foreign particles. A modification of the method described by Akingbala [12] was used for *ogi* production. Maize - sorghum *ogi* was produced from different ratios of the grains. The flow diagram for the process is shown in Figure 1. Grains (3 Kg) were soaked in distilled water for 72 hours, and rinsed out every 24 hrs to reduce odor produced from the fermentation process. The grains were milled in a commercial hammer mill at medium speed for 10 mins. The slurry was then passed through a 150 µm sieve and the suspension obtained was left to stand for 2 hr for the *ogi* to settle. The *ogi* was collected by decanting the supernatant and retaining the slurry, which was dried at 50°C for 48hr in a laboratory oven (LABAIDS Model: LABE 1201) to obtain the *ogi* in powdered form. It was pulverized manually and packaged in an air-tight container.

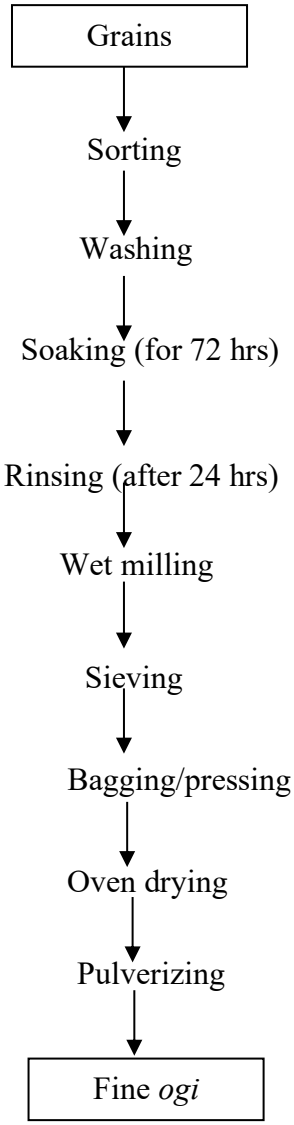

Figure 1: Production of "ogi" flour from fermented maize and sorghum

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Dry soybean flour was produced from soybean grains according to the method described by Akinrele [13]. Two kilograms of the grains were weighed, sorted, and washed. It was soaked for 24 hr, rinsed, and boiled for 1 hr using a gas cooker. The cooked grains were manually dehulled while still warm for easier dehulling, then oven-dried. Milling and pulverizing were done immediately after drying. The flour was stored in an air-tight plastic container. The flow diagram is shown in Figure 2.

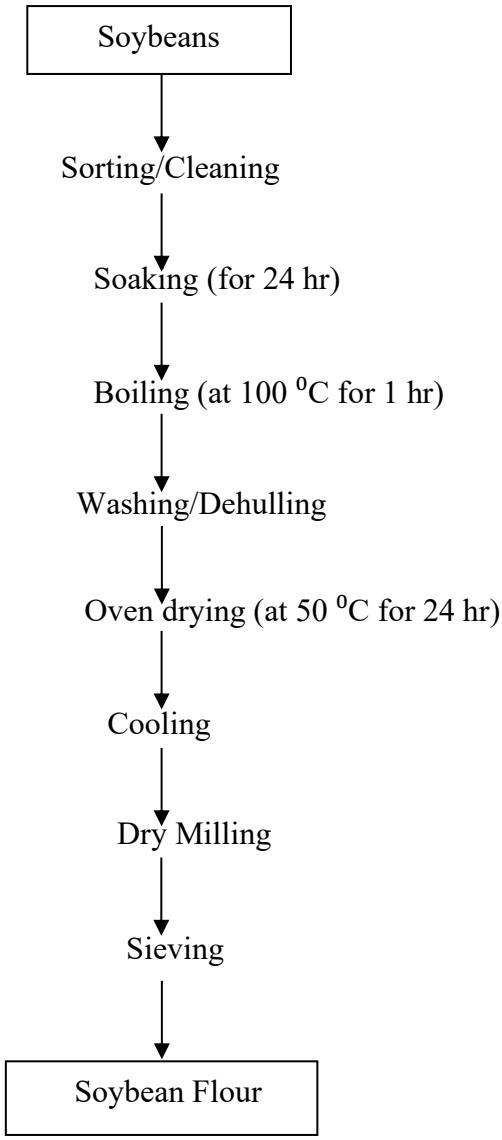

Figure 2: Preparation of soybean flour

Formulation of composites

Maize and sorghum were blended in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50, respectively, as shown in Table 1. *Ogi* from 100% maize flour served as the control. The samples were represented with the codes McA, MSB, MSC, MSD, MSE,

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and MSF, respectively. The best blend, which was determined by preliminary studies, was then supplemented with soy beans at graded levels of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50, as shown in Table 2.

Water absorption capacity (WAC)

Water absorption capacity was determined using the method of Lin *et al.* [14]. One gram sample was dispensed into a pre-weighed centrifuge tube with 10 ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hr before being centrifuged at 3500 rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain dry. The weight of water absorbed was determined by the difference. The WAC was calculated as:

$$\text{WAC\%} = \frac{\text{Volume of water used - Volume of free water}}{\text{Weight of sample used}} \times \frac{100}{1}$$

Swelling Capacity (SC)

Water binding capacity was derived using the method described by Ukpabi and Ndimele[15]. Ten grams (10g) sample was measured into a 300 ml measuring cylinder. Then 150 ml of distilled water was added to the sample and allowed to stand for 4 hr. The final volume after swelling was recorded. The percentage swelling was calculated as:

$$\text{Swelling capacity\%} = \frac{\text{Final volume - initial volume}}{\text{Initial volume}} \times \frac{100}{1}$$

Proximate analysis

Moisture, crude protein, fat, fibre and ash contents were determined using standard methods as described by AOAC [16]. Carbohydrate was determined by difference.

Moisture

Moisture content was determined using a laboratory air-oven (Fulton, Model NYC-101). The samples were dried at 100°C until constant weight was achieved, cooled in a desiccator, and reweighed. The percentage of moisture content was calculated as:

$$\textit{Moisture}(\%) = \frac{\text{Weight difference}}{\text{Original weight of sample}} \times \frac{100}{1}$$

Where weight difference = original sample weight – final sample weight

Crude Protein

Crude protein was determined using the Kjeldahl method. The samples went through the three essential steps of digestion, distillation, and titration using a conversion factor of 6.25 to convert total nitrogen to crude protein.

Nitrogen factor = 6.25

Crude protein = % total N x 6.25

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Fat

Crude fat was determined by weighing 5 g of each sample wrapped in a filter paper in a Soxhlet apparatus using petroleum ether. This was done for 6 hours, for each sample. The extracted materials left after the solvent had evaporated were weighed, and the fat content was calculated.

$$\% \text{ fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1}$$

Crude fibre

Crude fibre was determined after fat extraction by digesting extracted sample with 1.25% sulphuric acid and afew drops of anti-foaming agent without breaking suction; the insoluble matter was washed with boiling water until it was free of the acid, and then incinerated to ash. The difference in weight between oven dry weight and the weight after incineration was taken as the fibre content of the sample. This was expressed as a percentage weight of the original sample taken for analysis.

$$\text{Crude Fibre}(\%) = \frac{\text{Oven dried sample} - \text{Weight of sample after incineration}}{\text{Weight of sample taken}} \times 100$$

Ash

Ash determination was carried out at 550ºC in a muffle furnace for 3 hours, until grey ash was obtained. The dish and content were cooled in a dessicator and weighed. The percentage of ash was calculated by subtracting the weight of ash from the initial weight.

Carbohydrate

The Carbohydrate content was determined by difference as follows:
% Carbohydrates = 100 – (% moisture + % fat + % ash + % protein + % crude fibre).

Micronutrient determination

Beta-carotene

Vitamin A determination was carried out using spectrophotometric method described by Kirk and Sawyer [17]. One milliliter (1 ml) sample was pipetted in triplicate into a glass stopped test tube, and added to 1 ml of petroleum ether. It was heated in a water bath to dryness. After drying, 0.2 ml of the chloroform acetic anhydride was added, followed by 2 ml of citric acid added immediately and absorbance taken at 620 nm using spectrophotometer.

Vitamin B1 (Thiamine)

Vitamin B1 content of the samples was determined using the method described by Kirk and Sawyer [17]. Half gram (0.5 g) of the sample was weighed and dissolved in 20 ml distilled water. Then 2 ml of the sample was mixed with 18 ml of 1% potassium ferrocyanide and stirred for 1min. About 1ml of the solution was pippetted into a separating test tube. After shaking, the isobutyl alcohol was added. The mixture was shaken for 2 minutes. The isobutyl sulphate absorbance was determined at 365 nm using isobutyl alcohol as a blank.

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$$\text{Thiamine} = \frac{\text{Absorbance of test x dilution factor}}{\text{Slope (from standard curve)}}$$

Calcium

Calcium was determined according to AOAC [16], 2 ml of the sample was diluted with 3ml distilled water and 1 ml of 50 % ammonium oxalate. One drop of methyl red indicator was made alkaline with ammonium drops of glacial acetic acid until colour changed to pink. This stood for 4 hr and centrifuged for 5 minutes, followed by decanting of the supernatant. About 1 ml of hydrogen sulphate was added to the residues, which were diluted with 4 ml of distilled water. The solution was boiled with 0.2 N potassium permanganate.

$$\text{Calcium content (\%)} = \frac{\text{Volume of EDTA} \times \text{mol. EDTA} \times \text{Atomic weight of calcium} \times \text{DF} / 100}{\text{Weight of sample} \times 10}$$

Iron

The iron content was determined using the phenanthroline method by Kirk and Sawyer [17]. Five grams of samples were ashed and 10 ml of water and 5 ml of conc. citric acid was added. The mixture was stirred, filtered and the filtrate transferred to a 100 ml volumetric flask and made up to mark with water. Ten millilitre volume of mixture was placed in a 100ml volumetric flask. Then 3 ml of phenanthroline solution, 2 ml of hydrochloric acid and 1ml of hydroxylamine solution was added in sequence. The sample solution was boiled for 2 min and about 9 ml of ammonium acetate buffer solution was added and the solution was diluted with water to 100 ml volume. The absorbance was determined at 510 nm wavelength with spectrophotometer. From the standard graph, the number of mg/100g of iron equivalent to the absorbance of the sample and the blank determination at 510 nm were read.

Statistical analysis of data

The experiment was laid out in a completely randomized design (CRD). Data were subjected to Analysis of Variance (ANOVA) using statistical package for social sciences (SPSS) version 21.0. Duncan's New Multiple Range Test (DNMRT) was used to compare the treatment means. Statistical significance was accepted at $p < 0.05$ [18].

RESULTS AND DISCUSSION

The results of the functional properties and proximate composition of the *ogi* samples are presented in Table 3. Our findingsshowed significant ($p<0.05$) differences existed among the WAC of the samples and ranged from 120.2-238.2g/ml with MSsF (50% maize-sorghum and 50% soybean) having the highest value and MSD (100% maize-sorghum) having the lowest WAC. An increase implies high digestibility of the starch. Water absorption characteristics represent the ability of the product to associate with water under conditions where it is limiting, in order to improve handling [19]. It is a useful indication of whether flour can be incorporated into aqueous food formulation [19, 20]. According to Rosell *et al*. [21] proteins and starch have the tendency to bind

with water; this is apparently the reason sample MSsF which had the highest protein content, showed highest WAC value (Table 3). The swelling capacity is an indication of the water absorption index of the granules during heating [22]. The values ranged from 12.2% – 12.5% and did not differ, with McA (100% maize) having the highest value and MSsD having the lowest value.

The moisture content as seen in Table 3 indicates significant ($p<0.05$) difference existed between the samples, and ranged from 5.39 % – 7.72% with sample McA having the highest value (7.72 %) and sample MSsF (50% maize-sorghum and 50% soybean) having the lowest value (5.39 %). From the results, it can be deduced that the moisture content decreased with increase in soybean flour. The level of moisture in sample MSsC, MSsD and MSsE are adequate for good shelf stability since moisture level less than 15% has been found to inhibit the growth of microorganisms [23]. Microorganisms require moisture for their physiological activities within the food. The moisture content of all the blends were within the RDA values (5 – 10 %) for moisture content of complementary foods for infants up to one year of age [24].

The protein content of the samples ranged from 6.22 % – 21.46 % with McA (100 % maize) having the lowest protein content (6.22 %) and MSsF (50% maize-sorghum and 50% soybean) having the highest protein content. There were significant differences ($p<0.05$) among all samples at different levels of fortification. The result showed that the blending ratios had an influence on the protein content of the food samples and thus the most significant effects of fortification were on protein. It was observed that there was a significant increase in the protein content with an increase in the soybean flour addition. This affirms findings by Potter and Hotchkiss [23] that of the various legumes, soybean is the most outstanding source of protein due to its high protein content and the relative ease of its extractability. The high protein values observed in this study compare with those of Aminigo and Ossai [25] in their work on soy fortified *ogi*. The absence of soybean in McA explains why the sample was low in protein. The high protein content of soybean flour makes it a good protein supplement.

The ash content ranged from 2.66 % – 3.64 % with McA (100 % maize) having the lowest ash content and MSsF (50% maize-sorghum and 50% soybean) having the highest ash content. There was no significant ($p> 0.05$) difference between MSsB (90 % maize-sorghum and 10% soybean) and MSsC (80% the maize-sorghum and 20% soybean). The results obtained from this study correspond with results obtained by Anita *et al*. [26], where sorghum blended with groundnut was higher in ash content than that of pure '*ogi*' sample due to removal of most of the minerals concentrated in the bran and germ, by the wet sieving process. The ash content increased with level of soybean addition. The ash content of all blends was within RDA values of (not less than 2% and not more than 5%) for infants up to one year of age [24]. The ash content is an estimation of the total mineral content of food sample. Minerals are necessary for proper growth and human development.

The fibre content of the samples ranged from 2.22 – 2.65 % with MSsE (60 % maize-sorghum and 40 % soybean) having the lowest value and MSsF (50 % maize-sorghum and 50 % soybean) having the highest value. The low fibre content was due to the fact

that the fibre in the hull was removed during processing. The hull of cereals contains about 64% of the total fibre and during processing; the hulls are removed in the wet sieving process (for maize and sorghum) and before drying (soybean), stripping the flour of its large proportion of the fibre which is concentrated in the hull.

Fat content of the samples showed significant ($p<0.05$) differences and ranged from 4.22 % - 13.22 % with McA (100% maize) having the lowest value and MSsF (50 % maize-sorghum and 50 % soybean) having the highest value. The fat content in all samples was found to be generally high and were within RDA values of 10 – 24.8g [24], although this result obtained is contrary to the 2.5 % reported by Aminigo *et al.* [25]. Most of the lipids in grains are located in the scutellum and, therefore, can be significantly reduced when dehulled.

The carbohydrate content of the *ogi* flour blends was found to be high and ranged from 51.32 % - 79.14 %. Sample MSsF (50 % maize-sorghum and 50 % soybean) had the lowest carbohydrate content, while McA (100% maize) had the highest carbohydrate content. There was significant difference ($p<0.05$) in all the samples. This result showed that carbohydrate content decreased with increased proportion of soybean flour.

The results of micronutrient evaluation of the formulations are shown in Table 4. The mean iron levels ranged from 1.15- 3.22 mg/100g, with sample McA (100% maize) having the lowest iron content and MSsF having the highest score. This shows that addition of soybean increased the iron content of the flours. Analysis of variance showed significant ($p<0.05$) differences among the samples. Iron is necessary for red blood cell and muscle function and also for immune boost. Iron is a curative mineral for anemic problems.

The calcium content of the samples ranged from 166 – 360 mg/100g.The calcium content of sample McA (100 % maize) was the least while MSsF had the highest, thus addition of soybean increased the calcium content in this study. The results also revealed that blending maize and sorghum improved the mineral contents as seen in sample MSD, thereby suggesting that optimal nutritional values may not be achieved when *ogi* is produced with single cereals. However, soybean addition produced better results. Minerals are generally not affected by heat and are usually only affected or lost through leaching [27].

ß-carotene content of the *ogi* samples ranged from 2.43 - 4.76 mg/g with sample MSsF having the highest value and McA (100% maize) having the lowest value. Samples McA and MSD showed no significant ($p<0.05$) difference. Rickman *et al.* [28] reported that because carotenoids are lipid-soluble, they may not be significantly lost to leaching into water-soluble medium during soaking and wet sieving. They are rather heat sensitive and get lost to oxidation. Vitamin B1 content of the *ogi* samples ranged from 0.59 – 0.89 mg/100 g. Sample MSD had the highest vitamin B1 content while McA (100% maize) had the lowest. This indicates that cereal mixture and soybean addition greatly improved the vitamin contents of the samples.

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CONCLUSION

In this study, cereal gruel (*ogi*) modified in powdered form was produced from maize-sorghum and soybean blends. This composite flour product was observed to attain an optimal protein level of 21.46%. Results from this study also showed improved functional properties. For instance WAC increased with increase in soybean addition and this implies high starch digestibility. The ability to hold water is a significant function of some chemical properties in food such as protein.

The micronutrient contents of the samples were also greatly improved. The values for these micronutrients increased significantly with increase in soybean addition. This value-added product could help to reduce the problem of malnutrition especially among children who are usually fed with *ogi* as infant formulae in developing countries.

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Table 1: Formulation of Maize-sorghum blends

SAMPLES	MAIZE (%)	SORGHUM (%)
McA	100	0
MSB	90	10
MSC	80	20
MSD	70	30
MSE	60	40
MSF	50	50

Table 2: Formulation of maize-sorghum and soybean blends

SAMPLES	MAIZE -SORGHUM (%)	SOYBEAN (%)
MSD	100	0
MSsB	90	10
MSsC	80	20
MSsD	70	30
MSsE	60	40
MSsF	50	50

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Table 3: Proximate composition and functional properties of maize-sorghum *ogi* blends fortified with soybean

Samples	Moisture (%)	Protein (%)	Ash (%)	Fibre (%)	Fat (%)	Carbohydrate (%)	WAC (g/ml)	SC (%)
McA	7.72^{f} ±0.02	6.22^{a}±0.01	2.66^{a}±0.04	2.32^{d}±0.01	4.22^{a}±0.01	79.14^{g}±0.02	230.10^{f}±0.13	12.54^{a}±0.10
MSD	5.39^{a} ±0.01	7.97^{c}±0.02	3.11^{b}±0.01	2.46^{e}±0.00	8.84^{d}±0.01	72.23^{e}±0.01	120.21^{a}±0.30	12.46^{a}±0.10
MSsB	5.56^{b} ±0.05	7.66^{b}±0.01	3.12^{c}±0.03	2.31^{c}±0.01	4.43^{b}±0.05	76.94^{f}±0.05	120.43^{a}±0.38	12.47^{a}±0.04
MSsC	5.75^{c} ±0.01	10.66^{d}±0.01	3.13^{c}±0.03	2.27^{b}±0.02	6.90^{c}±0.10	71.30^{d}±0.02	121.28^{b}±0.40	12.38^{a}±0.01
MSsD	5.83^{d} ±0.03	12.69^{e}±0.12	3.28^{d}±0.01	2.23^{a}±0.02	10.22^{e}±0.04	65.75^{c}±0.01	218.11^{c}±0.20	12.23^{a}±0.00
MSsE	6.24^{e} ±0.02	18.04^{f}±0.09	3.34^{e}±0.02	2.22^{a}±0.01	10.42^{f}±0.01	59.73^{b}±0.02	221.19^{d}±0.18	12.36^{a}±0.01
MSsF	5.43^{a} ±0.01	21.46^{g}±0.02	3.64^{f}±0.01	2.65^{f}±0.01	13.22^{g}±0.03	51.32^{a} ±0.02	238.22^{e}±0.20	12.50^{a}±0.30

Values are means of triplicate determinations ± SD. Means with different superscript in the same column are significantly ($p<0.05$) different

Key: McA= *ogi* from 100 % maize (control)
MSD =*ogi* from 70 % maize and 30 % sorghum (100 % maize-sorghum)
MSsB=*ogi* from 90 % maize-sorghum and 10 % soybean
MSsC=*ogi* from 80 % maize-sorghum and 20 % soybean
MSsD=*ogi* from 70 % maize-sorghum and 30 % soybean
MSsE= *ogi* from 60 % maize-sorghum and 40 % soybean
MSsF= *ogi* from 50 % maize-sorghum and 50 % soybean

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Table 4: Micronutrient composition of maize-sorghum *ogi* blends fortified with soybean

Samples	Iron (mg/100g)	Calcium (mg/100g)	ß-carotene (IU)	Vitamin B1 (mg/100g)
McA	1.15^{a}±0.02	166^{a}±0.04	2.43^{a}±0.01	0.59^{a}±0.02
MSD	2.44^{d}±0.01	207^{b}±0.01	3.24^{b}±0.01	0.89^{c}±0.01
MSsB	1.65^{b}±0.03	241^{c}±0.02	3.30^{b}±0.01	0.65^{b}±0.01
MSsC	2.19^{c}±0.01	265^{d}±0.01	3.40^{bc}±0.03	0.69^{b}±0.10
MSsD	2.54^{e}±0.01	269^{e}±0.03	3.43^{bc}±0.01	0.84^{c}±0.13
MSsE	2.85^{f}±0.03	271^{f}±0.01	4.14^{c}±0.03	0.88^{c}±0.01
MSsF	3.22^{g}±0.12	360^{g}±0.02	4.76^{cd}±0.02	0.63^{b}±0.01

Values are means of triplicate determinations ± SD. Means with different superscript in the same column are significantly ($p<0.05$) different

Key: McA = *ogi* from 100 % maize (control).
MSD = *ogi* from 70 % maize and 30 % sorghum (100 % maize-sorghum)
MSsB = *ogi* from 90 % maize-sorghum and 10 % soybean
MSsC = *ogi* from 80 % maize-sorghum and 20 % soybean
MSsD = *ogi* from 70 % maize-sorghum and 30 % soybean
MSsE = *ogi* from 60 % maize-sorghum and 40 % soybean
MSsF = *ogi* from 50 % maize-sorghum and 50 % soybean

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