CHEMICAL COMPOSITION, PHYSICOCHEMICAL, AND SENSORY PROPERTIES OF FERMENTED MAIZE AND DEFATTED BAOBAB SEED FLOUR BLENDS

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ABSTRACT

This study investigated the chemical composition, physicochemical, and sensory properties of fermented maize and defatted baobab seed flour blends. Fermented maize (*ogi*) and defatted baobab seed powder (DBSP) were blended at ratios (%, w/w) 100:0 (control), 90:10, 80:20, 70:30, 60:40, and 50:50. Proximate, minerals, tannin, pasting, and colour order properties of the blends were determined. The sensory properties of gruels prepared from the blends were also determined. Protein, ash, fibre, vitamin C, K, Ca, and Fe of *ogi* increased significantly ($p < 0.05$) with an increasing level of DBSP while fat, carbohydrate, calorific value, and tannin decreased. Peak, breakdown, final, final viscosity, colour intensity, measures of lightness, redness, and yellowness of fermented maize decreased significantly ($p < 0.05$) with an increasing level of DBSP. The incorporation of ≤ 20% DBSP did not cause a significant change in pasting temperature and time. Gruels produced from blends that contained ≤ 20% DBSP compared favourably with the one prepared from the control. The study showed an improvement in the quality of *ogi* following the incorporation of 20% DBSP.

Keywords: Acceptability, baobab seed, enrichment, maize, *ogi*

INTRODUCTION

Maize (*Zea mays* L.) is an important staple crop in many parts of Africa and Central America (Correia *et al.,* 2016). Maize is a rich source of carbohydrate, which provides enough calories (414 kCal/100g) that is required for the day-to-day activities of man (Correia *et al.,* 2016). According to the International Institute of Tropical Agriculture, IITA (2019), maize is the most widely cultivated cereal crop in the world. The global production output of maize is estimated to be 785 million metric tons per annum, and Africa accounts for 6.5% of total production. Nigeria is the highest producer of maize in Africa with approximately 8 million tons per annum (IITA, 2019). In many developed countries, maize is mainly used for the production of industrial products and livestock feed. However, in sub-Saharan Africa, maize is mainly utilised as a raw material for the production of porridges and dough, and these are consumed as breakfast and complementary foods (Adedeji and Tadawus, 2019).

In many parts of West Africa, maize is often processed into thin or thick porridges such as *ogi, akamu, agidi, kappa* or *eko. Ogi* is a spontaneously fermented maize product, which is characterised by high digestibility (Ntso *et al.,* 2016). Consequently, it is often recommended as weaning food and for recuperating patients (Akanbi *et al.,* 2010). *Ogi* has been implicated in low nutrient density (Ntso *et al.,* 2016). This is attributed to the low protein content of maize and the loss of micronutrients during production, especially sieving operation (Akanbi *et al.,* 2010). Against this background, efforts are continuously made to ameliorate these challenges through fortification or enrichment with macro or micronutrients. This is required to reduce the prevalence of protein-energy malnutrition (Chadare *et al.,* 2019; Dauda *et al.,* 2020; Olawuyi and Oyetola, 2020). The use of cheap sources of macronutrients or micronutrients for the enrichment of local staples is considered suitable for a large population of sub-Sahara Africa, due to their low level of livelihood (Chadare *et al.,* 2019). The incorporation of specific nutrients to improve the nutrient density of *ogi* and other maize-based products is well documented (Adejuyitan *et al.,* 2012; Ajanaku *et al*., 2012; Ezekiel and Adedeji, 2020). Moreover, more studies are required on the exploration of nutrient-dense underutilised sources for the fortification and enrichment of staple foods.

Baobab (*Adansonia digitata* L.) seed cake is the by-product obtained after oil extraction from the seed (Darbe and Tange, 2018). Studies have shown that baobab seed cake is a rich source of nutrients, such as protein (14.4-36.7 g/100g), minerals (5.3-6.5 g/100g), and dietary fibre (16.9-49.7 g/100g) (Chadare *et al.,* 2009). Darbe and Tange (2018) reported that the baobab seed cake's protein consists of highly soluble globulin, which is responsible for its high digestibility. In spite of the high nutrient profile of baobab seed cake, information on its utilisation in food

enrichment and fortification is sparse. This study was designed to evaluate the quality of blends produced from fermented maize and defatted baobab seed flour blends.

MATERIALS AND METHODS

Materials

Maize (*Zea mays*) grains were supplied by IITA, Ibadan, Nigeria. Baobab fruits were obtained from Masaka Farm, Nasarawa state, Nigeria.

Methods

Production of *ogi* powder

Wholesome maize (*Zea mays* L.) grains (1 kg) were steeped in 6 L of potable water for 48 h. The grains were wet-milled and the resulting slurry was sieved using a 0.425 mm sieve. The residue was discarded while the filtrate was left to settle and sour for 24 h. After souring, the slurry was sieved with the aid of a 0.125 mm sieve. The resulting cake was dried ($60 \,^{\circ}C$, 204 h) and analysed.

Preparation of defatted baobab seed powder

The cold extraction procedure described by Ocheme *et al*. (2018) was employed for the production of defatted baobab seed powder. Briefly, baobab seeds were milled and soaked in a solvent mixture containing 3 L of chloroform and 1 L of methanol for the removal of oil.

Preparation of *ogi* and baobab defatted baobab seed powder blends

Blends of *ogi* powder and defatted baobab seed powder were prepared at levels (%, w/w) 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The blends were properly blended, packaged (ZipLock, China), labelled and stored ($-18 \,^{\circ}C$) for subsequent analyses.

Preparation of pap-like gruel from blends of *ogi* and defatted baobab seed powder

Pap-like gruels were prepared using the blends based on our previous study (Ezekiel and Adedeji, 2020). Briefly, a blend (20 g) was reconstituted with 20 mL of potable water to form a slurry. A 100 mL hot water ($90 \,^{\circ}C$) was poured into the slurry to form a thick pap-like consistency. The samples were served immediately for sensory evaluation.

Analyses

Protein, fat, ash, moisture, fibre contents, and energy value of the blends were determined using standard methods (AOAC, 2005). Carbohydrate was obtained by deducting the sum of protein, fat, ash, and moisture contents from 100% (AOAC, 2005). Phosphorus and Ca content of

samples were determined using flame photometric procedure while Fe was determined using atomic absorption spectrophotometry (AOAC, 2000). Vitamin C was determined using the 2, 6 dichloroindophenol method (AOAC, 2005). Pasting properties were determined with the aid of rapid visco analyzer (RVA 3D, Newport Scientific, Narrabeen, Australia) and colour order properties, $L*$ (a measure of lightness), $a*$ (a measure of redness) and $b*$ (a measure of yellowness), were determined with the aid of a colour meter (CIE Hunter Lab, Konica Minolta, Osaka, Japan). Hue angle and colour intensity were obtained with the aid of Equations 1 and 2.

$$Hue\ angle = Tan^{-1}b/a$$

(1)

$$Colour\ intensity = \sqrt{\Delta L^2} + \Delta a^2 + \Delta b^2$$

(2)

Sensory evaluation of gruels prepared from blends of *ogi* and defatted baobab seed powder was carried out using a 9-point Hedonic scale (Ezekiel and Adedeji, 2020). The samples presented to the panellists were gruels prepared from: 100% *ogi* powder (GFM1), 90% fermented maize and 10% DBSP (GFM2), 80% fermented maize and 20% DBSP (GFM3), 70% fermented maize and 30% DBSP (GFM4), 60% fermented maize and 40% DBSP (GFM5), 50% fermented maize and 50% DBSP (GFM6). The prepared well-labelled gruels were served to fifty panellists, previously recruited from staff and students of the Faculty of Technology, University of Ibadan, Nigeria, in separate lighted booths. The panellists rated the samples on the scale based on colour, aroma, taste, mouthfeel, consistency, and overall acceptability.

RESULTS AND DISCUSSION

Proximate composition

The selected chemical composition of blends of *ogi* and defatted baobab seed powders are presented in Table 1. The incorporation of 10% DBSP did not result in a significant ($p < 0.05$) increase in moisture content of *ogi*, however, the higher level of DBSP (> 20%) in *ogi* increased its moisture content by 2.67-6.79%. The samples' moisture content was below the threshold for spoilage by microorganisms (< 9%) and this indicated good shelf stability of the samples (Iwe *et al.*, 2016). Ocheme *et al.* (2018) also reported a moisture content that ranged between 8 and 9% for blends produced from wheat and groundnut protein powders. The protein content of *ogi* increased by 159.86-476.57% as the level of DBSP increased. This is an indication of increased nutrient density and digestibility (Chinma *et al.*, 2021; Darbe and Tange, 2018). These findings aligned with Adeyeye *et al.* (2017) who reported an increase in the protein content of maize-based cookies following the incorporation of soy protein isolate. The fat content of *ogi* reduced

by 11.99-22.34% as the level of DBSP increased due to the low-fat content of DBSP. This is an indication of improved shelf stability of the product owing to reduced susceptibility of fatty acid-mediated rancidity (Chinma *et al.*, 2021). The fibre and ash contents of *ogi* increased by 24.61-49.21% with an increasing level of DBSP and this could be attributed to the high mineral and fibre contents of baobab seed (Darbe and Tange, 2018).

Table 1: Chemical composition of fermented maize and defatted baobab seed flour blends

Parameter	Fermented maize: defatted baobab seed (%, w/w)					
	100:0	90:10	80:20	70:30	60:40	50:50
Moisture (g/100g)	8.37[b]±0.32	8.31[b]±0.01	8.60[ab]±0.10	8.72[ab]±0.02	8.98[a]±0.01	8.93[a]±0.03
Protein (g/100g)	4.31[f]±0.32	11.20[e]±0.52	14.73[d]±0.21	17.70[c]±0.10	20.62[b]±0.13	24.85[a]±0.10
Fat (g/100g)	3.67[a]±1.15	3.23[b]±0.35	3.13[bc]±0.12	3.10[c]±0.10	2.92[cd]±0.08	2.85[d]±0.05
Fibre (g/100g)	2.06[d]±0.06	2.33[cd]±0.08	2.45[c]±0.05	2.73[b]±0.03	2.93[a]±0.08	2.98[a]±0.08
Ash (g/100g)	1.91[d]±0.07	1.85[c]±0.05	2.38[b]±0.03	2.82[ab]±0.08	2.73[ab]±0.08	2.85[a]±0.05
Carbohydrate (g/100g)	81.74[a]±1.17	75.41[b]±0.25	71.16[c]±0.17	67.66[d]±0.09	64.75[e]±0.32	60.52[f]±0.18
Energy (kCal/100g)	377.23[a]±2.13	375.51[a]±0.82	371.73[ab]±1.42	369.34[b]±2.12	367.76[c]±2.52	367.13[c]±1.11
Vitamin C (mg/100g)	4.45[f]±1.34	7.00[e]±1.04	8.83[d]±1.91	9.33[c]±1.04	9.83[b]±1.18	11.33[a]±0.58
K (mg/100g)	185.00[f]±1.00	351.00[e]±1.41	477.50[d]±3.54	508.50[c]±0.71	546.00[b]±1.41	616.50[a]±2.12
Ca (mg/100g)	5.15[e]±0.71	6.63[d]±0.32	10.75[c]±0.21	18.35[b]±0.64	21.95[a]±0.42	21.95[a]±0.92
Fe (mg/100g)	5.01[c]±0.01	5.02[bc]±0.01	5.05[b]±0.01	5.09[b]±0.00	5.43[ab]±0.04	5.65[a]±0.01
Tannin (mg/100 g)	0.31[a]±0.03	0.15[b]±0.01	0.15[b]±0.01	0.15[b]±0.01	0.14[b]±0.01	0.14[b]±0.01

The means and standard deviations of triplicate scores were presented. Means with different superscript in rows were significantly ($p < 0.05$) different.

foods are increasing in recent times due to the contribution of fibre in the modulation of the gut microbiome, therefore, the increased fibre content of *ogi* following the incorporation of DBSP is a great advantage. The carbohydrate content and energy value of *ogi* reduced by 7.74-25.96% and 0.46-2.67%, respectively with an increasing level of DBSP and this could be due to the low carbohydrate and fat contents of DBSP. This could be advantageous because the reduction in fat and carbohydrate content of *ogi* could imply an increase in nutrient digestibility and assimilation.

Effect of defatted baobab seed powder inclusion on the vitamin C, mineral, and tannin contents of *ogi*

The vitamin C, K, Ca, and Fe contents of *ogi* increased by 57.30-154.61%, 89.73-232.97%, 28.74-326.21%, and 0.20-12.77%, respectively as the level of DBSP increased (Table 1) and this could be due to the high nutrient profile of baobab seed. Vitamin C content also followed a similar trend. This indicated that the complementation of fermented maize and baobab seed cake could prove advantageous in combatting micro-nutrient deficiency. The increase in vitamin C content of *ogi* following the incorporation of DBSP would improve its antioxidant properties (De Caluwe *et al.,* 2010). The tannin content of *ogi* reduced by 54.84-58.06%% following DBSP addition and this could be due to the loss of tannin during baobab seed processing. This is advantageous because low concentration of tannin in the blends will increase the bioavailability of minerals. According to Ijarotimi *et al.* (2013), anti-nutritional factors, such as tannin, bind with minerals thereby making them unavailable in the body.

Effect of defatted baobab seed powder inclusion on the pasting properties of *ogi*

The pasting profile of *ogi* as influenced by the addition of DBSP is presented in Table 2. The results showed a reduction in peak viscosity of *ogi* by 14.97-76.91% consequent to the inclusion of DBSP. This agreed with the finding of Akinwale *et al*. (2017) who reported a reduction in viscosity of custard as a result of soy protein addition. According to Assam *et al*. (2018), the reduction of the peak viscosity of starch-

Table 2: Pasting and colour order properties of fermented maize and defatted baobab seed flour blends

Parameter	Fermented maize: defatted baobab seed (%, w/w)					
	100:0	90:10	80:20	70:30	60:40	50:50
Peak viscosity (cP)	758.00[a]±0.00	649.00[b]±1.41	513.50[c]±19.09	330.00[d]±28.28	200.00[e]±14.14	175.00[f]±35.35
Through viscosity (cP)	722.50[a]±10.61	545.00[b]±7.07	460.50[c]±0.71	280.00[d]±28.28	167.50[e]±17.68	140.00[f]±14.14
Breakdown viscosity (cP)	35.50[c]±0.71	45.50[a]±2.12	36.00[b]±0.00	39.00[b]±2.83	35.00[c]±0.00	30.00[d]±14.14
Final viscosity (cP)	1099.00[a]±11.31	960.00[b]±84.85	889.50[c]±0.71	580.00[d]±56.57	350.00[e]±28.28	210.00[f]±42.43
Setback viscosity (cP)	376.50[b]±0.71	448.00[a]±5.66	428.50[a]±9.19	290.00[c]±28.28	180.00[d]±14.14	70.00[e]±28.28
Pasting time (min)	6.33[c]±0.00	6.44[bc]±0.05	6.53[b]±0.00	6.64[bc]±0.05	6.90[ab]±0.14	7.00[a]±0.00
Pasting temperature (oC)	92.08[ab]±0.04	92.83[ab]±0.04	92.88[ab]±0.04	93.68[a]±0.04	94.48[a]±0.04	95.05[a]±0.21
$L*$	97.11[a]±0.08	78.20[b]±0.03	75.89[c]±0.01	75.11[c]±0.01	71.91[e]±0.01	74.23[d]±0.00
$a*$	-1.02[a]±0.00	-0.68[b]±0.01	-0.57[c]±0.01	-0.38[d]±0.01	-0.15[f]±0.04	-0.25[e]±0.01
$b*$	19.07[a]±0.01	16.94[d]±0.03	16.78[d]±0.01	17.55[c]±0.00	17.38[c]±0.01	18.00[b]±0.00
Hue angle	-86.94[b]±1.81	-87.70[ab]±1.11	-88.05[a]±0.83	-88.76[a]±1.23	-89.51[a]±1.21	-89.20[a]±1.22
Colour intensity	12.79[d]±1.02	18.70[c]±0.24	20.56[cd]±0.71	21.50[b]±0.82	24.21[a]±0.22	22.42[ab]±0.51

The means and standard deviations of triplicate scores were presented. Means with different superscript in rows were significantly ($p < 0.05$) different.

based foods is attributable to the interference of starch swelling due to the presence of vegetable protein. Results also showed that the peak viscosity reduced with an increasing level of DBSP in *ogi*. Trough, breakdown, final and setback viscosity followed a similar pattern. This could be due to an increased interference of starch swelling with an increasing level of protein. The high pasting profile reported for 100% *ogi* powder could be due to the high concentration of starch. The pasting profile of the blends varied probably because of the differences in the rate of starch granule swelling and water absorption of the blends (Assam *et al.*, 2018). The incorporation of ≤ 30% DBSP into *ogi* did not cause a significant ($p >$ 0.05) change in pasting time. This indicated that the incorporation of ≤ 30% DBSP into *ogi* would not affect the time required for the preparation of the gruel. This corroborated the findings of Ezekiel and Adedeji (2020) who reported that the incorporation of 10% moringa seed protein concentrate did not affect the cooking time of fermented maize. Also, the incorporation of ≤ 20% DBSP into *ogi* did not cause a significant ($p > 0.05$) reduction in its pasting temperature. The incorporation of ≥ 30% DBSP increased ($p <$ 0.05) pasting temperature by 1.74-3.23%. This agreed with the findings of Idowu (2018) who reported higher pasting temperature as a result of the inclusion of African yam bean in maize flour.

Effect of defatted baobab seed powder inclusion on the colour order properties of *ogi*
The *L** of *ogi* reduced significantly ($p < 0.05$) by 19.47-25.95% as the level of DBSP increased. This could be due to the impartation of creamy-coloured DBSP. Adedeji and Tadawus (2019) also reported a reduction in *L** of maize flour following the incorporation of baobab pulp powder. Negative *a** was recorded for the samples, which indicated a deviation from red to green, and corroborated the result obtained for pre-gelatinised maize flour (Bolade and Adeyemi, 2014). The degree of deviation was 33.33-85.29%. The *b** also decreased by 12.00-5.61% with an increasing level of DBSP implying a reduction in yellowness (Abiodun *et al.,* 2020; Ojinaka *et al.,* 2013). This aligned with the result obtained for a complementary food prepared from maize and carrot (Oladeji, 2018). A negative hue angle that was less than 90º was obtained for all the samples and this validated the deviation from red colour, as previously discussed. This result corroborated with the findings obtained for fermented maize flour and moringa seed protein concentrate (Ezekiel and Adedeji, 2020). The colour intensity of *ogi* increased by 46.21-89.29% as the level of DBSP increased probably due to the impartation of pigments from DBSP. The high colour intensity of the blends is an indication of high colour purity (Adedeji and Tadawus, 2019). Tang and Liu (2017) also reported similar findings for cookies produced from wheat flour and soy protein isolate.

Sensory properties of gruels prepared from blends of *ogi* and defatted baobab seed powder
Figure 1 shows the sensory properties of gruels produced from blends of *ogi* and DBSP. The results showed that the panellists preferred the GFM1 in colour, taste, aroma, and mouthfeel, and this could be due to the familiarity of the panellists with the gruel prepared from 100% *ogi.* Tang and Liu (2017) also

reported a reduction in the acceptability of wheat-based cookies following the incorporation of soy protein isolate. However, GFM2 and GFM3 compared favourably with GFM1 in terms of consistency and this validated the good pasting profile of blends of *ogi* and ≤ 20% DBSP. GFM2 and GFM3 were more acceptable than GFM4, GFM5, and GFM6 in terms of colour, taste, aroma, mouthfeel, consistency, and overall acceptability. These findings showed that the incorporation of ≤ 20% DBSP into *ogi* did not affect consumer acceptability. Low acceptability was recorded for GFM4, GFM5, and GFM6 in all the sensory attributes investigated and this could be attributed to the impartation of beany flavour from DBSP. According to Ocheme *et al.* (2018), impartation of beaning flavour is one of the impediments to the utilisation of vegetable protein in the fortification and enrichment of complementary foods.
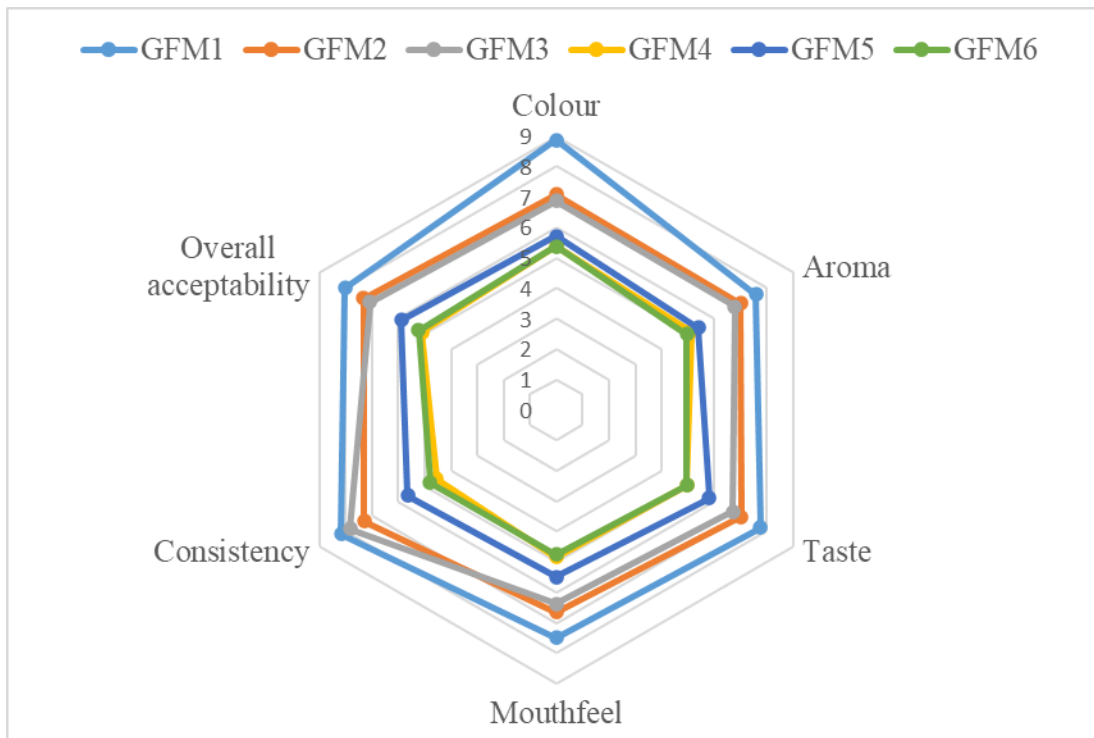
Figure 1. Sensory properties of gruel produced from blends of fermented maize and defatted baobab seed flours. GFM1-guel produced from 100% fermented maize, GFM2- gruel produced from 90% fermented maize and 10% defatted baobab seed powders, GFM3- gruel produced from 80% fermented maize and 20% defatted baobab seed powders, GFM4- gruel produced from 70% fermented maize and 30% defatted baobab seed powders, GFM5- gruel produced from 60% fermented maize and 40% defatted baobab seed powders, GFM6- gruel produced from 50% fermented maize and 50% defatted baobab seed powders.

CONCLUSIONS

There js an improvement in the chemical composition, physicochemical, and sensory properties of *ogi* following the incorporation of DBSP. The protein, vitamin C, and minerals increases while carbohydrate and peak viscosity reduces with an increasing DBSP level. Sensory data showed that gruels produced from blends that contained ≤ 20% DBSP compared favourably with the control sample.

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