# PROXIMATE COMPOSITION, FUNCTIONAL AND SENSORY PROPERTIES OF FERMENTED MAIZE (*ZEA MAYS*) AND MORINGA (*MORINGA OLEIFERA*) SEED PROTEIN CONCENTRATE FLOUR BLENDS

Olufunke Oluseyi **Ezekiel**[1] and Olajide Emmanuel **Adedeji**[2*]
[1]Department of Food Technology, University of Ibadan, Ibadan, Nigeria.
[2]Department of Food Science and Technology, Federal University Wukari, PMB 1020, Wukari, Nigeria.
*Corresponding author: adedeji@fuwukari.edu.ng

***Abstract***
*This study evaluated quality of fermented maize and moringa seed protein concentrate (MSPC) flour blends. Moringa protein concentrate (10%, w/w) was incorporated at different stages (souring, pre-drying and post drying) during the production of fermented maize flour (FMF). Proximate composition, functional, pasting, colour order and sensory properties of blends were determined using standard methods. Protein, fat and ash contents were 7.86-33.33, 0.14-1.20 and 0.41-1.44%, respectively. There was no significant (p>0.05) difference among the samples in terms of energy value. There was a significant (p<0.05) reduction in packed density, swelling capacity, peak, breakdown, final and setback viscosity while oil and water absorption capacity, and pasting temperature increased consequent to MSPC inclusion in FMF. Furthermore, there was a significant reduction in L* while a* and b* increased. Combined souring of maize mash and MSPC resulted in improved colour purity as indicated by high delta chrome and colour intensity. In addition, blend produced by this method compared significantly (p<0.05) with 100% FMF in terms of colour, consistency, appearance and overall acceptability. This study showed that stage of MSPC inclusion significantly (p<0.05) affected the quality of FMF.*

**Keywords:** Fermentation; Maize flour; Moringa seed; Protein concentrate

Received: 22.12.2019 Reviewed: 26.02.2020 Accepted: 02.03.2020

## 1. INTRODUCTION

Maize (*Zea mays*) is one of the major staple foods in many parts of Western and Central Africa, where it is consumed by no less than 50% of the entire population of the regions (Beugre et al., 2014). According to International Institute of Tropical Agriculture (IITA), annual global production output of maize is estimated at 785 million tons and Africa contributes 6.5% of the total output (IITA, 2019). Nigeria is the top producer in Africa with an average annual production volume of 8 million tons (IITA, 2019).

Due to its high functionality, maize and its products are enjoying increasing applications in many food and non-food systems (Abiose and Ikujenlola, 2014). In West Africa, maize is subjected to different processing operations, and thus, many products are obtained (Nsto et al., 2016). Particularly, production of *ogi*, a popular complementary/breakfast product in Nigeria, Cameroun and Benin is achieved through submerged fermentation of maize grains (Ayo-Omogie and Ogunsakin, 2013).

*Ogi* serves as a cheap and affordable food for the teeming West African population, however, it is characterised with low nutrient density (Nsto et al., 2016). Approaches for combating malnutrition, such as exogenous and endogenous fortification, provide promising evidence for dramatically improving the health and nutrition of many consumers of the product. Recent works on fortification of *ogi* to improve its nutritional density include supplementation with moringa leaves (Olorode et al., 2013), soybean (Akanbi et al., 2010) and bambara seed (Mbata et al., 2009). Quality improvement of *ogi* through co-fermentation of maize and protein-rich vegetables such as legumes are also well documented (Oyarekua, 2012; Oyarekua, 2013a; Oyarekua, 2013b).

Nutritional improvement of *ogi* with legumes is often characterised with poor acceptability by consumers owing to impartation of beany flavour (Mume et al., 2013), and reduced digestibility as a result of increased concentration of recalcitrant oligosaccharides in the product (Gayol et al., 2013). Concentration or isolation of protein from legumes prior to incorporation into foods has been reported to reduce these defects (Tang and Liu, 2017; Akinwale et al., 2017). Recent studies showed improvement in chemical composition, physicochemical and sensory properties of cereal-based cookies (Adeyeye et al., 2017; Tang and Liu, 2017) and pasta (Surasani et al., 2019) supplemented with vegetable protein concentrates/isolates. However, there is paucity of information on application of vegetable protein concentrates in fermented cereal-based products. Furthermore, information on stage of vegetable protein concentrate inclusion on quality parameters of foods is sparse. The objective of this study was to determine effects of stage of moringa seed protein concentrate (MSPC) inclusion on proximate composition, functional and sensory properties of fermented maize flour (FMF).

## 2. MATERIALS AND METHODS

### Materials

Moringa seeds and maize grains were sourced from Agbekoya market, Apata, Ibadan and IITA, Ibadan, respectively. Moringa seeds and maize grains were stored in separate sterile containers at refrigeration temperature (4±2$^{o}$C) until required.

### Methods

**Production of Defatted Moringa Seed Protein Concentrate**

Moringa seed flour was produced based on the methodology described by Ijarotimi et al. (2013). Having cleaned the seeds of extraneous materials, they were pretreated with 200 ppm 5.25% sodium hypochlorite for 5 minutes. The pretreated seeds were rinsed in de-ionized water (1:3 w/v) for 9 h at ambient temperature (28±2$^{o}$C), dehulled manually (with the aid of wooden mortar and pestle), and dried in a cabinet drier (Plus11 Sanyo Gallenkamp PLC, UK) at 50°C for 30 h. Subsequently, the dried seeds were milled in an attrition mill (Glope p44 China), sieved using a 0.425 mm sieve to obtain moringa seed flour. Moringa seed flour was defatted using cold extraction principle outlined by Kudre et al. (2013) using solvent that comprised of chloroform and methanol (2:1 v/v). Moringa seed flour (1:10, w/v) was soaked in the solvent and the mixture was heated in a water bath (NL42OS, England) at 60$^{o}$C with continuous shaking for 30 minutes. The mixture was rapidly cooled in an ice bath to 25$^{o}$C. The mixture was centrifuged at 10, 000 × g for 30 minutes at 10$^{O}$C, air dried at ambient temperature (28±2$^{o}$C) and milled to particle size ≤ 0.250 mm.

To obtain moringa seed protein concentrate (MSPC), defatted moringa seed flour was soaked in distilled water (1:10, w/v) and the mixture was agitated in an orbiter shaker (KS 260 Basic, USA) for 45 minutes. Subsequently, pH of the mixture was adjusted to 4.5 with the aid of 4M HCl and centrifuged at 4000 × g for 20 minutes. After centrifugation, the supernatant was discarded and the procedure was repeated two more times. The resulting precipitate was freez-dried (BK-FD20-100 Series, USA), packaged and stored (-18$^{O}$C) until required (Gayol et al., 2013).

**Production of Fermented Maize Flour**

Fermented maize flour (FMF) was produced according to procedure described by Oluwamukomi et al. (2005). Wholesome maize grains were steeped in potable water (1:6 w/v) for 48 h. The grains were wet-milled in an attrition mill (globe p44, China) and the resulting slurry was sieved using 0.425 mm sieve. The overtail was discarded while the filtrate was left to settle and sour simultaneously in water for 24 h. After souring, the slurry was sieved with the aid of 0.125 mm sieve. The resulting cake was dried in a cabinet drier (Plus11 Sanyo Gallenkamp PLC, UK) at 60$^{o}$C for 24 h, milled, sieved (0.250 mm sieve), packaged in a plastic container (ZipLock, China), labeled and stored (-18$^{o}$C) for subsequent analyses.

**Production of Fermented Maize and Moringa Protein Concentrate Flour Blends**

Three blends were prepared by incorporating MSPC (10%, w/w) at different identified stages during production of FMF. These stages included souring, pre-drying and post drying. The first blend was prepared by incorporating MSPC into milled maize slurry prior to souring (souring stage). The resulting mixture was thoroughly mixed, soured for 24 h, sieved with the aid of 0.125 mm sieve. The resulting cake was dried in a cabinet drier (Plus11 Sanyo Gallenkamp PLC, UK) at 60$^oC$ for 24 h, milled, sieved (0.250 mm sieve), packaged in a plastic container (ZipLock, China), labeled (FBFM) and stored (-18$^oC$) for subsequent analyses.

The second blend was prepared by incorporating MSPC into soured maize slurry prior to drying (pre-drying stage). The mixture was thoroughly mixed and dried in a cabinet drier (Plus11 Sanyo Gallenkamp PLC, UK) at 60$^oC$ for 24 h, milled, sieved (0.250 mm sieve), packaged in a plastic container (ZipLock, China), labeled (SBFM) and stored (-18$^oC$) for subsequent analyses.

The third blend was prepared by mixing MSPC and FMF (post-drying stage). The mixture was thoroughly mixed, packaged in a plastic container (ZipLock, China), labeled (TBFM) and stored (-18$^oC$) for subsequent analyses.

**Analyses**

**Proximate, Functional, Pasting and Colour Order Analyses**

Protein, fat, ash, moisture, carbohydrate content and energy value of samples were determined using standard methods (AOAC, 2005). Procedures described by Narayana and Narsinga (1992), Sasulki et al. (1996), and Akpata and Miachi (2001) were used for determination of bulk density (loose and packed), water and oil absorption capacity (WAC and OAC) and swelling capacity, respectively. Pasting profile of samples was evaluated with the aid of a Brabender visco-amylograph (Newport Scientific Pty Ltd. Warrie-wood NSW, Australia) based on the procedure outlined by Chinma et al. (2013) (2013). Colour order parameters of samples were determined using a handheld colorimeter (Chromameter CR-400/410).

**Sensory Analysis**

Each sample (30%, w/v) was reconstituted in water, heated to 85$^oC$ in a water bath (Polyscience WB20L11B) and held at this temperature for 15 minutes. Gruels with pap-like consistency were obtained. The gruels were subjected to sensory analysis using a 9 point hedonic scale where 0 and 9 represented dislike extremely and like extremely, respectively. Fifty panelists comprising of nursing mothers, male and female adults that were familiar with *ogi* were recruited for the analysis. Coded samples were served to the panelists in individual booths under fluorescent light. Samples were rated by panelists for colour, taste, aroma, consistency, appearance, mouthfeel and overall acceptability (Ijarotimi and Keshinro, 2012).

**Statistical Analysis**

All experiments were performed in triplicate. Raw data obtained were subjected to one-way analysis of variance to obtain means and standard deviations at 5% probability level, while Duncan's multiple range test was used to separate the means. These were achieved using Statistical Package for the Social Scientists (SPSS) version 17.0.

## 3. RESULTS AND DISCUSSION

Proximate composition of FMF as influenced by stage of MSPC inclusion is presented in Table 1.

**Table 1 Proximate composition of fermented maize and moringa seed protein concentrate flour blends**

| Stage of MSPC (10 g/100g) inclusion in FMF | Protein (%) | Fat (%) | Carbohydrate (%) | Moisture (%) | Ash (%) | Energy value (kCal/100g) |
|---|---|---|---|---|---|---|
| Souring | $27.15^b±0.80$ | $1.20^a±0.20$ | $60.89^b±1.09$ | $9.56^b±0.10$ | $1.20^{ab}±0.87$ | $362.96^a±10.50$ |
| Pre-drying | $33.33^a±0.69$ | $0.60^b±0.02$ | $54.05^c±2.81$ | $10.62^{ab}±0.02$ | $1.40^a±0.52$ | $354.92^a±11.06$ |
| Post-drying | $29.33^{ab}±1.14$ | $1.10^a±0.10$ | $57.14^{bc}±2.84$ | $10.99^a±0.08$ | $1.44^a±0.05$ | $355.78^a±5.51$ |
| Control (100% FMF) | $7.86^c±0.53$ | $0.14^c±0.11$ | $80.65^a±2.99$ | $10.94^a±0.07$ | $0.41^b±0.07$ | $355.30^a±10.24$ |

Values are means±standard deviations of triplicate scores. Means with different superscripts in the same colum were significantly different (p<0.05). MSPC Moringa seed protein concentrate), FMF Fermented maize flour.

Protein content of samples was 13.86-37.15% and varied significantly ($p<0.05$) among the samples. Lowest protein content (13.86%) was recorded for 100% FMF. This implies that inclusion of MSPC in FMF increased protein content significantly ($p<0.05$). Akanbi et al. (2010) also reported an increment in protein content of *ogi* as a result of addition of soybean flour. Among the blends, FMF that contained MSPC introduced during souring (FBFM) had lowest protein content of 27.15%. This could probably be due to leaching of protein in MSPC during souring and sieving operations. Inyang, and Effiong (2016) had reported loss of nutrients during soaking and sieving operations of fermented cereal products. Fat content of FMF increased significantly ($p<0.05$) as a result of addition of MSPC. This could be due to influence of traceable fat in MSPC. Furthermore, significantly ($p<0.05$) higher fat content was recorded in FBFM and FMF that contained MSPC introduced after drying (TBFM) compared to FMF that contained MSPC introduced before drying (SBFM). Carbohydrate content ranged between 54.05 (SBFM) and 80. 65% (100% FMF). Inclusion of MSPC caused a significant ($p<0.05$) reduction in carbohydrate content of FMF. Since carbohydrate content was obtained by difference (AOAC, 2005), its reduction could be attributed to increase in protein content of FMF as a result of MSPC inclusion. Ocheme et al. (2018) also reported reduction in carbohydrate content of wheat flour following supplementation with groundnut protein concentrate. Significantly ($p<0.05$) lower carbohydrate content obtained for SBFM compared to other blends might be due to its high protein content. Moisture content was 9.56-10.99%. This was less than 12% threshold considered to be appropriate for flour and stored grains (Iwe et al., 2016). This is advantageous because reduction of moisture content of FMF will reduce proliferation of spoilage organisms especially mould, thus, improving its shelf stability. Ash content ranged between 0.41 (100% FMF) and 1.44% (TBFM). Supplementation of FMF with MSPC resulted in an increase of ash content. This corroborated findings of Ade et al. (2012) who reported an increase in ash content of baked products produced from blend of wheat and water-extractable protein from African yam bean. The increase in ash content could be attributed to combination effect of ash content from FMF and MSPC. Furthermore, significantly ($p<0.05$) higher ash content was obtained for TBFM (1.44%) and SBFM (1.40%) compared to 1.20% obtained for FBFM. This difference could be connected with loss of water-soluble minerals in MSPC during souring and sieving (Bolaji et al., 2014). This was in contrast with increase in ash content of *ogi* obtained through co-fermentation of maize and soybean (Oluwamukomi et al., 2005). There was no significant ($p>0.05$) difference among the samples in terms of energy value. This implies that neither supplementation with MSPC nor stage of its inclusion had significant ($p<0.05$) effect on energy content of FMF.

**Effect of Moringa Seed Protein Concentrate Inclusion on Functional Properties of Fermented Maize Flour**

Table 2 shows functional properties of 100% FMF, and blends of FMF and MSPC.

**Table 2 Functional Properties of fermented maize and moringa seed protein concentrate blends**

| Stage of MSPC (10 g/100g) inclusion in FMF | Loose density ($g/cm^3$) | Packed density ($g/cm^3$) | Oil absorption capacity (mL/g) | Water absorption capacity (mL/g) | Swelling capacity (g/g) |
|---|---|---|---|---|---|
| Souring | $0.38^b±0.01$ | $0.66^a±0.01$ | $1.41^c±0.05$ | $1.30^a±0.02$ | $6.42^b±0.01$ |
| Pre-drying | $0.35^b±0.15$ | $0.64^a±0.75$ | $1.90^a±0.06$ | $1.23^b±0.06$ | $5.78^c±0.21$ |
| Post-drying | $0.37^b±0.02$ | $0.63^a±0.04$ | $1.79^b±0.05$ | $1.19^c±0.09$ | $5.81^c±0.07$ |
| Control (100% FMF) | $0.52^a±0.01$ | $0.57^c±0.02$ | $1.40^c±0.80$ | $1.10^d±0.01$ | $6.99^a±0.14$ |

Values are means±standard deviations of triplicate scores. Means with different superscripts in the same colum were significantly different ($p<0.05$). MSPC Moringa seed protein concentrate), FMF Fermented maize flour.

Loose and packed bulk density were 0.32-0.38 and 0.57-0.66 g/cm$^3$, respectively. Supplementation of FMF with MSPC caused a significant ($p<0.05$) reduction in loose and packed density. This agreed with reduction in bulk density of maize flour consequent to supplementation with soy protein isolate (Adeyeye et al., 2017).
Reduction in bulk density could be attributed to low carbohydrate content of blends of FMF and MSPC. Complex carbohydrates are often associated with high bulkiness, and supplementation of cereal-based product with vegetable protein reduces its carbohydrate content, and hence, its bulkiness (Gernah et al., 2011). Low bulk density is an advantage because it improves digestibility of food and bioavailability of nutrients (Asaam et al., 2018). Findings in this work showed that loose and packed bulk density of blends of FMF and MSPC were not significantly ($p>0.05$) different. This shows stability of MSPC irrespective of its stage of inclusion in FMF. This findings contradicted the report of Oyarekua (2012) who reported significant difference in bulkiness of FMF and co-fermented maize and cowpea flour.
Oil absorption and water absorption capacity were 1.40-1.90 and 1.10-1.30 mL/g, respectively. Oil absorption capacity varied significantly ($p<0.05$) among the blends, however, there was no significant ($p>0.05$) difference in OAC of 100% FMF and FBFM. High OAC (1.90 mL/g) was obtained for SBFM while low value (1.41 mL/g) was obtained for FBFM. This implied that souring of maize mash and MSPC together resulted in reduction in OAC. This reduction could be attributed to conformational imbalance between hydrophilic and hydrophobic constituents of the blend during souring operation (Apotiola, 2013). High OAC in SBFM is advantageous since high OAC contributes to organoleptic attributes of foods (Iwe et al., 2016). Significantly ($p<0.05$) higher WAC was obtained for FBFM compared to SBFM and TBFM. This could be due to modification of starch granules as a result of souring of FMF and MSPC. Adegunwa et al. (2011) had attributed improved WAC to amylose/amylopectin ratio and molecular modification of starch molecules.
Swelling capacity ranged from 5.78 (SBFM) and 6.99 (100% FMF). This implied reduction in swelling capacity of FMF consequent to MSPC supplementation. There was no significant ($p>0.05$) difference in swelling capacity of SBFM and TBFM. However, swelling capacity obtained for these two samples were significantly ($p<0.05$) lower that the one obtained for FBFM. High swelling capacity obtained for FBFM could be due to increased hydration of starch consequent to improved activities of lactic acid bacteria during souring operation of maize mash and MSPC. Ocheme et al. (2010) also attributed increased swelling capacity of millet flour to hydration of starch molecules during soaking operation of millet grains.

**Effect of Moringa Seed Protein Concentrate Inclusion on Pasting Properties of Fermented Maize Flour**

Pasting properties of fermented maize and MSPC flour blends are presented in Table 3.

**Table 3 Pasting Properties of fermented maize and moringa seed protein concentrate blends**

| Stage of MSPC (10g/100g) inclusion in FMF | Peak V. (mPa.s) | Trough V. (mPa.s) | Breakdown V. (mPa.s) | Final V. (mPa.s) | Setback V. (mPa.s) | Peak time(Min.) | Pasting Temp. ($^oC$) |
|---|---|---|---|---|---|---|---|
| Souring | 1261.67$^d$±184.75 | 784.67±108.54 | 477.00$^d$±76.21 | 1220.67$^d$±176.09 | 436.00$^c$±67.55 | 5.04$^b$±0.08 | 78.23$^b$±0.03 |
| Pre-drying | 1683.33$^c$±81.98 | 1055.00$^c$±39.84 | 628.33$^c$±42.15 | 1995.67$^c$±252.30 | 940.67$^b$±12.46 | 5.44$^a$±0.08 | 79.05$^a$±0.09 |
| Post-drying | 3025.67$^b$±501.14 | 1724.27$^b$±279.44 | 1301.00$^b$±221.70 | 3905.33$^b$±764.99 | 2180.67$^a$±85.55 | 5.38$^a$±0.04 | 78.20$^b$±0.09 |
| Control (100% FMF) | 4660.67$^a$±160.50 | 2940.00$^a$±180.13 | 1720.67$^a$±19.63 | 5451.67$^a$±184.75 | 2511.67$^a$±4.62 | 5.09$^b$±0.04 | 76.65$^c$±0.09 |

Values are means±standard deviations of triplicate scores. Means with different superscripts in the same colum were significantly different ($p<0.05$). MSPC Moringa seed protein concentrate), FMF Fermented maize flour, V. Viscosity, Temp. Temperature.

Peak, trough, breakdown, final and setback viscosity were 1261.67-4660.67, 784.67-29040.00, 477.00-1720, 1220.67-5451.67 and 436.00-2511.67 mPa.s, respectively. Findings in this study showed significant ($p<0.05$) reduction of the listed pasting parameters consequent to inclusion of MSPC. This implied interference of FMF starch swelling due to presence of MSPC (Asaam et al., 2018). Akinwale et al. (2017) also reported reduction in viscosity of cassava starch-based custard following inclusion with soy protein concentrate. High pasting profile recorded for 100% FMF could be attributed to its high carbohydrate content (Section 3.1) (Fila et al., 2013). Also, stage of MSPC inclusion had significant ($p<0.05$) effect on the pasting parameters. Results showed that lowest and highest peak, trough, breakdown, final and setback viscosity were recorded for FBFM and TBFM. Low pasting profile recorded for FBFM could be due to denaturation of protein during fermentation and consequent reduction in hydrophilic tendency of denatured proteins (Oluwamukomi et al., 2005). Differences in peak viscosity of the blends could be attributed to differences in rate of starch granule swelling and water absorption (Asaam et al., 2018).

Peak time varied between 5.04 (FBFM) and 5.44 minutes (SBFM). There was no significant ($p>0.05$) difference between FBFM and 100% FMF in terms of peak time. Low peak time of FBFM is is an indication of short preparation time of gruel which is a good advantage (Chinma et al., 2013). Generally, low pasting temperature (76.65-79.05$^{o}$C) was recorded for the samples. These values were lower than 81.10-89.80$^{o}$C reported for blends of maize-African yam bean flour (Idowu, 2015). Inclusion of MSPC in FMF caused a significant ($p<0.05$) increase in pasting temperature. This contradicted findings of Akinwale et al. (2017) who reported that inclusion of soy protein isolate did not cause any significant change on pasting temperature of cassava starch-based custard. Significantly ($p<0.05$) lower pasting temperature was recorded for FBFM and TBFM compared to SBFM. This implied lower energy requirement during preparation.

**Effect of Moringa Seed Protein Concentrate Inclusion on Colour Order Properties of Fermented Maize Flour**

Table 4 shows colour order parameters of fermented maize flour and MSPC blends. L* (measure of lightness) ranged from 81.31 (FBFM) to 93.11 (100% FMF). Results showed that addition of MSPC into FMF caused a significant ($p<0.05$) reduction in L*. Colour of MSPC was creamy white and its inclusion in FMF might have caused reduction in L* of FMF. This result corroborated the findings of Tang and Liu (2017) who reported reduction in L* of cookie as a result of partial replacement of wheat flour with whey and soy proteins. In addition, L* varied significantly ($p<0.05$) among blends of FMF and MSPC with FBFM and TBFM having lowest and highest value, respectively. Low L* recorded for FBFM could due to leaching of pigments from MSPC during souring operation and subsequent absorption of leached pigments by FMF during sieving operation (Ojinnaka et al., 2013). Degree of redness (a*) and yellowness (b*) of samples were 0.14-0.75 and 7.79-15.30, respectively. Both parameters decreased significanly ($p<0.05$) consequent to MSPC inclusion.

**Table 4 Colour order parameters of fermented maize flour and moringa seed protein concentrate blends**

| Stage of MSPC Inclusion in FMF | L | a* | b* | Hue angle | Delta chrome | Colour intensity |
|---|---|---|---|---|---|---|
| Souring | 81.31$^{d}$±4.92 | 0.75$^{a}$±0.13 | 15.30$^{a}$±0.58 | 87.20$^{b}$±0.39 | 14.99$^{a}$±0.57 | 16.28$^{a}$±1.67 |
| Pre-dering | 88.70$^{c}$±5.10 | 0.41$^{b}$±0.15 | 13.58b±0.67 | 88.28$^{a}$±0.59 | 13.26$^{b}$±0.67 | 14.02$^{b}$±1.76 |
| Post drying | 90.76$^{b}$±3.57 | 0.46$^{b}$±0.13 | 8.64$^{c}$±1.19 | 86.95$^{c}$±0.92 | 8.32$^{c}$±1.19 | 9.88$^{c}$±1.60 |
| Control (100% FMF) | 93.11$^{a}$±4.24 | 0.14$^{c}$±0.12 | 7.79$^{d}$±1.73 | 87.67$^{b}$±1.23 | 7.47$^{c}$±1.72 | 10.24$^{c}$±3.74 |

Values are means±standard deviations of triplicate scores. Means with different superscripts in the same colum were significantly different ($p<0.05$). MSPC Moringa seed protein concentrate), FMF Fermented maize flour.

**Table 5 Sensory properties of gruel produced from fermented maize and moringa seed protein concentrate blends**

| Stage of MSPC FMF | Colour | Taste | Aroma | Consistency | Appearance | Mouthfeel | Overall acceptability inclusion in |
|---|---|---|---|---|---|---|---|
| Souring | $8.18^{a}$±1.35 | $7.34^{b}$±1.26 | $7.54^{b}$±1.50 | $7.06^{a}$±1.63 | $8.02^{a}$±1.32 | $6.96^{b}$±1.59 | $7.44^{a}$±1.31 |
| Pre-dring | $7.30^{b}$±0.93 | $5.74^{c}$±1.31 | $6.52^{b}$±1.37 | $5.96^{b}$±1.11 | $6.42^{b}$±1.26 | $6.48^{c}$±1.20 | $6.64^{bc}$±1.05 |
| Post-drying | $5.38^{c}$±1.96 | $5.78^{d}$±1.15 | $5.84^{c}$±1.25 | $5.72^{b}$±1.40 | $6.00^{c}$±1.46 | $5.48^{d}$±1.34 | $6.46^{c}$±1.40 |
| Control (100% FMF) | $8.26^{a}$±1.37 | $8.20^{a}$±2.21 | $7.94^{a}$±1.48 | $6.98^{a}$±1.76 | $8.20^{a}$±1.47 | $7.40^{a}$±1.34 | $7.60^{a}$±1.09 |

Values are means±standard deviations of 50 scores. Means with different superscripts in the same colum were significantly different (p<0.05). MSPC Moringa seed protein concentrate), FMF Fermented maize flour.

This implied increased colouration and deviation from white colour (Ojinnaka et al., 2013). Higher b* was recorded for the blends as compared to a* and this implied higher deviation towards yellow than red. This could also be due to white creamy colouration of MSPC. Similar result was obtained for co-processed quality protein maize and carrot complementary food (Oladeji, 2018).

Hue angle, delta chrome and colour intensity were 86.95-88.28, 7.47-14.99 and 9.88-16.28, respectively. Hue angle obtained in this study showed deviation between 0 and $90^{o}$ and this implied deviation from red to yellow. This agreed with with results obtained for a* and b*. Significantly ($p<0.05$) higher delta chrome and colour intensity were obtained for FBFM and SBFM compared to TBFM and 100% FMF. This indicated darker colouration of these blends probably as a result to synthesis of pigments during co-souring and drying of maize mash and MSPC. Similar result was obtained for wheat-soy protein isolate-based cookie (Tang and Liu, 2017). High chroma and colour intensity recorded for FBFM and SBFM are indication of high colour purity of the blends (Correia et al., 2016).

**Sensory Properties of Gruel Produced from Fermented Maize and Moringa Seed Protein Concentrate Flour Blends**

Sensory properties of samples in terms of colour, taste, aroma, consistency, appearance, mouthfeel and overall acceptability are presented in Table 5. There was no significant ($p>0.05$) difference between FBFM and 100% FMF in terms of colour, consistency, appearance and overall acceptability and their scores were significantly ($p<0.05$) higher than those of SBFM and TBFM. In addition, higher scores were obtained for FBFM compared to SBFM and TBFM in terms of taste, aroma and mouthfeel. This implied better consumer acceptability of FBFM than other blends. Low acceptability recorded for SBFM and TBFM agreed with the findings of Tang and Liu (2017) who reported reduction in consumer acceptability of cookie with increasing level of whey and soy proteins. High consumer preference of FBFM showed the importance of co-souring of maize and MSPC and this conformed with the finding of Oyarekua (2013b) who reported improved sensory properties of a complementary food as a result of co-fermentation of maize, cowpea and sweet potato.

## 4. CONCLUSION

This study showed that inclusion of MSPC improved proximate composition, functional, pasting, colour order and sensory properties of FMF. Also, these parameters were significantly ($p<0.05$) affected by stage of MSPC inclusion in FMF. Inclusion of MSPC in FMF resulted in an increase in protein, fat and ash while crbohydrate reduced. Co-souring of maize mash and MSPC resulted in reduction of protein and ash contents. FBFM compared significantly with 100% FMF in terms of colour, consistency, appearance and overall acceptability.

## Declaration of Conflict of Interest

None declared

## Authors' Contributions

OOE designed the study and approved the final draft and OEA conducted laboratory experiment, statistical analysis and prepared the first draft.

## 5. REFERENCES


[1]. Abiose SH and Ikujenlola AV. (2014). Comparison of chemical composition, functional properties and amino acids composition of quality protein maize and common maize (Zea mays L). African Journal of Food Science and Technology 5(3): 81-89.

[2]. Ade IC, Ingbian EK and Abu JO. (2012). Physical, chemical and sensory properties of baked products from blends of wheat and African yam bean water-extractable proteins. Nigerian Food Journal 30(1): 109-115

[3]. Adegunwa MO, Sanni LO and Maziya-Dixon B. (2011). Effects of fermentation length and varieties on the pasting properties of sour cassava starch. African Journal of Biotechnology 42: 8428-8433.

[4]. Adeyeye SAO, Adebayo-Oyetoro AO and Omoniyi SA (2017). Quality and sensory properties of maize flour cookies enriched with soy protein isolate. Cogent Food and Agriculture 3: 1-11.

[5]. Akanbi BO, Olubunmi OA and Samuel, AG. (2010). Quality assessment of selected cereal - soybean mixtures in “ogi” production. New York Science Journal 3(10): 17-26.

[6]. Akinwale TE, Shittu TA, Adebowale AA, Adewuyi S and Abass AB. (2017). Effect of soy protein isolate on the functional, pasting, and sensory acceptability of cassava starch- based custard. Food Science and Nutrition 5: 1163-1169.

[7]. Akpata MI and Miachi OE. (2001). Proximate Composition and selected functional properties of Detarium microcarpum. Plant Foods for Human Nutrition 56: 297-302.

[8]. Apotiola ZO. (2013). Effect of soaking period on the ogi powder produced from sorghum, Nigerian Food Journal 31(1): 103-107.

[9]. Asaam ES, Adubofuor J, Amoah I and Apeku OD. (2018). Functional and pasting properties of yellow maize–soya bean–pumpkin composite flours and acceptability study on their breakfast cereals. Cogent Food and Agriculture 4: 1-15.

[10]. Ayo-Omogie HN and Ogunsakin R. (2013). Assessment of chemical, rheological and sensory properties of fermented maize-cardaba banana complementary food. Food and Nutrition Sciences 4: 844-850.

[11]. Association of Official Analytical Chemists (AOAC) (2005). Official Methods of Analysis, Gathersburg, MD U.S.A.

[12]. Beugre GAM, Yapo BM, Blei SH and Gnakri D. (2014). Effect of fermentation time on the physico-chemical properties of maize flour. International Journal of Research Studies in Biosciences 2(8): 30-38.

[13]. Bolaji OT, Oyewo AO and Adepoju PA. (2014). Soaking and drying effect on the functional properties of ogi produce from some selected maize varieties. American Journal of Food Science and Technology 2(5): 150-157.

[14]. Chinma CE, Gbadamosi KB, Ogunshina BS, Oloyede OO and Salami SO. (2013). Effect of addition of germinated moringa seed flour on the quality attributes of wheat-based cake. Journal of Food Processing and Preservation 12(1): 3-6.

[15]. Correia PMR, Soares AM and Brites C. (2016). Quality characteristics of maize flour and breads, International Journal of Food Engineering 2(2): 113-118.

[16]. Fila W, Itam E and Johnson J. (2013). Comparative proximate compositions of watermelon (Citrullus lanatus), squash (Cucurbita pepo’l) and rambutan (Nephelium lappaceum). International Journal of Science and Technology 2(1): 81–88.

[17]. Gayol MF, Pramparo MC, Nepote V, Fernendez H and Grosso NR. (2013). Optimization of the protein concentration process from residual peanut oil-cake. Grasaa Y aceites 64(5): 489-496.

[18]. Gernah DI, Ariahu CC and Ingbian EK (2011). Effects of malting and lactic fermentation on some chemical and functional properties of maize. American Journal of Food Technology 6: 404-412.

[19]. Idowu A. (2018). Chemical composition, sensory and pasting properties of blends of maize-African yam bean seed. Journal of Nutritional Health and Food Science 3(3): 1-6.

[20]. Ijarotimi OS, Adeoti OA and Ariyo O. (2013). Comparative study on nutrient composition, phytochemical,and functional characteristics of raw, germinated, and fermented moringa oleifera seed flour. Food Science and Nutrition 1(6): 452-463.

[21]. Ijarotimi OS and Keshinro OO. (2012). Formulation and nutritional quality of infant formula produced from germinated popcorn, bambara groundnut and African locust bean flour. Journal of Microbiology, Biotechnology and Food Sciences 1(6): 1358-1388.

[22]. International Institute for Tropical Agriculture (IITA), (2019). Maize (Zea mays). https:iita.org/crops/maize/ Accessed 15 June 2019.

[23]. Iwe MO, Onyeukwu U and Agiriga AN. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. Cogent Food and Agriculture 2(1): 42-49.
[24]. Inyang UE and Effiong WE. (2016). Chemical composition, functional and sensory properties of maize ogi fortified with periwinkle meat flour. International Journal of Nutrition and Food Sciences 5(3): 195-200.
[25]. Kudre TG, Benjakul S and kishimura H. (2013). Comparative study on chemicalcompositions and properties of protein isolates from mung bean, black bean and bambara groundnut. Journal of the Science of Food and Agriculture 93: 2429–2436.
[26]. Mbata TI, Ikenebomeh MJ and Ezeibe S. (2009). Evaluation of mineral content and functional properties of fermented maize (generic and specific) flour blended with bambara groundnut (Vigna Subterranean L). African Journal of Food Science 3(4): 107-112.
[27]. Mume MAM, Minka SR and Mboma IL (2013). Chemical composition and nutritional evaluation of a cowpea protein concentrate. Global Advanced Journal of Food Science and Technology 2(3): 35-43.
[28]. Narayana K and Narsinga MS. 1(992). Functional properties of raw and heat processed winged bean (Psophocarpus tertragonolobus) flour. Journal of Food Science 47: 534-538.
[29]. Ntso ASA, Njintang YN and Mbofung CMF. (2016). Physicochemical and pasting properties of maize flour as a function of the interactive effect of natural-fermentation and roasting. Food Measures, DOI 10.1007/s11694-016-9413-1.
[30]. Ocheme OB, Oloyede OO and Mikailu, ES. (2010). Effect of lime soaking and cooking (nixtamalization) on the proximate, functional and some anti-nutritional properties of millet flour, AU Journal of Technology 14(2): 131–138.
[31]. Ocheme OB, Adedeji OE, Chinma CE, Yakubu CM and Ajibo UH. (2018). Proximate composition, functional and pasting properties of wheat and groundnut protein concentrate flour blends. Food Science and Nutrition 6(5): 1173-1178.
[32]. Ojinnaka MC, Ebinyasi CS, Ihemeje A and Okorie SU. (2013). Nutritional evaluation of complementary food gruels formulated from blends of soybean flour and ginger modified cocoyam starch. Advance Journal of Food Science and Technology 5(10): 1325-1330.
[33]. Oladeji BS. (2018). Assessment of physico-chemical properties, pasting profiles and sensory scores of co-processed quality protein maize and carrot complementary food. Journal of Advancements in Food Technology 1(1): 1-8.
[34]. Olorode OO, Idowu MA and Ilori OA. (2013). Effect of Benoil (Moringa Oleifera) Leaf Powder on the Quality Characteristics of 'Ogi'. American Journal of Food and Nutrition 3(2): 83-89.
[35]. Oluwamukomi MO, Eleyinmi MO and Enujiugha MO. (2005). Effect of soy supplementation and its stage of inclusion on the quality of ogi – a fermented maize meal. Food Chemistry 91: 651-657.
[36]. Oyarekua MA. (2012). Effect of germination, boiling and co-fermentation on the viscosity of maize/cowpea mixture as complementary infant food. American Journal of Food Technology 7: 1-12.
[37]. Oyarekua MA. (2013a). Comparative studies of co-fermented maize/pigeon pea and maize/mucuna as infants complementary foods. Woodpecker Journal of Food Technology 1(1): 1-8.
[38]. Oyarekua MA. (2013b). Effect of co-fermentation on nutritive quality and pasting properties of maize/cowpea/sweet potato as complementary food. African Journal of Food, Agriculture, Nutrition and Development 13(1): 71-91.
[39]. Sasulki FW, Garrant MD and Slinkard AE. (1996). Functional properties of fern legume flour. Institute of Food Science and Technology Journal 9: 66-69.
[40]. Surasani VK, Singh A, Gupta A and Sharma S. (2019). Functionality and cooking characteristics of pasta supplemented with protein isolate from pangas processing waste. LWT Food Science and Technology 111: 443-448.
[41]. Tang X and Liu J. (2017). A comparative study of partial replacement of wheat flour with whey and soy protein on rheological properties of dough and cookie quality. Journal of Food Quality https://doi.org/10.1155/2017/2618020.