# EFFECT OF OYSTER MUSHROOM (PLEUROTUS OSTREATUS) FLOUR ADDITION ON THE NUTRITIONAL COMPOSITION AND FUNCTIONAL PROPERTIES OF SORGHUM-COMPOSITE FLOUR BLENDS

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**ABSTRACT**
The effects of oyster mushroom addition on nutritional composition and functional properties of sorghum-oyster mushroom composite flour blends were determined in this study. This is to improve the nutritional composition of sorghum since oyster mushroom is rich in both essential and non-essential amino acids. Oyster mushroom flour was added in different percentages to sorghum flour (0, 5 and 15%). The proximate, functional and pasting properties of the composited samples were determined, and 100% oyster mushroom and sorghum flours serve as the control. The proximate composition of composited flour increassed with increase in oyster mushroom flour. The protein content increased from 6.20 to 9.46%, fat content from 0.21 to 1.06% and ash content from 0.14 to 2.56%. The moisture and carbohydrate content decreased with an increase in the addition of oyster mushroom flour. The functional properties of composited flours decreased with increase in oyster mushroom flour added. Water absorption capacity decreased from 13.29 to 9.49 g/ml, swelling capacity from 2.26 to 1.26 g/ml and bulk density from 3.02 to 2.47 g/ml. The pasting properties also decreased with increase in the percentage of oyster mushroom flour added. In conclusion, the addition of oyster mushroom flour increases the nutritional composition of sorghum flour. Also, such composited flour can serve as a raw material in making biscuit, bread and cake.

**Keywords**:Sorghum flour, oyster mushroom flour, composited flour, pasting, proximate composition

## INTRODUCTION

Mushroom constitutes an integral part of the normal human diet and in recent times, the amount of consumption has been raised greatly, which includes a variety of species. This is because of the significant roles of mushrooms on human nutrition and health (Khan *et al.,* 2008). Mushroom is a good source of protein, vitamin and minerals (Ogundele*et al.,* 2017). One of the most cultivated mushrooms in the world is oyster mushroom (*Pleurotusostreatus*). Oyster mushroom (*P. ostreatus*) is known for its broad range of uses as food and medicine and its nutritional values have been reported. It has protein (25-30%), fat (2.5%), sugar (17-44%), mycocellulose (7-38%) and mineral (potassium, phosphorus, calcium and sodium) of about 8-12% (Stanley, 2011). Oyster mushroom is a good source of essential amino acids and non-essential amino acids such as the gamma-amino butyric acid (GABA) and ornithine. Gamma-amino butyric acid is a nonessential amino acid that functions as a neurotransmitter whereas ornithine helps in synthesizing of arginine (Manzi*et al.,* 1999).
Also, in Nigeria, the oyster mushroom is the most popular mushroom among others. This is because oyster mushrooms have a wide range of temperature tolerance (15-30 $^{\circ}$C) so; these are ideally suitable for cultivation under both temperate and tropical climatic condition. Oyster mushrooms are cultivated and harvested throughout the year (Alam*et al.,*2007).

Sorghum (*Sorghum bicolor*) grain ranked third among the domesticated cereal for human consumption in many African countries including Nigeria (Elkhalifa and El-Tinay, 2002). Sorghum grain is made into flour and used in preparing various dishes for both children and adults, mostly as pap for children (Okoth and Ohingo, 2004). The nutritional composition of sorghum flour is, protein (7.84-9.23%), fat (0.5-0.9%), Ash (0.7-0.9%), fibre (1.7-2.0%) and carbohydrate (80-90%) (Okoye *et al.,* 2017). Cereals are generally low in lysine which is one of the essential amino acids (Boisen*et al.,* 2000).

Addition of oyster mushroom (*P.ostreatus*) to wheat, with high-quality cassava flour (Ekunseitan*et al*., 2016); and cassava starch-mushroom (*P. pulmonarius*) flour blends (Ojo*et al.,*2016) to improve the nutritional composition and functional properties of resultant composited flours have been reported. Ekunseitan*et al.* (2016) hypothesized that mushroom and high-quality cassava flour substitution in wheat flour up to 30% could be compared to 100% wheat flour in terms of nutritional requirement and functionality. Since oyster mushroom is rich in both essential and non-essential amino acids, its addition to sorghum flour will also improve its nutritional composition (Ekunseitan*et al.,* 2016). However, information on addition of oyster mushroom flour to sorghum flour and its effect on nutritional or functional quality are inadequate if not lacking. Therefore, the present study is aimed at determining the nutritional composition and functional properties of composite flour blends made from sorghum (*Sorghum bicolor*) and oyster mushroom (*P.ostreatus*).

## MATERIALS AND METHODS

### Materials

Sorghum flour was produced from sorghum (white endosperm non-tannin type) grains purchased from a retail market in Offa, Kwara State, Nigeria and milled (ALPA, Power Technology Co. Ltd., Shandong, China) to flour. Fresh oyster mushroom (*P. ostreatus*) was procured from a commercial mushroom farm at Ibadan, Oyo State, Nigeria. Analytical grade reagents (Sigma-Aldrich, St. Louis, MO, USA) were used for all the analyses.

### Mushroom Flour Processing

The fresh mushroom obtained was pretreated with 1% potassium metabisulfite for 35 min and dried in hot air oven (LEEC, Ltd., Serial No. 3114, Nottingham, UK) at 50 °C for 10 h using a modified method of Ekunseitan et al. (2012), with reduction in drying temperature and increase in drying time. It was then milled, sieved, and stored in a zip lock bag and refrigerated (- 4 ºC) till when needed for further analyses. The flow chart for oyster mushroom flour processing is shown in Figure 1.

### Preparation of Composite Flour

Composite flour samples were prepared with varying quantities of sorghum and oyster mushroom. The flour samples (Sorghum, and oyster mushroom) were weighed and mixed using kitchen size mixer (KMX750AB, Kenwood Ltd., Havant PO9 2NH, UK). Sample A was 100% Sorghum flour, Sample B was 100% mushroom flour, sample C was 95% Sorghum flour and 5% mushroom flour, sample D was 90% Sorghum flour and 10% mushroom flour, while sample E was 85% Sorghum flour and 15 % mushroom flour. All analyses were carried out in triplicates.

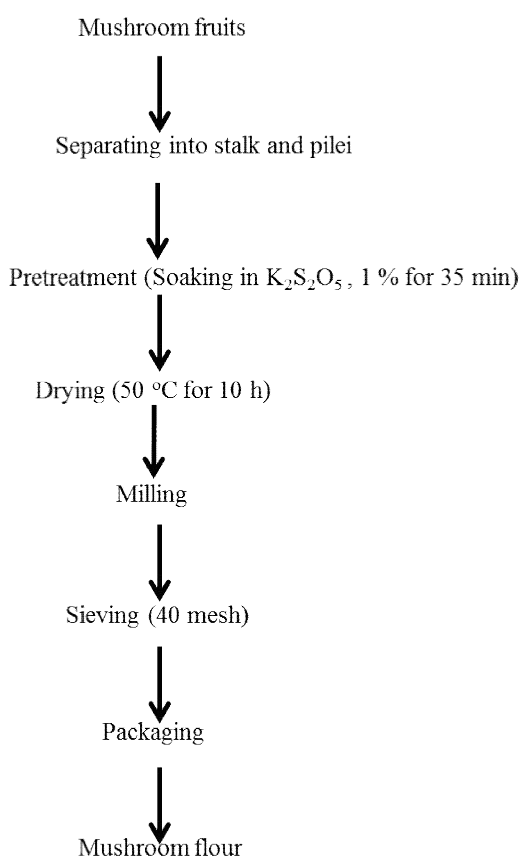


**Figure 1** Flow chart to produce mushroom flour (Ekunseitan*et al*. (2016) modified)

### Analyses

### Proximate composition

The moisture, crude protein, crude fat, ash, and crude fibre contents of the samples were determined according to standard analytical methods of Official Analytical Chemists' (A.O.A.C., 2000). Carbohydrate content of the samples was determined by difference [100 – % (moisture + ash + crude fibre + crude protein + crude fat)]. All proximate analyses of samples were carried out in triplicate and were reported in percentage.

**Determination of functional properties determination**

**Water absorption determination**

This was determined by a modified method of Lin and Zayas (1987). Each sample (2.0 g) was transferred into a lagged 50 ml centrifuge tube and weighed ($W_1$). Exactly 30 ml of hot distilled water (70 °C) was added to each sample gently to wash down samples at the sides of the centrifuge tubes using a glass stirring rod. The sample and the water were mixed for 25 min on a vortex. The flour-water suspension was rested for 12 min; the flour adhering to the side of the centrifuge tube was scrubbed down with the glass rod to prevent it from drying. Additional 10 ml of hot distilled water was used to wash the sample adhering to the stirring rod into the sample. The suspension was centrifuged (Z366K, Hermle Laboratory, Wehingen, Germany) at 1165× ***g*** for 25 min at 50 °C The tube was cooled in a desiccator and weighed ($W_2$).

$$\text{Water Absorption} = \frac{W2-W1}{Weightofsample}$$

**Bulk density determination**

This was determined using the gravimetric method as described by Okaka and Potter 1979). The sample (10 g) was weighed into a 25 ml graduated cylinder. The cylinder was gently tapped ten times against the palm of the hand. The bulk density was expressed as the sample per volume occupied by the sample.

**Swelling capacity determination**

This was done using the modified method of Lin and Zayas (1987). Each sample (2 g) was dispersed in 40 ml distilled water. The resultant slurry was heated to a temperature of 70 °C for 30 min in a water bath, cooled to room temperature, and centrifuged (Z366K, Hermle Laboratory, Wehingen, Germany) at 4100× *g*for 25 min at 20 °C. The supernatant liquid was decanted, and the centrifuge tube was placed in a hot air oven and dry for 25 min at 50 °C. The residue was weighed ($W_2$). The centrifuge tube containing the sample alone was weighed prior to the addition of distilled water ($W_1$).

$$\text{Swelling Capacity} = \frac{W2-W1}{Weightofsample}$$

**Determination of the Pasting Properties of Samples**

Pasting properties of the flour were determined using Rapid ViscoAnalyser (RVA TECMASTER, Perten Instrument, KungensKurva, Sweden) as described by Sanni*et al.* (2004).

**Statistical Analysis**

Data obtained for proximate composition, functional and pasting properties were expressed as means ± standard deviation of three replications and subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS; version 21) for windows. Significant means were separated using Duncan's multiple range comparison tests at 5% level of probability.

**RESULTS AND DISCUSSION**

**Proximate Composition**

The proximate composition results of sorghum flour mixed with oyster mushroom flour at different ratio are shown in Table 1. With the addition of mushroom flour to sorghum flour, it appears that there was a progressive and significant increase ($p < 0.05$) in protein, ash and crude fibre, while carbohydrate content decreased. The moisture content of all the samples reduced with the addition of mushroom flour. 100% sorghum flour had the highest value (9.62%) and 100% mushroom flour (MF) had the least value (7.46%). Addition of mushroom flour increased the protein content of sorghum flour (SF), with the sample that contained the highest ratio of mushroom flour having the highest value among the composited samples (9.46%) which followed 100% mushroom flour (20.4%). Sorghum flour (100%) had the least protein content (6.20%), followed by sample with 95 % SF + 5% MF (7.26%), and followed by 90% SF + 10% MF (8.44%). Differences in protein content between 100% SF and the composited flour samples suggest that MF is highly promising for improving the protein content of composited flours and their potential products. Ajala and Taiwo (2018) reported an increase in protein content and some other nutrients when oyster mushroom was composited with "Ogi".

The crude fat results showed oyster mushroom (*P. ostreatus*) flour had the least value (0.59%), followed by formulated sample with 85% SS +15% MF (1.06%), followed by sample with 90% SF +10% MF (1.98%), then formulated sample with 95% SF +5% MF (2.12%) and 100% sorghum flour having the highest value (2.98%). Ash and crude fibre followed the same trend as for crude fat, protein and moisture, with oyster mushroom flour having the highest value (3.44 and 0.74%) and 100% sorghum flour having the least value (0.14 and 0.28%). Increase in the ash content due to increase addition of mushroom flour agrees with the findings of Ekunseitan*et al.* (2016), which reported that mushroom is rich in mineral elements. The carbohydrate value of all the samples reduced with the addition of mushroom flour. Mushroom flour had the least (66.4%) and 100% sorghum flour had the highest (83.6%).

The increase in proximate composition of all the composited samples with oyster mushroom flour may be due to the increase addition of mushroom flour. This result agree with the report of Ekunseitan*et al*. (2016). They reported an increase in the nutritional composition of wheat flour and high-quality cassava flour blends with oyster mushroom. Also, the report of Oyetayo and Ariyo. (2013) showed that oyster mushroom is rich in protein and amino acids and the authors suggested that mushroom flour is an ingredient for the formulation of nutrient-based food products. Similarly, Aremu*et al.* (2009) strengthened further in their studies on the proximate compositions of some species of mushroom that they are good sources of protein and carbohydrates.

**Table 1.** Proximate Composition of Composite Flour from Sorghum and Mushroom Flour (%)

| Samples | Moisture | Protein | Crude fat | Ash | Crude fibre | Carbohydrate |
|---|---|---|---|---|---|---|
| 100% SF | 9.62±0.16$^{c}$ | 6.20±0.42$^{a}$ | 2.98±0.15$^{e}$ | 0.14±0.12$^{a}$ | 0.28±0.16$^{a}$ | 80.8±0.51$^{d}$ |
| 100% MF | 7.46±0.11$^{a}$ | 20.41±0.32$^{e}$ | 0.59±0.12$^{a}$ | 3.44±0.11$^{c}$ | 0.74±0.11$^{d}$ | 67.4±0.34$^{a}$ |
| 95% SF + 5 % MF | 8.14±0.12b | 7.26±0.22$^{b}$ | 2.12±0.13$^{d}$ | 2.17±0.13$^{b}$ | 0.46±0.25$^{b}$ | 79.9±0.41$^{c}$ |
| 90% SF + 10% MF | 8.02±0.20b | 8.44±0.12$^{c}$ | 1.98±0.12$^{c}$ | 2.25±0.16$^{b}$ | 0.52±0.12$^{c}$ | 78.8±0.35$^{b}$ |
| 85% SF + 15% MF | 7.84±0.37a | 9.46±0.22$^{d}$ | 1.06±0.11$^{b}$ | 2.56±0.15$^{b}$ | 0.58±0.10$^{c}$ | 78.5±0.44$^{b}$ |

Values within the same columns with different letters differ significantly ($p < 0.05$)
SF is sorghum flour
MF is Mushroom flour

**Functional Properties**

The functional properties result of 100% sorghum flour, 100% oyster mushroom flour and the formulated samples are shown in Table 2. The water absorption capacity of composite flour decreases with increase in amount of oyster mushroom added. 100% sorghum flour has the highest value (13.29 g/ml) and 100% oyster mushroom flour had the least (0.40 g/ml). The composited samples have similar results with a slight difference in value. Composited sample with 95% MF + 5% MF has the highest value (11.2 g/ml), after 100% sorghum flour. Composited sample with 90% SF +10% MF has 10.16 g/ml and 85% SF + 15% MF have 9.49 g/ml.
The swelling capacity results for all the composited samples followed the same trend. 100% sorghum flour having the highest value (2.26 g/ml) and 100% oyster mushroom flour with the least (0.41 g/ml). The swelling capacity of the composited samples reduced with increase in addition of oyster mushroom flour (i.e. 95% SF + 5% MF > 90% SF + 10% MF > 85% SF + 15% MF).

The bulk density result of 100% sorghum flour was the highest (3.02 g/ml), followed by composited sample 95% SF + 5 % MF (2.62 g/ml) and 100% oyster mushroom flour (1.08 g/ml). The remaining composited samples (90% SF + 10% MF and 85% SF + 15% MF) have the bulk density value of 2.60 g/ml and 2.47 g/ml. The bulk density is presumably influenced by the structure of starch polymers and loose structure of the starch polymer could result in low bulk density. Bulk density is an important factor in determining packaging requirements, raw material handling, and application in the wet processing food industry (Ajanaku*et al.,* 2012). These results indicated that the addition of oyster mushroom flour to sorghum flour slightly reduced the functional properties of the flour, which may not have a significant effect during the processing of the flour. These results are in line with the report of Ajala and Taiwo (2018), when they composited oyster mushroom with “Ogi”.
The reduction in water absorption capacity may be due to the level of hydrophilicity of the starch granules present in the flours (Sorghum and oyster mushroom flour). Starch granules with large amorphous site tend to absorb water more than starch granules with the less amorphous site (Lawal, 2004). Although the water absorbed may not be retained for long before retrogradation set in. This agrees with the report of Aremu *et al. (2009),* that flour with high water absorption capacity has high hydrophilic properties.

**Table 2.** Functional Properties of Composite Flour from Sorghum and Mushroom Flour

| Samples | Water Absorption Capacity | Swelling Capacity | Bulk density (g/ml) |
|---|---|---|---|
| 100% SF | 13.29± 0.51[e] | 2.26±0.35[e] | 3.02±0.17[c] |
| 100% MF | 0.40± 0.10[a] | 0.41±0.10[a] | 1.08±0.21[a] |
| 95% SF + 5 % MF | 11.22±0.21[d] | 1.86±0.19[d] | 2.62±0.14[b] |
| 90% SF + 10% MF | 10.16±0.22[c] | 1.64±0.58[c] | 2.60±0.12[b] |
| 85% SF + 15% MF | 9.49±0.15[b] | 1.26±0.16[b] | 2.47±0.21[b] |

Values within the same columns with different letters differ significantly ($p < 0.05$)
SF is sorghum flour
MF is mushroom flour

**Pasting profiles**

Table 3 shows the pasting profiles of sorghum flour blend with oyster mushroom flour at a different ratio measured at Rapid Visco Unit (RVU). Pasting profile of flour is one of the most important properties influencing the quality and aesthetic consideration of food in that it affects the texture, digestibility and end-use of starch-based food commodities (Ajanaku*et al.,* 2012). Addition of MF to SF affected the pasting profile of the composited flour samples. Inclusion of MF resulted in significant ($p < 0.05$) decrease all the pasting parameters. The peak viscosity of sorghum flour was the highest (173.54 RVU), followed by composited sample with 95% SF + 5 % MF (152.1 RVU), followed by 90% SF + 10% MF (123.43 RVU), and 85% SF + 15% MF (110.42 RVU). 100% oyster mushroom flour had the least peak viscosity of 12.36 RVU. The final viscosity of all the composited sample followed the same pattern with 100% sorghum flour having the highest value (198.17 RVU) and 100% oyster mushroom flour having the least value (21.26 RVU). There was a slight decrease in the peak time of all the samples except 100% oyster mushroom flour having the least peak time of 2.50 min. The remaining samples had peak time that ranged between 4.24 to 4.64 min. However, the pasting time was not significantly different in all the composited and 100 % SF samples. The pasting temperature was like peak time with 100% sorghum flour having the highest pasting temperature of 83.1°C and 100% oyster mushroom flour had the least (62 °C). The remaining samples have pasting temperature ranged between 82.3 ºC to 82.6 ºC.

| Samples | Peak Viscosity (RVU) | Trough (RVU) | Breakdown viscosity (RVU) | Final viscosity (RVU) | Setback Viscosity (RVU) | Peak time (min) | Pastin Temperatur |
|---|---|---|---|---|---|---|---|
| 100% SF | 173.54±1.52[e] | 131.72±0.75[e] | 30.49±0.21[e] | 198.17±1.52[e] | 67.12±0.32[e] | 4.64±0.12[b] | 83.12±0.52 |
| 100% MF | 12.36±0.81[a] | 9.56±0.10[a] | 2.80±0.11[a] | 21.26±0.11[a] | 11.70±0.12[a] | 2.50±0.21[a] | 62.02±0.32 |
| 95% SF + 5 % MF | 152.12±0.78[c] | 110.32±0.68[d] | 29.04±0.20[d] | 174.21±1.47[d] | 63.99±0.21[d] | 4.25±0.24[b] | 82.62±0.26 |
| 90% SF + 10% MF | 123.43±0.91[c] | 101.12±0.77[c] | 20.12±0.11[c] | 139.22±0.72[c] | 38.08±0.22[c] | 4.24±0.15[b] | 82.42±0.22 |
| 85% SF + 15% MF | 110.42±0.65[b] | 92.81±0.54[b] | 18.14±0.12[b] | 129.16±0.98[b] | 36.95±0.21[b] | 4.24±0.23[b] | 82.32±0.41 |

The pasting properties of sorghum flour that contain the various percentage of oyster mushroom flour blend indicated that oyster mushroom flour slightly affects the pasting properties of sorghum flour. This result agrees with the report of Ojo*et al.* (2016) who reported a decrease in pasting properties of cassava flour blend with mushroom flour. The decrease in the pasting properties of the composited sample may be associated with starch granular size, shape and type. Peak viscosity has been associated with the degree of starch damage which means, high peak viscosity resulted from high starch damage (Shimelis*et al.,*2006). Ai *et al.* (2011) reported that sorghum starch granules respond to shear thin more and have higher peak viscosity and low pasting time. The decrease reported in this study showed that oyster mushroom flour substituted for sorghum flour prevented the starch granule from absorbing water which led to a reduction in peak viscosity and final viscosity. This result concurs with the report of Ng *et al.* (2017), that incorporation of dietary fibre-rich oyster mushroom (*Pleurotussajor-caju*) powder reduced the pasting properties of biscuit made from composite flour blends from wheat and oyster mushroo

**Table 3.** Pasting Properties of Composite Flour from Sorghum and Mushroom Flour
Values within the same columns with different letters differ significantly ($p < 0.05$)
SF is sorghum flour
MF is mushroom flour
RVU is Rapid visco-analyze unit

## CONCLUSION

The addition of oyster mushroom (*P. ostreatus*) flour to sorghum flour generally increase the protein, ash and crude fibre contents of composited flours compared to the control (100% SF).Addition of 15% oyster mushroom flour to sorghum flour can still be used as raw materials in the confectionery industry in the production of cakes, doughnut and bread with better nutritional quality, value addition and could promote food security.

The use of the composited flour could reduce the burden of wheat importation and their nutritional contents would be an advantage over the conventional wheat-based food products. Further studies on the sensory characteristics and consumer acceptability of sorghum-oyster mushroom flour-based products are essential.

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## DISCLOSURE STATEMENT

The authors declare no conflict of interest

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