Proximate Composition Of Fermented Maize-Soybean Composite Flour Blends

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K E Y W O R D S

Fermentation,
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*** C O R R E S P O N D I N G A U T H O R**

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A B S T R A C T

The objective of this study was to determine the proximate composition of fermented maize-soybean flour blend. Maize grains were sorted, cleaned, fermented for 48 h, oven dried (60 °C to constant weight), milled to flour and then sieved (250 µm) to produce maize Flour. The soybean was sorted, cleaned, boiled, cooled, dehulled, and fermented for 48 h with Rhizopus oligosporus (0.4g per 100g of beans), oven dried (60 °C to constant weight), milled and sieved (250 µm) to produce fermented soybean flour. Through mixture design, maize and soybean flours samples were blended in the ratios 90:10, 80:20, 70:30, 60:40, and 50:50 to obtain composite flours while 100% maize flour and 100% soybean flour served as controls. Proximate composition of the samples was evaluated using standard AOAC method. The results showed that the composite flours produced were more nutritious than the control flour samples. Carbohydrate was the most abundant, followed by the moisture content and the crude protein. Flour sample with 90:10 (Fermented maize:fermented soybean) had the highest carbohydrate content (70.91%). Flour sample produced with 50:50 fermented maiz:fermented soybean had the highest moisture (10.76%), crude protein (11.55%), crude fibre (4.78%), fat (3.35%) and ash (2.39%). Based on the findings from this research, it recommended that for nutritional enhancement and optimum complementation, flour blends of fermented maize and fermented soybean could be produced at a ratio of 50:50.

INTRODUCTION

Maize (*Zea mays L*) is the foremost cereal crop globally and a crucial calorie source for a significant majority of the global populace (Chaves-López *et al.*, 2020). It contributes 40% of the overall cereal production in sub-Saharan Africa and serves as the provider of approximately 30% of the total calorie consumption for over 4.5 billion individuals in developing nations (Chaves-López *et al.*, 2020). Nevertheless, while maize is a valuable calorie and nutrient source, its protein content is comparatively lower in nutritional quality compared to proteins found in milk, soybeans, peas, and lupins (Edema,*et al.*, 2005). The lack of some essential amino acids in maize grains necessitates that legumes such as soybean with the amino acids could be complemented for optimal nutritional enrichment.

Soybean (*Glycine max*) is extensively cultivated rich protein or as oilseed. The protein content in these beans can range from 33% to 50%, depending on factors such as the specific variety and the processing methods employed (Oyeyinka *et al.*, 2020). Soybean grains are excellent sources of phytochemicals such as phytic acid, alpha-linolenic acid, and the isoflavones-genistein and daidzein (Basson *et al.*, 2021). Soybean, like other legumes, contains crucial minerals like calcium and phosphorus, as well as essential vitamins such as vitamin A, B-group vitamins, and vitamin C (Igyor *et al.*, 2011). Because of these nutritional qualities, soybean and other legumes have been, over the years, incorporated into diverse food products to address the limited availability of protein (Innocent *et al.*, 2019). They serve as an affordable protein source that can potentially be used to enhance staple foods like maize meal in developing nations (Oyeyinka *et al.,* 2020).

To enhance the nutritional value of legumes and maize-based products as well as to reduce the anti-nutrients they contain, fermentation is commonly employed (Edema, *et al.,* 2005). Fermentation technology stands at the forefront of food technology as a powerful tool, offering a strong basis for the creation of safe food products that possess enhanced nutritional and functional characteristics (Wakshama *et al., 2010*). Fermentation, a notable biochemical process, has been documented to bring about several beneficial transformations in bio-substrates. These encompass enhancements in nutritional value, intensified flavor, alterations in color, taste, and aroma, improvements in protein, amino acid, and lipid profiles modifications in crude fiber content, and the augmentation of bio-colors and pigmentation during solid-state fermentation ((Wakshama *et al., 2010*; Mhalaskar *et al.,* 2017). Solid-state fermentation (SSF) of agricultural residues and feedstock has gained attention as an appealing approach due to its ability to boost nutritional value and improve the availability of nutrients (Wang *et al.,* 2018). The practice of enhancing cereal-based confections with legume flours has long been acknowledged in areas where protein utilization is insufficient (Jideani and Onwubali, 2009). This is due to the fact that legumes are rich in essential nutrients such as proteins, minerals, vitamins B-complex and lysine, which is an amino acid that is often limited in most cereals (Jideani and Onwubali, 2009). Therefore, by blending legumes with cereals at the appropriate ratio, they can complement each other nutritionally (Okoye and Okaka, 2009). Details on the proximate composition of maize-soybean flour abound but there exists some gap in knowledge regarding the proximate composition of composite flours produced from fermented maize and fermented soybean. In the present era of advancing functional food, the application of bioprocessing methods like fermentation is driving notable changes in the realm of food and nutrition (Tsafrakidou *et al*., 2020).

Composite flour is a mix of several flours produced from roots, tubers, cereals and legumes either with or without the addition of wheat flour (Shittu *et al.,* 2007). Composite flours have been widely and effectively utilized in the manufacturing of baked goods. These reports indicate that the characteristics of the final product are influenced by the relative proportions of the composite ingredients and the properties of the flour (Oladunmoye *et al.,* 2010). Maize flour is often an inexpensive staple in many regions, while soybean flour, although relatively more expensive, can be added in smaller amounts to achieve the desired nutritional benefits. This combination allows for a cost- effective way to improve the nutritional value of maize-based products. Therefore, the objective of this study is to determine the proximate composition of composite flours produced from fermented maize (*Zea mays L*) and fermented soybean (*Glycine max*) flours.

MATERIALS AND METHOD

Sources of Raw Materials

Maize grains were purchased from Eke Awka Market in Awka, Anambra State, Nigeria while *Rhizopus oligosoprus was* purchased from Indonesia (Ragi Tempe, Raprima Inokulum Tempe, PT.Aneka Fermentasi Industri, Sandung 40553 -Indonesia).

Experimental Design

D-optimal mixture design was adopted for the ratio mix of fermented maize and fermented soybean. The composite flours were made from flour blends of fermented maize:soybean in the following order: 100:0, 0:100, 90:10, 80:20, 70:30, 60:40 and 50:50.

Production of fermented maize flour

The maize flour was prepared according to the method of Houssou and Ayemor (2002). The maize grains (free from dirt, damaged and contaminated grains) were cleaned, washed and then soaked in potable water for 48 h with occasional change of the soak water for fermentation to occur. After 48 h, the soaked grains were drained, rinsed and oven dried at 60°C to constant weight. The dried grains were milled with an attrition mill (DTGH 9826, UK) into flour. The powder obtained was sieved through a sieve of 250 μm aperture size into a clean plastic bowl. The maize flour produced was packaged in an airtight plastic container for further use.

Production of fermented soybean flour

The soybean flour was produced according to the method described by Edema *et al*. (2005). The soybean seeds were sorted to remove pebbles, stones and other extraneous materials. The seeds were washed with tap water and steeped in portable water for 2 h. The steeped soybeans were drained and boiled for 30 min at 100°C, dehulled manually by rubbing in between the palms and the hulls were removed by floatation and rinsing with clean water. The dehulled soybeans were inoculated with *Rhizopus oligosporus* (0.4g per 100g of beans) and vinegar (2.85ml per 1000g of beans) and left to ferment for 48 h. The fermented beans were oven dried at 60°C to constant weight and milled in attrition mill (DTGH 9826, UK). The soybean powder was sieved through a sieve of 250μm aperture size to obtain smooth flour. The soybean flour was packaged in a low-density polyethylene bag until used.

Determination of proximate composition

Flour samples were evaluated for ash, fat, protein, and moisture as described by AOAC (2010). The moisture content of the samples was determined using the oven-dry method, where samples were dried in an air-draft oven (Gallenkamp 300 plus series, Widnes, Cheshire, 105 U.K.) at 105 °C till constant weight was achieved. Fat was measured by Soxhlet extraction method using petroleum ether (Loba Chemie, Mumbai, India) as a solvent. Ash content was determined by incinerating the samples in a muffle furnace (Hasthas, Servell Engineers, Chennai, India) at 600 °C for 5 h. The micro-Kjeldahl method was used for protein analysis using a nitrogen conversion factor of 6.25. Carbohydrate value was calculated by difference (100 – the sum of moisture, ash, fat, and protein). Energy value was calculated based on the calorific coefficients of the samples corresponding to fat, protein, and carbohydrate i.e. energy value (kcal/100 g) = 4 (g carbohydrate) + 4(g protein) + 9(g 113 fat).

RESULT AND DISCUSSION

Proximate Composition of Fermented Maize-Soybean Flour Blends

The proximate composition of fermented maize-soybean composite flour was evaluated and the results are presented in Table 1. Moisture content of the flour samples ranged from 10.23 – 10.88%. The sample CHR which contains 100% maize (100:0 – Maize: soybean) had the least moisture content of 10.23%, while sample IST (100% soybean) had the highest moisture content of 10.88%. There was significant (p<0.05) difference in the moisture content of the composite flour samples, but the sample IST containing 100% soybean was not significantly different (p>0.05) to Samples SOM (60:40) and JAN (50:50).

Table 1: The proximate composition (%) and Energy value (kcal/100g) of fermented maize-fermented soybean composite flours

Sample Code	Moisture content (%)	Crude Protein content (%)	Ash content (%)	Crude fibre content (%)	Crude Fat content (%)	CHO (%)	Energy (kcal/100g)
CHR	$10.23^{d}\pm 0.02$	$8.73^{d}\pm 0.01$	$2.13^{d}\pm0.12$	$4.55^{b}\pm0.02$	$3.22^{b}\pm0.02$	$69.52^{c}\pm0.01$	$342.0^{g}\pm0.01$
IST	$10.88^{a}\pm0.03$	$20.3^{a}\pm 0.02$	$2.63^{a}\pm0.02$	$3.79^{c}\pm0.06$	$6.78^{a}\pm0.28$	$55.66^{g}\pm0.01$	$364.7^{a}\pm0.01$
ABE	$10.26^{cd}\pm0.02$	$8.81^{d}\pm0.04$	$2.18^{cd}\pm 0.05$	$4.57^{b}\pm0.02$	$3.26^{b}\pm0.06$	$70.91^{a}\pm0.01$	$348.3^{b}\pm0.01$
OBI	$10.4^{cd}\pm0.13$	$9.19^{d}\pm0.54$	$2.26^{bcd}\pm0.05$	$4.62^{b}\pm0.03$	$3.28^{b}\pm0.08$	$70.23^{b}\pm0.01$	$347.3^{c}\pm0.01$
NME	$10.5^{bc}\pm0.21$	$9.77^{cd}\pm0.53$	$2.33^{bc}\pm0.04$	$4.64^{b}\pm0.02$	$3.32^{b}\pm0.06$	$69.43^{d}\pm0.01$	$346.7^{d}\pm0.01$
SOM	$10.7^{ab}\pm0.20$	$10.49^{c}\pm0.55$	$2.36^{b}\pm0.06$	$4.68^{ab}\pm0.01$	$3.34^{b}\pm0.06$	$68.40^{e}\pm0.10$	$345.6^{e}\pm 0.01$
JAN	$10.76^{ab}\pm0.19$	$11.55^{b}\pm1.23$	$2.39^{b}\pm0.06$	$4.79^{a}\pm0.18$	$3.35^{b}\pm0.06$	$67.16^{f}\pm0.01$	$344.9^{f}\pm0.02$

Values are mean standard deviation of triplicate determinations. Values with different superscript within the same column show significant difference (p<0.05).

KEY: CHO = Carbohydrate, CHR= 100% maize, IST= 100% soybean, ABE= 90% maize:10% soybeans, OBI= 80% maize: 20% soybean, NME= 70% maize: 30% soybean, SOM= 60% maize: 40% soybean, JAN= 50% maize: 50% soybean.

Similarly, the sample CHR containing 100% maize was significantly similar (p>0.05) to samples ABE (90:10) and OBI (80:20).

It was observed that an increase in the proportion of soybean resulted in increase in the moisture content. However, the increase in moisture content could be a consequence of bound water arising from the presence of lipophilic-hydrophilic interaction of the soybean (oilseed crop). (Sharma *et al.*, 2020). This study tallies with the moisture content value reported by Ogodo *et al.* (2017) in a related study.

The crude protein content of the composite flours ranged from 8.73 – 20.3%, with the crude protein content value of the sample IST containing 100% soybean being the highest at 20.3%, while the crude protein content of sample CHR containing 100% maize being the least at 8.73%. Protein is the most important macronutrient necessary for growth and body-building (Rajkumar and Selvakulasingnam, 2019). The flour samples - ABE (90:10), OBI (80:20), NME (70:30), SOM (60:40), JAN (50:50) had higher crude protein content value compared to Sample CHR containing 100% maize. According to Nasseri *et al.* (2017), the proportion of protein in the total mass would have increased, as carbohydrates were utilized by the micro-organisms during fermentation as an energy source thereby producing carbon dioxide as a by-product and causing the nitrogen to be concentrated, as well as soybean incorporation in the composite flours.

The values (%) of the total fat content in the flour ranged from 3.22 – 6.78%. There was a notable significant (p<0.05) increase in the fat content of the samples as the proportion of soybean added was increased. The soybean is an oil seed with high oil content and would have contributed to the increase in the fat content as soybean quantity was increased. The sample CHR containing 100% maize had the least fat content at 3.22% value, while the sample IST containing 100% soybean had the highest fat content value at 6.78%. the sample CHR with 100:0 - maize:soybean was not significantly different (p>0.05) from samples ABE (90:10), OBI (80:20), NME (70:30), SOM (60:40), JAN (50:50) containing different proportions of soybean, while the sample IST containing 100% soybean was significantly (p>0.05) different from the other samples. Fat in the diet is necessary for the supply of essential fatty acids and helps to ease the absorption of fat-soluble vitamins (Musa *et al.,* 2022).

Crude fibre estimates the quantity of indigestible cellulose, lignin, pentose and other constituents of similar nature present in foods (Musa *et al.,* 2022). The crude fibre content of the composite flour samples ranged from 3.79 – 4.79% with Sample CHR containing 100% maize having the highest crude fibre content and Sample IST containing 100% soybean having the least crude fibre content value. The sample CHR containing 100% maize was not significantly (p>0.05) different to samples ABE (90:10), OBI (80:20), NME (70:30), SOM (60:40), but was significantly (p>0.05) different to sample that had 50:50 (maize:soybean) blends. The presence of high fibre in food products is essential owing to its ability to facilitate bowel movement (peristalsis), bulk addition to food and prevention of many gastrointestinal diseases in man (Satinder *et al.*, 2011).

The ash content of the flour samples ranged from 2.13 to 2.63% where the flour sample IST containing 100% soybean had the highest ash content value, while the sample CHR containing 100% maize had the least amount of ash content. The sample CHR containing 100% maize was not significantly (p>0.05) different from sample ABE (90:10) and OBI (80:20), but it was significantly (p<0.05) different to NME (70:30), SOM (60:40) and JAN (50:50). The sample IST containing 100% soybean was significantly (p<0.05) different and higher than all the other samples. The quantity of ash content in a food material is a reflection of its mineral content (Musa *et al.,* 2022). The variation of ash content of samples of different studies may be due to the nature and amount of ions present in the soil from which plant they draw their nutrients (Musa *et al.,* 2022). It was observed that there was an increase in ash content of flour samples with increasing levels of soybean flour and reducing levels of maize flour. The reason for this increase in ash content as soybean quantity was increased in the composite flours could have been a result of the high amount of ash that soybean contains.

The carbohydrate content was the highest nutrient in the composite flour. The carbohydrate content ranged from 55.66 to 70.91% with the control flour sample IST 100% soybean having the least carbohydrate content value, while the sample ABE (90:10 - maize:soybean) had the highest carbohydrate content value. There were significant (p<0.05) differences in the carbohydrate content of all the samples. The carbohydrate content of samples formulated with fermented maize and fermented soybean - 90:10 (ABE), 80:20 (OBI), 70:30 (NME), 60:40 (SOM), 50:50 (JAN) decreased significantly (p<0.05) from 70.91 to 67.16% with an increase in the ratio of soybean substitution. The current finding was in agreement with the findings of Ogodo *et al.* (2017) who reported a decrease in carbohydrate content from 70.82% to 68.01% of LAB consortiumfermented maize flour. The decrease in carbohydrate could be attributed to the use of carbohydrate as a source of energy by microorganisms during fermentation (Nasseri *et al.*, 2011).

Energy content ranged from 342.0 – 364.7 kcal/100g with sample made from 100% fermented soybean (IST) having the highest energy content value, while the sample made from 100% fermented maize (CHR) had the least energy content value. There was no significant ($p>0.05$) difference between all the samples.

CONCLUSION

In this study, there was partial substitution of fermented maize flour with fermented soybean flour in different proportions. The proximate composition of fermented maize-soybean composite flours revealed significant variations in nutrient content based on the maize-to-soybean ratio. The study confirmed that fermentation influenced nutrient composition, particularly by reducing carbohydrate content, while enhancing protein concentration. This research showed that blending fermented maize with fermented soybean in different proportions can help enhance the nutritional value of composite flour, making it a valuable option for improving dietary protein intake. Based on the results of the analyses carried out, it is highly recommended that composite flour blends be produced at a ratio of 50:50, fermented maize:fermented soybean flour blends for enhanced nutritional quality.

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