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RESEARCH ARTICLE

Chemical and Functional Properties of *Zea mays* Semolina Fortified with *Vigna subterranea (L.) Verde*

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ABSTRACT

Analysis was carried out on the sensory, mineral, functional, and proximate properties of maize semolina fortified with bambara groundnut flour using different formulations. The sensory evaluation of maize semolina fortified with bambara nut flours was carried out using the different formulations. Sample MWB which is sample produced between 40% maize, 40% wheat and 20% bambara nut flours. It had 7.60% color, 7.90% flavor, 6.90% taste, 8.50% texture, and 9.00% acceptability, respectively. The calcium, magnesium, iron, zinc, and phosphorus contents were 92.59 mg/kg, 179.46 mg/kg, 300.58 mg/kg, 16.35 mg/kg, and 6.80 mg/kg, respectively. For the functional properties, the oil absorption capacity (g/g) was 6.0, water absorption capacity (g/g) was 7.80, emulsion capacity was 54.00%, gelation capacity was 22.60%, foam capacity was 48.30%, and bulk density was 0.78 g/ml. The moisture content, ash content, crude fat, crude fiber, and the crude protein composition were 12.29%, 1.60%, 5.60%, 3.80%, 17.38%, and 59.33% carbohydrate, respectively. The results showed that the nutritive value of bambara nut flour incorporated into maize semolina flour can be used to supply protein to the human diet.

Key words: Semolina, *Triticum Flour, Vigna subterranea (L .) Verde*, *Zea mays*

INTRODUCTION

Cereals are the most widely cultivated and consumed crops globally. In Nigeria, specifically in the northern part of the country, cereal provides a major food resource for man. It is the major source of energy and protein in the diet for human. Maize is the second most important cereal crop in Nigeria ranking behind sorghum in the number of people it feeds. Estimated annual production of maize is about 5.6 million tones.[8] Maize is a multipurpose crop, providing food and fuel for human being, and feeds for animals (poultry and livestock). Its grain has great nutritional value and can be used as raw material for manufacturing many industrial products.[3] Due to nutritional composition of maize, it serves as a good substrate for fungi development that may cause nutritional losses and production of toxic substances known as mycotoxin. Maize is, after wheat and rice, the most important cereal grain in the world, providing nutrients for humans and animals and serving as basic raw materials for the production of starch, oil and protein, alcoholic beverages, food sweeteners, and more recently, fuel.

Botanically, maize *(Zea mays*) belongs to the grass family, "Germineae" and is a tall annual plant with an extensive fibrous root system. Maize (*Zea mays* L.) is an important cereal grain in the world, providing nutrients for animals.[10] In Sub-Saharan Africa, maize is a staple food for an estimated 50%; it is a cross-pollinating species, with the female (ear) and male (tassel) flowers in separate places on the plant. The grain develops in the ears or cobs, often one on each stalk; each ear has about 300 g per 1000 kernels in a variable number of rows (12 or 16). Weight depends on genetic, environmental, and cultural practices. Grain makes up about 42% of the dry weight of the plant. The kernels are often white or yellow in

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color, although black, red, and a mixture of colors are also found.There are a number of grain types in the population, and it remains the most important agricultural crop for over 70 million farm families worldwide. Of the 22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa.[17] Maize is used as human food in the form of tortillas, porridge, popcorn, and barbecues and as forage and silage for animals. It is also a good source of industrial products such as starch,[23] vitamin,[22] fiber,[20] oil,[9] weaning food,[12] porridges,[14] and ethanol (Mburu *et al*, 2013). Maize kernels are the largest cereal seed weighing 250–300 mg each; they are flat seed due to pressure during growth from adjacent kernels on the cab. The kernels have a blunt crown and pointed conical tip cap.[11] The kernel contains a complete embryo and all the structural, nutritional, and enzymatic functions required for growth and development into a plant.[7] About 80 species exist and consist of different colors, textures, and grain shapes and sizes.

Semolina is a type of flour that is remarkably versatile than the other varieties. Also known as Durum wheat, it is a popular (if not more economical) raw material for dried pasta. This wheat middling is particularly favored in the Middle East and Europe for making raised or flatbread or for thickening soups. This is also great as a coating or breading mix for fish fillet, fried chicken, or hash browns. This flour is a healthy source of the following vitamins and minerals: Selenium, thiamine, foliate is a B-complex vitamin, carbohydrate, and smaller structure called amino acids makes up the protein found in meat and legume, trace minerals such as zinc, phosphorus, and magnesium.

Bambara nut (*Voandzeia subterranea (L.)* thouars) is an indigenous African crop that is now grown from across Sahara to South Africa.[6] As the shortage of food continues to be a major problem in Africa, these legumes are being promoted more than before to help in combating malnutrition.[18] The affordability of plant protein source relative to that of animal origin has led to the intensified development of legume processing as a means of enhancing the availability, palatability, and diversity of leguminous source of dietary protein. Studies had revealed that detailed nutritional composition to be 16% crude protein, 9.7% moisture, 5.9% crude fat, 2.9% ash, and 64.9% total carbohydrate.[5] It contains an appreciable amount of lysine and a minimum amount of trypsin and chymotrypsin. Bambara groundnut oil is predominantly made of the unsaturated fatty acids such as palmitoleic, oleic, and caprylic acids which are among the essential fatty acids required by the body. These fatty acids are primarily used to produce hormone-like substance that regulates a wide range of functions, blood pressure, blood clotting, blood lip level, and inflammation response in human diet since no synthetic mechanisms are available for their production in human body.[19] Different food products have been prepared through fermentation process which has to the development of characteristic flavors, textures, and changes in nutritive properties of the foods. The proximate such as protein, ash, fiber, fat, moisture, and carbohydrate contents were investigated.

Due to much pressure exerted on the maize flour only together with deficiency in meeting up with the major nutrient requirements of the body such as protein, I was propelled to carry out research on how to fortify/enrich maize-semolina flour with bambara nut flour so as to incorporate more protein to the flour.

MATERIALS

Sources of raw materials

White maize seeds (*Zea mays*), wheat seeds, and Bambara groundnut (*Vigna subterranea* [L.] verde) seeds were purchased from within Nsukka market in Enugu State of Nigeria. Samples were collected in sterile polythene bags with proper identification and kept on a dry place.

Preparation of samples

The sample seeds were cleaned manually to remove all foreign materials such as dust, dirt, stones, small branches, and immature seeds. Samples were soaked in clean water for 2 h in separate bowls and boiled for 30 min each to reduce the antinutrient present. After boiling, the samples were sun dried. The seeds were ground to fine flour by harmer mill and sieved through fine cloth to obtain the flour of uniform particle size.

The obtained flour was stored in air-tight containers. Maize (40%), wheat (40%), and bambara groundnut (20%) were weighed and mixed. The sample was then taken to the research laboratory at National Centre for Energy Research and Development, University of Nigeria Nsukka for various analyses.

METHODS

Experiments

Product formulations

Composite flours were formulated with wheat, maize and bambara nut flours in the ratios of 40:40:20; 60:20:20;and 20:60:20 respectively. The sensory evaluation of maize semolina fortified with bambara nut flours was carried out using the above formulations. MWB which is sample produced between 40% maize, 40% wheat, and 20% bambara nut was rated highest and was thus used for analyses. The mineral content of the samples was determined by the dry ash extraction method following specific mineral element as described by AOAC (2005).[2] The minerals analyzed were Ca, Na, K, Mg, and Zn. Furthermore, the proximate composition of the blended flour sample was analyzed for moisture, ash, crude protein, crude fat, crude fiber, and carbohydrate using the standard method of AOAC (2005),[2] while the functional properties were determined using recommended standard method.

RESULTS AND DISCUSSION

Chemical and functional properties of Zea mays semolina fortified with Vigna subterranea are shown in the Tables below.

DISCUSSION

This comprehensive research work centered on the sensory mineral, functional properties, and proximate composition of maize semolina fortified with bambara nut in the ratio of 40:40:20 for maize/wheat/bambara nut flours, respectively. From Table 1, the results obtained have shown that the mineral contents of the maize semolina fortified with bambara nut were much higher than ordinary maize flour.[1] It can be seen that the calcium content was 92.59 mg/kg, magnesium being 179.46 mg/kg, iron was 300.58 mg/kg, and zinc and phosphorus were 16.35 mg/kg and 6.8 mg/kg, respectively. It can be deduced that the Ca claimed the highest value followed by Mg, Fe, Zn, and phosphorus finally. However, when compared to common maize/semolina, magnesium is 141.3, Ca was 64.70, zinc 11.48, iron being 1.10, and so on.[1] Thus, this has shown that maize semolina fortified with bambara nut differs significantly from ordinary maize or semolina flour. Hence, these nutrients are of great health significance to man. The mineral content of the maize semolina fortified with bambara nut shown above is slightly higher than that obtained from mineral content of bambara groundnut. However, when compared to bambara groundnut, calcium is 30.2, Mg was 136.0, Fe being 8.8, zinc having 1.9, and so on. This has shown that maize semolina fortified with bambara differs from ordinary bambara groundnut flour. Hence, it could play an important role in meeting the people's mineral needs in combined meals, especially in developing countries.

The functional properties of maize-semolina fortified with bambara nut are shown in Table 2. From the analysis conducted, it is seen that the oil absorption capacity (g/g) was 6.0 while water absorption capacity was 7.80. The emulsion capacity was 54% while the gelation capacity was 22.6%. Furthermore, the foam capacity was 48.30% while the bulk density is 0.78 g/ml. Thus, it can be deduced that the product has high emulsion capacity and foam capacity in relation to other functional properties. Furthermore, it can be stated that maize semolina fortified with bambara nut has good water absorption and gelation capacities and can be suitable for baking and other food processing operations. In the present study, the functional properties of maize semolina fortified with bambara nut resulted in a decrease in oil absorption capacity and water absorption capacity but on increase in emulsion capacity, gelation capacity, and foam capacity or compared to blend of full fat flour of maize and wheat in 1:1 ratio.[13]

Table 1: Results showing the mineral composition of maize semolina fortified with bambara nut flours

Mineral element	Composition (mg/kg)
Magnesium	179.46
Calcium	92.59
Iron	300.58
Zinc	16.36
Phosphorus	6.80

Table 2: Results showing the functional properties of maize semolina fortified with bambara nut flours

Functional properties	Proportion
Oil absorption capacity	6.0 (g/g)
Water absorption capacity	7.8 (g/g)
Emulsion capacity	54.00%
Gelation capacity	22.60%
Foam capacity	48.30%
Bulk density	0.78 g/ml

Foam capacity is much important in manufacturing and maintaining structure of different food products such as ice creams and bakery products during and after processing. The ability of the flours to form foam depends on the presence of the flexible protein molecules which may decrease the surface tension of water.[21]

The FC value of maize semolina fortified with bambara nut flour was found to be higher than that reported earlier for blend of full-fat flours of maize and wheat which has 16.29.[13] Due to high FC of maize semolina fortified with bambara nut, it will be good in manufacturing bakery product to maintain the structure of food products like ice creams.

The proximate analysis of maize-semolina fortified with bambara flour is shown in Table 3. The results showed that the moisture content of the maize semolina fortified with bambara nut flour was 12.29%, the ash content 1.60%, the crude fat 5.60%, the crude fiber 3.80%, and the crude protein 17.38%.

Therefore, it can be deduced that the moisture content of the product was relatively low which indicates a good storage or keeping quality. Furthermore, the result indicated that the crude fat is 5.60% which is relatively high. This is due to the lipid contents of the hulls, germs, and endosperm of the raw materials, especially maize and bambara nut which contains appreciable amount of oil in them.[1] Furthermore, the protein portion of the product was quite high (17.38%) and that was due to the incorporation of the bambara nut which is also a good source of protein and amino acids. The results also showed that maize semolina flour fortified with bambara nut is a good source of mineral and crude fiber (5.60%) in relation to common maize flour which is around 1.62% for total ash and 2.5% for crude fiber.[1] Therefore, incorporation of bambara nut flour to maize semolina flours has resulted to significant increase in the proximate composition of the product.

Table 3: Results showing the proximate composition of maize semolina fortified with bambara nut flours

Parameters	Proportion (%)
Moisture	12.29
Total ash	1.60
Crude fat	5.60
Crude fiber	3.80
Crude protein	17.38
Carbohydrate (by difference)	59.33

From Table 4, the color of the semolina samples ranges from 5.20 ± 1.99 to 7.60 ± 0.69 with MWB being the highest of all the samples. The color of the samples showed significant ($P \leq 0.05$) difference between the samples.

The flavor of the semolina samples ranges from 4.80 ± 2.17 to 7.90 ± 1.10 with MWB having the highest value. The flavor of the samples showed significant ($P \leq 0.05$) difference between the samples. The high flavor of sample MWB may be because of the incorporation of bambara nut.

The taste of the semolina samples ranges from 5.10 ± 1.73 to 6.90 ± 1.73 with sample MWB having the highest value. The taste of the samples showed significant ($P \leq 0.05$) difference between the samples. The high taste of MWB may be because of maximum ratio of maize.

The texture of the semolina samples ranges from 3.20 ± 2.44 to 8.50 ± 0.97 with MWB having the highest value. The texture of the samples showed significant ($P \leq 0.05$) difference between the samples. The highest texture of MWB may be due to the equal ratio of maize/wheat.

The general acceptability of the semolina samples ranges from 5.60 ± 1.07 to 9.00 ± 0.00 with MWB2 having the highest value. The acceptability of the samples showed significant ($P \leq 0.05$) difference between the samples. The high acceptability of MWB may be because of the well-selected ratio proportions of the blend.

Table 4: Result of sensory evaluation

Parameter	Color	Flavor		Taste	Texture	Acceptability
AWB	7.40 ± 1.84^{a}	4.80 ± 2.17^{b}		3.20 ± 0.92^{c}	3.20 ± 2.44^{c}	6.40 ± 0.97^{bc}
MWB	7.60 ± 0.69^{a}	7.90 ± 1.10^{a}		6.90 ± 1.73^{a}	8.50 ± 0.97^{a}	9.00 ± 0.00^{a}
CWB	5.20 ± 1.99^{b}	5.30 ± 1.89^{b}		5.90 ± 2.02^{ab}	5.70 ± 2.41^{b}	6.50 ± 1.08^{b}
DWB	6.25 ± 1.97^{b}	5.20 ± 1.55^{b}	4.90 ± 1.91^{b}	5.10 ± 1.72^{b}	5.40 ± 1.51^{b}	5.60 ± 1.07^{c}

AWB: 60% maize, 20% wheat, and 20% bambara nut, MWB: 40% maize, 40% wheat, and 20% bambara nut, CWB: 20% maize, 60% wheat, and 20% bambara nut, DWB: 50% maize, 30% wheat, and 20% bambara nut, $^{a, b, c}$: ($P<0.05$) among the samples.

CONCLUSION

This exploratory research work X-ray how maize semolina fortified with bambara groundnut flour can be produced. The comparative analysis on the mineral compositions which include magnesium (mg), calcium (Ca), iron (Fe), phosphorus (P), and zinc (Zn) was determined. Furthermore, the functional properties of the product such as oil absorption capacity, water absorption capacity, emulsion capacity, gelation capacity, foam capacity, and bulk density were effectively determined.

Consequently, the proximate compositions of maize semolina fortified with bambara groundnut were determined which include moisture content, ash content, crude fiber, crude fats, and crude protein. Thus, the results elucidated that the nutrients in the product are higher in relation to ordinary flour devoid of bambara nut flour, especially on protein and carbohydrate basis. Hence, this high protein may be due to essential amino acid composition of bambara groundnut used for the fortification.

RECOMMENDATION

From the result obtained, I recommend that maize semolina flour be fortified with bambara groundnut flour as it has marked an increase in the protein content of the flour. This can help to improve the nutrient need of consumers especially the protein aspect.

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