International Journal of
Food Sciences
(IJF)

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International Journal of Food Sciences
ISSN 2520-4637 (Online)
Vol. 2, Issue 1, No. 4, pp 43 - 64, 2019
www.iprjb.org

PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF DIFFERENT GRAIN FLOUR COMPOSITES FOR INDUSTRIAL APPLICATIONS

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Abstract

***Purpose**:* The study focused on evaluating proximate compositions and functional properties of different flour blends.

***Methodology**:* Three representative flour samples were produced from each mixture of maize-millet, soybean-wheat, and rice-wheat in the ratios of 70:30, 50:50, and 30:70 percent for all combinations. The proximate composition and functional properties of flour blends were determined using the methods of AOAC.

Findings: There was significant difference in the proximate compositions of the flours (p =0.05). The moisture content of the blends was highest at 5.41% for maize-millet blend ratio of 70:30% and lowest at 1.8% for soybean-wheat blend ratio of 30:70%. The crude protein content of the grain flour samples ranged from 16.32% to 44.10%. Soybean-wheat flour blend had the highest fat content of 7.34% for 70:30% and maize-millet blend had the least fat content of 1.30 for 50:50%. Maize-millet flour blend had the highest ash content of 4.02% for 30:70% and lowest for rice-wheat with 0.35% for 50:50%. The percent carbohydrate content of the flours ranged from 42.60% to 65.01%. The percent crude fibre content of the flours ranged from 2.13% to 10.01%. Soya bean-wheat flour blend had the highest average crude fibre content. There was significant difference in the functional properties of the flour blends (p =0.05). The oil absorption capacity (OAC) of the flours ranged from 1.00 to 2.25 ml/g. The rice-wheat flour blend had the highest water absorption capacity (WAC) of 2.60 ml/g for 30:70% blend ratio, while the lowest WAC was 0.50 ml/g for soybean-wheat blend. The foaming capacity (FC) of the flour blends ranged from 10.83 to 15.40%, while the emulsion capacity ranged from 35.05% to 50.95%. The swelling index ranged from 1.13% to 1.98%. The high emulsion capacity of soybean-wheat flour blend suggested that it was more digestible and therefore could be suitable for use as ingredient in infant food formulations.

Unique contribution to theory, practice and policy: The high swelling index indicates that rice-wheat flour blend could be more suitable in food systems where swelling is required. The high emulsion capacity of soybean-wheat flour blend suggested that it was more digestible and therefore could be suitable for use as ingredient in infant food formulations.

***Keywords**: Grain flour blends; proximate composition; Functional properties; blend ratios.*

1.0 INTRODUCTION

In both developed and developing countries with large segment of population depending on maize, wheat, rice, soybean, and millet as staple foods and wheat is one of the major recipes for preparation of baked foods. They are used in the production of traditional beverages such as burukutu (Igwe *et al*., 2018a; Igwe *et al.*, 2018b) in some parts of developing countries. The increasing changing life style of individuals has led to the demand for ready to cook, ready to eat, and ready to serve convenient foods. Nutrient deficiencies, such as protein deficiency, is a major dietary problem facing the world, particularly in the underdeveloped and developing countries of Asia, Africa, and parts of Southern America. Cookies rich in protein can be prepared from composite flours such as wheat flour fortified with soy. This study was designed to incorporate maize and millet, wheat and soya bean, rice and wheat as a source of protein, carbohydrates, mineral content, water, fat, and fibre. Population of many undeveloped nations are faced with the problem of malnutrition due to the nutrient deficiencies, particularly protein and calories. Proteins which have high nutritional value and form a part of individual's regular diet would be promising candidates for the purpose. Consequently, soybean is used in many foods to mitigate the dearth of protein supplies. Though, soybean is limiting in methionine, sulphur amino acid, but high in lysine. Soybean is a species of legume, which is widely grown for its beans which contain significant amounts of bioactive compounds like protein, alpha-Linolenic acid, phytic acid, daidzein, and isoflavones-genistein. Soybean contains over 48% proteins.

Maize (Zea mays) is major source of carbohydrates, vitamin B, protein, vitamin A (yellow maize) and minerals. The diets that rely greatly on corn may require the consuming complementary foods to supplement its deficiency in certain amino acids and vitamins. It is deficient in lysine and tryptophan. Maize is rich in starch. Cornstarch, a maize flour, is a major ingredient in home cooking and in many industrial food products. They constitute a vital component of the diet and can provide excellent means of improving the nutritional quality through the incorporation of vegetable protein. By supplementing wheat flour with a good quality soy protein, the nutritional quality of the blend can be improved significantly. Moreover, to improve the utilization of soybean in the diet of individuals, it is highly necessary to develop novel and more valuable soybean food products. The objective of the present study was to carry out the proximate composition and determine the functional properties of the wheat/soybean, maize-millet, rice and wheat flour blends.

Maize and wheat flours are often used in many pharmaceutical and food formulations all around the world. The flours are used either in pure form or in the form of blends with other seed (grain) flours such as soy bean and groundnut (Akapapunam and Darbe, 1994; Akubor and Onimawo, 2003). The industrial usage and food applications of these flours largely depend on their functional characteristics. The functional properties such as gelation, foaming, emulsifying, water absorption, and oil absorption capacities are the basic physicochemical properties which illustrate the structural behaviour of flour in the food systems. The study of the functional properties of seed and grain flours provide cutting-edge knowledge for their usage in the preparation of various food and pharmaceutical products, including ready to eat therapeutic foods. The benefits of using flours from grains and seeds in the pharmaceutical and food industries directly rely on their functional properties and characteristics (Ogungbenle *et al.*, 2002). Change in these functional properties during processing, storage, and transport may significantly influence the nutrients and consumption of the food materials and products. The factors affecting the functional properties of food products and materials during processing and storage should be optimized to enhance the functional characterization of the food products (materials.)

A number of statistical designs can be used to evaluate the relationship between a dependent variable (or input) and one or more input variables or factors. Analysis of variance (ANOVA), Correlation, Regression, and Response Surface Methodology (RSM) are among the commonly used statistical designs. Response Surface Methodology (RSM) is a statistical design used to create response-surface models for predicting changes in response variables due to the changes in the input variables (Montgomery, 2009). Response Surface Methodology is a mathematical and set of statistical tools which are useful for developing, designing, improving, as well as optimizing the process under study (evaluation). RSM has been used extensively in chemical and industrial engineering to study yield of a system (open, closed, or isolated) as it varies in response to the levels of changing of one or more factors or input variables. The response variable or factor is the measured quantity of output of a trial with its value assumed to be impacted by changing the levels of the input variables. Also, it is used to identify the optimum levels of input variables resulting to the required goals of response variable (Khuri and Cornell, 1987). In addition, in Response Surface Methodology, a central composite design (CCD) is frequently used for the building of a second order quadratic model needed by the response variable. The CCD has been acknowledged as a useful practice for the optimization of the process variable; the objective is the optimization of the response. It decreases the number of experimental runs required to establish mathematical trend in an experimental design allowing the determination and evaluation of the optimum levels of the required experimental factors for a given response. As an effective statistical technique for the optimization of process conditions, RSM (and CCD) are useful as cost-effective way of obtaining extreme information in a short period of time and lesser experiment number (Anarjan *et al.*, 2010). Response Surface Methodology has also been used earlier to optimize preparation conditions for the study of the effect of preparation variables on the functional properties of blends and the product characteristics of different flours (Ikegwu & Okoli, 2011; Asare *et al.*, 2004). Previous work has been done and reported on functional properties of maize flours and its blends with soy bean flour, Nile tilapia as well as groundnut seed flour (Akubor and Onimawo, 2003; Akapapunam & Darbe, 1994; Fasasi *et al.*, 2007).

In Uganda and, indeed most developing countries the underlying problems have been identified to include poverty, inadequate nutrient intake particularly during pregnancy, period of rapid growth and complementary feeding, ignorance about nutrient values of foodstuff and parasitic infections. Major international and national efforts channeled towards addressing these glitches include fortification of staple food, nutritional supplementation, and modification of traditional diets to meet specific requirements. Also due to flour inconsistency within the milling companies which the millers tend to solve through blending different grain flours, in order to make the production of certain flour products quicker, simpler and therefore cheaper since the blended flour contain more nutritional values than non-blended grain flour.

The study examined the proximate composition and functional properties of different blends of grain flour. This study was a part of the effort on the improving the nutritional quality of traditional complementary diets. It was designed to use staple grains indigenous to rural and indigenous folks and to formulate composite flour blends that is nutritious, readily available, as well as affordable to rural residents, urban people, and industrial purposes.

1.1. Overview of Grains

Grains are small and hard, dry seeds, with or without a hull or fruit layer attached, harvested for animal or human consumption. Any grain-producing plant is referred to as grain crop. The two major types of commercial grain crops are legumes and cereals. After harvest, dry grains are more durable and strong than other staple foods, like starchy fruits (breadfruit, plantains, etc.) and tubers (cassava, sweet potatoes, etc.); nutrients in tubers like sweet potatoes are often affected by salting (Awuchi and Nwankwere, 2018). This durability made grains well suitable to industrial agriculture, as they can be harvested mechanically, transported by ship or rail, stored in silos for long periods, and pressed for oil or milled for flour. Thus, major international commodity markets exist more for rice, soybeans, wheat, canola, maize, rice and other grains than for vegetables, tubers, or other crops.

1.2. Grains and cereals

Grain and cereal are synonymous with caryopses, fruits of the grass family. In commerce and agronomy, fruits or seeds from other families of plant are called grains if they bear a resemblance to caryopses. For instance, amaranth can be sold as grain amaranth, and products of amaranth may be designated as whole grains. The Andes pre-Hispanic civilizations had grain-based food systems, however, at the higher elevations, none was a cereal. All the three grains native to the Andes (kiwicha, quinoa, and kaniwa) are plants with broad-leafed rather than grasses such as wheat, corn, and rice. As grains are small, hard and very dry, they are stored, measured, and transported more readily than other kinds of food crops like fresh tubers, fruits, and roots. The grain agriculture development allowed excess foods to be easily produced and stored which could have resulted to the creation of the division of society into classes and the first permanent settlements.

1.3. Health Benefits of Grains

- People who consume whole grains as part of healthy diet have reduced risk of lots of chronic diseases.
- High-fiber foods like whole grains help offer a feeling of fullness with lesser calories. The selection of whole grains for at least half of one’s daily servings may help maintain one’s weight. Incorporate whole grains into healthy eating plan by including a whole wheat toast or bagel to breakfast, whole wheat bread sandwich at lunch or whole wheat pasta at dinner.
- Consuming whole grain as part of a healthy diet can reduce the risks of heart diseases.
- Consuming fiber-rich foods, such as whole grains, as integral part of a healthy diet, can reduce constipation.
- Consuming whole grains may help with the management of weight.
- Along with the basic benefits of consuming grains, they also help maintain optimum health as a result of the phytochemicals they contain – some of which are still under identification.
- Three to eight ounces are recommended per day for grains, depending on the required calories. About one-half should be whole grains.

- Grains and cereals are essential food group in our daily diet, as they offer good proportion of our daily energy requirements and nutrients intake.
- Consumption of grain products that are fortified with folates before and during pregnancy helps to prevent neural tube defects during the fetal development.
- Grains are essential sources of several nutrients, including fiber, B vitamins (riboflavin, niacin, folate, and thiamin) and minerals (selenium, iron, and magnesium).
- Consuming foods rich in fiber, for instance whole grains, as part of general healthy eating, reduces the risks of coronary heart diseases and may also reduce constipation.

1.4. Major nutritional values of grains

Grains provide our bodies with high quality nutrients (in abundance) such as protein, carbohydrates, fibre, moisture, Ash, zinc, B vitamins, magnesium, phosphorus, vitamin E, folate, iron, riboflavin, and thiamin.

Dietary fiber in whole grains or other foods, when consumed, may help reduce cholesterol levels in the blood and may reduce risk of heart disease, type 2 diabetes, and obesity. Fiber is important for the proper bowel function. It reduces constipation and risk of diverticulosis. Fiber-rich foods such as whole grains provide a feeling of fullness using fewer calories.

The B vitamins in grains (thiamin, riboflavin, niacin) play important role in metabolism – they help the release of energy from protein, fat, and carbohydrates in the body. Also, B vitamins are essential for healthy nervous system. Several refined grains are enriched with B vitamins. Folic acid (Folate), another B vitamin, helps the formation of red blood cells in the body. Women of childbearing age who might become pregnant ought to consume adequate folate from food, in addition to 400 mcg of synthetic folate from supplements or fortified foods. This will reduce risk of the neural tube defects, anencephaly, and spina bifida during the development of fetus.

In the blood, iron is used to carry oxygen. Many women and teenage girls in their years of childbearing have iron-deficiency anemia. As a result, they should consume foods (meats) high in heme-iron or eat other iron containing food along with diets rich in vitamin C, which improves the absorption of non-heme iron. Products of whole and enriched refined grains are the main sources of non-heme iron in typical American diets. Whole grains are rich sources of magnesium and selenium. Selenium protects cells from oxidation. Also, it is important for healthy immune system. Magnesium is a mineral used in releasing energy from muscles and for building bones.

Grains used in this food group are made of three main parts:

1. Bran: the outer layer of the grain (fibre, omega-3 fatty acids, dietary minerals, and vitamins)
2. Germ: smallest part of the grain (phosphorus, magnesium, vitamin E, folate, thiamine)
3. Endosperm: main part of the grain (mostly starch)

1.4. Functional Properties

Functional properties characterize the structural quality, nutritional value and acceptability of food or food products. Generally, food stuffs show several functional properties like hydration properties (protein solubility, protein dispensability, water- and fat- holding capacities), surface properties (emulsion and foam), structural and textural properties (viscosity, gelation and viscoelasticity). The proximal constituents of food (proteins, carbohydrates, fats, and fibre) undergo several changes during processing leading to favorable transformation in form, texture and taste of food or food product. Proteins in foods could be enzymatically modified by controlled proteolysis, which may enhance their functional properties over a wide range of pH, ionic concentration and other processing conditions (Panyam and Kilara, 1996). Protein solubility, gelling abilities, foaming properties, swelling capacity, water holding capacity, etc., are the intrinsic physicochemical properties of flours basing on the relative strength of the hydrophilic and the hydrophobic groups of the starch and protein. Proteins with comparatively higher amount of polar amino acids show very high hydrophilic strength whilst the protein hydrophobic character is based on the exposure of the non-polar amino acids (Alleoni, 2006). The pH, temperature, radiations, and ionic strength cause the denaturation of protein molecules and have effect on the functional properties of the flour. The variations in functional properties further results to the change in the quality of food products (Moses *et al.*, 2012; FAO, 2010). Bulk density of flour is influenced by the structural arrangement of the carbohydrates and other polymers present in the flour (Adejuyitan *et al.*, 2009). Legumes and cereals have played an important role in reducing malnutrition problem worldwide. They are rich sources of carbohydrates, protein and lipids and are used as major constituent in the formulation of starch and protein based food. Several legumes and cereals flours differ in biochemical composition, conformation of food components, molecular structure, and show diverse functional properties and characteristics (Alleoni, 2006; Wujun *et al.*, 2007). The variations in functional properties are attributed to the relative proportions of carbohydrates, protein, and lipids in different flours. Also, the functional properties of flours are changed by changes in the processing conditions such as milling, blending, fermentation, baking, extraction, isolation, drying, and cooking (Amza *et al.*, 2011; Barros *et al.*, 2010; Basediya *et al.*, 2013). A blend formation of low quality of frequently available cereals with good functional characteristics may be valuable in improving the economic value and quality of food products (Abou *et al.*, 2010; Olapade and Akinyanju, 2014; Ogori *et al.*, 2013). Previous studies have been done to investigate the effects of blend formation on the functional properties of cereal flours. Significant variations in water and oil absorption capacities, foaming capacity, bulk densities, emulsifying capacity, and gelling capacities have been found to change by altering the ratio of different grain flours in the blend (Adeleke and Odediji, 2010; Akpapunam and Darbe, 1994).

1.4.1. Emulsion capacity

The emulsion activity is the ability of protein in grains responsible for emulsion formation as well as stability of newly formed emulsion. The emulsion capacity depends on the shape, charge and hydrophobicity of the protein molecules, neutrality of dipoles and hydration of polar groups (Zayas 1997). Emulsifying capacity involves several physical and chemical factors and depends on the stabilizer properties and varies with the type of protein contents, concentration, ionic strength, pH, and viscosity of the system.

1.4.2. Foaming capacity

Foam is a two-phase system consisting of air cells separated by a thin continuous liquid layer (Zayas 1997). The optimum foam formation of a material depends on speed of rotation, interval of stirring and pH (Gassmann *et al.* 1987). The foaming capacity of food products depends on the distribution of gas bubbles in semisolid or liquid phase. Foaming improves the visual appeal and the texture of foods. Food systems which require high foaming capacities and stability are breads, icing and whipped creams, cakes, and sponges (Atuonwu and Akobundu, 2010). Conversely, foods which require low foaming capacities and stability are crackers, biscuits, and cookies.

1.4.3. Oil-absorption capacity

Oil absorption capacity (OAC) capacity represents the ability of a product to associate with oil under the conditions of oil limitation (Singh 2001). It will be usually dependent on starch and fibre contents in the given grain flour.

1.4.4. Gelation

Gelation of grain flour is one of the important functional properties to design grain flour with desired texture. Lower the level of the least gelation concentration (LGC) higher the gelling ability of the protein ingredient (Akintayo *et al.* 2002).

1.4.5. Water absorption capacity (WAC)

Water absorption capacity (WAC) is a measure of the interactions between flour and water which takes place in a lot of foods. WAC depends on the ability of a polysaccharide or protein matrix to absorb, retain, and also physically entrap water against the gravity (Traynham *et al.*, 2007). WAC has effects on flour thickness, maintenance of freshness, handling, and viscosity. Water absorption capacity is also associated with a flour ability to produce form viscoelastic dough, which leads to the flexibility and capacity of the dough to be stretched and molded. A high Water absorption capacity is an important quality of an ingredient in food that need hydration for textural and handling properties.

2.0 MATERIALS AND METHODS

2.1 Sources of materials

The maize, soybeans, rice, wheat, and millet were obtained from Kampala, Uganda.

2.2. Preparation of Grain Flour

2.2.1. Preparation of maize flour

Maize flour was produced from whole maize seeds, cereal grains by the traditional method, which involved sorting the grains to eliminate the bad grains, cleaning the grains to get them rid of debris and other foreign bodies that may constitute a problem to the quality of the end product, and steeping the clean grains in clean tap water for 5 minutes at room temperature. The steeped grains were washed again with clean water, wet milled using commercial corn mill and wet sieved using a 300 µm sieve.

2.2.2. Preparation of soybean flour

Soybean seeds were cleaned to remove unwanted particles and then soaked overnight in distill water. Testa was removed by rubbing in the palms and washed repeatedly with more water. The washed beans were air-dried, dehulled, and milled.

2.2.3. Preparation of wheat flour

Wheat flour was purchased from Kansanga market, and taken for blending with other grain flours.

2.2.4. Preparation of millet flour

Millet was first cleaned, sorted, dried and grinded on grinding stone followed sieving to obtain flour.

2.3. Preparation of different blends of grain flour.

Prepared samples of different grain flour were blended according to different percentage ratios and three blends were prepared as follows;

Sample (A): Maize-Millet flour, 50:50%, 70:30%, and 30:70% respectively.

Sample (B): Soybean-Wheat, 50:50%, 70:30%, and 30:70% respectively.

Sample (C): Rice-Wheat, 50:50%, 70:30%, and 30:70% respectively.

Then after the required blends had been prepared in their respective, the analysis was done from Uganda industrial research institute (UIRI) laboratory under the department of Analytical chemistry.

2.4. Proximate composition

Protein (micro- Kjeldahl, x 6.25), fat (solventextraction), crude fiber, moisture, and ash were determined by the methods of AOAC (2004). The carbohydrate content was calculated by difference.

2.4.1. Moisture content.

2g of the sample A was weighed in a weighing dish (W1). The weighed sample was transferred to the oven and dried for 30 minutes. The dried sample was again weighed to obtain consistence results (W2). The percentage moisture content was then determined from;

$$\%\textbf{Moisture} = \frac{(W1-W2)}{W1} \times 100$$

2.4.2 Determination of Protein content using the kjeldahl method.

The sample was digested in concentrated sulphuric acid and 1% copper sulphate (kjeldahl) tab as a catalyst, then distilled in 40% sodium hydroxide, the ammonia liberated was absorbed in 4%boric acid having methyl red/bromocresol as the indicator and later titrated with 0.1N hydrochloric acid. The boiling temperature was elevated by addition of potassium sulphate. The elevated boiling temperature is necessary protein to break the peptide bonds and convert amino groups in the protein to ammonium ions. A copper catalyst was added to enhance reaction rate. After digest mix was diluted with water to avoid mixing concentrated alkali with concentrated acid and prevent the digest from solidifying. Ammonia was liberated by alkaline distillation and quantified by titration with standardized acid.

2.4.3. Fat Content (%) determination

The fat content was determined using the Soxhlet apparatus. The percent crude fat was calculated using the following equation:

Percent crude fat content = $\frac{(W2-W1}{Weight\ of\ sample} \times 100$

Where: W2 = the weight of extraction flask after extraction process with fat. W1 = the weight of empty extraction flask.

2.4.4. Ash Content (%) determination

The ash content of the samples was measured according to the AOAC (2004) method. The ash content was calculated as follows:

Crude ash (%) =$\frac{(W2-W1)}{Weight\ of\ sample} \times 100$

Where: W1 = weight of empty crucible, and W2 = weight of crucible with ash.

2.4.5. Fibre content determination

The fibre content was determined using the method of AOAC (2000).

2.4.6. Carbohydrates Content (%) determination

The total carbohydrates were determined by difference according to AOAC (2004) method, with the following equation:

Total CHO = 100 – (moisture% + ash% + fiber%+ fat% + protein %).

2.5. Determination of functional properties

2.5.1. Oil and Water Absorption Capacity Determination

2g of the samples A, B, C was mixed with 10ml of distilled water for 5 minutes respectively on a magnetic stirrer. The mixture was centrifuged at 3500rpm for 30minutes and the volume of the supernatant was measured by using 10ml measuring cylinder on each of the sample. The water density was taken to be 1g/ml.

WAC=$\frac{volumeofwaterabsorbed}{\text{Weight of the sample used}} \times 100$

2.5.2. Foaming capacity

(3.0 g) of the samples were weighed and added 50 ml distilled water at 30±2 ^{0}C in graduated cylinder. The suspensions were mixed and shaken for 5 minutes to foam. The volume of the foam after whipping for 30 seconds was calculated as foaming capacity. The volume of foam was recorded after 1hourwhipping to determine foaming stability as percent of the initial foam volume.

FC (%) =$\boldsymbol{\frac{(AW-BW)}{BW} \times 100}$

Where, AW = after whipping, BW = before whipping

2.5.3. Swelling index

4.0g of the Sample A, B, and C was filled up to 10 ml mark in a 100 ml graduated cylinder and added with water to adjust the total volume to 50 ml mark. The top of the cylinder (graduated) was firmly covered and mixed by the inverting of the cylinder. The suspension was then inverted again after 2 minutes and stood for additional 10 min. The volume occupied by sample was taken after 15 minutes.

2.5.4. Emulsion capacity (EC)

The flour/blend (2g) was dispersed in distilled water (10mL) and height of solution in the cylinder was measured. The solution was homogenized with refined canola oil (5mL) and the resulting emulsion was centrifuged at 1100 × g for 5 minutes. The height of the emulsified layer was measured and the emulsifying activity was calculated as the percent increase in the height of the solution by following equation:

$$\textbf{EC (\%)} = \frac{H2}{H1} \times 100$$

Where H1 is the initial height of solution before emulsification, H_2 is height of the emulsified layer.

The machines used during this study were: muffle furnace which was used for providing extremely high temperature for determination of ash content in the blended sample, manual soxhlet machine system for determination of fats in the samples, Analytical balance which was used to take weights.

3.0 FINDINGS AND DISCUSSION

3.1 Results

Analysis of variance (ANOVA) as well as Fisher's LSD was applied to all the data obtained. The level of significance used was 95%. Statistical analysis of the results indicated no significant differences (P>0.05) between the three blended grain flours as indicated in Tables 4a-6b.

3.1.1 Proximate Compositions of different blends of Flours

Table 1 (a): proximate compositions of the maize-millet flour blends

Proximate composition	50:50% (maize-millet)	70:30% (maize-millet)	30:70% (maize-millet)
Carbohydrates (%)	$52.30^{c} \pm 3.59$	$65.01^{a} \pm 2.94$	$56.00^{b} \pm 2.36$
Fibre (%)	$5.01^{b} \pm 0.13$	$3.03^{c} \pm 0.08$	$6.10^{a} \pm 0.04$
Proteins (%)	$21.00^{c} \pm 0.00$	$32.40^{a} \pm 1.08$	$24.20^{b} \pm 0.62$
Fat (%)	$1.30^{b} \pm 0.22$	$2.70^{a} \pm 0.13$	$2.50^{a} \pm 0.20$
Ash (%)	$3.28^{b} \pm 0.41$	$3.98^{a} \pm 0.10$	$4.02^{a} \pm 0.33$
Moisture (%)	$4.98^{b} \pm 0.39$	$5.41^{a} \pm 0.26$	$5.14^{a} \pm 0.41$

P =0.05

Table 1 (b): proximate compositions of the soybean-wheat flour blends

Proximate composition	50:50% (soybean-wheat)	30:70% (soybean-wheat)	70:30% (soybean-wheat)
Carbohydrates (%)	$51.31^c \pm 2.06$	$63.11^b \pm 1.82$	$64.24^a \pm 2.13$
Fibre (%)	$10.01^a \pm 0.13$	$9.07^b \pm 0.08$	$9.01^c \pm 0.04$
Proteins (%)	$28.34^a \pm 0.93$	$16.32^b \pm 0.37$	$16.44^b \pm 0.09$
Fat (%)	$6.21^b \pm 0.17$	$7.28^a \pm 0.40$	$7.34^a \pm 0.28$
Ash (%)	$1.91^b \pm 0.02$	$2.42^a \pm 0.01$	$1.23^c \pm 0.07$
Moisture (%)	$2.30^a \pm 0.11$	$1.80^b \pm 0.04$	$1.82^b \pm 0.01$

P =0.05

Table 1 (c): proximate compositions of the rice-wheat flour blends

Proximate composition	50:50% (rice–wheat)	70:30% (rice–wheat)	30:70% (rice–wheat)
Carbohydrates (%)	$42.60^c \pm 0.92$	$58.43^a \pm 1.58$	$49.72^b \pm 1.04$
Fibre (%)	$5.02^b \pm 0.13$	$2.13^c \pm 0.08$	$8.19^a \pm 0.04$
Proteins (%)	$44.13^a \pm 1.20$	$28.22^c \pm 0.41$	$33.16^b \pm 0.95$
Fat (%)	$4.23^b \pm 0.08$	$5.93^a \pm 0.17$	$3.54^c \pm 0.03$
Ash (%)	$0.35^c \pm 0.02$	$0.69^a \pm 0.06$	$0.55^b \pm 0.01$
Moisture (%)	$3.74^b \pm 0.19$	$4.65^a \pm 0.04$	$4.90^a \pm 0.11$

P =0.05

Proximate compositions of different blends of grain flour which include maize-millet, soybean-wheat and rice wheat were as shown in Table 1. Analyses on these blends were done to study the proximate nutritional composition, that is, to compare the nutritional values of the control made by preparing 50:50% of the samples and their respective ratios of 70:30% and 30:70%. The proximate composition analysis done was for moisture, ash, crude protein, crude fat, and carbohydrate content of each blend.

Moisture Content

There was significant difference in the moisture content of the flours (p =0.05). The moisture content of the blends was highest at 5.41% for maize-millet blend ratio of 70:30% and lowest at 1.8% for soybean-wheat blend ratio of 30:70%. The maize-millet blend had the highest moisture content, followed by rice-wheat and lastly soybean-wheat blend. The results obtained in this study were similar to the results reported by Oppong *et al.* (2015) for the Proximate Composition and Some Functional Properties of Soft Wheat Flour. The moisture content of all samples was within the acceptable limit of not more than 10% for long term storage of flour but soybean-wheat flour blend had the best results. Moisture content of a food is influenced by type of food, food variety, and the storage conditions (Oppong *et al.*, 2015). The low moisture content of wheat flour enhances its storage stability by preventing the growth of mold and reducing biochemical reactions (Singh *et al.*, 2005). Consequently, the low moisture content of soft soybean-wheat flour blend will in the end extend the shelf life of the final product made from them.

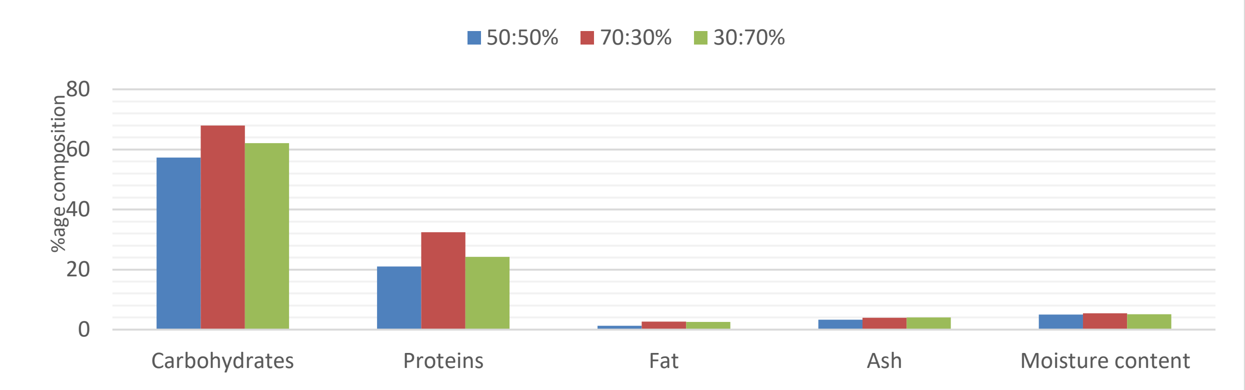

Figure 4: A graph of proximate composition of the maize-millet blend

Crude Protein Content

The percent crude protein content of the flour samples ranged from 16.32% to 44.10%. The protein content of soya bean-wheat flour blend reported in this study was found to be higher than the other blends. This is because the presence of soybean in the formulations considerably increased the protein content. Soybean contains high protein content. This increase was anticipated because legumes contain more protein than cereals hence the resultant synergistic effects of protein complement (Yetunde *et al*., 2009). The highest percentage was for soybean-Wheat composite, 44.10%, for 50:50% blend, and lowest at 16.32% for 70:30% of rice-wheat as shown in Table 1 (a) to 1 (c). There was significant difference in the crude protein content of the flours ($p = 0.05$). The protein and quality of wheat flours can be improved by blending wheat flours with soybean flours and used as composite flours. Crude protein is defined as the value obtained by quantitating nitrogen in a sample by the Kjeldahl method in which nitrogen compounds in the sample is degraded by sulfuric acid to become ammonia, sodium hydroxide is added, steam distillation is conducted under the alkaline conditions, distilled ammonia is absorbed in acid and measured by titration and multiplying the result by the factor 6.25 (6.38 for milk products).

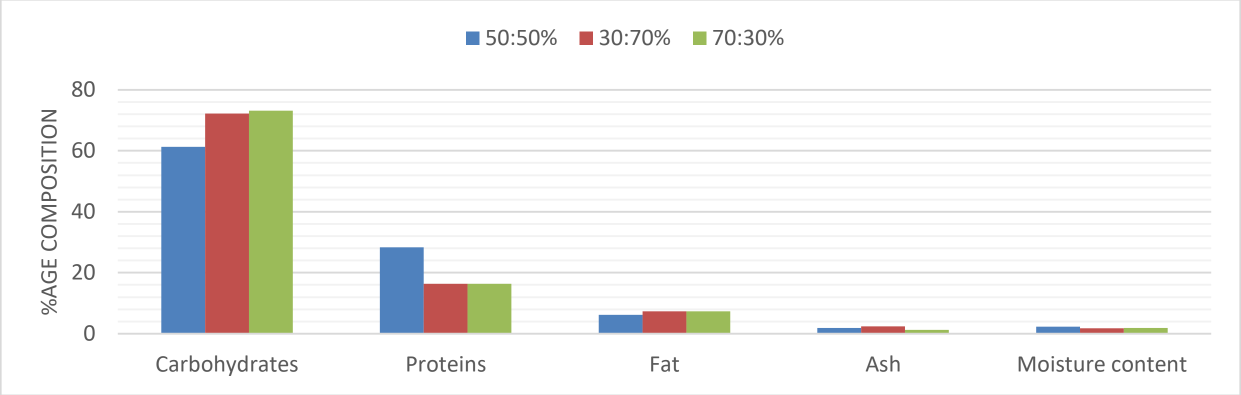

Figure 5: Proximate composition of soybean –wheat blend

Crude Fat Content

The fat content of the flours ranged from 1.30% to 7.34%, which is generally low. This may be due to the science that legumes, cereals, and tubers store energy as starch rather than lipids (Iwe *et al*., 2016). The low fat levels may be beneficial as it ensures longer shelf life and stability for the products (Reebe *et al*., 2000) due to all fats and fat containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity. There was significant difference in the fat content of the flours (p =0.05). Soybean-wheat flour blend had the highest fat content of 7.34% for 70:30% and maize-millet blend had the least fat content of 1.30 for 50:50% as shown in Table 1 (a) to 1 (c). The values obtained were similar to the values, 1.64% (100% rice) to 5.79% (100% cowpea), reported by Iwe *et al.* (2016) for the Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. Food with high fat content contributes significantly to the energy requirements for humans. High fat content of soybean-wheat flour blend in this study would make it a better source of fat than other flour blends. Flours with high fat content are also good as flavor enhancers and useful in improving the palatability of food in which it is incorporated (Aiyesanmi and Oguntokun, 1996). Fats contribute to the flavor of foods. When feeds are stored for a long period, a phenomenon is observed in that moisture does not change while ether extract decreases gradually. This is because unsaturated fatty acids contained in feeds are oxidatively polymerized absorbing oxygen in the air and becomes insoluble in ether.

Ash Content

Maize-millet flour blend had the highest ash content of 4.02% for 30:70% and lowest for rice-wheat with 0.35% for 50:50% as shown in Table 1 (a) to 1 (c). Soybean-wheat blend had the second highest ash content of 2.42% for 30:70%. The results of the ash content were similar to the range of 1.00 to 3.00% reported by Oppong *et al.* (2015). There was significant difference in the ash content of the flours (p =0.05). Ash content is an indication of the mineral content of a food. This therefore suggests that maize-millet flour blend could be important sources of minerals than other flour blends. Ash content in millet flours can be improved if maize flour is incorporated. Ash content indicates the level of minerals, and also it may be a quality parameter for contamination in a given food sample (Kavitha and Parimalavalli, 2014). The ash content of food gives an idea of the total quantity of the mineral elements in the food. Ash indicates the inorganic constituents' composition after organic materials (fats, proteins and carbohydrates) and moisture have been removed (Iwe *et al*., 2016) by oxidation/incineration. It is basically the mineral content of food sample. Minerals are essential nutrients which serve a variety of essential metabolic functions and among the parts of molecules such as adenosine triphosphate (ATP), haemoglobin, and deoxyribonucleic acid (DNA) (Iwe *et al*., 2016).

Carbohydrate Content

The percent carbohydrate content of the flours ranged from 42.60% to 65.01%. Maize-millet flour blend (70:30%) had the highest carbohydrate content (65.01%). Carbohydrate content of 51.31% to 64.24% was reported for soybean-wheat flour blend and that of Rice-wheat flour blend ranged from 42.60% for 50:50% and 58.43% for 70:30%. There was significant difference in the carbohydrate content of the flours (p =0.05). It can be observed that the flour blends used for these studies had higher carbohydrate content. The high carbohydrate content of Soya bean-wheat flour blend suggested that it can be used in combating protein-energy malnutrition, as there is carbohydrates to provide energy to the body in order to spare protein. Protein can then be used for its primary function; building the body and repairing worn out tissues, rather than being used as energy source. Carbohydrates are good sources of energy (Butt and Batool, 2010). A high concentration of carbohydrates is desirable in weaning formulas and breakfast meals. The high carbohydrates content of the Soya bean-wheat flour blend would make it a good source of energy in breakfast formulations (Butt and Batool, 2010).

Crude Fibre

The crude fibre content of the grain flours ranged from 2.13% to 10.01%. Soya bean-wheat flour blend had the highest average crude fibre content. There was significant difference in the crude fibre content of the flours (p =0.05). These values obtained for fibre are relatively higher than the average value of 0.51% reported by Oppong *et al.* (2015) for refined wheat flour. Some level of crude fibre is lost during the refining process. Chinma and Gernah (2007) reported crude fiber content of 8.19% for pigeon pea, 9.58% cowpea, 4.61% mungbean and 6.83% for peas flour. These values are related to the values obtained in this study. Crude fiber clearly corresponds only to feeds of plant origin considering the component compounds; however, a small amount of it is contained in feeds of animal origin. This is because organic residue that is not dissolved by acid/alkali boiling is observed in feeds of animal origin, and the residue is chitin and some of scleroprotein (albuminoid), which are completely different from so-called crude fiber in content. Crude fibre helps to prevent heart diseases, diabetes, colon cancer, etc. (Oppong *et al.*, 2015). Addition of rice decreased the fibre content of rice-wheat blend. The fibre content of a whole wheat flour is over ten times more than that of its whole rice counterpart. Crude fibre contents of the flour blends increased slightly as the levels of legume flour substitutions increased. This may be be because of the high crude fibre contents of legumes which had a greater effect on the cereal. Crude fibre reduces the rate of the release of glucose into the blood stream and also reduces the intercolonic pressure hence reducing the risks of colon cancer (Gibney, 1989). Plant fiber is mainly consisted of cell wall which is comprised of indigestible carbohydrate substances such as cellulose, hemicellulose, lignin and pectin.

3.1.2 Functional Properties

Table 2 (a): Functional properties of the maize-millet flour blends

Functional properties	50:50% (maize-millet)	70:30% (maize-millet)	30:70% (maize-millet)
OAC (ml/g)	1.19 ^{c} ± 0.01	1.42 ^{b} ± 0.38	1.61^{a} ± 0.19
WAC (ml/g)	1.90^{b} ± 0.99	1.81^{c} ± 0.20	2.31^{a} ± 0.85
SI	1.41^{b} ± 0.53	1.50 ^{a} ± 0.03	1.23 ^{c} ± 0.08
EC (%)	40.11^{b} ± 1.11	39.23^{c} ± 0.72	43.70^{a} ± 1.15
FC (%)	10.94^{c} ± 0.63	11.40^{b} ± 0.47	12.34^{a} ± 0.07

OAC = Oil Absorption Capacity, WAC = Water Absorption Capacity, SI = Swelling Index, EC = Emulsion Capacity, FC = Foaming Capacity

Table 2 (b): Functional properties of the soybean-wheat flour blends

Functional properties	50:50% (soybean-wheat)	30:70% (soybean-wheat)	70:30% (soybean-wheat)
OAC (ml/g)	1.81^{a} ± 0.06	1.00^{c} ± 0.01	1.24^{b} ± 0.93
WAC (ml/g)	0.50^{c} ± 0.01	1.22^{a} ± 0.83	1.14^{b} ± 0.07
SI	1.13^{c} ± 0.09	1.28^{c} ± 0.13	1.38^{a} ± 0.04
EC (%)	50.45^{c} ± 1.20	50.88^{b} ± 0.85	50.95^{a} ± 1.03
FC (%)	13.21^{c} ± 0.33	14.51^{b} ± 0.06	15.40^{a} ± 0.17

OAC = Oil Absorption Capacity, WAC = Water Absorption Capacity, SI = Swelling Index, EC = Emulsion Capacity, FC = Foaming Capacity

Table 2 (c): Functional properties of the rice-wheat flour blends

Functional properties	50:50% (rice-wheat)	70:30% (rice-wheat)	30:70% (rice-wheat)
OAC (ml/g)	$2.10^{b} \pm 0.03$	$1.93^{c} \pm 0.16$	$2.25^{a} \pm 0.91$
WAC (ml/g)	$2.53^{c} \pm 0.01$	$2.43^{b} \pm 0.07$	$2.60^{a} \pm 0.02$
SI	$1.64^{c} \pm 0.16$	$1.98^{a} \pm 0.31$	$1.83^{b} \pm 0.29$
EC (%)	$40.00^{b} \pm 0.00$	$35.05^{c} \pm 0.03$	$47.40^{a} \pm 0.13$
FC (%)	$10.83^{c} \pm 0.07$	$11.01^{b} \pm 0.12$	$12.83^{a} \pm 0.08$

OAC = Oil Absorption Capacity, WAC = Water Absorption Capacity, SI = Swelling Index, EC = Emulsion Capacity, FC = Foaming Capacity

Oil Absorption Capacity (OAC)

Oil absorption capacity (OAC) is mainly attributed to the physical entrapment of oils (Singh *et al*., 2005). OAC is an indication of the rate at which protein binds to fat in food formulations (Singh *et al*., 2005). A lower oil absorption capacity of flour could be due to low hydrophobic proteins which show superior binding of lipids (Adeleke and Odedeji, 2010). The OAC of the flours ranged from 1.00 to 2.25 ml/g. There was significant difference in the OAC of the flours (p =0.05). Higher oil absorption capacity of 2.25 ml/g for 30:70% was recorded for Rice-wheat blend among the three blends, as shown in Table 2 (a) to 2 (c). Then, 1.81 ml/g for 50:50% of soybean-wheat was recorded to be the lowest. The relatively high oil absorption capacity of rice-wheat flour blend indicates that it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products (Ahmed and Lynda, 2012). This shows that rice-wheat flour blend would be useful in this respect than the two other blends since it had significantly higher oil absorption capacity. The water and oil binding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity (Suresh and Samsher, 2013). The ability of the protein of these grain flours to bind easily with oil makes it valuable in food products where optimum oil absorption is required. This makes flour to have potential functional uses in foods such as sausage production. The OAC also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods such as whipped toppings, sausages, chiffon dessert, angel and sponge cakes etc. (Suresh and Samsher, 2013).

Water Absorption Capacity (WAC)

The WAC of a food product measures the water holding capacity by the starch after swelling in excess water, which corresponds to the weight of the gel formed, and thus is an index of the degree of starch gelatinization. WAC depends on the availability of the hydrophilic groups that bind to the molecules of water and on the gel-forming capacity of the macromolecules (Ding *et al.*, 2006). The WAC of the flour blends ranged from 0.50 to 2.60 ml/g. The rice-wheat flour blend had the highest water absorption capacity of 2.60 ml/g for 30:70% blend ratio, followed by rice-wheat with 2.53 ml/g for 30:70%. The lowest was 0.50 ml/g blend ratio for soybean-wheat blend. There was significant difference in the WAC of the flours (p =0.05). The high WAC obtained from the samples may be due to relative high fibre contents. Fibre has been reported to contribute to water holding and retention abilities. Water absorption capacity represents ability of the food products to associate with water during the conditions when water is limiting such as in dough's and pastes (Oppong *et al*., 2015). The result show that the flour blends would be useful in foods such as bakery products which require hydration to improve handling features. According to previous reports, a lower WAC may be desirable for making thinner gruels or porridges in which more flour can be added per unit volume of the gruel (Tenagashaw *et al.*, 2015). On the other hand, it also results in increasing the energy- and nutrient-density of the infant foods, a very important aspect in infant feeding. Both under- and over-absorption lead to quality issues in the dough and finished product (AIB International, 2018).

Foaming Capacity (FC)

The FC of the flour blends ranged from 10.83 to 15.40%. These values are similar to the values of 10.40% to 18.17% reported by Iwe *et al.* (2016). Foaming capacity (FC) is the ability of substance in a solution to produce foam after shaking vigorously Proteins foam when whipped because they are surface active (Tongpun, 2006). The foaming properties serve as the indices of the whipping features of the protein isolates (Appiah *et al*., 2011). This explains why soybean-wheat flour blend had higher foaming capacity, since it recorded the highest crude protein content. The high foaming capacity of soybean-wheat blend was at 70:30%; that of rice-wheat blend was at 30:70% and 30:70% for maize-millet blend. There was significant difference in the FC of the flours (p =0.05). The higher the protein content of the flour, the higher the foaming capacity. Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus always been due to protein which forms a continuous cohesive film around the air bubbles in the foam (Kaushal *et al.*, 2012). Good foam capacity and stability are desirable qualities for flours used for the production of various baked products such as angel cakes, muffins, *akara* (bean cake), cookies, etc. and also function as functional agents in other food or feed formulations (El-Adawy, 2001).

Emulsion capacity (EC)

The emulsion capacity ranged from 35.05% to 50.95% in all the flour blends where the maize-millet blend recorded 40.11% for 50:50% as the least among the blends and soybean-wheat recorded the highest at 50.95% for 30:70%ratio. There was significant difference in the EC of the flours (p = 0.05). The presence of lipids may result in reduced water absorption capacity of the flours which can lead to reduced swelling and, as a result, reduced emulsion capacity. This describes the reason for the high emulsion capacity in soybean-wheat flour blend than other flour blends. Higher emulsion capacity may be due to higher protein content (Iwe *et al.*, 2016). The values detected in this study are similar and related to the values of 42.50, 56.78 and 56.67% for rice, cowpea and AYB flours, respectively, reported by Iwe *et al*. (2016). The high emulsion capacity of soybean-wheat flour blend suggested that it was more digestible and therefore could be suitable for use as ingredient in infant food formulations.

International Journal of Food Sciences
ISSN 2520-4637 (Online)
Vol. 2, Issue 1, No. 4, pp 43 - 64, 2019
www.iprjb.org

Swelling index (SI)

Swelling capacity (SI) is considered a quality criterion in many good formulations as bakery products. It is evidence of the non-covalent bonding between the molecules within the granules of starch and also a factor of the amylopectin and α-amylose ratios (Rašper, 1969). The swelling index of the flour blends varied between 1.13% and 1.98%. There was significant difference in the SI of the flours ($p = 0.05$). The observed values were lowest in soybean-wheat flour which had 1.13% and highest in rice-wheat blend with 1.98%. Formation of the protein-amylose complex in the native starches and flours blends may be the cause a decrease in swelling index. The extent of the swelling ability depends on the availability of water, temperature, type of starch and other carbohydrates as well as proteins (Sui *et al*., 2006). The high swelling power suggested that these blend flours could be useful in food systems where swelling is required. Gelatinization and swelling index provide suitable predictive method for identifying noodle-quality flours (Fu, 2008). Increase in water absorption capacity (WAC) increases the swelling index leading to improved solubility (Fu, 2008), and explains why rice-wheat flour blend with the highest WAC also had the highest swelling index. The high swelling index indicates that rice-wheat flour blend could be more suitable in food systems where swelling is required.

4.0 CONCLUSION

The study evaluated the proximate and functional properties of soybean-wheat flour, maize-millet, and rice-wheat flour blends. There was significant difference in the proximate compositions and functional properties of the flours ($p = 0.05$). The moisture content of the blends was highest at 5.41% for maize-millet blend ratio of 70:30% and lowest at 1.8% for soybean-wheat blend ratio of 30:70%. The percent crude protein content of the flour samples ranged from 16.32% to 44.10%. The highest percentage of crude protein was for soybean-Wheat composite, 44.10%, for 50:50% blend, as shown in Table 2a, and lowest at 16.32% for 70:30% of rice-wheat as shown in Table 3a. Soybean-wheat flour blend had the highest fat content of 7.34% for 70:30% and maize-millet blend had the least fat content of 1.30 for 50:50% as shown in Table 1 (a) to 1 (c). Maize-millet flour blend had the highest ash content of 4.02% for 30:70% and lowest for rice-wheat with 0.35% for 50:50% as shown in Table 1. Soybean-wheat blend had the second highest ash content of 2.42% for 30:70%. The percent carbohydrate content of the flours ranged from 42.60% to 65.01%. Maize-millet flour blend (70:30%) had the highest carbohydrate content (65.01%). The crude fibre contents of the grain flours ranged from 2.13% to 10.01%. Soya bean-wheat flour blend had the highest average crude fibre content. There was significant difference in the functional properties of the flour blends ($p = 0.05$). The OAC of the flours ranged from 1.00 to 2.25 ml/g. The relatively high oil absorption capacity of rice-wheat flour blend indicates that it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products. This shows that rice-wheat flour blend would be useful in this respect than the two other blends since it had significantly higher oil absorption capacity. The rice-wheat flour blend had the highest water absorption capacity of 2.60 ml/g for 30:70% blend ratio, followed by rice-wheat with 2.53 ml/g for 30:70%. The lowest WAC was 0.50 ml/g blend ratio for soybean-wheat blend. The WAC results of this study suggest that the flour blends would be useful in foods such as bakery products which require hydration to improve handling features. The FC of the flour blends ranged from 10.83 to 15.40%, while the emulsion capacity ranged from 35.05% to 50.95% in all the flour blends. The swelling index of the flour blends varied between 1.13% and 1.98%. The high swelling index indicates that rice-wheat flour blend could be more suitable in food systems where swelling is required. The high emulsion capacity of soybean-wheat flour blend suggested that it was more digestible and therefore could be suitable for use as ingredient in infant food formulations.

Acknowledgement

I recognize the assistance of Prof. Owuamanam, I. C., Dr. Thompson E. Nwankwere and Prof. Awolusi, O. D. for their kind and selfless support and advice. As the author did not seek for funding, no funding was received for this study.

REFERENCES

Abou, E., Arab, A., Helmy, I.M.F., & Bareh, G.F. (2010). Nutritional evaluation and functional properties of chickpea (*Cicer arietinum* L.) flour and the improvement of spaghetti produced from its. *Journal of American Science*, 6(10): 1055-1072.

Adeleke, R.O., & Odedeji, J.O. (2010). Functional Properties of Wheat & Sweet Potato Flour Blends. *Pakistan Journal of Nutrition*, 9(6): 535-538.

Ahmed, A.M. and Lydia J. Campbell (2012). "Evaluation of Baking Properties & Sensory Quality of Wheat-Cowpea Flour" *World Academy of Science, Engineering and Technology* 70.

AIB International (2018). Bread Manufacturing Process, Distance Learning Course, "Module 02 – Mixing." https://www.aibonline.org/Start-Your-Training/Baking/Baking-Foundations/Bread-Manufacturing-Process-Online, 2018.

Aiyesanmi, A. F. and Oguntokun, M. O., (1996). "Nutrient composition of the Dioclea reflexa seed an underutilized edible legume" Rivista Italiana delle Sostanze Grasse. Vol. 73 pp. 521–523.

Akintayo E.T., Adebayo E.A. and Arogundade L.A. 2002. Chemical composition, physicochemical & functional properties of akee (*Bilphia sapida*) pulp and seed flours. Food Chemistry, 77: 333–336

Akpapunam, M.A., & Darbe, J.W. (1994). Chemical composition & functional properties of blends of maize & bambara groundnut flours for cookie production. *Plant Foods for Human Nutrition*, 46: 147-155.

Akubor, P.I. and I.A. Onimawo. (2003). Functional properties & performance of soybean & maize flour blends in cookies. *Plant Foods Hum. Nutr*., 58: 1-12.

Akupapaman, M.A. and J.W. Darbe. (1994). The chemical composition and the functional properties of blends of maize and bambara groundnut flours for cookie production. *PlantFoods Hum. Nutr*., 46(2): 147-155.

Alleoni, A.C.C. (2006). Albumen protein and functional properties of gelation and foaming. *Science and Agriculture (Piracicaba, Braz)*, 63(3): 291-298.

Amza, T., Amadou, I., Zhu, K., & Zhou, H. (2011). Effect of extraction and isolation on physicochemical and functional properties of an underutilized seed protein: Gingerbread plum (*Neocarya macrophylla*). *Food Research International*, 44: 2843-2850.

Anarjan, N., H. Mirhosseini, B.S. Baharin and C.P. Tan. (2010). Effect of processing conditions on the physicochemical properties of astaxanthin nanodispersions. *Food Chem*., 123: 477-483

Appiah, F., Asibuo, J.Y, & Kumah, P. (2011). "Physical & functional properties of bean flours of three cowpea (*Vigna unguiculata L. walp*) varieties in Ghana", *African Journal of Food Science*. Vol. 5(2), pp. 100-104.

Asare, E.K., S. Sefa-Dedeh, E. Sakyi-Dawson and E.O. Afoakwa. (2004). Application of response surface methodology (RSM) for studying the product characteristics of

Atuonwu, A.C., Akobundu, E.N. (2010). Functional and pasting properties of pumpkin (*Cucurbita pepo*). *Journal of Agricultural and Veterinary Science*, *2*, 36 – 49.

Awuchi, C. G. and Nwankwere, E. T. (2018). Residual Calcium Content of Sweet Potato Slices after Osmotic Pre-treatment with Salt (NaCl) Solution. *American Journal of Food, Nutrition, and Health*, 3 (1); 8 – 15. ISSN: 2375-3935.

Barros, F., Alviola, J.N., & Rooney, L.W. (2010). Comparison of quality of refined & whole wheat tortillas. *Journal of Cereal Science*, 51(1): 49-56.

Basediya, A.L., Pandey, S., Shrivastava, S.P., Khan, K.A., & Nema, A. (2013). Effect of process and machine parameters on physical properties of extrudate during extrusion cooking of sorghum, horse gram and defatted soy flour blends. *Journal of Food Sci & Technology*, 50(1): 44-52.extruded rice-cowpea-groundnut blends. *Int. J. Food Sci. Nutr*. 55(5): 431-439.

Butt and MS Batool R. (2010). "Nutritional & Functional Properties of Some Promising Legumes Protein Isolates", Pak, J. Nutri. 9(4): 373-379, 2010.

Chinma, C. E. and Gernah, D. I. Z. (2007). "Physicochemical & Sensory Properties of Cookies Produced from Cassava/Soybean/Mango Composite Flours", Mexiwen Journal of Food Technology 5 (3): 256-260.

Ding, Q.B., Ainswort, P., Plunkett, A., Tucker, G. and Marson, H. 2006. The effect of extrusion conditions on the functional and physical properties of wheat-based expanded snacks. Journal of Food Engineering 73(2):142–148.

El-Adawy, A. T. (2001). Characteristics & composition of watermelon, pumpkin, and paprika seed oils and flours. *J. of Agricultural and Food Chem.*, *49*, 1253–1259. http://dx.doi.org/10.1021/jf001117+

Fasasi, O.S., I.A. Adeyemi and O.A. Fagbenro. (2007). Functional and pasting characteristics of fermented maize and Nile tilapia (*Oreochromis niloticus*) flour diet. *Pak. J. Nutr*., 4: 304-309.

Fu, B. X. (2008). "Asian noodles: History, classification, raw materials, & processing", Food Research International, 41(9), 888-902.

Gassmann B., Kroll, J. and Cifuentes S. 1987. Determination of foaming properties of proteins. Molecular Nutrition and Food Research, 31: 321-330.

Gibney, M. J. (1989). *Nutrition diet and health* (p. 168). New York, NY, Cambridge University Press.

Igwe Victory Somtochukwu; Omeire Gloria Chinenyenwa; Awuchi Chinaza Godswill; Kwari Mercy Ibrahim; Oledimma Ngozi Uchenna; Amagwula Ikechukwu Otuosorochi (2018). Ethyl Carbamate in Burukutu Produced from Different Sorghum Varieties Under Varying Storage Conditions Using Response Surface Methodology. *American Journal of Food Science and Nutrition*, 2018, 5 (4); 82 – 88. ISSN: 2375-3935.

Igwe Victory Somtochukwu; Omeire Gloria Chinenyenwa; Awuchi Chinaza Godswill; Kwari Mercy Ibrahim; Oledimma Ngozi Uchenna; Amagwula Ikechukwu Otuosorochi (2018). Effect of Storage Conditions on the Methanol Content of Burukutu Produced from Different Sorghum Varieties; a Response Surface Methodology Approach. *American Journal of Food, Nutrition, and Health*, 2018, 3 (3); 42 – 47.

Iwe M.O., U. Onyeukwu and A.N. Agiriga (2016). Proximate, functional & pasting properties of FARO 44 rice, African yam bean & brown cowpea seeds composite flour. *Cogent Food & Agriculture* (2016), 2: 1142409. http://dx.doi.org/10.1080/23311932.2016.1142409.

Kaushal P, Kumar V, and Sharma HK (2012). Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pegion pea (*Cajanus cajan*) flour and their blends. *LWT-Food Sci. Technol*. 48:59-68.

Kavitha, S. and Parimalavalli, R. 2014. Development and evaluation of extruded weaning foods. *European Academic Research*. II (4): 5197-5210.

Moses, O., Olawuni, I., & Iwouno, J.O. (2012). The Proximate Composition & Functional Properties of Full-Fat Flour, & Protein Isolate of Lima Bean *(Phaseolus lunatus). Open Access Scientific Reports*, 1: 349.

Ogori, A.F., Jatua, M.K., Apeh, M.O., & Adamu, L. (2013). Chemical & functional characteristics of the flours from blend of millet grain flour from distilled water soaking and malting. (*Pennesitum glacum*). *International J. of Food Science and Technology*, 1(1): 01-07.

Ogungbenle, H.N., A.A. Oshodi and M.O. Oladimeji. (2002). Effect of salts on the functional properties of beniseed (*Sesanumradiatum*) seed flour. *Int. J. Food Sci. Nutr*. 53: 1-5.

Olapade, A.A., & Akinyanju, F.T. (2014). Chemical and functional properties and performance of blends of water yam (Dioscorea Alata) and Soybean (Glycine Max) flours for water yam ball (Ojojo) preparation. *American Journal of Chemistry*, 4(3): 89-96.

Oppong David, Eric Arthur, Samuel Osei Kwadwo, Eric Badu, and Patrick Sakyi (2015). Proximate Composition & Some Functional Properties of Soft Wheat Flour. *Int'l J. of Innovative Research in Sci, Engineering and Technol*. 4 (2): 753 – 758. DOI: 10.15680/IJIRSET.2015.0402097

Panyam D. and Kilara A. (1996). Enhancing the functionality of the food protein by enzymatic modification. *Trends in Food Science and Technology*, 7: 120-125.

Rašper, V. (1969). Investigations on the starches from the major starch crop grown in Ghana I. — the Hot paste viscosity and the gel-forming power. *J. of the Sci of Food and Agric*, *20*, 165–171. http://dx.doi.org/10.1002/ (ISSN) 1097-0010

Reebe, S., Gonzalez, V. N., and Rengifo, J. (2000). Research on trace elements in common beans. *Food Nutrition Bulletin*, *21*, 387–391.

Singh, A., Hung, Y., Corredig, M., Phillips, D. R., Chinnan, S. M., and McWatters, H. K. (2005) "Effect of milling method on selected physical and functional properties of cowpea (Vigna unguiculata) paste", International Journal of Food Science and Technology, Vol. 40, pp. 525-536.

Singh, U. (2001). The functional properties of grain legume flours. *J. of Food Sci and Technol.* 38: 191-199.

Sui, Z., Lucas, W. P., and Corke, H. (2006). "Optimal cooking time of noodles related to their notch sensitivity", Journal of Texture Studies. Vol. 37, pp. 428–441.

Suresh Chandra and Samsher L (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research*, 8 (38): 4849 – 4852.

Tenagashaw, M.W.; Kenji, G.M.1; Melaku, E.T. 3; Huyskens-Keil, S.; & Kinyuru, J.N. (2015). Proximate composition and selected functional properties of complementary foods from teff fortified with soybean and orange-fleshed sweet potato. RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (1): 953-965. Available from http://repository.ruforum.org

Tongpun, N. (2006). "Formulation of soy protein-enriched instant noodles", Master Thesis of Science [Nutrition], Faculty of Graduate Studies, Mahidol University, Bangkok, Thailand, 2006.

Traynham, T.L., Myers, D. J., Carriquiry, A.L. & Johnson, L.A. (2007). Evaluation of Water-holding capacity for wheat-soy flour blends. *J Amer Oil Chem Soc*., *84*, 151-155.

Yetunde, E. A., Ukpong, U. S., Olajumoke, L., & Ime, A. F. (2009). Nutritional composition & sensory property of cakes made from wheat & African yam bean flour blends. *J. of Food Technol*, *7*, 115–118.

Zayas J.F. (1997). Emulsifying properties of proteins. In: Functionality of Proteins in Food. Springer-Verlag, Berlin, 134-227.

Zayas, J.F. (1997). Foaming properties of proteins. In: Functionality of Proteins in Food. Springer Verlag, Berlin, 260-309.