American Journal of Food Science and Nutrition
2020; 6(1): 6-19
http://www.aascit.org/journal/ajfsn
ISSN: 2375-3935

American Association for Science and Technology

Comparative Study of the Proximate Composition and Functional Properties of Composite Flours of Amaranth, Rice, Millet, and Soybean

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Citation

Hannington Twinomuhwezi, Chinaza Godswill Awuchi, Mihigo Rachael. Comparative Study of the Proximate Composition and Functional Properties of Composite Flours of Amaranth, Rice, Millet, and Soybean. *American Journal of Food Science and Nutrition.* Vol. 6, No. 1, 2020, pp. 6-19.

Received: December 20, 2019; **Accepted**: January 9, 2020; **Published**: February 4, 2020

Abstract: The study compared the proximate composition and functional properties of various combinations of rice, millet, amaranth, and soybean flour composites. The rice and millet, rice and amaranth, and rice and soybean flours were mixed in the ratios of 70:30; 50:50; 40:60 percent. The results on proximate composition showed that the moisture content ranged from 5.99% to 9.82%. The highest moisture content was observed in rice 40%-millet 60%; the ash content ranged from 1.01% to 2.83%. the highest ash content was found in RSOYc; the fat content ranged between 0.77% (RMa) to 8.96% (RSOYc); the protein content ranged between 6.91% (RMb) to 18.17% (RSOYc), carbohydrate content ranged between 67.1 (RSOYb) to 81.58% (RMa); the total energy ranged between 363.95 kcal (RMc) to 413.94 kcal (RSOYc) and fiber content ranged between 0.99% to 1.12. The results of the functional properties showed that the emulsion capacity ranged between 50.0% to 53.69% with highest in RSOYa; the emulsion stability ranged between 48.57% to 54.76%, with the highest in RSOYa; the water absorption capacity ranged between 5.79% to 7.17%, with the highest in RSOYb; the oil absorption capacity ranged between 5.89% to 7.72%, with the highest in RSOYc; bulk density ranged between 0.99% to 1.212; and the swelling capacity ranged between 5.0 ml to 23.5ml with the highest in RSOYc. The mixture of rice-soybean flour (40%-60%) is suitable for the preparation of foods for the young children with protein-energy malnutrition (PEM).

Keywords: Proximate Composition, Functional Properties, Composite Flours, Grains, Rice Flour, Amaranth Flour, Millet Flour, Soybean Flour

1. Introduction

Composite flours are considered firstly as blends of many flours for the production of leavened breads, unleavened baked products, porridges, snack foods, etc. [1]. A flour made by blending varying proportions of more than one non-wheat flours with or without wheat flour and utilized for production of unleavened or leavened baked products that are traditionally produced from wheat flour and increase essential nutrients in human diet is referred to as composite flour [1]. The reason to mixed different flours can be economically or nutritionally. The FAO reported that application of composite flour in many food products would be advantageous economically if the wheat imports could be eliminated or reduced, and that demand for bread and pastry products may be met by the use of domestically grown products instead of wheat [2]. Cookies rich in protein may be produced from composite flours like wheat flours fortified with soy [3], or any suitable complementary grain flour. Grains used for the production of flours can also be used in production of traditional beverages such as burukutu [4, 5], mukomboti, in some countries.

Functional properties are those quantities that determine the applications and end uses of food materials for many food products; their application in food production and in the industries, depend on various functional properties [6].

Functional properties also defines the behavior of ingredients during the preparation and cooking, as well as how the ingredients affect the finished products in terms of how it appearance, texture, and tastes [7]. Functional properties include oil absorption capacity, water absorption capacity, Emulsion capacity, Emulsion stability, Swelling capacity, Foam capacity, Foam stability, Gelatinization, Bulk density, Dextrinization, Denaturation, Coagulation, Gluten formation, Retention of moisture, Aeration, Jelling, Shortening, Plasticity, Flakiness, Sensory attributes, among others [7].

Bakery products can be varied by the addition of value-added ingredients [8]. Thus, the growing number of applications of composite flours in many bakery and pastry products has spurred an increasing number of studies on the effect of different types of materials used to produce flours on their physicochemical and functional properties.

Malnutrition in childhood negatively affect the child survival and long-term well-being and it is considered as very serious issue of concern in developing countries where we have a high number of illiterate and low-income mothers. The consequences of malnutrition should be taken seriously since it affects many children and even leads to stunting. Stunting results from growing under limited provision of health, care, and food. One of the solutions to malnutrition and stunting in children is using mixed flours. A part from the porridge, which is one of the main food for a child, these flours can be used as ingredient in a bakery or pasting. However, the quality of these flours needs to be checked. Determining and comparing the proximate composition and functional properties of different mixed flours gives enough information on the flour quality.

In this research, the main objective was to evaluate the proximate composition and functional properties of mixed rice flour with other selected flours. This study was based on determining the proximate composition and the functional properties of the mixture of flour. The findings of the research are crucial as they can help to identify the best choice of mixed flour used to overcome the problem of malnutrition. The findings will provide literature as baseline information for future researchers who will wish to curry out studies in fields related to the mixed flours. The results of this study can also be used be policy makers in advising mothers on how best to feed their babies.

2. Brief Review

2.1. Rice

Rice *oryza sativa* or *oryza glaberrina,* is a cereal mostly consumed as a staple food for a large part of human population in the world. It plant can grow to 1-1.8m tall depending on the variety and soil fertility, the edible seed is a grain (*caryopsis*) 5 to 12mm long and 2-3mm thick. The varieties of rice are classified as long, medium, and short grained. The long-grain rice is high in amylose and tend to remain intact after cooking; medium rice is high in amylopectin and become stickier after cooking. Rice grains can be used in different ways. Rice can be cooked by boiling (fully cooked) the drying; it can also be blended to flour or starch and be used in batters and breading's to increased crispiness.

Rice flour is a flour made from finely milled rice grains. It is distinct from the rice starch, which is usually made by steeping rice in lye. It can be made from either brown rice or white rice. Rice flour is a staple food in India, Japan, Thailand, and Southeast Asia. It is mainly used for production of noodles, sweets, and desserts. It is also an excellent thickener for custards, gravies, and sauces. Rice flour is also used as thickening agent in refrigerated or frozen recipes since it inhibits liquid separation [9].

2.2. Millet

Millets are a group of highly varied small-seeded grasses (*Poaceae*) widely grown around the world as cereal crops for fodder and human food. Millets are important crops in the semiarid tropic of Africa and Asia (especially in Nigeria [4, 5], India, Niger, and Mali), with the 97% of millet production in developing countries. The crop is favored because of its productivity and short growing season in dry, high-temperature conditions. The most widely cultivated millet is pearl millet (*Pennidetum glaucum*), which is an important crop in India and parts of Africa. Finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), and foxtail millet (*Setaria italic*) are also important crop species. Millet flour can be used as a porridge; ingredient in seeded bread; it can replace gluten-containing cereals for people who are affected by gluten-related disorder.

2.3. Amaranth

Amaranth, (*Amaranthus hypochondriacus*), *A. cruentus* (Grain type) and *A. tricolor* (Vegetable type) is an herbaceous annual grain with vertical growth habit, grown for both its leaves which are used as vegetable or green and its seeds which are used as grain. Both leaves and seeds contain an unusually high quality protein [10]. The grain may be popped like popcorn and also used as flour (after milling). The leaves of both the vegetable and grain types may be consumed raw or cooked. Amaranths principally cultivated for vegetable use have leaves with better taste than the grain counterpart.

Amaranth is a highly nutritious food. Amaranth leaves, tender stems, and shoots are consumed as a potherb in soups and sauces, cooked with other types of vegetables, by itself or with a main dish. The seed or grain is also fit for human consumption. Chopped plants can be used as forage for livestock consumption. Amaranth is not in grass family, and as a result is not classified as a cereal grain. However, as it is used much like the cereal grains, it is often referred to as a pseudocereal [10]. As with other small grains, amaranths may be processed in flaked, extruded, popped and milled flour forms. The flaked or flour forms are combined with other flours from grains such as wheat, millet, maize, etc., to make cereals, bread, cookies and other baked products. It was originally recommended that amaranth make up only 10 to

20% of the flour blend, but studies indicated that it can be blended up to 50 to 75% levels and still maintain the functional properties and flavor [10]. [11] reported that amaranth flour has the chemical composition as follow: moisture (%) 6.21, Ash (%) 2.53, Protein (%) 17.00 and Fat (%) 4.90.

2.4. Soybean

Soybean, (*glycine max*), also known as soya bean, is annual legume of pea family (*fabaceae*) grown for its edible seed. The soybean can be cultivated in various types of soil, but it thrives more in warm, fertile, well-drained, sandy loam. Soybean is one of the cheapest and richest sources of protein and is the diets of individuals and animals in many parts of the world [12]. Soybean protein contains all the required essential amino acids and significant amounts of minerals (Ca, Mg, Fe, Zn). The oil is 85% unsaturated, and comprised of oleic acid and linoleic acid shown to reduce the risks of heart diseases. As a result, soybean can boost the nutritional status of communities and individuals involved in its cultivation and utilization [12].

The valuable oil of the soybean, used widely in many industrial applications, is extracted either by expellers or by solvents. The distribution of amino acids in soy protein is similar to that found in animal protein rather than the protein from many vegetable sources; for instance, lysine constitutes about 5.4%. The soy oil includes useful amounts of phosphorus; the phosphatide in soy flour is approximately 2% and is mixture of cephalin and lecithin. Being low in carbohydrates, whole soybeans are very low on the glycemic index, which is a measure of how food affect the rise in blood sugar after meal. This make soybeans suitable for people with diabetes [13].

Soybean is milled to produce soy flour. Addition of soybean flour to cereal based products could be a good option to provide better overall essential amino acid balance, helping to overcome the world protein calorie malnutrition problems. Soybean flour and soybean protein have been used as composite flour in the production of bread, cookies and biscuit, and pasta [14].

2.5. Proximate Compositions

Proximate composition is the term often used in the field of feed/food and means the 6 major components of foods; moisture, ash, fat, protein, carbohydrate, and fiber, which are expressed as the content (%) in the feed, respectively [3].

2.5.1. Moisture Content

The moisture content of foods can range from 0 (e.g., for granulated sugar or vegetable oil) to over 90% (e.g., in raw watermelon or cucumbers). The determination of the water or moisture content of a food and, conversely, of the dry matter or total solids is important not only to provide a basis for expressing the content of the other components on a wet- or dry-basis, but also as an important factor in food stability and quality [15]. Water plays a significant role as a constituent of basically every food, not only as solvent and filling materials, but also as means to maintain the functions and structure of macromolecules and cells [16]. During processing, food products undergo different modifications in which certain chemical changes might take place depending on the moisture present [3]. Therefore, the comprehension of moisture content is important to predict the behavior of foods during the processing, storage, and consumption.

2.5.2. Ash Content

The ash content can be determined from the loss of weight, which occurs from complete oxidation of the sample at a high temperature (usually 500–600◦C) through combustion and volatilization of organic materials [17]. Ash refers to the total inorganic residue remaining after ignition or complete oxidation of organic matter in a foodstuff [18]. It is used to refer to the total minerals in food. Calcium is a mineral in most foods such as milk, cereals, legumes, and tubers [19]. Minerals in foods may occur as complexes with other minerals, or with macromolecules such as proteins [15]. The incineration or oxidation of organic matter during ashing may result in volatilization of some minerals, or formation of new complexes of other minerals, Both the amount and the composition of ash that remains after incineration or oxidation therefore depend on the nature of the food and the method of ashing [15]. This is an important consideration in selection of the ashing method and conditions, especially if further analysis of specific minerals (e.g., Ca, Zn, Fe, and so on) Ash is considered as a measure of quality and microbiological stability of foodstuffs, where high mineral contents are sometimes used to retard the growth of certain microorganisms [15, 3]. The quality of many foods in terms of taste, appearance, texture, and stability depends on the concentration and type of minerals they contain.

Ash content is important in monitoring the technological processing of foods during which time, it may change affecting certain physicochemical properties of foods [3]. The quality of certain food products, in terms of their purity and degree of refining, is estimated on the basis of the total ash content, as well [7, 3], and other chemical components [20]. The ash content of various foods may vary over a wide range. Ash contents of fresh food rarely exceed 5%, whereas some processed foods may contain over 12% of ash.

2.5.3. Fat Content

The term “lipid” is usually used synonymously with “fat” or “oil”. Lipids are a group of substances which are generally soluble in chloroform, ether, or other organic solvents but are very sparingly soluble in water [3, 7]. The lipids in foods consist primarily of highly hydrophobic or non-polar molecules called triacylglycerols (triacylglycerides), with smaller quantities of mono-acylglycerols and diacylglycerols, sterols, and the slightly more polar molecules such as sphingolipids and phospholipids [15]. Minor components such as fat-soluble vitamins, pigments, or hydrocarbons are also included as “fat” when defined by the property of solubility, whereas free fatty acids, especially the shorter chain fatty acids, may be water-soluble and therefore not included as fat [15].

Foods contain various types of lipids, but those which are of greatest importance are the triacylglycerols and phospholipids. Solid triacylglycerols at room temperature are known as fats. Tallow and lard are examples of fats, generally from animals. The liquid triacylglycerols at room temperature are known as oils such as olive oil and soybean oil, and are generally of plant origin. The term fat is applicable to all triacylglycerols whether they are normally solid or liquid at ambient temperatures [18]. Heating of oil may have impact on the functional properties of oil such as refractive index [21].

2.5.4. Protein Content

Proteins are macromolecules made up of amino acids linked together through amide or peptide bonds to form polypeptide chains, which can range in molecular mass from a few thousand to over a million Daltons. Proteins contribute to the nutritional value as well as textural and sensory properties of foods, and they also perform structural and biologically important functions [15, 7]. Proteins play major role in the growth and maintenance of the body of human and are, along with carbohydrate and lipid, the energy giving nutrient in food. Proteins also play a wide range of other functions in the human body, such as enzymatic activities and the transport of nutrients and biochemical compounds across cellular membranes [3, 7, 15]. In order to maintain these essential functions, it is required to provide the body with high quality protein through food. Inadequate intake of dietary protein containing the essential amino acids results to increased turnover of muscular protein, resulting in reduced growth and loss of muscle mass. Impaired immunity, and reduced hormonal and enzymatic activities may subsequently follow [15].

Proteins perform various functions in processed foods. The functional properties of proteins, such as foaming (e.g. marshmallow, whipped cream), emulsifying (e.g. ice cream, mayonnaise), gelling (e.g. gelatin, custard), thickening, texturizing, dough forming, whipping, curdling, water binding, flavor binding, and fat binding properties, are important for imparting desirable sensory attributes in a variety of food products [22]. Determination of protein content is necessary for measuring muscle food composition to meet human nutritional requirements [23].

2.5.5. Carbohydrate

Carbohydrates are a class of organic compounds historically designated the “hydrates of carbon” because of their observed elemental composition. They have the general chemical formula $C_n(H_2O)_n$. Carbohydrates are the primary components of plants and exoskeletons of insects and crustaceans. Carbohydrates are virtually an unavoidable and essential element of daily life; they constitute a bulk of our daily diet (in form of starch, glucose, sucrose, fructose, fibre, etc.), wood, cotton (cellulose), and paper [15].

Carbohydrates in foods include the monosaccharides (particularly D-glucose and D-fructose), the disaccharides (e.g., sucrose, maltose, lactose), higher oligosaccharides (e.g., raffinose, stachyose and fructo-oligosaccharides) and polysaccharides (e.g., starch, food gums and hydrocolloids, pectin, hemicellulose, cellulose) [7]. The sugar alcohols, such as sorbitol, mannitol, xylitol, lactitol, and maltitol, are also considered as carbohydrates. Carbohydrates in foods include monosaccharides (particularly D-glucose and D-fructose), disaccharides (e.g., sucrose, lactose, maltose), higher oligosaccharides (e.g., raffinose, stachyose and fructo-oligosaccharides) and polysaccharides (e.g., starch, food gums and hydro colloids, pectin, hemicellulose, cellulose) [15].

2.5.6. Energy Content

According to nutrition labeling regulations, one method allowed to calculate calories involves subtracting the amount of insoluble dietary fiber from the value for total carbohydrate, before calculating the calories based on protein, fat, and carbohydrate content [18].

2.5.7. Fiber Content

Dietary fiber is essentially the sum of the non-digestible components of a foodstuff or food product. It is composed primarily of polysaccharide molecules. As only the amylopectin and amylose molecules in cooked starch are digestible, all other polysaccharides are also components of dietary fiber [18]. According to the definition adopted in 2001 by the American Association of Cereal Chemists (now AACC International); Dietary fiber is the edible parts of plants or analogous carbohydrates resistant to digestion and absorption in the small intestine with fermentation (complete or partial) in the large intestine [7]. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fiber promotes beneficial physiological effects, such as laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation [18].

2.6. Functional Properties

Functional properties are the important physicochemical properties that reflect the complex interactions between the structure, composition, physicochemical properties and molecular conformation of food components together with the nature of environment in which these are associated and measured [9]. The functional properties of foods and flours are usually influenced by the food components, especially the carbohydrates, fats and oils, proteins, moisture, ash, fibre, and other ingredients or food additives added to the food (flour), such as sugar alcohols [24, 25], as well as structures of these components. The mycotoxins such as patulin in grains can also affect the functional properties of flours [7]. Functionality of foods is a characteristics of the food ingredients other than its nutritional quality, and has a great influence on its use and application, how they affect the finished product in terms of how it tastes, looks, and feels [26]. Functional properties include SC, Swelling capacity; WAC, Water absorption capacity; OAC, Oil absorption capacity; EA, Emulsion capacity; ES, Emulsion stability; FC, Foam capacity; FS, Foam stability; GT, Gelatinization temperature; LGC, Least gelatinization concentration; BD, Bulk density [7].

2.6.1. Emulsion Capacity and Stability

Emulsions are defined as dispersions of two (or more) immiscible liquids which are inherently thermodynamically unstable and tend to phase separate overtime via creaming, flocculation and/or coalescence. The emulsifying capacity is a molecule´s ability to function as agent that facilities the dispersion or solubilization of two immiscible liquids, whereas emulsifying stability is the ability to maintain integrity of an emulsion [27]. Emulsion capacity is the maximum amount of oil emulsified by protein in the given amount of flour [28]. Emulsion stability is highly dependent upon liquid droplet size and distribution, emulsion processing conditions (i.e., homogenization rates), protein characteristics (i.e., size, conformation, surface reactivity, concentration and solubility), solvent conditions (i.e., pH, salts and temperature), phase volume ratio and continuous phase viscosity.

2.6.2. Water Absorption Capacity

Water absorption capacity (WAC) is the ability of a food product to associate with water in a water limiting condition [26]. Adsorbed water is the water adsorbed on surface of macromolecular colloids like proteins, pectins, starches, and cellulose (Pierce, 2003). Water absorption capacity (WAC) is a critical function of protein in many food products such as dough, soups, and baked products [29].

2.6.3. Oil Absorption Capacity

The oil absorption capacity (OAC) is the flavor retaining capacity of flour which is very important in food formulations [26]. According to [9], The OAC makes the flour suitable in facilitating enhancement in mouth feel and flavor when used in food preparations. Due to these characteristics, the protein probably can be used as a functional ingredient in foods such as sausages, chiffon dessert, whipped toppings, angel and sponge cakes etc.

2.6.4. Bulk Density

Bulk density of flour is the density measured without the influence of any compression. The high bulk density (BD) of flour suggests their suitability for use in food preparations since it help to reduce paste thickness which is an important factor in convalescent and child feeding or as a thickener in food product; on contrast, low bulk density would be an advantage in the formulation of complementary food [1].

2.6.5. Swelling Capacity

SC is a function of the volume increase of product when having interaction with water. It is an indication of the extent of associative forces within flour granules and depends on the particle size, variety and type of processing or unit operation [30].

3. Materials and Methods

3.1. Sample Collection and Preparation

Rice, millet, soybean, and amaranth flour samples were obtained and milled using ArtsWays Roller Mill. The samples were prepared by mixing rice flour with these other flours using different ratios shown in the table below:

Table 1. *Showing Sample Ratios of the Mixed Flours*

Samples		Ratios (%)	
R: Am	70:30	50:50	40:60
R: M	70:30	50:50	40:60
R: Soy	70:30	50:50	40:60

These samples were mixed manually. The sample preparation and the laboratory work for proximate composition and functional properties were carried at Uganda industrial research institute. The different percent flour composites include RMa: 70% rice flour mixed with 30% millet flour, RMb: 50% rice flour mixed with 50% millet flour, RMc: 40% rice flour mixed with 60% millet flour, RAMa: 70% rice flour mixed with 30% amaranth flour, RAMb: 50% rice flour mixed with 50% amaranth flour, RAMc: 40% rice flour mixed with 60% amaranth flour, RSOYa: 70% rice four mixed with 30% soybean flour, RSOYb: 50% rice flour mixed with 50% soybean flour, RSOYC: 40% rice flour mixed with 60% soybean flour.

3.2. Reagents and Chemicals

The chemicals used for the study were obtained from the Uganda Industrial Research Institute and include petroleum ether (solvent), hydrogen chloride, sodium hydroxide (20%), boric acid (4%), sulfuric acid, methyl red.

3.3. Procedures of Determination of Proximate Composition

3.3.1. Determination of Moisture Content

Moisture content was determined according to the method described by [31]. The petri-dishes were washed with distilled water, then dried in electric oven for 4 hours at 105◦c. after the 4hours, petri-dishes were removed from the oven and then cooled in the desiccator for 30mins. After the 30mins, the petri-dishes were labelled, weighed respectively. 5g of sample were weighed according to the UNBS standard in two replicates. The petri-dishes and the samples were heated in an electric oven for 4hours set at 105°C. after the 4hours, the samples were removed from the electric oven transferred to the desiccator to cool to room temperature for 30 mins. The petri-dishes and the samples were weighed and the results were recorded. The moisture content was expressed as the moisture percentage.

$$\%moisture = \frac{weight\ of\ wet\ sample - weight\ of\ dry\ sample}{weight\ of\ wet\ sample} x100$$

3.3.2. Determination of Ash Content

Ash were determined using the dry ashing method, described by [31]. The crucibles were cleaned using hydrochloric acid 1:1 solution and rinsed with distilled water. The crucibles were dried in electric oven for 30 mins, then cooled in desiccator. After the desiccator, the crucibles were labelled for two replicates and weighed. 3g of each sample were weighed (UNBS standard) and recorded. After getting their weight, the crucibles were placed on a hot plate in a fume hood to carbonize the sample. The crucibles were placed in cool muffle furnace for 5hours at 550°c and the arrangement were recorded because the markings would be removed at high temperature in the furnace. After the 5 hours, the muffle furnace was turned off and waited for 3 hours for the temperature to drop to 150°C before opening, the crucibles were re-labelled and transferred to the desiccator to cool for 30 mins. After 30 mins, the samples and the crucibles were weighed and recorded. The ash content was expressed as percentage of ash.

$$\%Ash = \frac{G_2 - G_1}{W} \text{ x } 100$$

Where, G_2 = weight of sample after ashing (sample + crucible)

G_1 =Tare weight of crucible

W = Original sample weight

3.3.3. Determination of Fat Content

The fat content was evaluated using the Soxhlet apparatus. Samples were dried in the electric oven at 105°C for 4hours. The aluminum cups were weighed (W_2) and the dried samples were weighed out accurately 3g (W_1) in a labelled thimble placed in an aluminum cup. A thin layer of cotton wool was put on top of the sample thimble. 60ml of petroleum ether was measured in a measuring cylinder and transferred to each of the cups 60ml. each cup was placed on top of the extraction hot plates and adjust using the lower knobs, so as to attach each cup under its corresponding thimble as labelled. The upper adjustable knob in the boiling position was raised so as to allow the thimble units get inserted into the solvent (petroleum ether) in each cup.

After making sure that tubing connected from the service unit and the tap (H_2O) to the extraction unit were in position as required, open tap water, ensure the flow to the condensing unit and return to the sink through the chain. Switch the mains of the service unit. Adjust the extraction temperature to 100°C and set the safety knob to 150°C. start monitoring the extraction process and ensure that when condensation of the solvent starts, it is seen rolling down back to the sample trough the extraction unit taps in open position. When condensate was rolling down, the timer was turned in the clockwise direction to the 15min mark, so that boiling should run for 15min. at the end of boiling time, timer rings while turning back to the 60 min marks. At the end of boiling, thimbles were raised out of the solvent by pressing the upper buttons to the rinse position for 30min. at the end of the rise time, taps of the extractions unit were closed to stop solvent from condensing through the thimbles. solvent was left to condense and collected above the taps at the base the condenser. This process was left to run until no more solvent was condensing. At this point, the compresses air valves were raised upward to open the extraction unit and the timer was set to 15min to facilitate drying of the residue in the thimbles and evaporation of solvent further from thimbles and aluminum cups. At the end of drying process, the aluminum cups were put in the oven set at 105°C for 2hours. After the 2 hours, the cups were put in a desiccator and left to cool for 30min. at the end of 30min, each cup was weighed obtaining weight W_3. The fat content was expressed as percentage of fat.

$$\%Fat = \frac{W_3 - W_2}{W_1} \times 100$$

Where, W_3 =Weight of extraction cup + residue weight (g)

W_2 =Weight of extraction cup (g)

W_1 =original sample weight (g)

3.3.4. Determination of Protein Content

Crude protein of the flours was determined using the Kjedahl method according to [32]. One gram of each sample was introduced into a digestion flask. The Kjedahl catalyst (Selenium tablets) was then added to the sample. 20ml of concentrated sulphuric acid was added to the sample and fixed to the digester for 8h until a clear solution was obtained. The cooled digest was transferred into 100ml volumetric flask and made up to mark with distilled water. Distillation apparatus was set and rinsed for 10 mins after boiling. 20ml of 4% boric acid was pipetted into conical flask. Five drops of methyl red were added to the flask as indicator and the samples were diluted with seventy-five mils distilled water. 10ml of the digest was made alkaline with 20ml of NaOH (20%) and distilled. The steam exit of the distillatory will be closed and the change of color of boric acid solution to green was timed. The mixture was distilled for 15min. The filtrate was titrated against 0.1 N hydrochloric acid, HCl. The protein value was determined using 6.25 as conversion factor, and the result expressed as amount of crude protein.

$$\text{Percent crude protein} = = \%\text{N2} \frac{100 \text{ x N } 14 \text{ x Vf T}}{\text{W x } 1000 \text{ x Va}} \text{ x } 6.25$$

Where W = weight of sample analyzed, T = titre value-blank, V_f = Total volume of digest, N = Concentration of H_2SO_4 titrant, V_a = Volume of digest distilled

3.3.5. Determination of energy content

The energy content was computed using the macronutrients composition data.

3.3.6. Determination of Crude Fiber Content

The crude fiber of the flour samples was determined according to [32]. Two grams of each sample was boiled under reflux for thirty minutes with 200 ml of solution containing 1.25 g of H_2SO_4 per 100ml of the solution. Solution was filtered using linen on a flaunted funnel and then washed with water until the washing was no longer acidic. Residue was then transferred to beaker and boiled for 30 minutes with 100ml of solution. The final residue was filtered using a thin but closer pad of washed and ignited asbestos in Gosh crucible. The residue was dried in electric oven and weighed. The residue was incinerated, cooled, and weighed.

$$\frac{W_2 - W_3}{W_1} \times 100$$

W_1=weight of sample used,

W_2=weight of crucible plus sample,

W_3=weight of sample crucible + ash.

3.3.7. Determination of Carbohydrate Content

Carbohydrate content of the flours was determined using the difference formula described by [33].

% carbohydrate =100 − %(protein + fat + fiber + ash +moisture content)

3.4. Procedure of Determination of Functional Properties

3.4.1. Determination of Emulsion Capacity and Stability

The emulsion capacity and stability were determined by the method described by [34]. One g sample, 10 ml vegetable oil and 10 ml distilled water were prepared in calibrated centrifuged tube. Emulsion was centrifuged for 5 minutes at 2000g. The ratio of the height of emulsion layer to the total height of the mixture was calculated as emulsion capacity in percentage. The emulsion stability of the samples was estimated after heating emulsion contained in the calibrated centrifuged tube in a water-bath for 30 min at 80°C, cooling for 15 min under running water and centrifuging for 15 min at 2000 × g. The emulsion stability expressed in percentage was calculated as ratio of height of the emulsified layer to total height of mixture.

3.4.2. Determination of Swelling Capacity

Swelling capacity was determined by the modified method described by [35]. The samples were filled up to 10ml mark in a 100ml graduated cylinder and water was added to adjust total volume to 50 ml mark. The top of graduated cylinder was covered tightly and mixed by invertion of the cylinder. The suspension was inverted once again after 2 minutes and allowed to stand for further 30 minutes. The volume occupied by sample was taken after 30 minutes.

3.4.3. Determination of Water and Oil Absorption Capacity

Water absorption capacity and oil absorption capacity were determined by the method described by [36]. 1g of the sample was mixed with 10ml of distilled water or refined soybean oil, kept at ambient temperature for 30min and centrifuged for 10min at 2000Xg. The value obtained was expressed as % water and oil bound per gram of the sample.

3.4.4. Determination of Bulk Density (BD)

The bulk density (BD) was determined according to method of [35]. The flour sample (50 g) was placed into 100 ml graduated cylinder and tapped 20 to 30 times, until no noticeable change in volume. The bulk density was determined as weight per unit volume of the sample.

3.5. Energy Determination

The energy content of the samples was estimated by multiplying the number of grams of carbohydrates, protein, and fast by 4 kcal, 4 kcal, and 9 kcal, respectively. Then added the results together. 100 g of flour was used as basis.

4. Results and Discussions

4.1. Proximate Compositions

Table 2. *Showing the proximate composition of the mixed flours.*

Sample	%MC	%ASH	%FAT	%PC	%FB	%CAB	TE (kcal)
RMa	9.81^{d} ±0.15	1.01^{a} ±0.24	0.77^{a} ±0.02	6.93^{a} ±0.13	0.99^{a}±0.21	81.53^{a}±2.13	366.27
RMb	9.78^{d} ±0.22	1.39^{a} ±0.24	0.78^{a} ±0.02	6.91^{a} ±0.13	0.99^{a}±0.21	81.31^{a} ±1.94	365.29
RMc	9.82^{d} ±0.18	1.57^{a} ±0.38	0.82^{a} ±0.04	7.24^{b} ±0.23	1.00^{b}±0.06	80.54^{a} ±2.07	363.95
RAMa	9.02^{d} ±0.01	1.06^{a} ±0.18	3.17^{b}±1.49	14.52^{e}±0.08	0.99^{a}±0.32	72.25^{c} ±1.49	380.55
RAMb	8.6f ±0.29	1.41^{a} ±0.08	3.45^{b} ±0.5	9.49^{c} ±0.14	0.99^{a}±0.09	77.23^{b} ±2.06	382.91
RAMc	8.52^{c} ±0.2	1.62^{a}±0.01	4.3f ±0.13	12.17^{d} ±0.09	0.99^{a}±0.41	73.39^{c} ±2.17	388.15
RSOYa	8.58^{c} ±0.05	1.81^{a} ±0.43	4.8f ±0.15	12.9f^{d} ±0.47	0.99^{a}±0.23	71.90^{cd}±2.18	387.08
RSOYb	6.25^{b}±0.09	2.83^{b}±0.06	6.1f^{d} ±2.68	17.23^{f}±0.34	1.01^{b}±0.08	67.10^{e} ±1.85	396.56
RSOYc	5.99^{a} ±0.21	2.57^{b}±1.15	8.96^{e} ±0.63	18.17^{g}±1.02	0.99^{a}±0.12	64.65^{f}±1.72	413.94

RMa: 70% rice flour mixed with 30% millet flour, RMb: 50% rice flour mixed with 50% millet flour, RMc: 40% rice flour mixed with 60% millet flour, RAMa: 70% rice flour mixed with 30% amaranth flour, RAMb: 50% rice flour mixed with 50% amaranth flour, RAMc: 40% rice flour mixed with 60% amaranth flour, RSOYa: 70% rice four mixed with 30% soybean flour, RSOYb: 50% rice flour mixed with 50% soybean flour, RSOYC: 40% rice flour mixed with 60% soybean flour. TE: Total energy.

Values are means ± standard deviation of replicate determination. Mean with different superscript in the same column are significantly different p<0.05 and 80% of confident level. RMa (70% rice flour and 30%millet flour); RMb (50%rice flour and 50%millet flour); RMc (40%rice flour and 60% millet flour); RAMa (70% rice flour and 30%amaranth flour); RAMb (50%rice flour and 50% amaranth flour); RAMc (40%rice flour and 60% amaranth flour); RSOYa (70% rice flour and 30%soybean flour); RSOYb (50%rice flour and 50% soybean flour); RSOYc (40%rice flour and 60% soybean flour).

The results for proximate analysis are shown in Table 2. It could be seen that moisture content of the samples ranged from 5.99% to 9.82%. These values were similar to the range of 8 to 14% obtained by [37] for proximate, functional & pasting properties of FARO 44 rice, African yam bean & brown cowpea seeds composite flour. Also, the values are comparable to the values obtained by [3] for proximate composition and functional properties of different grain flour composites for industrial applications. It is believed that food materials such as flour containing more than 12% moisture have lesser storage stability than those with a lower moisture content [38]. According to these results, there were significant different $p<0.05$ in moisture content of the nine samples. RMc had the highest moisture content and significantly differed $p<0.05$ to other samples. The low moisture content of RSOY and RAM makes them easy to store at room temperature and less prone to fungal and microorganism infections. The Moisture content of food is influenced by the type of food, food variety, and storage conditions [3]. Flours with moisture content above 14 percent are not often stable at room temperature and as a result organisms in them will start to grow, producing off odours and flavours.

The ash content of food gives an idea of the total quantity of the mineral elements in the food. Ash content indicates the total inorganic compositions after the moisture and organic materials (fats, proteins and carbohydrates) have been removed [37] by oxidation or incineration in usually muffle furnace. The ash content ranged from 1.01% to 2.83%. These values were similar to the range of values reported by [37] and [3]. RSOYb (2.83%) had the highest ash content and significantly differed $p<0.05$ from other samples but did not differ to RSOYc. RM and RAM did not differ significantly to each other $p>0.05$. The lowest ash content was found in RMa (1.01%). [39] reported that the amount of ash present in a food sample played an important role while determining levels of essential minerals. It could be observed that as the ratio of rice flour decreased in the mixture, there was a corresponding increase in ash content of the mixed flour. High ash content as result of soybean flour addition to rice flour could imply increase quantity of minerals in mixed flour. Ash is the total mineral content of food sample. Minerals are essential micronutrients which serve variety of essential functions in metabolism and are among the parts of biomolecules such as hemoglobin, deoxyribonucleic acid (DNA), and adenosine triphosphate (ATP) [3].

Crude protein is the value obtained by quantitating the nitrogen in a sample using the Kjeldahl method in which the nitrogen compounds in the sample is digested by sulfuric acid to give ammonia; sodium hydroxide is added [3]. A steam distillation is conducted. Under alkaline conditions, the distilled ammonia is absorbed in the acid and measured by titration and then multiplying the results by the factor 6.25 (6.38 for milk products) [3]. The crude protein content of all the mixed flours evaluated ranged from 6.91% to 18.17%. These values agree with the work of [40] and that of [41]. The crude protein of the mixed flours was significantly different $p<0.05$ from each other. RSOYc (18.17%) had the highest crude protein followed by RSOYb (17.23%), this could be attributed to the high protein content in soybean flour. Legumes such as soybean, cowpea, beans, etc. have higher protein content than cereals such as rice, maize, etc. The least crude protein content was found in RMb (6.91%). This result indicated that the purpose of fortification, which was to increase the protein contain, was achieved while at the same time producing a shelf stable product due to its lower moisture content.

The fat content of the mixed flour was observed to range from 0.77% to 8.96%. These range of values were very much similar to the values of 1.30% to 7.34% reported by [3] for proximate composition and functional properties of different grain flour composites for industrial applications. The lowest fat content was recorded in RMa, which did not differ significantly from RMb and RMc. The highest fat content was observed in RSOYc (8.96%), followed by RSOYb. This could be associated with the high percent oil in soybean flour. When fat content of a weaning diet is higher, it can give more energy to infants. In the event that it exceeds the desired level, it will be affect the product stability as the unsaturated fatty acids are more vulnerable to oxidative rancidity [41]. Flours with high fat content are good as flavor enhancers and beneficial in improving the lusciousness of food in which it is integrated. Fats contribute to food flavor [3]. When feeds are stored for a prolonged period, ether extract gradually decreases. This is because the unsaturated fatty acids in feeds are polymerized oxidatively, absorbing oxygen in air and becomes insoluble in ether [3].

The carbohydrate content ranged from 64.64% to 81.53%; which were similar to the range of values of 68.23 to 74.10 g/100 g and 52.62 to 72.58% reported by [41] and [37], respectively. The highest carbohydrate content was found in RMa followed by RMb while the least carbohydrate content was found in RSOYc. The carbohydrate contents of RMa, RMb, and RMc were not significantly different ($p<0.05$), but the remaining samples differed significantly ($p>0.05$). There was a decrease in carbohydrate as the ratio of the rice flour decrease in all the mixed flour. The high carbohydrate content of RMa and RMb suggested their usefulness in combating protein-energy malnutrition (PEM), as there is carbohydrates to provide energy to the body to spare protein. Then protein can be used for its primary functions; building and repairing worn out tissues, instead of being used as source of energy [3]. Carbohydrates are good sources of energy [3]. A high concentration of carbohydrates is desired in breakfast meals and weaning formula.

The crude fiber of the mixed flours ranged from 0.09% to 1.01%. The fiber contents of the samples were slightly significantly different ($p>0.05$). Crude fiber contents of the blends increased slightly as the level of the legume flour substitution increased. This can be as a result of high crude fiber contents of the legumes which had greater effect on the cereal [37]. Crude fiber clearly corresponds only to the feeds of plant origin considering the constituent compounds; however, a small quantity of it is contained in the feeds of animal origin. This is due to organic residue that is undissolved by alkali/acid boiling is observed in the feeds of animal origin, and also the residue is chitin and some scleroprotein (albuminoid) that are completely different from the so-called crude fiber in content. The crude fiber helps to prevent heart diseases, colon cancer, diabetes, etc. [3]. Crude fiber reduces the rate of release of glucose into blood stream and also reduces intercolonic pressure thereby reducing the risk of colon cancer [3]. Plant fiber is mainly made up of cell wall which comprised of indigestible carbohydrates such as cellulose, hemicellulose, pectin, and lignin.

The total energy of the mixed flours ranged between 363.95 kcal to 413.94 kcal (1522.77 kJ to 1731.92 kJ) per 100 g of flour. 1 kcal is equal to 4.184 kJ. Carbohydrates yield an average of 4 kcal/g, protein kcal/g (although the primary role of protein is not for energy), and fat 9 kcal/g. RSOY had higher energy compared to others. Energy is an essential property of food. The energy our body requires for running, talking, walking, working, relaxing, breathing, etc. is supplied by the food we eat. Carbohydrates are primary energy source for cells, especially cells of the central nervous system (CNS) and red blood cells. The energy content of foods are measured by their carbohydrates, fats, and, in some cases, protein contents. The high carbohydrate content of the flours suggested that they can be used in combating protein-energy malnutrition (PEM), as there are carbohydrates to provide energy to the body to spare protein. Protein will then be used for its primary functions; building and repairing worn out tissues, instead of being used as energy source [3]. Carbohydrates and fats are good sources of energy.

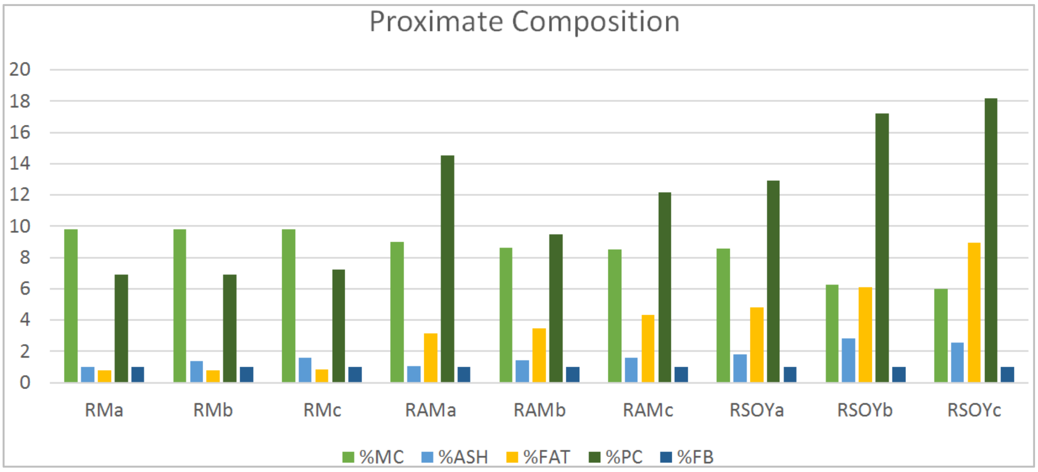

Figure 1. *Graph of moisture, ash, fat protein and fiber content.*

4.2. Functional Properties

Table 3. *Showing the functional properties of the mixed flour.*

Sample	%EC	%ES	%WAC	%OAC	BD	SC
RMa	52.5^{c}±3.61	50.51^{C}±0.72	5.85^{a}±0.41	6.87^{b}±0.04	1.12^{b}±0.01	8.0^{d}±1.41
RMb	50.0^{a}±3.43	51.19^{d}±1.68	5.79^{a}±0.47	7.31^{C}±0.06	1.12^{b}±0.032	5.0^{a}±0.0
RMc	52.38^{C}±0.01	48.57^{a}±1.35	6.35^{b}±0.93	6.86^{b}±0.07	1.12^{b}±0.01	5.5^{a}±0.71
RAMa	51.58^{b}±1.69	52.98^{e}±8.59	6.30^{b}±9.49	5.89^{a}±0.16	1.07^{b}±0.01	6.75^{b}±0.35
RAMb	53.46^{d}±1.55	51.77^{d}±3.92	6.71^{b}±0.29	6.82^{b}±0.04	1.06^{b}±0.01	7.7^{C}±2.12
RAMc	51.68^{b}±1.0	52.64^{e}±2.34	6.63^{b}±0.59	6.69^{b}±0.24	0.99^{a}±0.2	7.5^{C}±3.54
RSOYa	53.69^{d}±1.85	54.76^{f}±3.37	6.37^{b}±0.13	6.40^{b}±0.08	1.11^{b}±0.02	7.25^{C}±1.06
RSOYb	51.19^{b}±1.70	51.19^{d}±1.68	7.17^{C}±1.13	6.76^{b}±0.32	1.10^{b}±0.01	6.5^{b}±0.71
RSOYc	51.19^{b}±1.70	49.32^{b}±2.41	6.73^{b}±0.03	7.72^{C}±0.34	1.08^{b}±0.01	23.5^{e}±0.71

RMa: 70% rice flour mixed with 30% millet flour, RMb: 50% rice flour mixed with 50% millet flour, RMc: 40% rice flour mixed with 60% millet flour, RAMa: 70% rice flour mixed with 30% amaranth flour, RAMb: 50% rice flour mixed with 50% amaranth flour, RAMc: 40% rice flour mixed with 60% amaranth flour, RSOYa: 70% rice four mixed with 30% soybean flour, RSOYb: 50% rice flour mixed with 50% soybean flour, RSOYC: 40% rice flour mixed with 60% soybean flour. EC: emulsion capacity, ES: emulsion stability, WAC: water absorption capacity, OAC: oil absorption capacity, BD: bulk density, SC: swelling capacity.

The values are means ± standard deviation of replicate determination. Mean with different superscript in the same column are significantly different $p<0.05$ and 80% of confident level. RMa (70% rice flour and 30%millet flour); RMb (50%rice flour and 50%millet flour); RMc (40%rice flour and 60% millet flour); RAMa (70% rice flour and 30%amaranth flour); RAMb (50%rice flour and 50% amaranth flour); RAMc (40%rice flour and 60% amaranth flour); RSOYa (70% rice flour and 30%soybean flour); RSOYb (50%rice flour and 50% soybean flour); RSOYc (40%rice flour and 60% soybean flour).

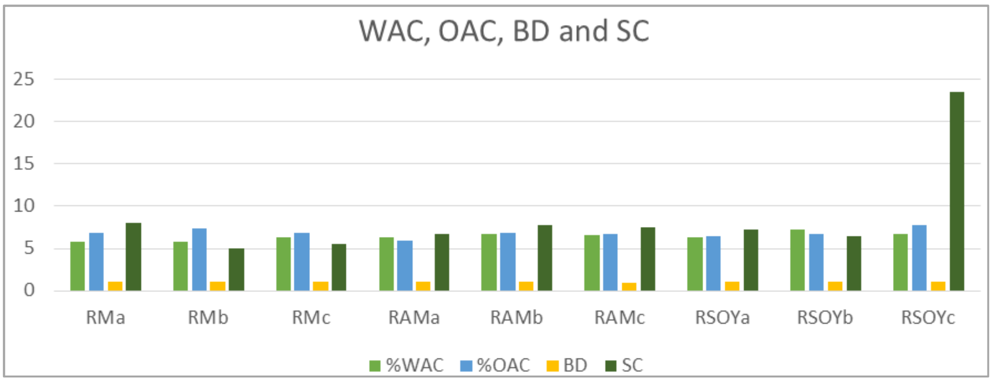

Figure 2. *Water absorption capacity, oil absorption capacity, bulk density, and swelling capacity.*

4.2.1. Emulsion Capacity and Stability

Emulsions are part of common classes of two-phase food systems of matter known as colloids [7]. Emulsifying properties are useful functional characteristics of foods and flours which play a vital role in the development of novel sources of plant protein products for use as foods [42]. The results of emulsion capacity (EC) and emulsion stability (ES) are shown in Table 2.

The emulsion capacity of the mixed flours ranged from 50.0% to 53.69%. These values were similar to the values of 42.50, 56.78 and 56.67% reported by [37]. The EA was observed highest in RSOYa (53.69%) and lowest in RMb (50.0%). The emulsion capacity (EC) of foods is associated with the amount of oil, water, residues of non-polar amino acids on the surface of protein, and other constituents in the food [7]. An increased amount of non-polar amino acids residues on surface of protein will reduce energy barrier to adsorptions which relies on the protein structure [7]. RSOYa was not significantly different $p<0.05$ from RAMb but significantly different to other samples because it had the highest emulsion capacity. RSOYb, RSOYc, RAMa and RAMc were not significantly different to each other $p>0.05$. RMa and RMc did not differ significantly from each other. RMb differed significantly to other samples because it had the least emulsion capacity. There was an increase in emulsion capacity as the rice was mixed with other flours.

Emulsion stability (ES) is the ability of the emulsion system of food to resist the alterations and changes in its physicochemical properties with time. Many mechanisms such as coalescence, creaming, flocculation, etc., cause the breakdown of emulsion [7] in foods. The emulsion stability of the mixed flours ranged from 48.57% to 54.76%. The ES was observed highest in RSOYa, which significantly differ to the other samples. The least ES was observed in RMc (48.57%), which was significantly different to other samples. RMb, RAMb, RSOYb were not significantly different to each other. It was observed that there was a decreased of emulsion capacity stability as the ratio of the soybean flour increased in the mixture. While there was an increase, then a decrease of emulsion stability when the percentage of millet flour and amaranth flour increased, there was a decrease, then an increase of emulsion capacity when the percentage of millet flour and amaranth flour increased. Increasing emulsion capacity (EC), emulsion stability and fat binding during food processing are the primary functional properties of protein in such food as comminuted meat products, salad dressings, frozen desserts and mayonnaise [1]. EC and ES are influenced by various factors such as pH, solubility, and concentration [43]. EC reflects the ability of the proteins to aid the formation and the stabilization of newly created emulsion.

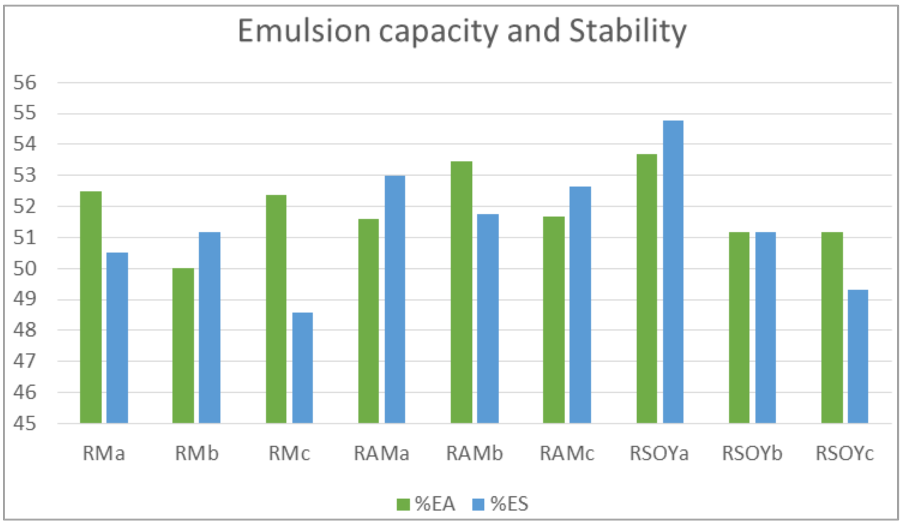

Figure 3. *Graph of emulsion capacity and stability.*

4.2.2. Water and Oil Absorption Capacity

The results of WAC and OAC are shown in Table 3. The water absorption capacity ranged from 5.79% to 7.17%. These values were somewhat higher than the values of 2.20 to 4.81 g/g reported by [41] for proximate composition and selected functional properties of complementary foods from teff fortified with soybean and orange-fleshed sweet potato. Water absorption capacity (WAC) is the capacity of the flour to absorb water and swell for enhanced consistency in food [38]. The sample RSOYb was significantly different $p<0.05$ to other samples because it had the highest WAC. The WAC of a food product measures the water holding ability by the starch after the swelling in excess water, which corresponds to weight of the gel formed, and therefore is an index of degree of starch gelatinization [3]. It depends on the availability of the hydrophilic groups which bind the water molecules and also on the gel-forming capacity of the macromolecules [41]. The least WAC was observed in RMb which was not significantly different to RMa. The samples RMc, RAMa, RAMb, RAMc, RSOYa, and RSOYc were not significantly different to each other. Water absorption capacity is considered a critical function of protein in viscous foods, like soups, gravies, doughs and baked products [44]. WAC is important in foods as it relates to other functional properties such as emulsification, solubility, adhesion, dispersibility, wettability, cohesion, viscosity and gelation [30].

Oil absorption capacity (OAC), also called oil absorption, is the binding of fat by the proteins' non-polar side chain [7]. Oil absorption capacity (OAC) is mainly attributed to the entrapment of oils physically. It is an indication of the rates at which proteins bind to fat in food formulations [45]. The oil absorption capacity ranged from 5.89% to 7.72%. The sample RSOYc was significantly different $p<0.05$ to other samples because it had the highest OAC but did not differ significantly to RMb and the sample RAMa was significantly different $p>0.05$ because it had the least OAC. The samples RMa, RMc, RAMb, RAMc, RSOYa, and RSOYb did not significantly differ. [9] reported that the ability of the proteins of flour to bind with oil is useful in food system where an optimum oil absorption is desirable. It makes flour to have functional uses in foods such as in sausage production. Oil absorption capacity is important for nutrient and energy density of food products especially for infant and young children. In addition, the high oil absorption capacity also makes the flours suitable in facilitating enhancement in mouth feel and flavor when used in food preparations [46].

4.2.3. Bulk Density (g/ml)

Bulk density, also called apparent density or volumetric density, is the mass of several particles of flour materials per total volume they occupy [7]. It is a functional property of flours, granules, powders, fine particles, and other divided solids of foods (or food ingredients). The results of bulk density are shown in Table 3. The bulk density of the flour ranged from 0.99% to 1.12%. It was observed that the samples RMa, RMb, RMc had the highest bulk density. The sample RAMc was the only sample which was significantly different to other samples and it had the least bulk density. A higher bulk density was desirable, since it helped to reduce the paste thickness which is an important factor in convalescent and child feeding [44]. Bulk density depends on interrelated factors including intensity of attractive inter particle forces, particle size and number of contact points [48]. The high bulk density of flours suggests their suitability for application and use in food preparations. On contrast, the low bulk density would be an advantage in the formulation of complementary foods. The change in bulk density is affected by the particle size and density of the flours, it is very vital in determining the packaging requirement and material handling [38].

4.2.4. Swelling Capacity (ml)

The results of the swelling capacity (SC) are shown in Table 3. The value of the swelling capacity ranged between 5ml to 23.5ml. The sample RSOYc differed significantly $p<0.05$ to other samples because it had the highest swelling capacity. The least swelling capacity was found in the sample RMb, which did not significantly differ to RMc. The swelling capacity is the volume in milliliters taken up by the swelling of 1 g of food material under specific conditions [3]. The samples RAMb, RAMc and RSOYa did not differ significantly to each other, and the samples RAMa and RSOYb did not differ significantly to each other. The swelling capacity is the measure of starch ability to absorb water molecules and swell, and also reflects extent of associative forces in starch granules. Swelling capacity (SC) is considered a quality measure in most food products such as bakery products. It indicates the non-covalent bonding between molecules of starch granules and is also one of the factors of α-amylose and amylopectin ratios [37]. RMa differed significantly to other samples. Swelling Capacity is a function of the volume increase of product when having interaction with water. It is an indication of the extent of associative forces within flour granules and depends on the particle size, variety and type of processing or unit operation [30]. The variation in the swelling capacity (SC) indicates degree of exposure of internal structure of starch present in the flour to action of water [38], and may be influenced by the presence of other particles such as mycotoxins [47].

5. Conclusion and Recommendation

5.1. Conclusion

In the recent research, the proximate composition of the mixture of flour is observed to decrease in moisture content when the percentage of rice flour decrease in the mixture. This shows that the soybean flour and amaranth flour improve the moisture content of the mixture, hence, its shelf life. It was observed that in all the samples, the value of ash content and fat content increased when the percentage of rice flour decreased in the mixture. The mixture of rice and soybean flour had higher ash content, this imply that it had higher mineral content. The protein content increased when percentage of amaranth flour and soybean flour increased in the mixture while a decrease, then an increase when percentage of amaranth flour increased. The mixture of rice flour and soybean flour had higher protein content, probably due to the high protein content in soybean. That make it suitable for feeding children with malnutrition. The carbohydrate content reduced in rice-millet flour and rice-soybean flour the samples as the percentage of rice flour decreased but increased in rice-amaranth flour. This shows that rice flour has best carbohydrate content compare to millet and soybean flour. There was a reduction in total energy in the mixture of rice flour and millet flour but an increase of total energy in the mixture of rice flour and amaranth flour and rice flour and soybean flour. The best mixed flour in term of proximate composition was found in the mixture of rice- soybean (40%-60%) The functional properties of the mixed flour were observed to have a decrease, then an increase in emulsion capacity in the mixture of rice and millet, but an increase, then a decrease in emulsion stability as the percentage of rice decrease. The opposite situation was observed in the mixture of amaranth. In the mixture of rice and soybean, both emulsion capacity and stability decreased as the percentage of rice decreased. The mixture of rice flour 70% and soybean flour 30% had the best emulsion capacity and stability than the others. There was an increase, then a decrease in water absorption capacity in the mixture of rice flour and amaranth flour, and rice flour and soybean flour, but a decrease then an increase in the mixture of rice flour and millet flour. The best water absorption capacity was found in the mixture rice flour 50% and soybean flour 50%. The oil absorption capacity increased in the rice-amaranth flour and rice-soybean flour while increase, then decrease in rice-millet flour as the percentage of rice decreased. The best oil absorption capacity was observed in rice 40%-soybean 60%. As the percentage of rice decreased the mixture, the bulk density was the same in rice-millet flour but decreased in the rice-amaranth and rice-soybean flour. The least bulk density was observed in rice 40%-amaranth 60%. This seems the best to be used as a complementary food. It was observed that the swelling capacity of the rice-millet flour and rice-soybean flour decreased, then increased as the percentage of rice decreased while increased, then decreased in rice-amaranth flour.

5.2. Recommendations

Due to its best proximate composition such as protein, fat, moisture, ash, energy and fiber content, the mixture of rice-soybean flour (40%-60%) can be used as a porridge for the young children with malnutrition. And it has longer shelf life compare to other flour. The mixture of rice-soybean flour and rice amaranth flour can be used bakery for making pies, cakes, bread because they had a good fiber content, water absorption capacity and swelling capacity compare to rice-millet flour. They are also suitable for individuals with gluten allergy (protein responsible for the elasticity in dough and the structure in backed bread). The mixture of rice-amaranth can be used as complementary food because of its low bulk density and its good proximate composition.

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