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EVALUATION OF COMPLEMENTARY FOODS FROM BLENDS OF ROASTED RICE AND SOYBEAN FLOURS

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ABSTRACT

Objective: The study was carried out to evaluate the chemical and functional properties of complementary food produced from blends of rice and soybean flours.

Methods: Rice and soybean grains were cleaned, de-hulled, roasted, winnowed and milled. The flours were used to formulated 90:10, 80:20, 70:30, 60:40 and 50:50 rice:soybean complementary food. The various blends of the rice:soybean complementary food were analysed for their proximate composition, vitamin and mineral content, anti-nutrient composition and sensory properties.

Results: Moisture, protein, fat, fibre, ash and carbohydrate content of the blends ranged from 6.98-7.87, 5.70-19.15, 4.83-13.76, 0.41-1.39, 0.77-5.52 and 50.09-83.45% respectively. Mineral and vitamin contents of the rice-soybean complementary food blends ranged from 0.88-2.82 mg/100 g for Zn, 1.93-4.15 mg/100 g for Fe, 5.94-12.78 mg/100 g for Ca, 0.35-0.96 mg/100 g for vitamin B_1 and 0.49-0.81 mg/100 g for vitamin B_2. Bulk density, water absorption capacity and swelling capacity of the samples ranged from 0.83-0.89 g/cm^3, 147.75-207.40% and 4.0-6.9 g/g respectively. Protein, fat, ash, mineral and vitamin contents of the rice-soybean complementary food blends showed an increase with increase in soybean addition. Anti-nutrient composition of the complementary food blends showed oxalate, phytate, haemagglutinin and tannin to be within safe levels.

Conclusion: Blending of rice with soybean in various ratios for production of complementary food, affected the chemical, functional and sensory properties of the blends. Roasting of the grains before milling were instrumental in reducing the various anti-nutrients that are associated with rice and soybean to a minimum no- risk level.

Keywords: rice, soybean, roasting, flour blends, complementary food.

INTRODUCTION

Complementary foods are foods (liquid, semi-solid and/or solids) other than breast milk or baby formula introduced to an infant to provide nutrients when breast milk alone is no longer enough to meet the nutritional needs of the infant[1]. It is required that complementary food be given in appropriate amount, frequency and consistency using a variety of foods to meet the nutritional needs of the growing child while maintaining breastfeeding. A proper complementary feed should be rich in energy and micronutrients (especially iron, zinc, calcium, vitamin A, vitamin C and folates), free of contamination (pathogens, toxins or harmful chemicals), without much salt or spices, easy to eat and easily accepted by the infant, easy to prepare, easy to digest, and at a cost that is acceptable and affordable by most families[2]. Rice (Oryza sativa L.) is the most important cereal crop in developing countries and is a staple food for over half the world's population[3]. Soybean (Glycine max) is an annual legume of the Fabaceae family and is economically the most important bean in the world, providing vegetable protein for millions of people and ingredients for hundreds of chemical products[4]. Most of weaning foods in Nigeria are based on cereals (mainly, maize, yam, millet, sorghum and other family diets) without adequate supplementation with high quality protein sources[5]. Over dependence on such poor protein sources is the main cause for the widespread protein-energy malnutrition problems. This is because cereals are deficient in lysine and tryptophan but have sufficient sulphur containing amino acids which are limiting in legumes[6] while legumes are rich in lysine. Supplementation of cereals with legumes is beneficial as the nutritive value of the final product is improved. However, for this flour blend to be useful and successful in food application, it should possess desirable micronutrients and functional properties[7]. Roasting is the simple and easily adaptable technology for reduction of bulkiness and increasing shelf life of cereal and legume based food formulations[8]. Roasting has been reported to induce an Increase in free limiting amino acids and available vitamins with modified functional properties of seed components[9]. Roasting has also been shown to decrease anti nutritional factors, increase protein digestibility, crude fibre and protein contents, improve colour, extend shelf life and enhance flavour of cereals and legumes[10, 11]. This study evaluated the effects of roasting on the functional, chemical and functional properties of rice-soybean complementary food.

MATERIALS AND METHODS

Paddy rice was procured from Adani rice mill in Uzo-uwani Local Government Area, Enugu State, Nigeria while soybean was purchased from Ogige market, Nsukka, Enugu state, Nigeria.

Processing of roasted rice and soybean flour

The rice flour was produced using the method described by Solomon[12]. Unparboiled paddy rice grains were winnowed, cleaned and de-hulled mechanically using Engelberg rice dehuller by the Engelberg Huller Company located in the Department of Food Science and Technology, University of Nigeria, Nsukka. The dehulled rice grains were washed and sundried for 9 hours prior to roasting at of 120 °C for 20 minutes using a locally fabricated mechanical roaster located in the Department of Food Science and Technology, University of Nigeria, Nsukka. The roasted rice grains were milled into fine flour, using a hammer mill. Soybean flour on the other hand, was prepared as described by Ikpeme-Emmanuel et al.[13]. Soybean seeds were cleaned to remove stones and extraneous materials. The cleaned seeds were washed in water and soaked for12 hours and the water drained. The testa was removed, the seeds were washed again several times with more water, air-dried for 48 hours and then roasted at 120 °C for 20 minutes using a locally fabricated mechanical roaster located in the Department of Food Science and Technology, University of Nigeria, Nsukka.

Formulation of rice-soybean complementary food

The flours produced from the roasted rice and soybean were used to formulate 90:10, 80:20, 70:30, 60:40 and 50:50 rice:soybean complementary food.

Analytical methods

Proximate composition

The proximate composition of the samples was determined according to the methods of A.O.A.C.[14].

Minerals and vitamins

Mineral (calcium, iron and zinc) and vitamin (thiamin and riboflavin) contents were determined according to the methods of the A.O.A.C.[14].

Anti-nutrient

Tannin

Tannin content was determined by the Folis-Denis method as described by Kirk and Sawyer[15]. The sample (5 g) was dispersed in 50 mL distilled water and was shaken. The mixture was allowed to stand for 30 minutes at 28 ^oC before it was filtered through Whatman No. 42 grade of filter paper. Two milliliter (mL) of the extract was dispersed into a 50 mL volumetric flask. Similarly, 2 mL standard tannin solution and 2 mL of distilled water was put in separate volumetric flasks to serve as blank standard, reagent was added to each of the flasks, made up to 50 mL with distilled water and allowed to incubate at 28 ^oC for 90 minutes. The respective absorbance was measured in spectrophotometer at 260 nm using the reagent blank to calibrate the instrument at zero. Tannin content was calculated as:

$$\text{Tannin (g/100g)} = \text{concentration of standard} \times \text{Absorbance of sample}$$

Phytate

Phytate was determined according to the method described by Latta and Eskin[16]. Five grams of the sample was weighed into a 250 mL conical flask. Phytate was extracted with 100 mL of 2.45M HCl. After extraction, it was allowed to stand for one hour at room temperature and then centrifuged. Supernatant (2.4%) was decanted and diluted with 1 mL of distilled water. A diluted sample of 10 mL was passed through an amberlite resin. Inorganic phosphorus was eluted with 0.7M NaCl into a 15 mL centrifuge tube, 3 mL of the 0.7M eluent was pipetted, mixed on a vortex for 5 seconds and centrifuged. Water was used to zero the spectrophotometer. After centrifugation, the samples were augmented with additional HCl to ensure that phytate is de-complexed from the metals. For samples containing greater than 15 % fat, fat was extracted with 25 mL petroleum ether. Absorbance of supernatant was read at 500 nm. Phytate content was then estimated from the standard.

Oxalate

Oxalate content was determined using the method of Fasset[17]. Two grams of the flour samples were dissolved in 200 mL of 30% HCl. The extract was titrated with 0.1 M $KmnO_4$ [potassium tetraoxomanganate (IV)] and the solution read at 490 nm in an Ultraviolet BIOCHROM 4049 spectrophotometer. The concentration of oxalate was read off a standard curve prepared with the standard solution and the value expressed as mg oxalate/100 g.

Haemagglutinin

Haemagglutinin was determined by the spectrophotometric method of A.O.A.C.[14].

Functional properties

Water absorption capacity

Water absorption capacity was determined by the method described by Ghandi and Srivasta[18]. The sample (1 g) was weighed into a conical graduated centrifuge tube. Using a whirl mixer by Sri Murugan Foundry Equipment located in the Department of Food Science and Technology, University of Nigeria, Nsukka, the sample was mixed thoroughly with 10 mL distilled water for 30 seconds. The sample was allowed to stand for 30 minutes at room temperature (23-25 ^oC) and then centrifuged at 5000 rpm for 30 minutes. The volume of free water (the supernatant) was read directly from the graduated centrifuge tube. The water absorption capacity was expressed as grams of water absorbed (or retained) per gram of sample.

Swelling capacity

The swelling capacity was determined by the method described by Ukpabi and Ndimelu[19] (1977). 100 mL graduated cylinder was filled with the sample to 10 mL mark. The distilled water was added to give a total volume of 50 mL. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 minutes and left to stand for a further 8 minutes. The volume occupied by the sample was taken after the 8th minute.

Bulk density

The bulk density was determined by the method described by Okaka and Potter[20]. The measuring cylinder (10 mL) was weighed and gently filled with the sample followed by gently tapping the bottom until there was no further diminution of the sample level after filling to the 10 mL mark. The bulk density was calculated as:

$$\text{Bulk density (cm}^3) = \frac{\text{weight of sample (g)}}{\text{volume of sample (g)}}$$

Experimental Design and Statistical Analysis

The experiment was designed using Completely Randomized Design. All data generated was subjected to one way analysis of variance and Duncan's Multiple Range Test was used to separate the means at 5% level of significance[21].

RESULTS AND DISCUSSION

Proximate composition of the rice-soybean complementary food blend

Proximate composition of the samples is shown in Table 1. Moisture content ranged from 6.98-7.87% and were all below 10%. Protein, fat, fibre and ash contents ranged from 5.70-19.15, 4.83-13.76, 0.41-1.39 and 0.77-5.52% respectively and they were found to increase with an increase in soybean addition while carbohydrate content of the samples reduced with an increase in soybean addition in the blend and ranged from 53.20-80.42%. Moisture content of the samples was relatively low (<10%) and it was within RDA values of 5-10% for moisture content of complementary foods[22]. Blending with soybean significantly ($p>0.05$) affected the crude protein content of the complementary food blends as soybean is a rich protein source. The increase in fat content as soybean is increased in the blend could be attributed to the high oil content of soybean. Fat have been known to impart on the sensory attributes of food products, however, high fat content of food products can predispose the food to rancidity and may therefore, reduce its keeping quality. From the results, fibre content of the samples was found to be relatively low. The low fibre content of the samples could be attributed to the dehulling process of the base grains which is a desireable attribute for complementary foods. Dehulling of pulses, legumes, oil seeds and certain cereals used in infant complementary food, is recommended by FAO/WHO Food Standards Programme[23] to decrease and if possible, eliminate phytate, tannins and other phenolic materials, which can lower the protein digestibility, amino acid bioavailability and mineral absorption. Also low fibre content in complementary food reduces bulkiness of the food and encourages high digestibility and absorption of nutrients such as proteins and minerals[24]. Increase in ash content of the samples with increase in soybean addition will mean an increase in their mineral content because ash is used as an index of mineral content in foods. According to Madukwe et al.[25], there was a higher observed value for minerals in soybean flour than in rice flour. The carbohydrate content of the samples decreased with increased addition of soybean flour which could be attributed to the relatively low carbohydrate content and high protein content of soybean flour. The protein levels of the complementary food blends agreed with the reports of Baiyeri[26] and Nnam[27] and the range of carbohydrate observed correlated with the values (50.09-83.45%) reported by Ebuchi and Oyewole[28]. There were significant ($p<0.05$) differences in the proximate content of the samples.

Table 1: Proximate composition of complementary food made from roasted rice and soybean flour blends

Samples	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
90:10:00	$7.87^a \pm 0.10$	$5.70^e \pm 0.57$	$4.83^e \pm 0.12$	$0.41^e \pm 0.05$	$0.77^e \pm 0.21$	$80.42^a \pm 0.06$
80:20:00	$7.77^a \pm 0.00$	$10.55^d \pm 0.04$	$6.05^d \pm 0.06$	$0.69^d \pm 0.02$	$1.65^d \pm 0.21$	$73.29^b \pm 0.24$
70:30:00	$7.45^b \pm 0.06$	$13.83^c \pm 0.02$	$7.08^c \pm 0.28$	$0.88^c \pm 0.02$	$2.68^c \pm 0.04$	$68.08^b \pm 0.06$
60:40:00	$7.16^c \pm 0.04$	$16.06^b \pm 0.06$	$9.67^b \pm 0.03$	$1.28^b \pm 0.02$	$3.03^b \pm 0.03$	$62.80^c \pm 0.28$
50:50:00	$6.98^d \pm 0.01$	$19.15^a \pm 0.42$	$13.76^a \pm 0.21$	$1.39^a \pm 0.63$	$5.52^a \pm 0.99$	$53.20^d \pm 3.95$

Values are means ± standard deviation of duplicate determination. Values with the same superscript within the same column were not significantly ($p>0.05$) different. Sample = rice:soybean complementary food.

Mineral and vitamin content of the rice-soybean complementary food blend

Mineral and vitamin content of the samples is shown in Table 2. The mineral and vitamin content increased as soybean is increased in the blend and they were in the range of 0.88-2.82, 1.93-4.15, 5.94-12.78, 0.35-0.96 and 0.49-0.81 mg/100g for zinc, iron, calcium, vitamins B_1 and B_2 respectively.

The values for the analysed minerals (zinc, iron and calcium) and vitamins (thiamin and riboflavin) showed an increase of the minerals and vitamins with increase in soybean is needed for bone and teeth formation and also required for clotting of blood and control of fluid movement through the cell membrane. Iron is a component of haemoglobin which transports oxygen in the blood and is related to the rate of gain and loss of blood. There were significant ($p<0.05$) differences in the zinc content of the samples. No significant ($p>0.05$) difference was observed in the iron and calcium contents of the samples at 10 and 20% soybean addition. Also, there was no significant ($p>0.05$) in the vitamin B_1 and B_2 content of the samples at 40 and 50% soybean addition.

Table 2: Mineral and vitamin composition of complementary food made from roasted rice and soybean flour blends

Samples	Zn (mg/100g)	Fe (mg/100g)	Ca (mg/100g)	Vit.B_1 (mg/100g)	Vit.B_2 (mg/100g)
90:10:00	$0.88^e \pm 0.03$	$1.93^d \pm 0.06$	$5.94^d \pm 0.06$	$0.35^c \pm 0.64$	$0.49^c \pm 0.05$
80:20:00	$1.04^d \pm 0.01$	$1.93^d \pm 0.07$	$6.69^d \pm 0.06$	$0.82^b \pm 0.03$	$0.52^{bc} \pm 0.03$
70:30:00	$1.28^c \pm 0.04$	$2.42^c \pm 0.05$	$7.39^c \pm 0.58$	$0.89^{ab} \pm 0.01$	$0.67^b \pm 0.04$
60:40:00	$2.11^b \pm 0.02$	$3.46^b \pm 0.03$	$11.48^b \pm 0.04$	$0.95^a \pm 0.02$	$0.70^a \pm 0.07$
50:50:00	$2.82^a \pm 0.04$	$4.15^a \pm 0.03$	$12.78^a \pm 0.42$	$0.96^a \pm 0.03$	$0.81^a \pm 0.11$

Values are means ± standard deviation of duplicate determination. Values with the same superscript within the same column were not significantly ($p>0.05$) different. Sample = rice:soybean.

Anti-nutrient content of the rice-soybean complementary food blend

Anti-nutrient content of the samples is shown in Table 3. Oxalate ranged from 2.28-4.78 mg/100g. Phytate ranged from 2.49-3.37 mg/100g. Haemagglutinin ranged from 0.57-0.69 mg/100g and tannin ranged from 12.84-14.85 mg/100g. Oxalate and haemagglutinin decreased as soybean is increased in the blend while the reverse was the case for phytate and tannin. The oxalate content of the samples decreased significantly ($p>0.05$) with increase in soybean addition. Phytate content was found to increase with increase in soybean flour addition. The level of phytate in the rice-soybean complementary food blends can be said to be within safe level. According to Ife and Emeruwa[29], phytate in foods should not exceed the limits of 178 mg/g. Haemagglutinin decreased with increase in soybean flour addition while the tannin content increased with increase in soybean flour addition. Ife and Emeruwa[30] reported that tannin levels of up to 76-190 g/kg can be detrimental to health. In general, anti-nutrients are considered toxic and roasting is known to play a role in the reduction of anti-nutrient in food system which could be the reason for the relatively low values recorded for the anti-nutrient content of the rice-soybean complementary food blends. The nutritional implication of these reductions in the samples concentration of anti-nutrients is that it will lead to improvement in protein digestibility. Higher protein digestibility has been attributed to heat treatment during processing (autoclaving and roasting) as a result of destruction of heat labile protease inhibitor and opening up of protein structures by denaturation, leading to increased accessibility of the protein to enzymatic attack[31, 32].

Table 3: Anti-nutrient composition of complementary food made from roasted rice and soybean flour blends

Sample	Oxalate (mg/100g)	Phytate (mg/100g)	Haemagglutinin (mg/100g)	Tannin (mg/100g)
90:10:00	$4.78^a \pm 0.04$	$2.73^c \pm 0.00$	$0.67^b \pm 0.00$	$12.84^d \pm 0.07$
80:20:00	$4.28^b \pm 0.04$	$2.49^d \pm 0.00$	$0.67^b \pm 0.00$	$13.40^c \pm 0.12$
70:30:00	$3.26^c \pm 0.00$	$2.56^d \pm 0.01$	$0.69^a \pm 0.00$	$13.91^b \pm 0.09$
60:40:00	$2.73^d \pm 0.02$	$2.99^b \pm 0.08$	$0.58^c \pm 0.00$	$14.65^a \pm 0.05$
50:50:00	$2.28^e \pm 0.04$	$3.37^a \pm 0.00$	$0.57^c \pm 0.00$	$14.85^a \pm 0.09$

Values are means ± standard deviation of duplicate determination.Values with the same superscript within the same column were not significantly ($p>0.05$)different.Sampler ice: soybean

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Functional property of the rice-soybean complementary food blend

Functional property of the samples is shown in Table 4. Bulk density, water absorption capacity and swelling capacity of the samples ranged from 0.83-0.89 g/cm^3, 147.75-207.40% and 4.0-6.9 g/g respectively. Increase in soybean addition in the complementary food blends led to an increase in water absorption capacity of the samples and a decrease in their swelling capacity. Bulk density depends on the particle size and initial moisture content of the flour samples[33]. Hence, the lower the bulk density, the higher the amount of flour particles that can stay together. The bulk density of the various blends showed a gradual decrease with an increase in the percentage of soybean in the blend. The 50:50 rice-soybean blend had the least bulk density while the 90:10 rice-soybean blend recorded the highest value for bulk density. Water absorption capacity of the samples increased significantly (p>0.05) with increase in soybean addition which can be an indication that soybean flour contains higher amounts of hydrophilic constituents than rice. This is because the major chemical compositions that enhance the water absorption capacity of flours are proteins and carbohydrates which both contain hydrophilic parts. Swelling capacity of flours depends on particle size, variety and method of processing[33].The swelling capacity of the samples decreasedsignificantly (p>0.05) with increase in soybean addition. The functionality of the complementary food was significantly (p<0.05) affected by blending with rice and soybean.The implication of the results of this study is that soybean can be employed as an enrichment material in the production of rice-based complementary food and this could be used by mothers in developing countries like Nigeria where protein-energy malnutrition is highly prevalent and the conventional complementary food in the market is expensive. It is recommended that roasting be employed as unit operation in the preparation of this complementary food as it is instrumental in improving the nutritional quality and reduction of the anti-nutrient composition of the final product. However, roasting of the rice grains hardened the starchy endosperm which is one the limiting factors of this study. Therefore, milling of the grains should be done several times to obtain a smooth powder in order to get a smooth paste after reconstitution with water.

Table 4: Functional properties of complementary food made from roasted rice and soybean flour blends

Sample	Bulk density (g/cm^3)	Water absorption capacity (%)	Swelling capacity (g/g)
90:10:00	$0.89^{a} \pm 0.00$	$147.75^{e} \pm 0.21$	$6.90^{a} \pm 1.41$
80:20:00	$0.86^{b} \pm 0.00$	$162.40^{d} \pm 0.14$	$6.65^{a} \pm 0.70$
70:30:00	$0.85^{bc} \pm 0.00$	$176.45^{c} \pm 0.49$	$6.00^{b} \pm 1.41$
60:40:00	$0.84^{cd} \pm 0.00$	$194.20^{b} \pm 0.14$	$5.35^{c} \pm 0.70$
50:50:00	$0.83^{d} \pm 0.00$	$207.40^{a} \pm 0.42$	$4.00^{d} \pm 0.00$

Values are means ± standard deviation of duplicate determination. Values with the same superscript within the same column were not significantly (p>0.05) different. Sample = rice:soybean complementary food.

CONCLUSION

Blending of rice with soybean in various ratios for production of complementary food, affected the chemical, functional and sensory properties of the blends. Addition of soybean significantly (p<0.05) improved the protein, vitamin and mineral content of the blends. Roasting of the grains before milling were instrumental in reducing the various anti-nutrients that are associated with rice and soybean to a minimum no- risk level. The use of soybean in formulation of complementary food would help to alleviate problems of protein-energy malnutrition and micro-nutrient deficiency in Nigeria and other developing countries. The complementary food produced could be used to replace the predominant carbohydrate-base complementary food. Soybean, a protein of high biological value can be used as a replacement for animal protein (usually expensive) in complementary food formulas.

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