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Physiochemical Properties of Rice- Soybean Flour Blends and Sensory Evaluation of Their Cooked Products

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Authors' contributions

This work was carried out in collaboration between all authors. Author OOO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors TAF and OCO managed the analyses of the study. Author TOA managed the literature searches, typing and proof reading of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Rice is a common cereal carbohydrate, while soya bean is a legume protein. World's rice consumption estimates reflect unbalanced nutrition and health implications of nutrients deficiency. This study examines the nutritional impact of fortifying rice with soya beans. "Rice-soy flour blends"; a mixture of rice and soya beans flours was produced using the following ratios: 100:0, 90:10, 80:20, 70:30, and 60:40. Results obtained showed that, fortification of rice flour with soya beans flour significantly ($p \leq 0.05$) affected the physico-chemical qualities and sensory properties of the end product. While proximate composition of rice flour increased, carbohydrate content decreased

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(87.37 to 57.80%). The rice functional properties were also altered. The water absorption capacity decreased (3.20 – 2.00 g/cm) initially, followed by an increase (2.00 – 3.85 g/cm) as substitution levels increased from 10 to 20% and decreased (1.75 – 1.50 g/cm) from 20 to 40%. The bulk density decreased from 0.97 to 0.70%, while values of swelling index remained almost constant (3.0cm^3) throughout the substitution. Organolepticaly, rice-soy ratio 20:80 was the most acceptable, followed by 100:00, 70:30, while 60:40 was the least acceptable. This study showed that fortifying rice flour with soya beans flour is a significant way of improving nutritive quality, especially the protein.

Keywords: Rice flour; soya beans flour; rice-soy flour; proximate composition; fortification and nutrition.

1. INTRODUCTION

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). Rice is grown in all the ecological and dietary zones of Nigeria with different processing adaptation trait for ecology [1]. Rice is an economic crop, which is important in household food security, ceremonies, nutritional diversification, income generation and employment [2]. As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with the third-highest worldwide production, after sugarcane and maize, according to 2012 FAOSTAT data [3].

Rice is generally consumed as whole grains and not milled rice flour; accordingly the processing of paddy or rough rice (rice with husk) is designed to give the yield of unbroken kernel. Rice breakage during milling process is affected by different parameters such as paddy rice harvesting conditions, drying, physical properties of paddy kernels, the environmental conditions and the types and quality of the processing machine moving components [3].

Nigerian traditionally produced rice has been known to be highly nutritious; however, the quality of its milled rice is usually poor. They are characterized with high percentage of impurities and under size/broken grains which results in reduction of its economic value and makes it difficult to compete favourably with imported ones. The low level technology input in rice production has contributed to high grain losses and poor quality of Nigerian rice, thereby limiting sustainable food chain [4].

Locally produced rice in Nigeria is parboiled before consumption except for raw milled rice that is used in preparation of special foods such as “Tuwo” in the northern parts of the country [5]. Rice that seems to be cracked while still in the husk is further broken during harvesting, handling, drying and milling steps. The broken rice can be milled into flour and used for the preparation of ‘ground rice.

Soya beans are probably one of the oldest legumes being cultivated. The biological value of soya beans is very high when compared with other legumes like cowpeas; or cereals like rice and maize. Soybeans protein forms a good source of essential amino acid and is known to be high according to WHO [6] in lysine and tryptophan which is missing in rice(). Soya beans contain some anti-nutritional factors such as trypsin inhibitor which is removed by heat and about 54% proteins while milled rice contains about 8.1%.

In developing countries like Africa, production of food is grossly inadequate and if something is not done to abate the situation, hunger and malnutrition will sweep through the population (remove) [7]. Malnutrition continues to be a major public health problem throughout the developing world, particularly in southern Asia and sub-Saharan Africa [8]. Diets of populations are frequently deficient in macronutrients (protein, carbohydrates and fat, leading to protein–energy malnutrition). In developing countries such as Nigeria where the staple food is very low in protein content, such as cassava, yams and plantain; kwashiorkor is known to be prevalent. Thus, there is a need for the development and production of new nutritious foods to improve the diet of people so as to prevent malnutrition and also, to provide adequate group specific diets, for the young and adults (under condition of stress, pregnant and lactating mothers, kwashiorkor and diabetic patients) [8]. This study investigated the effect of fortifying ground rice with soya beans flour on its proximate, functional and sensory properties.

2. MATERIALS AND METHODS

2.1 Materials

The materials used: soya beans (*Glycine max*) and rice (*Oryza glaberrima*) were purchased from Ojagboro in Ilorin, Kwara State.

2.2 Method for the Production of Fortifying Ground Rice with Soya Beans Flour

Soya bean seeds boiled for 15 minutes were dehulled by vigorous hand rubbing; after which they were boiled for another 5minutes, then rinsed, drained and oven-dried at 60°C for 8 hours (Nigerian Stored product Research Institute (NSPRI) Ilorin – Nigeria, processing centre). The rice grains were (..remove) cleaned by handpicking dirt's like stones, metal, dust and other foreign materials. The cleaned rice was parboiled and oven dried at 60°C for 12 hrs. The rice and soya beans were milled separately in an electric miller (polymix hammer mill) in the chemistry laboratory of NSPRI and the fraction which passed through sieve of 500 µm were collected and used for the study. Mixture of rice flour and soya beans flour were produced using the following rice flour to soya beans flour ratio respectively: 100:0, 90:10, 80:20, 70:30, and 60:40. The flour mixtures were package in polythene bags and kept in air tight condition for observation and further analysis. The blended mixture of rice flour and soya beans flours were referred to as "rice-soy flour blends".

2.3 Proximate Analysis of "rice-soy flour blends"

Moisture, crude protein (g N x 6.25), fat, ash and crude fibre were determined in triplicate by standard procedures [9]. Total carbohydrate was calculated by difference (100 – value of moisture content, protein, fat, ash and crude fibre).

2.4 Functional Properties

The functional properties of the rice, soya beans and "rice-soy flour blends" that were investigated are: water absorption and bulk density which were determined as described by Ikpeme-Emmanuel, et al. [10] and swelling index by Nwosu, et al. [11].

2.5 Sesnsory Evaluation

Sensory evaluation was carried out using a ten–member panel of judges consisting staff of NSPRI familiar with ground rice, soya beans and "rice-soy flour blends". The blends were made into dough. The dough was prepared by simulating domestic cooking process that is by heating the desired amount of water to a boiling point, then evenly spread desired quantity of each of the flours (ground rice, soya beans and "rice-soy flour blends".) in the boiling water; the heating was then reduced to minimum; stirred with paddle and cooked for 3 to 5 minutes to give smooth blended whole meal called "tuwo shinkafa". The cooked blends ("tuwo shinkafa"). were labelled and presented in different plates three times to the panellist in a well-lighted room. Each panellist was asked to indicate their preference, by scoring using a nine point hedonic scale with 9 representing like extremely, 5 neither like nor dislike, 1 dislike extremely to express their degree of like or dislike of each of the blend [12]. The quality factors that were assessed for the blends are colour, texture, aroma, taste, flavour, appearance and overall acceptability.

2.6 Statistical Analysis

Data obtained in the work was statistically analysed using the software, statistical package for social science (SPSS) version 11.00 SPSS Inc., Chicago, IL, USA at the 0.05 level of significant using analysis of variance (ANOVA) test. Duncan multiple range tests was used to determine significant difference among the various samples and difference between means by comparison of means.

3. RESULTS AND DISCUSSION

The proximate composition is shown in Table 1. The analysis was carried out on dry weight basis. The proximate analysis showed that all the flour samples have moisture content not more than13-15% which according to Vincent, [13] is the standard moisture contents for flours. According to these results there are significant differences ($p<0.05$) in the moisture content of the 100% rice, soya beans and the formulations. The moisture content range between 8.30±0.06% and 9.89±0.06% with moisture content of rice flour substituted with 40% soybeans flour been the highest.

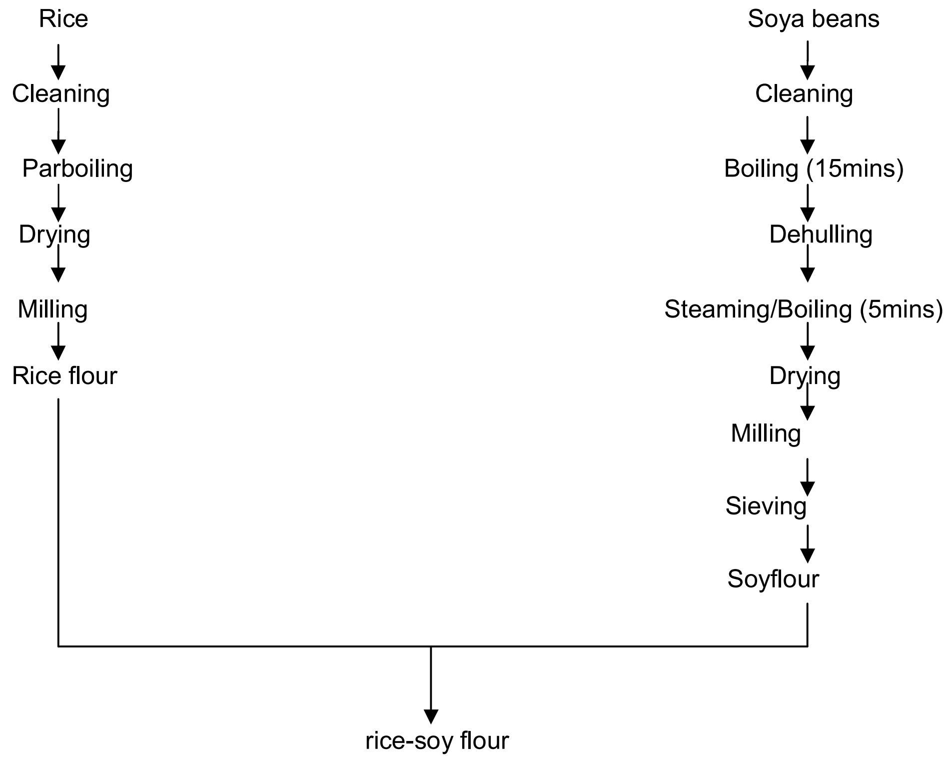

Fig. 2.1. Flow Chart for "rice-soy flour blends" Production [14]

The low moisture content observed for the four formulations and the rice and soybeans flour is a good indicator of their potential to have longer shelf life. This is in line with the findings of Vincent, [13]. It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content. For this reason, a water content of 10% is generally specified for flours and other related products. It should be pointed out that when these products are allowed to equilibrate for periods of more than one week at 60% relative humidity and at room temperature (25 to 27°C), moisture content might increase.

The ash content ranged from 2.10% to 4.50% with 100% rice having the lowest. There were significant differences ($p<0.05$) in the ash content of the flour formulations and 100% control (rice and soybeans flour). These values were similar to the work on production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults as reported by Kanu, et al. [15]. The increase noted in the ash content of the rice and soy beans flour blends may be attributed to the high mineral content of soy beans.

Fat content ranged from 2.90% to 11.50%. There was significantly different ($p<0.05$) in the fat content of the formulations. "rice-soy flour blend" with 40% soy beans flour substitution having the highest fat content followed by soy-rice with 30% soy beans flour substitution. (removed) The increase in fat content was as result of soybeans substitution.

Protein content ranged from 6.40% to 42.50%. The protein content of the four formulations and the 100% control (rice and soya beans flour) flour was significantly different ($p<0.05$) from each other. "rice-soy flour blend" with 40% soy beans substitution had the highest protein content while "rice-soy flour blend" with 10% soy beans flour substitution had the least. Ashaye, et al. [16] reported an increase in protein content (7.28%) and ash (3.58%) when yam flour was substituted with 40% cowpea flour while Achi, [17] reported an increase in protein content from 3.5% in the control (yam flour) to 19.7% for yam flour fortified with 40% soybeans flour.

Carbohydrate content of the formulations varied significantly ($p<0.05$) and decreased with addition of soy beans flour. The carbohydrate value ranged from 38.77% to 87.37% with "rice-soy flour blend" of 40% soy beans flour substitution having the least and 100% rice flour the highest.

The addition of soya beans flour also, affect significantly ($p\leq0.05$) the functional properties of rice flour as can be seen in the different "rice-soy flour blends" in Table 2. The water absorption capacity value varies from 1.50 to 3.85 g/cm; bulk density value varies from 0.57 to 0.97 g/cm^3 and that of swelling index varies from 2.00 to 6.00. The water absorption capacity of the 100% soya beans flour wheat flour was lower than that of the rice soy flour blends (rice-soy (90:10) and rice-soy (80:20) but higher than that of rice-soy (70:30) and rice-soy (60:40). This may perhaps be indicative of the fact that the incorporation of soya beans flour to rice flour improves the water binding capacity of the soya beans, which in turn improves the reconstitution ability and textural properties of dough obtainable from rice-soy flour blends. This is in line with the work reported by Ajanaku et al. [18]. However, the high water absorption capacity of the soya beans flour over that of rice-soy (70:30) and rice-soy (60:40) can be attributed to lose structure of starch polymers while the low value indicates the compactness of the structure as reported by Oladipo and Nwokocha [19]. Etudaiye, et al. [20] reported that water absorption capacity is an important factor in the development of ready to eat foods and that high absorption capacity indicate product cohesiveness. The "rice-soy flour blend" having the 20% substitution ratio recorded the highest value of 3.85 g/cm for water absorption capacity while "rice-soy flour blend" of 40% substitution had the lowest value of 1.50 g/cm. These values are significantly different ($p \leq 0.05$) from each other. (remove) Etudaiye, et al. [20] reported the same pattern of result for WAC. WAC gives an indication of the amount of water available for gelatinization [21]. The water absorption capacities of these flours are useful indications of whether protein can be incorporated into the aqueous food formulations, especially, those involving dough handing. Interactions of protein with water, is important to properties such as hydration, swelling power, solubility gelation [22]. Bulk density is the ratio of the mass per unit volume of a substance. It is an indication of the porosity of a product which influences package design. The bulk densities of the rice-soy flour blends "ranged from 0.70 g/cm^3 to 0.89 g/cm^3 and this will help in determining suitable packaging requirements of the flours as it relates to the load the sample could carry if allowed to rest directly on one another. The swelling index values of the rice-soy flour blends" remain almost constant 3.0 to 3.1 cm^3 throughout the substitution. There was no significant ($p\leq0.05$) difference in the swelling index value of the soy-rice flour mixture but vary significantly ($p\leq0.05$) from the control (rice and soya beans flour respectively). Swelling power of starch depends on the capacity of starch molecules to hold water through hydrogen bonding. The differences in the extent of swelling also indicate structural differences among starches. From the result shown in the Table 2, it is indicative that there were no significant ($p\leq0.05$) structural differences among the "rice-soy flour blends" starches.

Table 3 shows the result of the sensory evaluation of the samples. The appearance varies significantly ($p < 0.05$), rating ranged from 4.33 to 7.92. Rice-soy (80:20) had the highest rating of 7.92 and soya beans flour the least (4.33). The difference in appearance is as a result of the addition of dull coloured soya beans flour. There was a significant ($p < 0.05$) difference in the colour ratings of the samples by the panellists compared to control (rice and soybeans). rice-soy (90:10) was significantly ($p < 0.05$) rated best, while rice-soy (60:40) and soya beans (control) had the least colour rating. Factors that may have affected the colour of the composite blends include the chemical composition of the rice and soya bean flour, the drying temperature and duration, composition ratio of rice and soya bean flours. Low colour ratings of product can decrease the acceptability as colour is an important organoleptic attribute which enhances the product acceptability. The colour ratings of the evaluated samples could be further improved by adjusting processing conditions.

The consistency or texture ratings of the samples ranged from 4.33-6.83. There was significant ($p < 0.05$) difference between the control sample and substituted samples. rice-soy (80:20) flour sample had the best consistency rating (6.83), and was followed by rice flour sample (control), while soya beans flour sample received the least consistency ratings of 4.33. WAC and SI are important parameters which determine the consistency of flour [23].

Table 1. Proximate composition of rice-soy flour blends

Sample	Moisture content (MC) (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)
Rice	8.30^{a} ± 0.06	2.10^{a} ±0.06	2.90^{a} ± 0.01	6.40^{a} ± 0.02	1.03^{a} ± 0.12	87.37^{f} ± 0.02
Soya beans	9.40^{b} ± 0.10	4.50^{f} ± 0.06	11.50^{e} ± 0.01	42.50^{f} ± 0.02	2.63^{e} ± 0.09	$38,77^{a}$ ± 0.02
rice-soy (90:10)	9.60^{c} ± 0.10	2.30^{b} ± 0.10	4.50^{b} ± 0.12	15.30^{b} ± 0.01	1.20^{b} ± 0.06	76.70^{e} ± 0.06
rice-soy (80:20)	9.80^{d} ± 0.06	2.60^{c} ± 0.12	4.70^{b} ± 0.01	21.90^{c} ± 0.10	1.26^{b} ± 0.16	69.54^{d} ± 0.06
rice-soy (70:30)	9.87^{d} ± 0.12	3.30^{d} ± 0.06	5.20^{c} ± 0.03	26.30^{d} ± 0.06	1.32^{c} ± 0.06	63.88^{c} ± 0.01
rice-soy (60:40)	9.89^{d} ± 0.03	3.90^{e} ± 0.07	6.30^{d} ± 0.02	30.60^{e} ± 0.02	1.40^{d} ± 0.12	57.80^{b} ± 0.12

*All data are average of means ± SD of three replicates *Means with the same letters in a column are not significantly different (P > 0.05)*

Table 2. Functional properties of rice-soy flour blends

Sample	Water absorption capacity (WAC)g/cm	Bulk density (BD) g/ cm^3	Swelling Index (SI) cm^3
Rice	3.20^{d} ± 0.12	0.97^{f} ± 0.01	2.00^{a} ± 0.00
Soya beans	1.95^{c} ± 0.06	0.57^{a} ± 0.01	6.00^{c} ±0.00
rice-soy (90:10)	2.00^{c} ± 0.10	0.89^{e} ± 0.10	3.10^{b} ± 0.10
rice-soy (80:20)	3.85^{e} ± 0.06	0.82^{d} ±0.01	3.00^{b} ± 0.00
rice-soy (70:30)	1.75^{b} ± 0.06	0.80^{c} ± 0.02	3.10^{b} ± 0.10
rice-soy (60:40)	1.50^{a} ± 0.12	0.70^{b} ± 0.01	3.00^{b} ± 0.00

*All data are average of means ± SD of three replicates *Means with the same letters in a column are not significantly different (P > 0.05)*

Table 3. Sensory evaluation of cooked rice-soy flour blends

Sample	Appearance	Colour	Texture	Taste	Flavour	Aroma	Overall acceptability
Rice	7.03^{e} ± 0.42	6.70^{e} ± 1.66	6.33^{e} ± 0.46	7.12^{e} ± 1.53	6.10^{c} ±0.83	6.51^{f} ± 0.75	6.92^{e} ± 0.44
Soya beans	4.33^{a} ± 0.44	4.34^{a} ± 0.39	4.33^{a} ± 0.40	4.52^{a} ± 0.52	5.20^{a} ± 1.02	5.53^{c} ± 1.20	5.07^{a} ± 0.51
rice-soy (90:10)	6.83^{d} ± 0.45	7.80^{d} ± 0.83	6.12^{c} ± 0.82	5.13^{d} ± 0.62	6.34^{d} ± 0.46	5.32^{b} ± 0.19	6.83^{d} ± 1.53
rice-soy (80:20)	7.92^{f} ± 0.73	6.83^{f} ± 0.95	6.83^{e} ± 0.47	6.04^{f} ± 1.48	6.43^{e} ± 0.46	6.13^{e} ± 0.28	7.23^{f} ± 0.58
rice-soy (70:30)	5.80^{c} ± 0.36	5.54^{c} ±1.03	5.54^{d} ± 0.38	5.23^{c} ± 1.23	5.23^{a} ± 0.36	5.03^{a} ± 0.95	5.63^{c} ± 0.34
rice-soy (60:40)	4.50^{b} ± 1.42	4.57^{b} ± 0.41	4.56^{b} ± 1.41	4.84^{b} ± 0.49	5.33^{b} ± 0.39	5.60^{d} ± 0.92	5.13^{b} ± 0.61

*N.B. Higher values indicate high acceptability *Means with the same letters in a column are not significantly different (P > 0.05)*

There was a significant difference ($p < 0.05$) between the taste of the control Sample and that of the formulated composite blends. The taste rating ranged from 4.84 to 7.12. Rice flour (control) had the highest rating (7.12) followed by rice-soy (80:20) formulated samples with 6.04 and soya beans flour (control) having the least value. The best score rating of the reference would be as a result of the bland nature. Therefore, to further improve the taste ratings, mixing ratio between 90:10 and 80:20 should be considered.

The aroma (flavour) ratings of the samples ranged from 5.03–6.53. The reference sample (rice) was rated best for aroma, followed by rice-soy (80:20) flour sample. There was significant difference between the control and formulated sample rating scores. There was significant difference ($p < 0.05$) in the overall acceptability ratings of the control (rice flour) sample and rice-soy (80:20) sample, recorded the highest rating. From the result on Table 3, soy-rice (80:20 flour samples had the highest ratings hence, best sensory quality in terms of appearance, texture, flavour and overall acceptability.

4. CONCLUSION

The addition of undefatted soybean flour increases the protein content but decreased the sensory qualities of rice flour. Fortification with 20% soya beans flour was rated best by the taste panellist. This level of soya fortification corresponds to a maximum of 21.90% of protein thus, enhancing the protein content. The other proximate composition like ash, fat and fibre content also increased while the carbohydrate content decreased. The moisture content increased with the addition of soya beans flour but it is still within safe moisture level. It is recommended that soya beans flour could be added to rice flour to improve its nutritional quality. Fortification of rice flour with 20% soybeans flour will give an acceptable, nutritional and aesthetic “rice-soy flour blend”.

FURTHER WORK

There is still need to subject the developed “rice-soy flour blends” to different quality evaluation, shelf life, antinutritional factors, mineral and vitamin content analysis.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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