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Research article

Gluten free rice-soy pasta: proximate composition, textural properties and sensory attributes

Islamiyat Folashade Bolarinwa *, Oyewole Oluwaseun Oyesiji

Department of Food Science, Faculty of Food and Consumer Sciences, Ladoke Akintola University of Technology (LAUTECH), P.M.B. 4000, Ogbomoso, Nigeria

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ABSTRACT

Recent increase in gluten allergy has led to high demand for gluten free products such as rice pasta. Although rice grains are rich in bioactive compounds and B vitamins, they are generally low in protein compared to wheat grains. The aim of this study was to determine the quality attributes of soy enriched rice pasta. Five Rice-soy pastas were produced from different blends (10–30%) of soybean flour and rice flour. The proximate composition, cooking quality, colour, texture profile, and sensory attributes of the pastas were determined. Results showed increased in protein (6.7–12.1%), crude fibre (0.8–1.3%), ash (0.6–2.2%) and energy values (379–389 kcal/100g). Fortification improved the colour, reduce cooking time (15.59–15.11 min) but increased cooking loss (7.30–7.49%). The hardness (506–314 g), springiness (1.25–0.71 mm) and chewiness (417–334 g x mm) values decreased while gumminess (417–334 g) increased. Rice pasta enriched with 15% soybean flour was highly ranked for sensory attributes. In conclusion, this study demonstrated that Rice-soy pasta can serve as nutritious alternative to conventional rice pasta, and also add variety to food groups for people suffering from celiac disease.

1. Introduction

Pasta is a staple food in most developed and developing countries, and commonly produced from wheat (semolina) (Owen, 2001). However, the climate of most developing regions of the world does not favour wheat cultivation, thus making pasta an expensive food in these regions. In addition, people suffering from celiac disease are deprived of delicacy made from pasta.

The use of rice flour for the preparation of gluten free products is increasingly gaining attention due to the qualities (high digestibility, hypoallergenic properties and bland taste) it possessed (Rosell, 2008). Increased rice production, leading to generation of large quantities of broken rice in some tropical countries including Nigeria, highlights the opportunities for the production of rice pasta. Rice flour has been used as major ingredient for pasta production (Lai, 2001; Sandhu and Kaur, 2010; Ahmed et al., 2016; Ribeiro et al., 2018; Bouasla and Wójtowicz, 2019).

Generally, gluten-free dough such as rice dough is fragile, less elastic and more susceptible to overworking (Hager et al., 2012). Hence, previous studies have investigated various means of improving the quality of rice pasta. The use of fruit peel (Ribeiro et al., 2018), hydrocolloids (Qazi et al., 2011), emulsifiers (Lai, 2001) and tropical starches (Qazi et al., 2014) have been investigated and reported.

Soybean (*Glycine max*) is a cheap legume crop commonly cultivated in tropical regions of the developing world. It is a rich source of high-quality protein (38%–55%) and essential amino-acid (Dhingra and Jood, 2004), carbohydrates (27.1 %) and oil (20.6 %) (Osundahunsi et al., 2007). Soy-rich food products have been reported to exhibit beneficial effects in reducing the risks of coronary heart disease and cancers (Messina, 2003; Wietrzyk et al., 2005). Thus, the consumption of soybean food or soybean fortified products is on the increase recently due to its beneficial effects on human nutrition and health (Mishra and Bhatt, 2017).

Enrichment of wheat pastas with soybean flour (Omeire et al., 2014) and soya protein isolate powder (Mishra and Bhatt, 2017) have been recommended, despite the relatively high protein contents in wheat pasta compared to rice pasta. Traditional rice pasta is mainly rich in carbohydrates and contain low protein (Mubarak, 2005). Rice protein is high in cysteine and methionine, but low in essential amino acid, lysine (Carvalho et al., 2013). Hence, the need for enrichment of rice pasta with protein rich legumes such as soybeans. This study aimed at investigating the chemical composition, colour, cooking quality, textural properties, and sensory attributes of soy enriched rice pasta.

* Corresponding author.
E-mail address: ifbolarinwa@lautech.edu.ng (I.F. Bolarinwa).

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2. Materials and methods

The object of study was the *Oryza sativa* rice variety commonly grown in Nigeria. The Rice grains were obtained from a local farm in Enugu state, Nigeria. Soybeans (TGX 1448-2E variety) and tapioca starch (Psaltry tapioca starch) were procured from a local market in Ogbomoso, Oyo State, Nigeria.

2.1. Production of rice flour

Rice flour was produced using traditional method, as described by Rosell (2008). Rice grains were washed, dried in an oven (60 °C) for 12 h. The dried rice was milled using a hammer mill, sieved to 250 μm particle size and stored in hermetically sealed polyethylene bags until further used.

2.2. Production of soy flour

Soy flour was prepared according to the method described by Ndife et al. (2013). Soybeans (1 kg) was thoroughly cleaned to remove dirt and other extraneous materials such as stones and sticks, and washed. The cleaned soybeans were soaked, dehulled, oven dried at 55 °C for 24 h, milled into fine flour using hammer mill (model EU 5000 D), and sieved to 250 μm particle size. The flour was stored in hermetically sealed polyethylene bags until further used.

2.3. Production of cassava starch flour

Cassava starch was produced according to the procedure described by Stupak et al. (2006). Fresh cassava roots were peeled to remove the woody bark. The peeled roots were washed with clean water to remove dirt and all foreign materials. The washed roots were pulverized with a mechanical grater to reduce particle size and to facilitate hydrolysis of cyanogens. The grated cassava was sieved with a muslin cloth under water to separate the slurry according to particle size, leaving starch and water as the filtrate, and shaft as the residue. The extracted starch was allowed to settle at the base of the container and water decanted. The extracted starch was washed several times with water, to remove fibrous materials and to obtain a pure and high-quality starch. The extracted starch was then dewatered and oven dried at 60 °C for 12 h, milled into fine flour using hammer mill (model EU 5000 D), sieved to obtain 200 μm particle size and stored until further used.

2.4. Preparation of composite flour

Composite flour was prepared from the blends of rice, soy bean and tapioca flour based on the formulations in Table 1. The samples were thoroughly mixed, packed in polyethylene bags until further used.

2.5. Production of pasta

The method of Collins and Pangloli (1997) was used with some modifications for pasta preparation. Composite flour (300 g) was mixed with salt (2 g), oil (20 mL) and water (180 mL) to obtain uniform dough. The dough was kneaded and cut using pasta extruder (Marcato Ampia 180). Pasta was dried (60 °C) using cabinet dryer for 12 h to obtain dried pasta.

2.6. Proximate analyses of the rice-soy pastas

The proximate components (protein, moisture, crude fibre, crude fat and ash) of the pasta were determined using standard analytical procedures. Protein was determined by AOAC (2000) method 960.52, ash, moisture content and total fat were determined by AOAC (2000) method 923.03, 934.01 and 963.15, respectively. Total Dietary fibre was determined by AACC (2000) method 32–05.01. Carbohydrate was determined by difference [i.e. 100 - (% protein + %moisture + % crude fibre + % crude fat + % ash)] (AOAC, 2000). Energy values of the pastas were determined by multiplying the protein and carbohydrate values of the rice pasta by their calorific value (4 kcal/100g), and the fat value by its calorific value of 9 kcal/100g.

2.7. Colour measurement

Color values of un-cooked pasta were obtained using a hand-held Konica Minolta Chroma Meter (Model CR-410, Konica Minolta Sensing, Inc., Japan). The rice-soy pastas were arranged side-by-side in a high-density polyethylene bag, and the Chroma Meter was gently placed on each sample for colour measurements. Four readings were taken from each pasta sample. Testing was performed in duplicate (Petitot et al., 2010). Values were reported using CIELAB colour scale where L^* values denote lightness or darkness, a^* values signify redness or greenness, and b^* values denote yellowness or blueness.

2.8. Cooking qualities

2.8.1. Cooking time and cooking loss

The cooking time for the pasta samples were established using the method described by AACC (2000). Cooking loss was determined by the method described by Chakraborty et al. (2003).

2.9. Texture profile analysis of the rice-soy pasta

The texture profile of the cooked soy fortified and un-fortified rice pastas were determined as described by Bhattacharya et al. (1999), using a texture analyser (Stable Microsystem TA-XT Plus, UK). The hardness, cohesiveness, gumminess (hardness × cohesiveness), springiness, and chewiness (gumminess × springiness) were computed by the instrument software.

2.10. Sensory evaluation

Sensory evaluation was carried out with 50 semi-trained panelists comprising of students and staff of the Department of Food Science and Engineering, LAUTECH. Sensory test was conducted in compliance with all regulations and according to establish ethical guidelines at LAUTECH. Prior to the sensory evaluation, LAUTECH ethics committee carefully

Table 1. Formulations of the composite flour (%) used for the rice-soy pasta.

Sample	Rice flour	Tapioca flour	Soybean flour
RF	80	20	0
10%SRF	70	20	10
15%SRF	65	20	15
20%SRF	60	20	20
25%SRF	55	20	25
30%SRF	50	20	30

reviewed the sensory analysis procedures and approved the procedure for handling of human subjects.

The panelists were informed that the food to be evaluated is a functional food "fortified pasta" which is a nutritious alternative to conventional rice pasta, and the aim of the study was to determine consumers' acceptability/liking of the soy-fortified rice pasta samples. The evaluation is limited to organoleptic properties of the products. The participants signed an informed consent form if they were in agreement with the purpose of the study. Informed consent was obtained from the participants and the ethics committee of LAUTECH Ogbomoşo approved the study.

Sample testing was done in the sensory laboratory. Each panelist was served with 6 randomly arranged cooked pasta samples on coded disposable plates. Water was provided for mouth rinsing in-between sample tasting. Panelists were requested to evaluate the colour, taste, texture, aroma, and overall acceptance of the pastas using 9-point hedonic scale, with 1 representing dislike extremely while 9 represents like extremely.

2.11. Statistical analysis

All analyses were replicated and data obtained were subjected to analysis of variance (ANOVA) using statistical software (SPSS version 17.0). Duncan's multiple range test was used to separate means. Significant differences were determined at $p < 0.05$.

3. Results and discussion

3.1. Proximate composition of the rice-soy pastas

The proximate composition of the pastas is presented in Table 2. Moisture content is an important proximate parameter which is vital for stability of a product during storage. The level of moisture in the pastas varied from 10.02 to 11.34% with sample RP (0% soybean pasta) having the highest value while sample 30% SRP (30% soybean pasta) had the lowest value. This indicates that the moisture content of the pastas decreased with increased in the proportion of soybean flour in the pasta samples. This could be due to the ability of soybeans protein to form complex with water, leading to less free water availability for analysis (Aremu et al., 2006). The results of the moisture content of the soy fortified pasta indicates that the soy fortified samples with low moisture content will have longer shelf life compared with the un-fortified pasta. The moisture content of the pasta samples reported in this study is within the range of moisture content (10.44–11.12%) reported for pasta produced from blends of maize, sorghum and watermelon seed flour (Ikujenlola, 2016).

The protein content of the pastas significantly increased ($P < 0.05$) with increased in proportion of soybeans in the pasta samples. This could be as a result of high protein content of soybean (Dhingra and Jood, 2004). The protein content of soy fortified pasta (9.4–12.1%) reported in this study is within the range of the protein content (8.29–12.34%) of pasta produced from rice flour substituted with 5–15% defatted soybean flour (Sereewat et al., 2015). This result indicates that addition of soybeans flour to rice flour for pasta production will improve the protein content of rice pasta, thus increase the protein intake of the consumers.

The fat content of the pastas ranged from 3.51 to 5.77 % with sample RP (0% soybean pasta) having the lowest value while sample 30% SRP (30% soybean pasta) had the highest value. This indicates that fat content increased as the percentage of soybean flour in the pasta samples increased. This result is expected since un-defatted soybean flour was used in the blends, and soybean contains high fat (20.6%) (Osundahunsi et al., 2007). The finding of this study is in agreement with the findings of Caperuto et al. (2000), who reported fat content of gluten-free spaghetti made from quinoa (*Chenopodium quinoa* wild) flour to be 2.80–6.77%.

Ash content is a measure of the nutritive mineral elements in food. Fortification of rice flour with soybean flour increased the ash content of the pastas from 0.59 to 2.17%. This could be as a result of high mineral content in soybean. Thus, the ash content of all the fortified pasta samples was higher than that of the un-fortified rice pasta (Table 2). Similar findings were reported by Omeire et al. (2014), who reported higher ash content (2.1–2.63%) for noodles produced from wheat, acha and soybeans composite compared to the control sample (0.87%).

Fibre contributes to satiety after food consumption and lowers the glycemic index of food (Ribeiro et al., 2018). The crude fibre content (0.8%) of the un-fortified rice pasta was lower than those of the fortified rice pasta (0.9–1.3%), with the highest fortification level having the highest fibre value (Table 2). This could be due to high fibre contents (2–33%) in legumes, including soy beans (20%) (Bolarinwa et al., 2019). Similar results were reported by Mishra and Bhatt (2017), who reported higher fiber contents (0.52–0.54%) in pasta samples enriched with 1–5% soya protein isolate powder in comparison to the control sample (0.45%). Kaur et al. (2013) also reported that addition of chickpea flour to pasta increased the fiber contents (4.67–6.07%) of the pastas. Pasta sample produced from rice flour fortified with 30% soybean flour (30%SRP) can provide half of the fibre content (1.3 g) required per portion of food (bib_citation_to_be_resolved Ribeiro et al., 2018).

The carbohydrate content of the soy fortified pasta decreases with increment in the proportion of soybeans in the sample. This could be due to low carbohydrate content (13%) of soybean flour (Bolarinwa et al., 2019). Omeire et al. (2014), also reported decrease in carbohydrate contents (82-60%) for noodles from composite blends of wheat, acha and soybean flour, with increase in percentage soybean flour in the blend.

Table 2. Proximate composition of the rice-soy pastas.

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	Energy value (Kcal/100g)
RP	$11.34^a \pm 0.01$	$6.67^d \pm 0.05$	$3.51^f \pm 0.03$	$0.59^e \pm 0.00$	$0.77^e \pm 0.01$	$82.12^a \pm 0.04$	378.75
10% SRP	$11.15^a \pm 0.04$	$9.42^c \pm 0.06$	$3.68^e \pm 0.04$	$0.68^d \pm 0.04$	$0.90^d \pm 0.02$	$79.17^b \pm 0.02$	379.48
15% SRP	$10.98^b \pm 0.03$	$10.68^b \pm 0.04$	$4.00^d \pm 0.02$	$0.75^d \pm 0.03$	$1.10^c \pm 0.01$	$78.39^b \pm 0.02^c$	380.68
20% SRP	$10.72^b \pm 0.06$	$10.92^b \pm 0.03$	$4.48^c \pm 0.03$	$1.18^c \pm 0.05$	$1.21^b \pm 0.05$	$77.32^{bc}\pm0.12$	381.96
25% SRP	$10.15^c \pm 0.05$	$11.57^a \pm 0.04$	$5.15^b \pm 0.01$	$1.85^b \pm 0.03$	$1.23^b \pm 0.02$	$75.96^c \pm 0.04$	384.47
30% SRP	$10.02^d \pm 0.20$	$12.11^a \pm 0.06$	$5.77^a \pm 0.13$	$2.17^a \pm 0.02$	$1.32^a \pm 0.01$	$75.40^c \pm 0.17$	388.77

Means with different superscript(s) along the same column are significantly different ($P < 0.05$).
RP = Rice:Tapioca (80:20), 10%SRP = Rice:Tapioca:Soybeans Pasta (70:20:10).
15%SRP = Rice:Tapioca: Soybeans Pasta (70:20:15), 20%SRP = Rice:Tapioca:Soybeans Pasta (70:20:20), 25%SRP = Rice:Tapioca:Soybeans Pasta (70:20:25), 30%SRP = Rice:Tapioca:soy Soybeans Pasta (70:20:30).

Table 3. Colour attributes of the un-cooked rice-soy pastas.

Sample	Colour Measurement		
	L*	a*	b*
RP	$75.76^{a} \pm 0.41$	$8.94^{e} \pm 0.30$	$25.22^{c} \pm 0.57$
10%SRP	$74.96^{a} \pm 0.45$	$9.53^{d} \pm 0.51$	$28.75^{b} \pm 0.73$
15%SRP	$74.08^{a} \pm 0.64$	$10.66^{c} \pm 0.57$	$31.16^{a} \pm 0.02$
20%SRP	$69.56^{b} \pm 0.48$	$12.97^{b} \pm 0.13$	$31.52^{a} \pm 0.31$
25%SRP	$67.28^{b} \pm 0.90$	$12.35^{b} \pm 0.27$	$32.10^{a} \pm 0.20$
30%SRP	$66.57^{b} \pm 1.04$	$13.02^{a} \pm 0.11$	$32.37^{a} \pm 0.28$

Means with different superscript along the same column are significantly different ($P < 0.05$).
L* = Lightness, a* = Redness, b* = Yellowness.
RP = Rice:Tapioca (80:20), 10%SRP = Rice:Tapioca:Soybeans Pasta (70:20:10), 15%SRP = Rice:Tapioca: Soybeans Pasta (70:20:15), 20%SRP = Rice:Tapioca:Soybeans Pasta (70:20:20), 25%SRP = Rice:Tapioca:Soybeans Pasta (70:20:25), 30%SRP = Rice:Tapioca:soy Soybeans Pasta (70:20:30).

The estimated energy values of the soy fortified pastas (379.5–388.8 kcal/100g) were higher than that of the un-fortified pasta (378.8 kcal/100g). This could be due to the addition of soybeans to the composite flour, since soybean flour has high fat content, and fat contributes to high energy value. Thus, consumption of the soy fortified rice pastas can contribute to the caloric intake of the rice-soy pasta consumers.

3.2. Colour of the rice-soy pastas

Colour is an important parameter in food, because it adds aesthetic value to food products. The results of the colour attributes of the pastas are presented in Table 3. Generally, the results showed that addition of soybeans to rice flour significantly affected the colour of the fortified rice pastas. However, the colour of the un-fortified pasta and the 10% soy-fortified pasta was not significantly different. The lightness value (L*) of the pastas decreases with increase in soybeans flour fortification at >10% soybean flour enrichment.

In contrary to the lightness, the a* values of the pasta samples increases with increased in the proportion of soybeans flour in the pastas. This could be due to the effect of drying temperature and time (see section 2.5) on the soy protein. This result is in conformity with the findings of Petitot et al. (2010), who reported increase in redness of pasta fortified with faba bean flour. The b* values of the fortified pasta samples significantly differed from that of the un-fortified pasta. However, there was no significant difference ($p > 0.05$) in the yellowness values of the fortified rice pastas especially at 15–30% fortification level (Table 3). This result is not surprising because the cream colour of soybeans is expected to contribute to the yellowness of the pastas. The findings of this study are in agreement with that of Petitot et al. (2010), who reported that there were no changes in the yellowness of pasta fortified with split peas and faba beans. However, in contrary to the findings of this study, decrease in yellowness values were reported for pastas containing lentil, chickpea, green pea and yellow pea (Zhao et al., 2005). Differences in the yellowness values reported in this study and that of the study of Zhao et al. (2005) could be due to differences in the composition of the composite flour and colour of the legumes. Since conventional wheat pastas are generally bright yellow (Ugarcic-Hardi et al., 2003), high levels of yellowness recorded in the samples with high percentage of soybeans flour is desirable.

3.3. Cooking quality of the rice-soy pastas

The results of the cooking quality of the pastas are illustrated in Figure 1. Cooking time and cooking loss are important parameters

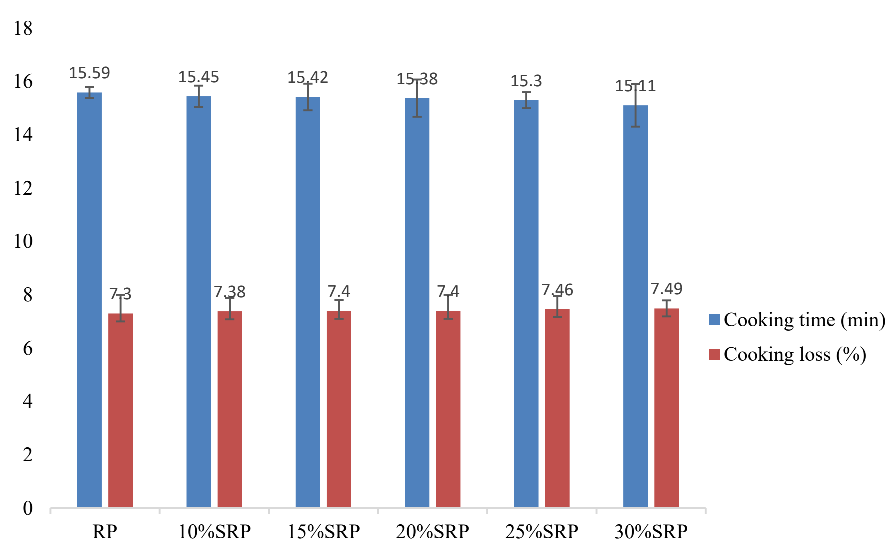

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Figure 1. Cooking time and cooking loss of the rice-soy pastas.

Table 4. Texture profile of the rice-soy pasta.

Sample	Hardness (N)	Cohesiveness	Gumminess (g)	Springiness (mm)	Chewiness (g x mm)
RP	4.96[a]	0.66[c]	334[d]	1.25[a]	417[a]
10%SRP	4.74[b]	0.70[c]	339[d]	1.11[b]	376[b]
15%SRP	4.16[c]	0.83[b]	352[d]	1.05[b]	370[c]
20%SRP	4.07[c]	0.97[b]	403[c]	0.93[c]	375[d]
25%SRP	3.22[d]	1.15[a]	378[b]	0.90[c]	340[e]
30%SRP	3.08[e]	1.50[a]	471[a]	0.71[d]	334[a]

Means with different superscript along the same column are significantly different ($P < 0.05$).
Sample codes are as defined in Table 2.
RP = Rice:Tapioca (80:20), 10%SRP = Rice:Tapioca:Soybeans Pasta (70:20:10), 15%SRP = Rice:Tapioca: Soybeans Pasta (70:20:15), 20%SRP = Rice:Tapioca:Soybeans Pasta (70:20:20), 25%SRP = Rice:Tapioca:Soybeans Pasta (70:20:25), 30%SRP = Rice:Tapioca:soy Soybeans Pasta (70:20:30).

influencing consumers' acceptability of pasta. High cooking time and cooking loss are undesirable, since high cooking time is an indication of high energy requirement for cooking, while high cooking loss indicates high starch solubility, resulting in poor pasta quality. The cooking time and cooking loss of the soy fortified rice pasta and the un-fortified rice pasta were not significantly different. Shorter cooking time (15.45–15.11 min) and higher cooking loss (7.38–7.49%) were recorded for the soy fortified rice pasta compared to cooking time (15.59 min) and cooking loss (7.30%) of the un-fortified rice pasta. These results indicate that fortification of rice pasta with soy flour does not significantly affect the cooking time and cooking loss of the pasta. In contrary, Petitot et al. (2010), reported that addition of legume flours (split pea and faba bean) to wheat flour led to a decrease in pasta cooking time and increased the cooking loss.

Increased cooking loss recorded for the pasta samples can be attributed to weakening of the gluten free pasta structure, causing soluble solids from the pastas to leach out into the cooking water (Rayas-Duarte et al., 1996). Higher cooking loss can also be attributed to increase starch damage (Lorenz et al., 1993), caused by higher water penetration in the pasta core, leading to physical disruption of the pasta matrix due to absence of gluten in all the ingredients used for the pasta preparation (Chillo et al., 2008). High cooking loss recorded for the soy-fortified pastas indicates that the pastas will have less over-cooking tolerance and high sticky mouthfeel (Bhattacharya et al., 1999).

The cooking time recorded for the soy fortified pastas in this study is higher than the cooking time (10.05–10.36 min) reported for rice pasta produced from rice-maize-passion fruit peel composite flour. The differences in the cooking time could be due to differences in the composition of the composite flour used for the pasta preparation. Longer cooking time recorded for the pastas in this study could be due to the use of cassava starch as binder, as cassava dough generally require long cooking time (12–15 min) (Rodríguez-Sandoval et al., 2008).

3.4. Texture profile of the rice-soy pastas

Texture of cooked pastas is an important parameter for consumers acceptability of the products (Bhattacharya et al., 1999). The texture profile of the soy fortified pastas and unfortified pasta is presented in Table 4. Addition of soybean flour to rice flour resulted in decrease in the hardness (4.96–3.08 N), springiness (1.25–0.71 g) and chewiness (417–334 g x mm), but increased in cohesiveness (0.66–1.50) and gumminess (334–471 g) of the soy fortified rice pasta. Highest hardness value (4.96 N) recorded for the un-fortified rice pasta indicates that the pasta will be fragile. Cohesiveness is a measure of the strength of the

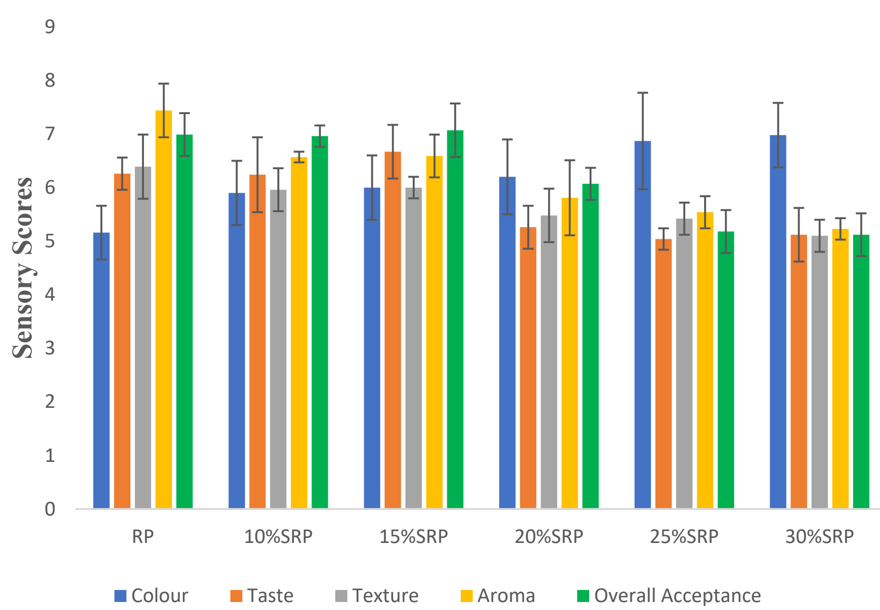

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Figure 2. Average sensory scores of the rice-soy pastas.

internal bonds of the pastas. Addition of soy flour to rice flour increased the cohesiveness of the pasta samples (Table 4). Increasing gumminess values recorded for the soy fortified rice pastas indicate that the fortified samples will have sticky mouth feel. This could be due to high fibre contents of soy flour. Springiness is a measure of the ability of a compressed pasta to return to its original height. Lower springiness values recorded for the fortified rice pastas could be due to high crude fibre contents in the fortified rice pastas, as shown in Table 2. The low chewiness values indicate that the pastas may be preferred by children and adults who may not have the ability to chew for long time.

3.5. Sensory attributes of the rice-soy pastas

The results of the sensory attributes of the soy fortified pastas and the unfortified rice pasta is presented in Figure 2. Sensory scores for colour increased in the fortified pastas with increasing proportion of soy flour in the pastas, with the un-fortified sample having the least score (5.2). Thus, pasta samples fortified with >15% soy flour were most preferred to the panelists in terms of colour. This could be due to the yellowness of the soy fortified pasta. The un-fortified pasta and the 10–15% soy fortified pastas were highly rated in terms of taste. Although there were no significant differences ($p > 0.05$) between the un-fortified pasta and the 10–15% soy fortified pastas in terms of taste, there was significant differences ($p < 0.05$) between the un-fortified pasta and the 20–30% soy fortified pastas. These results are slightly different from the findings of Bouasla et al. (2017), who reported no changes in the colour and taste of rice pastas enriched with 10, 20 and 30% legume flours (yellow pea, chickpea and lentil) and 100% rice pasta. The differences could be due to differences in the composition and properties of the legume flour used for the pasta formulation.

Sensory scores for texture, aroma and overall acceptance of the soy fortified pastas decreases with increasing levels of soy flour (>15%) in the pasta formulation. This could be due to high protein contents of the soy fortified pasta. However, the taste, aroma and overall acceptance values of the 10% and 15% soy fortified pastas were not significantly different ($p < 0.05$) from that of the un-fortified pasta. Thus, the maximum level of soy flour that can be used for rice pasta fortification for better consumers' acceptability is 15%. Lower sensory scores recorded for aroma and overall acceptance of rice flour fortified with >15% soy flour could be due to beany flavour of soy flour, which adversely affected the aroma and overall acceptance of the densely fortified pastas.

4. Conclusion

Fortification of rice pasta with soy flour produced nutritious alternative to plain rice pasta. The soy fortified rice pastas had higher protein and other chemical components, and better colour than the un-fortified rice pasta. Fortification reduced the cooking time, but slightly increased the cooking loss, and improved the textural properties of the pastas. Cooked fortified rice pastas at 15% fortification level was acceptable and highly rated in terms of colour, taste, aroma and overall acceptance. Future studies should be done on optimization of pasta formulations for better pasta sensory and textural properties at high fortification levels, and the storage requirements and shelf life of the soy fortified rice pasta.

Declarations

Author contribution statement

Islamiyat Folashade Bolarinwa: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Oyewole Oluwaseun Oyesiji: Analyzed and interpreted the data.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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