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Impact of Soy Enrichment on Physico-Chemical, In-Vitro Protein and Starch Digestibility, Vitamin, Antioxidant and Sensory Properties of "Lafun" Flour

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ABSTRACT

The study evaluated the physico-chemical, *in-vitro* protein and starch digestibility, vitamin and antioxidant properties of soy-enriched "lafun" flours as well as the quality acceptability of the reconstituted dough meal from the flours through sensory evaluation. "Lafun"' was enriched with soy protein supplements (curd or residue at 10%) during the mashing before drying (wet-mix method) followed by thorough mixing to ensure uniform distribution of the soy curd and residue. The total titratable acidity of the flours ranged from 0.65 – 0.86% and pH ranged from 3.43 – 4.07. While enrichment increased the *in-vitro* protein digestibility from 8.70 to 71.20%, an inversely correlated observation was obtained for the *in-vitro* starch digestibility which ranged between 45.55 and 71.20. Enrichment also increased the vitamin (B-vitamins) as well as the antioxidant properties of the flour. While this study showed the possibility of enriching cassava flour ("Lafun") with soy curd or residue, the quality acceptability result revealed higher preference for the non-enriched samples.

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Introduction

Cassava (*Manihot esculenta*, Crantz) is a popular tuber in many countries of the world due to its high adaptability to several environmental conditions. However, being a high carbohydrate and very low protein content food items, it is mostly regarded by many as food for the poor [1,2]. Several products have been developed from cassava all over the countries where it grown. Some of these include, *gari*, *fufu*, *tapioca*, *lafun*, *pupuru*, chips. Out of these products, gari seems to be more common and so enjoys wider acceptability especially in Nigeria who is currently the largest producer of cassava in the world. Conversely, products such as "*fufu*" and "*lafun*" are more of regional foods. Specifically, "*lafun*" is commonly consumed by the Yorubas, a South Western part of Nigeri [3-6]. It is produced from fermented cassava tubers. The tubers are peeled, washed cut into smaller pieces to aid fermentation and soaked in water for up to five 5 days, depending on the climatic conditions until the tubers are softened by the fermentation process. Thereafter, the water is drained and the mash is dried, pulverized, sieved and packaged as "*lafun*". It is made into a dough meal be mixing the flour with hot water and the relatively elastic dough meal obtained is eaten with soup.

Gari, being the more popular and preferred product has enjoyed more attention and consequently, several research efforts had been focused on gari than the other products in order to improve it nutritional quality [2]. However, unlike gari that is coarse, "*lafun*" is in a form of fine powders and so may provide a better avenue for enrichment with other food items, especially those higher in protein content, an essential nutrient in which cassava flour is grossly deficient. A potential high protein food item that had also been used in supplementing gari is soy bean. Soybeans is an oilseed and could be a good source of high protein (32.4% - 50.2%) to supplement "lafun". Besides, it is cheap and commonly available. Therefore, the objectives of this study was to enrich "*lafun*" with soy curd or residue and evaluate the impact of the enrichment on the physicochemical, *in--vitro* protein and starch digestibility, functional properties as well as the quality acceptability of the dough meal from the flours.

Materials and Methods

Sources of Raw Materials

Cassava roots (*Manihot esculenta* crantz) were obtained from the Teaching and Research farm of the Federal University of Technology, Akure, Nigeria. Soybean (*Glycine max* -TGX) was purchased from Michael Okpara University of Agriculture, Umudike, Nigeria.

Soy Curd and Residue Extraction

Soy bean seed (150 g) were sorted, cleaned, soaked (12 h) in 2 L of tap water containing 0.5 g $NaHC0_3$ in a cooking pot and boiled for 25 min. The boiled and dehulled soybean seeds were then wet milled in a hammer mill. Water was added in ratio 1:8 and a muslin cloth was used to extract the milk (pH 6.40) and the residue was kept separate. Thereafter, the pH of the extracted milk was adjusted to 4.6 by adding 1 M citric acid. The soy milk was allowed to stand and the clear whey at the upper part was

decanted while the lower part (curd) was collected after six hours. The curd and residue were oven dried (at 60°C for 24 h), milled, packaged in high density polyethylene HDPE and stored in the refrigerator until needed for further use. Figure 1A shows the production chart for the curd and residue.

"Lafun" Production and Enrichment

Freshly harvested cassava roots were peeled with knife, washed and cut into chunks, fermented for 4 days (pH 3.67), washed, sifted, milled into pulp and divided into two portions (Figure 1B). One portion was used as control (CL) while the other portion was enriched with either dry soy curd or residue using Pearson scale with, 10% enrichment level and also taking into consideration the water content of the mash at 100%. Sample supplemented with curd was named ""lafun" enriched with curd" (LEC) and the other sample ""lafun" enriched with residue" (LER). A commercial "lafun" sample (CS) was obtained from FIIRO Oshodi, Lagos for comparison.

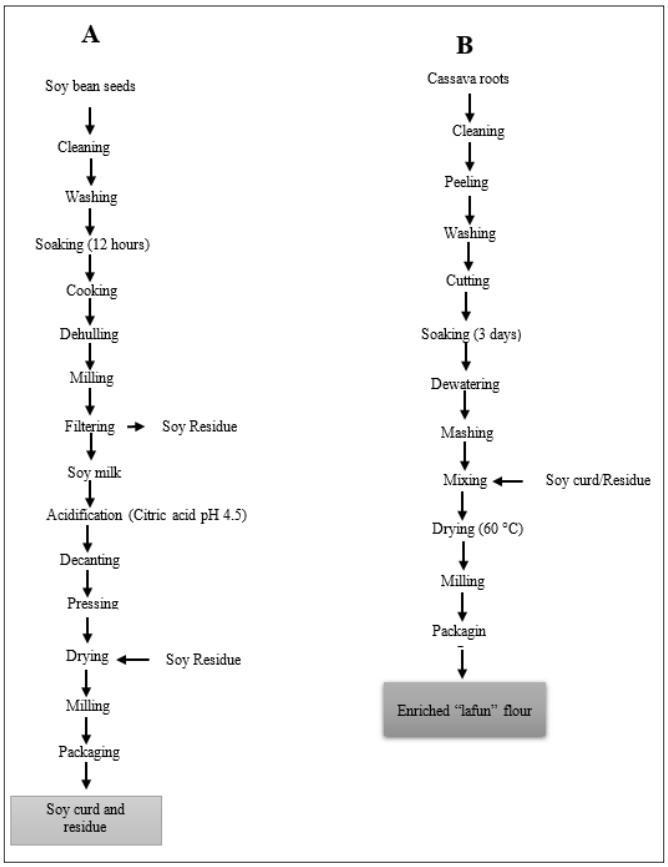

Figure 1: Production of soy supplement (curd and residue) (A) and enriched "lafun" samples (B)

Physico-Chemical Properties of Soy-Enriched "Lafun" Flour
Determination of Total Titratable Acidity

For the determination of titratable acidity, 10 g of sample was weighed and crushed with 105 ml water (40°C) in porcelain mortar. This solution was filtered and 25 mL of filtered solution was used for titration. Three drops of phenolphthalein were added and titrated with 0.1 N NaOH until the first permanent pink color [7].

$$Percentage\ of\ \text{lactic acid} = \frac{(0.1N\ \text{NaOH amount (ml)} \times 0.009 \times 100)}{Weight\ of\ sample\ (W_1)} \times 100$$

Determination of Ph

The pH of "lafun" samples were measured using pH meter (model 7020 Electroc Ltd, England) after standardization with pH 4 and buffer (BDH, England). The slurry of "lafun" was obtained by dipping the electrode into a reconstituted dried "lafun" samples in a beaker with temperature ranging between 20 - 25oC after pH meter calibration.

Determination of In-Vitro Protein Digestibility of Soy-Enriched "Lafun" Flour

In vitro protein digestibility was determined with slight modifications using standard method [8]. One tablet of Panzynorm-N (manufactured by M/s German Remedies India, Ltd., Mumbai, India) containing 10,000 units of lipase, 9000 units of alpha- amylase and 500 units of protease, was dissolved in 5.0 mL sodium phosphate buffer (0.1 M; pH 8.0). One milliliter of the digestive enzyme was added and incubated at 37°C for 1 h. Enzyme and sample blanks were also simultaneously kept and after the reaction period, the enzyme was heat killed and the total amino acid content in the supernatant was quantified using ninhydrin reagent. In vitro protein digestibility is expressed as mg amino groups (Leucine equivalent) released per h per 100 g.

Determination of In-Vitro Starch Digestibility of Soy-Enriched "Lafun" Flour

In vitro starch digestibility of lafun samples was analysed following a previously described modified method. Amyloglucosidase (No. 9913, Sigma–Aldrich) (1 ml) was added to deionized water (2 ml) [9]. Porcine pancreatic alpha-amylase (No. 7545, Sigma–Aldrich, St. Louis, MO) (3.89 g) was dispersed in water (25.7 ml) and centrifuged for 10 min at 2,500 g, and 18.7 ml of supernatant was collected. This supernatant was mixed with 1 ml of diluted amyloglucosidase for making the enzyme solution. The solution was freshly prepared for the digestion analysis. Aliquots of guar gum (10 ml, 5 g/l) and sodium acetate (5 ml, 0.5 M) were added to the flour samples (0.5 g, db) in a test tube. Seven glass balls (10 mm diameter) and 5 ml of enzyme solution were then added to each tube; following the incubation in shaking water bath at 37 °C with agitation (170 rpm). Aliquots (0.5 ml) were taken at intervals and mixed with 4 ml of 80 % ethanol, and the glucose contents in the mixture were measured using glucose oxidase and peroxidise assay kits (No. GAGO-20, Sigma–Aldrich). The total starch content was measured according to [10]. The starch classification based on its digestibility was: RDS as the starch that was hydrolyzed within 20 min of incubation, RS as the starch not hydrolyzed with 120 min, and SDS as the starch digested during the period between 20 and 120 min.

Determination of Vitamins Contents of Soy-Enriched "Lafun" Flour

The vitamin contents of the sample was analyzed by following standard method with some modification [8]. The sample was made to attain the laboratory atmospheric condition on the bench after removing the samples from the storage chamber at less than 4°C. The sample was pressed and completely homogenized in the mortar carefully with pestle to avoid forming balls. A quality (0.10 g) of the sample was weighed into 10 mL beaker capacity. The sample was extracted in the container by the above stated modified methods. After the extraction, the extract was concentrated to 1.0 mL for the chromatographic analysis

Antioxidant Properties of Soy-Enriched "Lafun" Flour
Determination of Total Flavonoid Content Determination

The total flavonoid content of lafun samples was determined using a slightly modified method [11]. Briefly, 0.5 ml of appropriately diluted sample was mixed with 0.5 ml methanol, 50 ml of 10% Aluminium chloride ($AlCl_3$), 50 ml of 1 mol/l potassium acetate and 1.4 ml water, and allowed to incubate at room temperature

for 30 min. Thereafter, the absorbance of the reaction mixture was subsequently measured at 415 nm using a spectrophotometer (JENWAY 6305). The total flavonoid was calculated using quercetin as standard.

Determination of Total Phenolic Content

The phenolic content was determined according to a previously reported method with slight modifiactions. Appropriate dilutions of the extracts were mixed with 2.5 mL of 10% Folin-Ciocalteau's reagent v/v and neutralized with 2.0 mL of 7.5% sodium carbonate [11]. The reaction mixture was incubated for 40 min at 45°C and the absorbance was measured at 765 nm in a spectrophotometer (JENWAY 6305). The total phenolic content was subsequently calculated using gallic acid as standard.

Dpph Free Radical Scavenging Ability

The free radical scavenging ability using 1, 1-diphenyl-2-picryl hydrazyl (DPPH) was determined as previously described [12]. Different concentrations of the sample were taken in different test tubes and the volume was made up to 1 ml with distilled water. 4 ml of 0.1 mM methanolic solution of DPPH was added. The tubes were shaken vigorously and allowed to stand for 20 min at room temperature. A control was prepared as above without the sample and distilled water was used for base line correction. Changes in absorbance of samples were measured at 517 nm in a spectrophotometer (JENWAY 6305). Free radical scavenging ability was expressed as percentage inhibition and was calculated using the following formula

$$Free\ Radical\ Scavenging\ Ability\ (\%) = \frac{Absorbance\ of\ control - Absorbance\ of\ sample}{Absorbance\ of\ control\ x\ 100}$$

Determination of Ferric Reducing Antioxidant Power (Frap)

The reducing property of the *lafun* sample was determined by assessing the ability of the sample to reduce ferric chloride ($FeCl_3$) [13]. A 2.5 ml aliquot was mixed with 2.5 ml of 200 mM sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide. The mixture was incubated at 50°C for 20 min; thereafter 2.5 ml of 10% trichloroacetic acid was added. This mixture was centrifuged at 2 000 x g for 10 min; 5 ml of the supernatant was mixed with an equal volume of water and 1 ml of 0.1% ferric chloride. The absorbance was measured at 700 nm in a spectrophotometer (JENWAY 6305) and ferric reducing antioxidant property was subsequently calculated using ascorbic acid as standard.

Sensory Evaluation of Dough Meal from Soy-Enriched "Lafun" Flour

Sensory evaluation of dough meal from "*lafun*" flour was prepared according to a previous method and evaluated for its appearance, taste, aroma, texture and overall acceptability using a 9 point Hedonic scale (where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely). The dough meal was prepared by mixing "*lafun*" with boiling water in a stainless steel pot on a gas cooker at a ratio of 1:4 (w/v). Wooden stirrer was used to stir the mixture continuously until the "lafun" absorb all the water and attain appropriate consistency [14]. An untrained 30 member panelists were served with the "lafun" dough meal and asked to observe the appearance to check for the colour whether it was light or dark, finger feel to check for texture whether it was gritty or smooth, soft or thick; taste test to check the taste whether it was sour or not. They were also to sniff test to detect any objectionable odour, beany flavour or any off flavour. The overall acceptability was evaluated by eating a small ball of dough.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) and the means were separated using Duncan Multiple Range Test at ($P \leq 0.05$) using Statistical Package for Social Scientists (SPSS) version 17.

Result and Discussion

Effect of Enrichment on the Vitamin Composition of "Lafun" Samples

Enrichment or food fortification is a common food processing technique aimed at improving the nutritional contents of both liquid/beverage and dry foods [15-17]. The vitamin composition of the samples are presented in Table 1. From the results, significant differences ($p < 0.05$) exist among the samples. The major vitamins for all the samples are Vit A: 7.23 (CL) - 9.28 (LEC) mg/100 g; Vit B2: 5.19 (CL) -6.54 (LEC) mg/100 g but the LER showed considerably lower content (1.18 mg/100 g) and Vit B12: 5.61 (LEC) - 6.32 (CL). Also, the LEC showed higher concentrations of Vit B1 (8.85) and Vit. B3 (9.70) mg/100 g when compared to the concentrations of these vitamins in other samples. Sample (LEC) had the highest value of vitamin A when compared with others but slightly different from the sample enriched with residue (LER). Vitamin A is one of the major micronutrient deficiency that is of public health concern in sub-Saharan Africa, especially, among children and women who constitute major consumers of the product [18,19]. Therefore, the slight increase in the vitamin may be crucial in addressing this challenge. Efforts geared towards increasing vitamin A content of plant foods, including cassava tubers had also been reported. It was observed that sample LEC had the highest value of vitamin A, B1, B2 and B3 contents while the control samples are lower in value which might be due to absence of soy supplement. hence, the enrichment of 'lafun' with soy supplement may influence the nutritional quality of the enriched samples [19-23]. Vitamins, like minerals are essential micronutrients for the regulation of several body processes. Specifically, the B-class of vitamins are important co-factors in the metabolism of the macronutrients – protein, carbohydrate and fat. For instance, while thiamine is involved in energy generation from carbohydrate, riboflavin is involved in fatty acid catabolism and niacin in fat, alcohol and fat metabolism. The vitamin compositions of the lafun samples investigated in this study are higher when compared to the *Koganesengan* and *Beniazuma* sweet potatoes varieties - B1 (0.052-0.126), B2 (0.037-0.058), B6 (0.036-0.105) mg/100 g) and niacin (0.627- 0.913 mg/100g) contents. Apparently, the differences in the results are due to the difference in specie [24,25].

Table 1: Vitamin Content of "Lafun" Enriched with Soy Curd and Residue (Mg/100g)

Samples	Vitamin A (Retinol)	Vitamin B1 (Thiamine)	Vitamin B2 (Riboflavin)	Vitamin B3 (Niacin)	Vitamin B5 (Pantothenic acid)	Vitamin B6 (Pyridoxine)	Vitamin B9 (Folic acid)	Vitamin B12 (Cobalamin)
CL	7.23±0.00^{c}	1.21±0.00^{c}	5.19±0.01^{c}	1.12±0.00^{c}	1.20±0.00^{b}	1.35±0.01^{c}	2.47±0.02^{a}	6.32±0.02^{a}
CS	7.05±0.01^{d}	1.22±0.02^{c}	5.87±0.05^{b}	1.13±0.00^{c}	1.21±0.00^{b}	1.46±0.00^{b}	2.39±0.01^{b}	5.90±0.08^{c}
LEC	9.28±0.80^{a}	8.85±0.00^{a}	6.54±0.01^{a}	9.70±0.00^{a}	1.13±0.00^{c}	1.27±0.02^{d}	2.05±0.00^{d}	5.61±0.06^{d}
LER	8.69±0.06^{b}	1.26±0.00^{b}	1.18±0.00^{d}	1.48±0.01^{b}	4.56±0.03^{a}	2.23±0.02^{a}	2.32±0.01^{c}	5.97±0.02^{b}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: CL = Control sample, CS= commercial sample, LEC, "lafun" enriched with 10% curd, LER= "lafun" enriched with 10% residue

Physico-Chemical Properties of "Lafun" Samples

Table 2 shows the physico-chemical – total titratable acidity (TTA), pH and average particle size of "*lafun*" flour. Significant difference ($p\leq0.05$) was observed between the enriched and control samples. The titratable acidity (TTA) correspondingly decreased from 0.86 (CS) to 0.65% (LEC) while the pH values ranged between 3.43 (CS) and 4.07 (LER). This showed that enrichment with soy supplement (curd or residue) tended to make "lafun" less acidic by the dilution effect of the supplement which reduces the sourness of the "lafun" enriched product. This is expected since the CL and CS samples are mainly products of cassava fermentation. However, the pH values of the "*lafun*" samples was still within the range recommended value (3.50-4.5) for acid fermented products (Oluwamukomi et al., 2005) and also comparable to previous result reported for "*lafun*" from different cultivars while the TTA was within the previous 0.6–1.2 reported for cassava products but considerably lower than those earlier reported for similar product [2,3,6,14,26]. The values of TTA recorded in all the "lafun" samples were in agreement with Nigerian Industrial Standard (NIS, 2004) who recommended less than 1.00% TTA for cassava products. A range of 0.77 and 1.62% TTA was also reported by for cassava food. The control sample was acidic in nature due to the role of the lactic acid bacteria during fermentation of the cassava root [26,27].

Table 2: Physico-Chemical Properties of Enriched "Lafun" and Control Sample

Samples	TTA (%)	PH	Average Particle Size (mm)
CL	0.81±045^{b}	3.50±0.10^{b}	0.33±0.03^{ab}
CS	0.86±0.00^{a}	3.43±1.59^{b}	0.31±0.01^{ab}
LEC	0.65±0.05^{c}	4.00±0.15^{a}	0.39±0.02^{a}
LER	0.69±0.35^{c}	4.07±0.15^{a}	0.37±0.01^{a}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: CL = Control sample, CS= commercial sample LEC, = "lafun" enriched with 10% curd, LER= "lafun" enriched with 10% residue

Particle-size distributions of all the samples are as shown and summarized (Table 1). "Lafun" flour without enrichment had a greater proportion of small or finer particles 0.33 (CL) and 0.31 mm (CS) than the soy enriched samples which particle size ranged from 0.37 (LER) to 0.39 mm (LEC). There was a change in the particle size distribution observed after enrichment of the "lafun" samples. The addition of soy supplement to the "lafun" samples increased the particle size of the "lafun" sample relatively. Samples enriched with soy curd showed a greater proportion of larger particles (0.39 mm) than the samples without enrichment CL 0.33 mm and CS 0.31mm, this might be as a result of adherence of each particle resulting in the greater proportion of larger particles in the enriched "lafun" sample.

In-Vitro Protein and Starch Digestibility of "Lafun" Samples

The in-vitro protein and starch digestibility (IVPD) of the "lafun" samples are presented in Table 3. The in-vitro protein digestibility of the "lafun" samples ranged from 8.70 (CL) to 66.23% (LEC) with the enriched "lafun" being significantly ($p\leq0.05$) different from the control. IVPD of "lafun" increased with soy curd and residue supplementation. The soy curd enriched "lafun" had the highest IVPD (66.23%) while the control samples had a very low in-vitro protein digestibility. The trend of this result suggests that higher protein content due to the supplementation does imply improved protein digestibility. IVPD indicates the amount of protein the body absorbed relative to the ingested or consumed protein. The IVPD estimates evaluates nutrient bioavailability upon consumption since the protein content is not sufficient to predict bioavailability. The result may also indicate improved bioavailability of protein due to the supplementation of "lafun" with soy curd and residue. These results is in agreement with previous study who increased the digestibility of wheat flour by soy bean supplementation [28]. The differences in IVPD values between the enriched and the non-enriched samples could be explained by the fact that the non-enriched samples were more resistant to enzymatic hydrolysis due to the presence of carbohydrate in form of starch and other non-protein ingredients. This result is slightly lower but comparable to 83.2% previous study that reported that higher soy meal digestibility depends on the nature of protein and percentage added in the formulated meal [29].

As could be expected, the in-vitro starch digestibility (Table 3) showed and inversely correlated observation to that obtained for the IVPD. There were remarkable significant difference (P≤0.05) between the non-enriched samples (CS: 70.21 and CL: 71.20) when compared to the enriched samples (LEC: 45.55 and LER: 52.21). Presence of resistant starch and percentage of amylose to amylopectin would affect starch digestibility. With the addition of soy supplement to "lafun" flour also decreased starch digestibility rate of the "lafun" flour which could be due to presence of protein, fats and other nutritional substances embedded in the soy supplement. Hence, enrichment of "lafun" with soy-curd and residue had influence on the in-vitro starch digestibility of the enriched samples.

Table 3: In-Vitro Protein and Starch Digestibility of "Lafun" Samples

Samples	CL	CS	LEC	LER
In-vitro Protein Digestibility (%)	8.70±0.50^{c}	9.23±0.13^{c}	66.23±0.00^{a}	51.12±2.20^{b}
In-vitro Starch Digestibility (%)	71.20±0.00^{a}	70.21±0.00^{a}	45.55±1.39^{c}	52.21±0.76^{b}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same row are significantly different (p<0.05) KEY: CL = Control sample, CS= commercial sample LEC, = "lafun" enriched with 10% curd, LER= "lafun" enriched with 10% residue.

Phytochemical and Antioxidant Properties of Lafun Samples

The phytochemical (flavonoid and phenolic) contents as well as the antioxidant abilities of the samples are shown in Table 4. The result showed that enrichment significantly increased the total flavonoid as well as the phenolic contents of enriched samples. This is more obvious considering the apparent insignificant difference between the control 'lafun' sample (CL) and the commercial sample (CS). Phenolic and flavonoids compounds are important scavengers of free radical and other oxidative species [30]. The antioxidant properties of the samples were assayed through the free radical scavenging (DPPH) and ferric reducing (FRAP) tests. A direct relationship was observed between the DPPH and FRAP assays with improved antioxidant properties from the enriched sample. The higher antioxidant properties observed for the enriched samples may also be due to the higher total flavonoid and phenolic contents in these samples when compared to the control and commercial samples. Thus, it may support earlier observation suggestion that there is a correlation between phenolic content and antioxidant activities [31]. However, while the curd enriched sample had better DPPH radical scavenging ability, the residue enriched counterpart showed better ability to reduce ferric ion – Fe (III) to ferrous ion – Fe (II). In summary, supplementation with soy curd or residue may provide increased health benefit by preventing oxidative stress and its related diseases. The study is also in conformity with previous studies where supplementation with soy led to increased radical scavenging ability of the products [32,33].

Table 4: Antioxidant and Phytochemical Properties of Enriched "Lafun" and Control Samples

Sample	Total flavonoid content (mg/g)	Total phenolic content (mg/g)	DPPH (IC_{50}, mg/mL)	FRAP (mg/g)
CL	0.31± 0.02^{b}	0.19± 0.2^{b}	24.80±0.15^{a}	9.41±0.03^{c}
CS	0.27± 0.01^{b}	0.21± 0.29^{b}	21.67±0.01^{ab}	7.32±0.26^{d}
LEC	0.72±0.01^{a}	1.13 ±0.19^{a}	3.07±0.03^{d}	14.65±0.09^{a}
LER	0.75± 0.02^{a}	1.15± 0.01^{a}	7.67±0.06^{c}	23.97±0.29^{b}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different (p<0.05) KEY: CL = Control sample, CS= commercial sample LEC, = 'lafun' enriched with 10% curd, LER= 'lafun' enriched with 10% residue

Sensory Qualities of Enriched "Lafun" and Control Samples

Sensory evaluation is an important aspect in new product development. It is often used to measure the relative comparison and acceptability of the new product to other existing alternatives or substitutes. Untrained panellists were used to evaluate different attributes and overall preference of "lafun" and the enriched samples. "Lafun" enriched with soy curd and residue was light brown in appearance (Table 5) with the ratings ranging between 6.60 (LER) and 7.60 (LEC) and were significantly different (p≤0.05) from the commercial (CS, 8.42) and control (CL, 8.35) samples. The control and commercial samples were rated better virtually in all the sensory qualities evaluated (appearance, taste, aroma, texture and overall acceptability) except for the texture attribute where the enriched samples were rated better. Ratings on visual appearance demonstrated that enrichment of "lafun" with soy supplement affected the colour. Since application of heat had been reported to affect the colour of food products, light brown coloration observed in the enriched samples may be attributed to the fact that the soy curd and residue supplement underwent a drying process which must have initiated a browning reaction. Evaluation of sensory qualities of a food item is a subjective measurement and is often affected by the panellist bias. Panellists often rate food items that they are already familiar with and have accepted in terms of taste, appearance, texture, aroma better than a new food product regardless of improved nutritional benefits the new product may offer. Previous studies comparing new food product with existing one have also reported similar trends of lower rating when compared with the previously existing ones. For instance, the higher ratings obtained for the non-enriched samples may be attributed to the organic acid produced by microorganisms during fermentation process which was totally diluted with supplement. And hence a lower rating for the enriched samples since the panellists are already familiar with acidic aroma. When the prepared "lafun" samples

was finger tested, the texture of the enriched was stronger, fluffier and slightly less cohesive than the control samples which was soft and highly elastic in nature. Observation showed that the "lafun" samples were smooth and not sticky to the hand. Consumers had described good texture as one that does not stick to their hands [34]. The preference of "lafun" produced from control with that of soy supplement was as result of the consumers being used to "lafun" without enrichment. However, the values obtained for the enriched samples showed that the enriched "lafun" could gain acceptability among consumers of the product and also indicated the feasibility of incorporating soy supplement in "lafun" production.

Table 5: Sensory Attributes of Enriched "Lafun" and Control Samples

Samples	Appearance	Taste	Aroma	Texture	Overall Acceptability
CL	8.35±1.35^{a}	8.30±1.49^{a}	9.25±1.57^{a}	7.62±2.01^{b}	8.36±1.54^{a}
CS	8.42±1.10^{a}	8.22±1.25^{a}	8.15±1.07^{b}	7.63±1.34^{b}	8.08±1.43^{b}
LEC	7.60±1.23^{b}	7.44±1.59^{b}	6.60±1.31^{c}	8.36±1.43^{a}	7.43±1.45^{c}
LER	6.60±1.45^{c}	6.61±1.64^{c}	6.37±1.59^{cd}	8.30±1.14^{a}	6.96±1.47^{d}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: CL = Control sample, CS= commercial sample, LEC,"lafun" enriched with 10% curd, LER= "lafun" enriched with 10% residue

Conclusion

The study established that "*lafun*" could be enriched with soy residue or curd without any potential adverse effects on the physicochemical properties of the flour. The enrichment actually increased the vitamin content and anti-oxidant properties of the flour, improved the protein digestibility and the ratings for the quality acceptability through the sensory evaluation was fair and was even rated better in texture Though the enriched samples were rated lower when compared to the control samples, except in texture, the allocated values were relatively comparable. Besides, the evaluation being a subjective assessment, the panelist could be said to be biased with their familiarity with the control samples.

Declarations of interest

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