Journal of Food Security, 2017, Vol. 5, No. 2, 43-50
Available online at http://pubs.sciepub.com/jfs/5/2/4

DOI:10.12691/jfs-5-2-4

Fortification of Carbohydrate-rich Foods (Spaghetti and Tapioca Pearls) with Soybean Flour, a Timely and Evergreen Necessity

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Abstract The economic meltdown or recession in many parts of the world has subjected many people to food insecurity, hence, there is need to establish effective measures by which food security can be attained, especially among the low income group, even amidst global economic crisis. Soybean being a cheap source of valuable nutrients and phytochemicals has been established to be a functional food. This study was therefore designed to evaluate the nutritional and sensory properties of two commonly consumed carbohydrate-rich foods (Spaghetti and Tapioca pearls) fortified with soybean flour and compare these with that of unfortified samples as well as estimate the nutritional and economic significance. The possibility of incorporating cassava flour in the production of spaghetti was also explored. Cassava four was incorporated in the spaghetti production towards the implementation of cassava flour inclusion policy. Spaghetti was prepared with different blends of wheat flour WF, soybean flour (SF) and cassava flour (CF) and designated thus: Spag 0 (100% WF- control); Spag 1 (90%WF, 5%SF and 5%CF); Spag 2 (80%WF, 10%SF and 10%CF); Spag 3 70%WF, 15%SF and 15%CF) and Spag 4 (60%WF, 20%F and 20%CF). In the same vein Tapioca pearls were prepared using the following cassava starch (CS) and soybean flour(SF) blends; Tap 0 (100%CS); Tap 1 (90%CS and 10%SF); Tap 2 (80%CS and 20%SF); Tap 3 (70%CS and 30%SF) and Tap 4 (60%CS and 40%SF). These were subjected to proximate, thiamine, riboflavin, niacin analyses using standard methods. Sensory properties (colour, appearance, flavour, texture, taste, aroma, overall acceptability) were evaluated with twenty trained taste panellists using a 9 point hedonic scale with 1 denoting ‘dislike extremely’ and 9 denoting ‘like extremely’. Mean data were compared using Least Significant Difference at p<0.05. Fortification of spaghetti ad tapioca with soybean flour significantly increased the nutritional and sensory quality appreciably and the inclusion of cassava flour in spaghetti did not adversely affect the quality of the product. Consumption of either of these fortified foods as one of the three square meals a day would make an individual to meet his or her Recommended Dietary Allowance for the nutrients analysed at a relatively lesser cost. Household and commercial production and consumption of soy-spaghetti and soy-tapioca is hereby recommended. However, soybean flour must be processed appropriately in order to exert desirable and favourable expected effect.

Keywords: *fortification, soybean flour, spaghetti, tapioca pearls*

Cite This Article: Adeniyi Paulina O., Obatolu Veronica A., Bakare A.D., Lawal S.B., Bolaji A.T., and Banjo O.A., “Fortification of Carbohydrate-rich Foods (Spaghetti and Tapioca Pearls) with Soybean Flour, a Timely and Evergreen Necessity.” *Journal of Food Security*, vol. 5, no. 2 (2017): 43-50. doi: 10.12691/jfs-5-2-4.

1. Introduction

Under nutrition is a major malnutrition problem that people in poor and developing nations commonly encounter. This may be as a result of food shortages and monotonous diets. High income earners may attain food security because they have easy economic access to supplement their dietary staples with micronutrient-rich foods such as meat, fish, poultry, egg, milk, dairy products and a wide variety of fruits and vegetables which are relatively expensive and may not be affordable by the low income earners who rely mainly on more monotonous diets based on cereals, roots and tubers which are mostly deficient in valuable nutrients [1]. The growing economic recession in many parts of the world aggravates the state of food insecurity especially among the poor [1,2,3], hence, there is need to establish feasible models through which the low income group can be able to attain food security even amidst global economic meltdown. Fortification of existing acceptable carbohydrate-rich foods which are deficient in other nutrients with relatively cheaper sources of nutrients could be a laudable step towards combating food insecurity among the poor at all times. Fortification of traditional cereal-based meals with protein-rich legumes has been identified as a possible means of alleviating Protein-Energy Malnutrition among low income population [4], hence, fortification of foods with low nutritive value with food staples of high nutritional quality of lesser costs could be an effective laudable approach in enhancing food security.

Despite the unrivalled nutritional and health benefits derivable from soybean, the wonder bean is still grossly underutilized especially for human consumption, for instance, soybean was the least consumed staple in 2007 [5]. Apart from being the only source of complete protein from plants, it has been found to be effective in the prevention and treatment/ management of non-communicable diseases such as under nutrition, osteoporosis, cardiovascular diseases, diabetes and some types of cancer. Soybean is an excellent source of protein, fat, carbohydrate, minerals, vitamins and fibre. On the average soybean contains 40% protein, 20% oil, 35% carbohydrate, 3% ash at a moisture content of about 10-13% [6]. Soy protein quality was rated 1 which is the same as that of meat and milk products [7] and it is the only plant source of complete protein. Soybean is very good source of manganese, phosphorous, iron, molybdenum, copper, omega-3 fatty acids, vitamin K and potassium as well as dietary fibre [8]. It also contains 14% saturated fatty acids, 23% monounsaturated fatty acids and 63% polyunsaturated fatty acids [8]. Furthermore, soybean is a cheap source of quality protein, for instance, 1kg of soybean contains as much as protein in 2kg of boneless meat or protein in 45 cups of cow milk or 3 dozens of chicken eggs [9]. The major beneficial phytochemicals in soybean are the isoflavones (genistein and diadzein) and anthocyanin while the anti-nutritional factors include; saponnins and trypsin inhibitor [10]. Soybean owes its medicinal value to the functional protein, lipids, dietary fibre and the phytoestrogen, isoflavones, which it contains.

Spaghetti is long, thin, cylindrical solid pasta which is a staple of Italian origin. It is commonly made with durum wheat and water while in different parts of the world other types of flour could be used. Spaghetti from durum wheat contains; 9.89% protein, 0.68% fat,0.73% ash, 0.08% dietary fibre and 80.42% carbohydrate at 7.19% moisture content [11]., hence, spaghetti is a carbohydrate food. It is a culturally acceptable food globally and is well enjoyed by virtually all age groups but most especially children, adolescents as well as young adults whose health status is easily challenged in the occurrences of food crisis. Improving the nutritional quality of this staple with soybean, which is a cheap source of valuable nutrients and phytochemicals, would be an effective measure of improving public health nutrition via enhancement of food security. The possibility of incorporating cassava flour in the production of spaghetti needs to be explored in order to increase the utilization of cassava which may concomitantly boost the economic development of cassava producing nations like Nigeria. This is in line with the implementation of the cassava flour inclusion policy which was formulated in 2015 for the successful diversification of the Nigerian economy towards agriculture [12].

Tapioca pearls is basically cassava starch made into tiny small round shapes. It is staple food commonly consumed with either cow milk or coconut milk because of its low nutritive value and bland taste. It can also be used as a thickening agent in some traditional cuisines. Tapioca pearls at 8.79% moisture content contains 0.55% protein, 0.345 fat, 0.32% ash (minerals), 0.10% crude fibre and 89.62% carbohydrate [13] showing tapioca pearls as a carbohydrate-rich staple deficient in other valuable nutrients. The poor nutritive value of tapioca pearls as well as its bland taste requires its being consumed with cow or coconut milk and sugar. Hence, fortifying tapioca pearls with soybean flour may be a relatively cheaper way of enriching it with nutrients and improving its sensory quality. This study was therefore designed to evaluate the nutritional and sensory properties of spaghetti and tapioca pearls fortified with different proportions of soybean flour as well as estimate the nutritional and economic significance or importance. The possibility of including cassava flour in the production of spaghetti was also explored.

2. Methodology

Cassava flour production: This was produced from freshly harvested cassava roots. These were washed, peeled, washed, grated, pressed, oven-dried (at 60°C for 3 days), milled, sieved and packaged to give cassava flour.

Cassava starch production: This was also produced from freshly harvested cassava roots. These were washed, peeled, grated, sieved, allowed to settle and the water was decanted to leave the wet starch. This was then oven-dried, milled and sieved to give cassava starch powder.

Soybean flour production: Soybean (TGX-1740) was cleaned, soaked (for 16 hours at ambient temperature), blanched, dehulled (to remove seed coat), oven-dried (at 50^{o}C for 3 days), milled and sieved to give soybean flour.

2.1. Spaghetti Production

Spaghetti was prepared using durum wheat flour and soybean flour formulations as designated below:

Spag 0: 100% wheat flour (control)

Spag 1: 90% wheat flour: 5% soybean flour: 5% cassava flour

Spag 2: 80% wheat flour: 10% soybean flour: 10% cassava flour

Spag 3: 70% wheat flour: 15% soybean flour: 15% cassava flour

Spag 4: 60% wheat flour: 20% soybean flour: 20% cassava flour

The total formulation of the flour blends was 400g and this was mixed with 190ml of water. This was thoroughly kneaded and was cut into spaghetti strips using Deluxe Pasta Maker, Italy. These were then oven-dried at 50^{o}C for 2 days in a conventional oven drier (Gallenkamp oven, BS 1005, England).

2.2. Tapioca Pearls Production

The cassava starch to soybean flour blends are as follows:

Tap 0: 100% cassava starch (control)

Tap 1: 90% cassava starch: 10% soybean flour

Tap 2: 80% cassava starch: 20% soybean flour

Tap 3: 70% cassava starch: 30% soybean flour

Tap 4: 60% cassava starch: 40% soybean flour

The total blend was 300g and 300ml of boiling water was added to this. This was quickly mixed together to form a partially gelatinized dough. This was then cut into tiny pieces and rolled into round shapes after which it was oven-dried at 50°C for 2 days.

2.3. Determination of Nutritional Composition

The Spaghetti and Tapioca pearls samples were subjected to moisture, protein, fat, ash, crude fibre, carbohydrate, thiamine, riboflavin and niacin content determination.

2.4. Moisture Content Determination

This was determined using the air oven method [14]. A known weight of the sample (3g) was put in a washed, dried and cooled crucible and this was dried at 103°C until a constant weight was obtained. This was allowed to cool in a desiccator and the difference in weight was used to calculate the moisture content.

2.5. Protein Content Determination

The crude protein content was determined using the micro Kjeldahl method as described by Pearson, [14]. A tablet of Kjeldahl catalyst was added to a known weight of the sample (0.2077g) in a long necked Kjedahl flask. This was heated in a fume cupboard with 25cm^3 of concentrated H_2SO_4 until a clear solution was obtained. This was cooled, poured into a 10cm^3 volumetric flask and made up to mark with distilled water after which 10ml of this was measured into a distillation set. 5cm^3 of boric acid was pipette into a 100ml conical flask and placed at the receiving end of the distillation unit with the delivery tube completely dipped into the flask. 40% NaOH was used to liberate ammonia out of the digest into the boric acid under alkaline condition and this was titrated against 0.1N HCl until the first permanent colour change was observed. Blank sample was run through the procedure and the titre value was used to correct the titre value for the test samples. The protein content was calculated thus:

$$\%N = \frac{\left(\begin{array}{l}\text{Molarity of HCl x}\left(\text{sample titre} - \text{blank titre}\right)\\ \text{x0.014xDFx100}\end{array}\right)}{\text{Weight of sample}}$$

%N was converted to the percentage crude protein by multiplying by 6.25.

2.6. Crude Fat Content Determination

The fat content was determined using Soxhlets extraction method as described by Pearson, [14]. A known weight of the sample (2g) was put into a weighed filter paper and folded neatly. This was put inside a pre-weighed thimble (W_1). The thimble with the sample (W_2) was inserted into the soxhlets apparatus and extraction was carried out under reflux with petroleum ether (40°C – 60°C boiling range) or 6 hours. At the end of the extraction, the thimble was dried in the oven for about for about 30 minutes at 100°C to evaporate the solvent and thimble was cooled in a desiccator and later weighed (W_3). Crude fat content of the sample was calculated thus:

$$\%\ \text{Fat} = \frac{\text{Loss in weight of sample x 100}}{\text{Original weight of the sample}} = \frac{W_2 - W_3}{W_2 - W_1}\text{x}100.$$

2.7. Ash Content Determination

The ash content denotes the total amount of minerals present in the products. This was determined using the method as described by Pearson, [14]. A known weight (1.5g) of finely ground sample was weighed into clean and dry previously weighed crucible with lid (W_1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600°C for 6 hours until it was turned to ash completely. This was then transferred directly to desiccators to cool and was later weighed (W_2).

$$\%\ \text{Ash} = \frac{W_2 - W_1}{\text{Weight of sample}}\text{x}100.$$

2.8. Crude Fibre Determination

The crude fibre was determined using the method as described by Pearson, [14]. Two hundred millilitres (200ml) of freshly prepared 1.25%H2SO4 was added to a known weight (3g) of the residue obtained from fat extraction and this was boiled for 30 minutes and then filtered after which the residue was washed until it was free from acid. The residue was transferred quantitatively into a digestion flask and 1.25%NaOH was added after which this was boiled for 30 minutes. This was followed by filtration and the residue was then washed with methylated spirit and then petroleum ether to be free of alkali. This was then allowed to drain and the residue was transferred to a silica dish (previously ignited at 600°C and cooled). The dish and its content were dried to constant weight at 105°C. The organic matter of the residue was burnt by igniting for 30 minutes in a muffle furnace at 600°C). The residue was cooled and weighed while the loss on ignition was reported as crude fibre.

2.9. Carbohydrate Content Determination

This was calculated by difference of all other nutrients from 100.

2.10. Thiamine, Riboflavin and Niacin Determination

These B vitamins content were determined using the method as described Pearson, [14].

2.11. Thiamine Determination

Fifty millilitres (50ml) of 50% methanol and 50ml 0f 17% sodium carbonate was added to 1g of the sample in order to extract the vitamin. This was then filtered after which Folins-Denis reagent was added. This was allowed to cool until a bluish colour was developed and absorbance was read in a spectrophotometer at 415nm. A standard curve was prepared using the data obtained with Tannic acid in place of the sample and the values for the sample were extrapolated from this curve.

2.12. Riboflavin Determination

To 0.5g of the sample 30ml of Dichloroethane and 30ml of 30% HCl was added. This was followed by the addition of 50ml of ammonium hydroxide solution after which filtration was carried out and later the absorbance was read at 415nm. A standard curve was constructed using the data obtained from the use of standard Riboflavin in place of the sample and the curve was used to extrapolate the values for the samples.

2.13. Niacin Determination

Niacin was extracted by autoclaving the sample (1g) with 0.75g calcium hydroxide and 20ml deionised water at 121°C for 30 minutes. The mixture was diluted with 30 ml of water, mixed thoroughly and allowed to cool after which it was centrifuged at 0°C and 2500 rpm for 15 minutes. A 15ml sample of the supernatant was adjusted to pH 7 with aqueous oxalic acid. The resulting suspension was centrifuged at 2500 rpm for 10 minutes to precipitate the calcium oxalate and the absorbance was measured at 650nm. A standard curve was constructed using the absorbance readings obtained from the reference niacin solutions in place of the sample and this was used to extrapolate the niacin content of the samples.

2.14. Sensory Evaluation

The spaghetti samples were boiled in water for 9 minutes. The Tapioca pearls samples were soaked in water for 30 minutes and then allowed to boil for 5 minutes. These were subjected to sensory evaluation with a total of 20 taste panellists using a 9 point hedonic scale with 1 denoting ‘dislike extremely’ and 9 denoting ‘like extremely’. The food samples were evaluated for the following sensory properties: colour, appearance, flavour, texture, taste, aroma and overall acceptability.

3. Result and Discussion

Flours and starch yields: 1kg of freshly harvested cassava roots yielded 92g of cassava flour, 1kg of cassava roots yielded 56g of cassava starch while 1kg of soybeans yielded 650g of soybean flour.

Nutritional composition of spaghetti samples: Table 1 shows the nutritional composition of spaghetti samples in Dry Weight Basis (DWB).

As expected, the nutrient composition of the spaghetti samples significantly increased with increase in the proportion of soybean flour used in the fortification except the carbohydrate which reduced significantly. In Spag 1 which was made of wheat flour : soybean flour: cassava flour in the ratio 90:5:5 (45:1:1), the protein, fat, ash, fibre, thiamine, riboflavin and niacin increased by 34%,25%, 3.9%, 17.5%, 5.5%, 9.3% and 44.8% respectively relative to the control (Spag 0). These continued to increase in Spag 2 and Spag 3. Spag 4 which contained the highest proportion of soybean and cassava flours was the most nutritious. The protein, fat, ash, fibre, thiamine, riboflavin and niacin increased by 108.0%, 90.2%, 18.7%, 117.5%,41.1%, 93.02% and 146.8% respectively relative to the control as can be deduced from Table 1. When an appreciable increase in nutritional composition was observed with increase in the fortifying ingredient (soybean flour) another sample made of 50% wheat flour, 25% soybean flour and 25% cassava flour was prepared so as to achieve a more nutritious product. The dough of this composition was not easy to work with and cut into strips easily even after kneading thoroughly. This shows that the maximum soybean flour and cassava flour that can be added and feasible in the production of soy-spaghetti is at 20% for each type of flour. The addition of cassava flour did not adversely affect the smoothness and workability of the dough because the dough was workable even at 20% of cassava flour inclusion; hence addition of cassava flour up to 20% in the production of spaghetti is feasible. This would increase the industrial; utilization of cassava and will concomitantly improve the economic development of cassava-producing countries like Nigeria. The improvement in the nutritional quality of the fortified spaghetti samples is attributable to the soybean flour that was added but the percentage increase is in disparity with the report of Shogren *et al.*, [15] who observed a 117.5% increase in protein (33.5% in fortified spaghetti compared with 15.4% in control) in spaghetti produced with the addition of soybean flour up to 50% [38]. In this study there was a 108% increase in protein content in spaghetti samples fortified with soybean flour at just 20% and that if fortified with soybean flour up to 50%, the protein content could increase to an estimate of 216%. This disparity in the level of increase in these two studies may be as a result of use of different varieties of soybean. Similarly, the report of Sereni *et al*., [16] also revealed that the soybeans used in this study could be of higher protein content because fortification of wheat and sorghum with defatted soybean flour up to 50% doubled the protein content of the biscuits produced and also increased the protein digestibility (in vitro) while fortification with only 20% soybean flour in this study more than doubled the protein content (Table 1). Several studies have affirmed that carbohydrate foods fortified with soybean flour could be used to prevent and treat Protein Energy Malnutrition and reverse the effect of stunting, wasting and underweight due to the improved nutrient composition [17,18,19]. It is therefore an established fact that consumption of foods fortified with soybean flour could improve the nutritional status of consumers and ultimately improve public health nutrition since the health benefits derivable from soybean will also be utilized.

3.1. Sensory Evaluation

Fortification of spaghetti with soybean flour improved the sensory quality (Table 2).

The fortified spaghetti samples had significantly higher scores in all the sensory properties evaluate showing clearly that fortification of wheat with soybean flour improves the sensory quality. On the other hand, Shogren *et al*, [15] observed a beany flavour and bitter taste in spaghetti fortified with 50% soybean flour but at 35% there was no significant difference in the flavour and texture relative to control. In this study the fortified spaghetti samples were more acceptable in all the sensory properties evaluated and even the overall acceptability. It is of notable interest to point out here that when the taste panellists were allowed to take the remaining spaghetti samples after the sensory evaluation the control which was made of 100% wheat (similar to the brands available in the market) was neglected by the panellists but all the fortified samples were taken. This shows clearly that fortification of wheat flour with soybean flour in spaghetti production improves the sensory quality of the product. The report of Shogren *et al*., [15] was in conflict with this because beany flavour and bitter taste was reportedly observed. This may be as a result of improper processing of the soybean flour or the proportion added for fortification was too high. In another study the fortification of sorghum and wheat in biscuit production up to 50% resulted into biscuits with acceptable crispy and dry texture and the acceptability by school children was also high and favourably compared with the control [16]. Similarly, Mashayekh *et al*., [18] reported an improved nutritional and sensory qualities of wheat bread fortified with soybean flour at 3,7 and 12% but fortification at 3% soybean flour gave an acceptable sensory and rheological qualities comparable to that of control made with 100% wheat flour though the increase in the nutritional composition was not significant. Comparing this with this study, spaghetti could accommodate more soybean flour to effect an appreciable improvement in both nutritional and sensory quality. Bread may not be able to accommodate high level of fortification with soybean flour as can be deduced from the report of Mashayekh *et al.*, [18] because gluten development may be impaired. In general, fortification of carbohydrate foods with soybean flour resulted in the improvement in nutritional and sensory quality of the foods [20,21,22].

3.2. Nutritional Significance

The percentage of the Recommended Dietary Allowance of protein, thiamine, riboflavin and niacin that would be met by the consumption of the fortified spaghetti (Spag 4) for boys and girls (14-17 years) as well as that of men and women were estimated (from as-is-basis) in Table 3 to show the nutritional significance of the improved nutritional quality of the fortified spaghetti. The serving size is 100g.

Table 1. Nutritional composition of Spaghetti samples (DWB)

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Thiamine (%)	Riboflavin (%)	Niacin (%)
Spag 0	15.53±0.95	3.33±0.29	3.37±0.05	0.40±0.10	77.37±1.18	0.073±.01	0.043±0.01	0.373±0.06
Spag 1	20.73*±0.49	4.17*±0.23	3.50*±0.10	0.47*±0.58	77.13±0.70	0.077±0.02	0.047±0.01	0.540*±0.11
Spag 2	23.33*±0.46	5.07*±0.71	3.67*±0.15	0.67*±0.15	67.27↓±0.73	0.090*±0.01	0.067*±0.02	0.717*±0.06
Spag 3	29.93*±0.49	5.53*±0.67	3.90*±0.20	0.80*±0.10	59.83↓±1.36	0.093*±0.01	0.080*±0.01	0.793*±0.07
Spag 4	32.37*±0.61	6.33*±0.67	4.00*±0.10	0.87*±0.15	56.43↓±1.44	0.103*±0.01	0.083*±0.02	0.797*±0.07

*--significantly higher than the control (Spag 0) in column ($p<0.05$)
↓ - significantly lower than the control (in column)
Spag 0: 100% wheat flour (control)
Spag 1: 90% wheat flour: 5% soybean flour: 5% cassava flour
Spag2: 80% wheat flour: 10% soybean flour: 10% cassava flour
Spag 3: 70% wheat flour : 15% soybean flour : 15% cassava flour
Spag 4: 60% wheat flour : 20% soybean flour : 20% cassava flour.

Table 2. Sensory evaluation of spaghetti samples fortified with soybean flour

Samples	Colour	Appearance	Flavour	Texture	Taste	Aroma	Overall acceptability
Spag 0	5.85±1.84	5.30±2.22	5.45±2.13	5.85±1.66	5.90±2.59	5.85±2.30	5.80±2.17
Spag 1	7.87*±2.47	6.20*±1.77	6.20*±1.64	6.45*±1.23	7.23*±3.21	6.90*±2.07	7.75*±2.87
Spag 2	8.90*±1.48	7.65*±1.93	7.65*±2.20	7.15*±3.21	7.10*±2.10	7.00*±1.75	7.50*±1.62
Spag 3	8.25*±2.49	7.70*±1.98	7.70*±1.69	7.50*±1.94	8.20*±2.26	8.10*±2.33	8.10*±2.22
Spag 4	8.55*±2.19	7.65*±1.69	7.40*±2.24	8.20*±2.56	8.70*±1.72	8.70*±2.56	8.49*±0.22

*--significantly higher than the control (Spag 0) in column ($p<0.05$)
Spag 0: 100% wheat flour (control)
Spag 1: 90% wheat flour: 5% soybean flour: 5% cassava flour
Spag2: 80% wheat flour: 10% soybean flour: 10% cassava flour
Spag 3: 70% wheat flour : 15% soybean flour : 15% cassava flour
Spag 4: 60% wheat flour : 20% soybean flour : 20% cassava flour.

Table 3. % Recommended Dietary Allowance met by the consumption of Spag 4

Group	Age (years)	Protein (%)	Thiamine (%)	Riboflavin (%)	Niacin (%)
Boys	14-17	57.44	7.75	5.92	4.38
Girls	14-17	64.93	9.30	7.70	5.00
Men	18-70	53.34	7.75	5.92	4.38
Women	18-70	64.93	8.45	7.00	5.00

Consumption of soy-spaghetti made with fortification at 20% soybean flour as one of the three square meals commonly consumed daily will more than satisfy the daily protein requirement because the soy-spaghetti only would provide more than 50% of the protein required for the day as can be deduced from Table 3. With the inclusion of the accompaniments such as stews, meat/fish, etc, the percentage RDA for protein that would be met will be higher than 50%. More percentage of the B vitamins would be supplied by the stew, meat and other accompaniments. This shows that consumers of soy-spaghetti so prepared will be able to meet their Recommended Dietary Allowance for these nutrients and possibly other nutrients if this fortified product is taken as one of the square meals a day.

3.3. Tapioca Pearls

Cassava starch yield: 1kg of freshly harvested cassava roots yielded 56g of cassava starch.

Soybean flour yield: 1kg of soybean yielded 650g of soybean flour.

3.4. Nutritional Composition of Tapioca Pearls Fortified with Soybean Flour

The nutritional composition of tapioca samples in Dry Weight Basis (DWB) is expressed in Table 4. Fortification of cassava starch with soybean flour in the production of tapioca significantly increased the nutrient composition. The higher the proportion of soybean flour incorporated, the higher the increase in nutrient content (Table 4).

The workability of the gelatinized starch was smoother when soybean flour was added and the stickiness to hand reduced, hence, cassava starch fortified with soybean flour in the production of tapioca pearls is better to handle during processing. The protein, fat, ash, crude fibre, riboflavin, thiamine and niacin content significantly increased by 383%, 300%, 100%, 26%, 286%, 109% and 223% respectively in Tap 4 (60% cassava starch+ 40% soybean flour) relative to control (Tap 0). This increase was really appreciable and higher than the increase reported from past research findings. Ilesanmi, [23] reported the value ranges for protein, fat, ash and crude fibre to be: 1.9-2.27%, 0.4-0.8%, 0.86-0.98% and 1.10-1.18% respectively, although he did not specify the proportion of the soybean incorporated during the fortification. Bankole *et al.,* [24] reported that fortifying cassava flour (lafun) with soybean at 10%, 20%, 30% and 40% significantly improved both the nutritional and functional properties but surprisingly, the highest protein content was 12.54% in the sample with 40% soybean. This is quite lower compared to the protein of the fortification at 40% in this study which was 19.33%. This could be as a result of variation in the soybean varieties used. Similarly, fortification of fufu (fermented cassava meal) with soy flour at 20% increased the protein content from 1.17% to 6.90% [25], while Tap 2 in this study which contained 20% soybean flour contained 12.00% protein while the control contained 4.00% protein (Table 4) giving a 200% increase. This clearly affirms that the soybean variety used in this study (TGX-1740) could be higher in protein content than the varieties used in the studies used for comparison. In overall, fortification of tapioca with soybean flour improved the nutritional quality.

3.5. Sensory Evaluation of the Tapioca Pearls Samples

Table 5 shows the result of sensory evaluation of the Tapioca samples.

Table 4. Nutritional composition of Tapioca pearls samples

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Riboflavin (%)	Thiamine (%)	Niacin (%)
Tap 0	4.00±1.00	2.00±0.04	2.00±0.02	2.00±0.23	91.00±0.00	0.050±0.42	0.81±.17	0.567±1.17
Tap 1	8.00*±0.02	3.67*±0.58	2.33±0.58	1.50↓±0.62	85.00↓±0.24	0.087*±0.18	0.092*±0.02	0.900*±0.08
Tap 2	12.00*±0.24	5.00*±0.65	3.00*±0.12	1.67↓±0.58	78.33↓±0.50	0.103*±0.55	0.141*±0.08	1.281*±0.15
Tap 3	15.00*±0.45	7.00*±0.20	3.50*±0.45	2.00±0.44	74.00↓±0.54	0.167*±0.60	0.143*±0.21	1.421*±2.09
Tap 4	19.33*±1.58	8.00*±0.51	4.00*±0.91	2.52*±0.32	66.33↓±0.56	0.193*±0.18	0.170*±0.15	1.823*±0.45

* - significantly higher than the control (Tap 0) among data in the same column ($p<0.05$)
↓ -- significantly lower than the control among data in the same column ($p<0.05$)
Tap 0: Tapioca pearls produced with 100% cassava starch and 0% soybean flour
Tap 1: Tapioca pearls produced with 90% cassava starch and 10% soybean flour
Tap 2: Tapioca pearls produced with 80%cassava starch and 20% soybean flour
Tap 3: Tapioca pearls produced with 70% cassava starch and 30% soybean flour
Tap 4: Tapioca pearls produced with 60% cassava starch and 40% soybean flour.

Table 5. Scores for the sensory evaluation of Tapioca pearls samples

Samples	Colour	Appearance	Flavour	Texture	Taste	Aroma	Overall acceptability
Tap 0	6.45±1.44	6.55±1.28	6.47±2.12	6.20±1.41	6.30±1.25	5.80±1.27	6.10±3.12
Tap 1	7.25*±1.23	5.90↓±0.34	6.45±0.93	6.30±3.22	6.45*±2.13	6.10*±2.56	6.50*±2.33
Tap 2	7.50*±0.02	7.00±1.54	7.56*±1.42	7.57*±3.11	6.34±1.17	6.78*±3.24	7.21*±1.23
Tap 3	7.20*±0.45	7.78*±3.22	7.35*±2.34	7.55*±2.33	7.26*±2.34	7.68*±2.13	7.78*±1.20
Tap 4	8.23*±1.34	7.85*±0.23	7.93*±0.15	8.20*±1.45	7.89*±0.44	8.17*±2.45	7.98*±3.21

* -- significantly higher than the control (Tap 0) among data in the same column ($p<0.05$)
↓ -- significantly lower than the control among data in the same column ($p<0.05$)
Tap 0: Tapioca pearls produced with 100% cassava starch and 0% soybean flour
Tap 1: Tapioca pearls produced with 90% cassava starch and 10% soybean flour
Tap 2: Tapioca pearls produced with 80%cassava starch and 20% soybean flour
Tap 3: Tapioca pearls produced with 70% cassava starch and 30% soybean flour
Tap 4: Tapioca pearls produced with 60% cassava starch and 40% soybean flour.

Table 6. % RDA met by the consumption of 100g serving size of soy-tapioca pearls (Tap 4)

Group	Age (years)	Protein (%)	Thiamine (%)	Riboflavin (%)	Niacin (%)
Boys	14-17	34.17	12.75	13.62	10.44
Girls	14-17	38.63	15.30	17.77	11.92
Men	18-70	31.73	12.75	13.62	10.44
Women	18-70	38.63	13.91	16.09	11.92

It is clearly evidenced from the data in the scores of the sensory evaluation in Table 5 that fortifying cassava starch with soybean flour in the production of tapioca pearls improved the sensory quality. This is because the scores for all the sensory properties significantly increased with increase in the soybean flour incorporated as can be seen in Table 5, hence, the higher the soybean flour added the higher the acceptability. This result was contrary to the observation of [23] who reported that incorporation of soybean flour beyond 15% only improved the functional properties of the product but adversely affected the acceptability. This is because fortification of tapioca with soybean flour up to 40% in this study maximally improved or enhanced the sensory quality (Table 5) and even the overall acceptability. This corroborates the report of Padhi *et al.*, [26] who observed a significant increase in the likeness of the appearance, aroma, flavour, taste, texture, feeling of fullness and overall acceptability of muffins fortified with soybean flour compared with that prepared with 100% wheat flour. In the same vein, fortification of cassava flour (lafun) with soybean significantly enhanced the functional and sensory properties [24]. The result of the sensory scores of the tapioca samples followed similar trend with that observed in the spaghetti samples in this study. This shows clearly that fortifying these carbohydrate-rich foods with soybean flour did not only improve the nutritional quality but also the sensory properties and it was properly processed soybean flour that can be used to achieve this.

3.6. Nutritional Significance

The relevance of the improvement in the nutritional and sensory quality of tapioca pearls fortified with soybean flour could be reflected in the percentage of Recommended Dietary Allowance (RDA) of the nutrients it could meet when consumed. Table 6 shows the percentage RDA of protein, thiamine, riboflavin and niacin that will be met when a100g serving size of the soy-tapioca pearls produced in this study is consumed by different categories of age groups.

Consumption of the soy-tapioca pearls by these age groups at 100g serving size as one of the three square meals a day would supply one third of the protein requirement for the day which is quite adequate and the age groups would be able to meet their protein requirement for the day when other meals are consumed. Since the soy-tapioca is expected to be consumed alone without addition of cow milk, these age groups will need to consume foods rich in thiamine, riboflavin and niacin in the other meals of the day to be able to meet their daily requirement or the soy-tapioca may be eaten with egg to increase the supply of these B vitamins by the meal.

3.7. Economic Importance

Using the Nigerian Naira (₦) which is the official currency, 100g of soy-spaghetti (Spag 4) costs ₦80.00 while 100g of the conventional commercial brand with beef that gives equivalent quantity of protein costs ₦180.00. Similarly, 100g of soy-tapioca (Tap 4) costs ₦100.00 while 100g of the conventional commercial tapioca brand with cow milk the contains equivalent quantity of protein costs ₦210.00. These show that soy-spaghetti and soy-tapioca are more affordable and consumers will be able to attain adequate nutrition at lesser cost especially in this period of economic recession or meltdown in many parts of the world, for instance Nigeria, which has subjected many to food and nutrition insecurity. Also incorporating cassava flour into the production of spaghetti will increase the industrial utilization of the staple which would concomitantly improve the economic development of cassava producing countries like Nigeria. Hence, fortifying spaghetti and tapioca pearls with soybean flour is a very sure and effective approach towards combating food insecurity now and always.

4. Conclusion and Recommendation

Fortification of carbohydrate-rich foods such as Spaghetti and Tapioca pearls with soybean flour significantly improved both the nutritional and sensory quality and may be a cheaper measure of attaining individual and household food security especially in his dispensation of economic recession in many parts of the world. However, the soybean flour must be properly processed to give a desirable and favourable effect. Also, incorporating cassava flour in the production of spaghetti is feasible and may increase the industrial utilization of the staple which may improve the economic development of cassava producing nations. Household and commercial production and consumption of soy-spaghetti and soy-tapioca pearls is hereby recommended.

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