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Comparative Study of the Proximate and Mineral Compositions of Extruded African Breadfruit (*Treculia africana*) Mix with Some Commercial Pasta Products

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Authors' contributions

This study was carried out in collaboration between all authors. All authors jointly designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors SJ, TUN and MAU managed the literature searches, analyses of the study, performed the spectroscopy analysis and authors OS, NL, and YJ managed the experimental process and authors SJ and TUN identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

This study compared the proximate and mineral composition of extruded samples of African breadfruit flour mixtures with some commercial pasta products (whole wheat spaghetti, enriched macaroni and corn pasta). Sample A composed of African breadfruit, soybean and corn flours while sample B had the mixture of African breadfruit, defatted soybean and corn flours. The flours were blended at ratios 70:25:5 African breadfruit, soybean and corn respectively. The two samples were separately extruded in a Brabender single screw extruder at 21% moisture content, 140ºC barrel temperature and 140 rpm screw speed fitted with 2 mm die diameter. The results show that, the extrudates were significantly high in crude protein (23.90 to 24.50%), fat (3.16 to 7.60%), carbohydrate (54.10 to 54.60%) and energy values (376.06 to 382.80 kcal) than commercial pastas. However, commercial pastas were significantly ($p<0.05$) high in crude fibre (7.00 to 19.00%) than the extrudates (4.50 to 4.60%). Commercial pasta corn was significantly ($p<0.05$) high in magnesium (36.00 mg/100 g) but, the extrudates compared favourably in magnesium with whole wheat spaghetti. The extrudates were significantly ($p<0.05$) high in phosphorus (248.80 to 255.20 mg/100 g), iron (7.20 to 7.60 mg/100 g), zinc (6.80 mg/100 g) and manganese (8.30 to 9.20 mg/100 g) than the commercial pastas. This finding shows that the extrudates could be useful in addressing nutrient inadequacies in areas where it is consumed.

Keywords: African breadfruit; soybean; corn extrusion; pasta.

1. INTRODUCTION

Pasta is a type of food made from durum wheat flour and shaped into forms such as lasagne, macaroni, noodles, ravioli and spaghetti [1]. It is one of the most common sources of carbohydrate in a diet. Production and consumption of pasta products vary depending on the region of the world and culinary traditions within a society [2]. Precooked pasta is usually made following a conventional technology, supplemented with a pasta cooking stage in water or steam, or hot oil, followed by drying as in traditional pasta processing [2].

The machinery set needed to produce pasta of good quality, proper rheological and sensory values consists of a mixer working at normal or low pressure, a press with a forming die, a drying unit set to a suitable drying cycle and a packaging device portioning the product into single packets [3,1]. Extruder with a deep-flighted screw operating at a low speed in a smooth barrel is used to produce pasta and some types of confectionery [4].

In pasta production, various types of additives may be used such as eggs, vegetable oil (influencing the colour and flavour of products) and substances affecting the rheological characteristics of the dough, such as natural emulsifiers or artificial chemical additives. Protein supplements are also added to improve the nutritional properties of the pasta or final product and enriching supplements, such as vitamins or minerals [2].

African breadfruit (*Treculia africana*) tree grows wildly in tropical regions of West Africa [5]. The tree remains ever green in both rainy and dry seasons producing fruits that have immense potential as a nutritional source for man and other domestic animals [6]. In Nigeria the tree is mostly found in the southern part, known as '*Afon'* in the south-west and *'Ukwa*' in the south-east. A mature tree produces approximately fifty fruits annually measuring five to ten kilograms after processing [4,7]. The kernels from the seeds are traditionally prepared and consumed either as boiled porridge, sauce meal or roasted and eaten as dessert snack [4,7,8]. A number of studies on extruded African breadfruit flour mixtures have been reported [4-6,8,9]. Response surface model of the study predicted an acceptable extrudate at 21% moisture content, 140ºC barrel temperature, 140 rpm screw speed in a single screw extruder fitted with 2mm die nozzle diameter.

Soybean contains significant amounts of all the essential amino acids for humans. It is a good source of vegetable protein, polyunsaturated fatty acids and has no cholesterol and lactose [10,11]. Furthermore, it is a good source of minerals and vitamins and the primary ingredients in many processed foods including dairy product substitutes. Yellow corn flour per 100 g contains 360 kJ energy, 3.2 g protein, 1.2 g fat, 19 g carbohydrate, 2.7 g fibre and 76 g water [1]. The whole flour is rich in certain minerals (potassium, magnesium, phosphorus, sodium and calcium) and vitamins (A, B_1, B_2, C, and K). Blending African breadfruit, soybean and corn would create a nutritional balanced mixture. The objective of this study therefore, was to compare the quality of extruded blends of African breadfruit, soybean and corn with some commercially sold pasta products.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

African breadfruit (*Treculia africana*) seeds were purchased from Umuahia main market, Abia state, Nigeria; corn (16 DT-across pool) variety was obtained from the International Institute for Tropical Agriculture (IITA), Kano substation; while soybean (TGX 1740-1 MJ) seeds were obtained from the National Cereal Research Institute, Badeggi, Niger State, Nigeria.

2.2 Preparation of Raw Materials

African breadfruit seeds were manually sorted, washed in cold portable water and drained. Washed seeds were cooked in boiling water for 14 min to facilitate the separation of the seed coats from the endosperm. Partially cooked seeds were then drained and allowed to stand for 20 min to further soften the seed coat and effect cooling. Softened seeds were then decoated in an adjustable dics attrition mill and the kernels were manually separated from the seed coat. The kernels were oven dried at 60ºC for 17 h and milled in to a fine flour of 75 µm size. Soybean seeds were sorted and winnowed manually in air current. The seeds were soaked in portable water for 18 h at room temparature in a stainless steel container. Soaked seeds were gently mashed in a mortar to loosen the seed coat and the coats were seperated from the cotyledon via water floatation. The kernels were dried in an air convection oven at 60ºC for 17 h and milled in to a fine flour of 75 µm size. Corn grains were sorted and dried at 60ºC for 17 h in an air convection oven. Dried seeds were milled in to a fine flour of 75 µm size. The three individual flours were coded and stored inside high density polyethylene bags.

2.3 Soybean Flour Defatting Procedure

Method described by [4] was adopted for soybean defatting. Soybean flour was soaked in a food grade ethanol in 1:3 for 3 h at room temparature and centifuged at 4000 rpm for 15 min. The mixture was allowed to stand for some time and the supernatant was decanted off leaving a semi solid mass. The flour mass was spread under fan to reduce the concentration of ethanol in the sample. Defatted flour was then dried in an air convection oven at 60ºC for 24 h to desolventize residual ethanol in the flour. It was then milled in a hammer mill to break flour lumps and packaged in an air tight container until needed for blending.

2.4 Flour Blending

The flours were blended according to the method reported by [9] in to samples A and B. African breadfruit-soybean-corn flour mixtures were in the ratios of 70:25:5 respectively. Sample A composed of African breadfruit, soybean and corn flours while sample B had the mixture of African breadfruit, defatted soybean and corn flours. Soybean flour was defatted to 3.21% fat before blending. The two samples were separately subjected to extrusion cooking.

2.5 Extrusion Pretreatment

The two samples were seperately brought to 21% MC by water addition through material balance and differently extruded at screw speed of 140rpm and barrel temparature of 140ºC in a Brabender laboratory single-screw extruder (Duisburg DCE 330, New Jersey USA). The extruder had grooved barrel length to diameter (L/D) ratio of 20:1 fitted with 2mm die opening.

2.6 Handling of Extrudates

The emerging extrudates as pellets at the die nozzle were collected and spread under fan on the laboratory table at room temperature (28±2ºC) for 3 h. The extrudates were later dried in an air convection oven (Gallenkamp, England) at 60ºC for 10 h. The resulting dried extrudates were packaged inside coded high density polyethylene bag. Few grams needed for laboratory analysis were taken and milled in a Brabender roller mill and sieved through a 75 µm opening. The resulting flours were packaged inside coded high density polyethylene bag and stored under room temperature (28±2ºC) until needed for analysis.

2.7 Methods

2.7.1 Determination of moisture content

The percentage moisture content was determined according to the method described by [9]. Two gram of the sample was weighed into a petri dish of known weight and the moisture substantially evaporated over water bath. The sample was immediately transferred into an oven and dried at 105±2ºC for 3 to 5 h. The sample was then removed from the oven and placed in a desiccator to cool for 15 min before weighing. The process was repeated until constant a weight was recorded. The loss in weight from the original weight was reported as the moisture content.

Percentage moisture content = [Weight loss × 100/ Weight of sample taken]

2.7.2 Determination of fat content

Fat content was determined using Soxhlet solvent extraction method outlined in [9]. Two gram of the sample labeled A were weighed into the extraction thimble and the thimble was blocked with cotton wool. It was then placed back in the Soxhlet apparatus fitted with a weighed flat bottom flask (B) which was filled to about three quarter of its volume with petroleum ether with boiling point of 40 to 60ºC. The extraction was carried out for a period of 4 to 8 h after which complete extraction was done. Petroleum ether was removed by evaporation on water bath and the remaining portion in the flask was removed along with water during drying in an oven at 80ºC for 30 min. Defatted sample was then cooled in a desiccator and weighed (C). The percentage fat was calculated as:

$$\text{Percentage fat} = \frac{C - B}{A} \times 100 = \frac{\text{Weight of extracted fat}}{\text{Weight of sample}} \times 100$$

Where; A = Weight of sample; B = Weight of empty flask and C = Weight of flask + oil.

2.7.3 Determination of crude protein

Kjeidahl method was used for the determination of protein content as described by [9]. The sample (1.0 g) was first digested in Kjeldahl digesting system. The digestion process involve weighing 1.0 g of sample into 500 ml Kjeldahl flask, followed by the addition of two selenium tablets. Twenty milliliters of concentrated sulfuric acid was then added gently down the side of the flask, and swirled. The content of the flask was heated gently in a fume cupboard in an inclined position and swirl occasionally until the liquid was clear. The digested sample was allowed to cool and then distilled into 2% boric acid solution containing screened methyl orange indicator, after being appropriately diluted with water and the introduction of 40% sodium hydroxide solution. The distilled samples were then titrated against 0.1 M HCl solution. A blank titration was carried out and the percentage protein content was estimated as percentage nitrogen × 6.25 (1 ml of 0.1 M HCl = 0.014 g N)

$$\% \text{ Nitrogen} = \frac{(S-B) \times 0.1N \times 14.01}{\text{Weight of sample}} \times 100$$

Where; S= Sample titre value; B= Blank titre value and % crude protein was obtained as % N × 6.25.

2.7.4 Determination of ash content

The ash content was determined as described by [9]. The weight of the crucible dish was determined. Two gram of the sample was added to the crucible. The dish and content was placed on the furnace rake and the furnace temperature was set to 500ºC for 16 h until the sample completely turned into ashes. The crucible dish was removed and kept in desiccator to cool and percentage ash was calculated as:

$$\text{Percentage ash} = \frac{\text{Weight of extracted ash}}{\text{Weight of sample}} \times 100$$

2.7.5 Crude fiber determination

This was determined as described by [9]. Five gram of the sample was weighed into a 500 ml beaker and the content was boiled in 200 ml hydrochloric acid (1%) for 30 min. The suspension was filtered and the residue was washed vigorously with boiling water until it was no longer acidic. The sample residue was then boiled again in a 200 ml sodium hydroxide solution for 30 min, filtered through filter paper (Whatman no.1) and the residue obtained was transferred into a crucible in an air oven 80ºC for 30 min. The dried residue was then cooled in a desiccator and weighed. The weighed sample residue was ashed in a muffle furnace at 550ºC for 30 min. The sample was removed from furnace when its temperature was 200ºC. It was cooled in a desiccator and weighed. The loss in weight of the incinerated residue before and after incineration was taken as the crude fiber content.

Percentage crude fiber was calculated as: [Total weight of fibre × 100/Weight of sample]

2.7.6 Determination of carbohydrate content

Carbohydrate was determined by difference as described by [9].

% Carbohydrate content = 100 - (% protein + % moisture + % fat + % ash).

2.8 Minerals Determination

The minerals were evaluated using an atomic absorption spectrophotometer (Buck 2010, VGP Germany) as described by [12]. The samples were digested and filtered with Whatman 1 quantitative circles 125 mm filter paper. The filtrates were placed in different cuvettes and labeled accordingly. Since each metal has its characteristics wavelength that it absorbs, the Specific Hitachi Hallow Cathode Lamp were selected accordingly. The slit width for each element was also identified. Samples were aspirated into the flame. The metal present in the sample absorbed some of the light thus reducing the intensity of the light. The computer data system converted the changed intensity of light into an absorbance which is directly proportional to the concentration of the metal ion present in the sample. The concentration of metals present were determined from the working curve after calibrating the instrument with standard of known concentration.

2.9 Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) and separation of the mean values was carried out using Duncan Multiple Range Test at ($p<0.05$) level.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Raw Materials

Table 1 shows the proximate composition of the raw flours. The flours were significantly ($p<0.05$) different in crude protein, fat, crude fibre, ash and carbohydrate, but not significant ($p>0.05$) in moisture. The moisture contents of the raw flours ranged from 8.45 to 9.69% with soybean (9.69%) having the highest value and corn (8.45%) having the lowest value. Moisture content of either raw or processed food material plays a major role in their storagibility. All the measured moisture contents are within the permitted level in flour ≤13% [13].

The protein contents of the raw flours ranged from 8.59 to 42.65%. Soybean though considered as an oil seed had the highest protein (42.65%) and corn, a carbohydrate source, had the least protein content (8.59%). Blending these flours in appropriate ratios would give a formulation rich in protein and capable of addressing protein inadequacies among the consuming population. The crude protein content of African breadfruit (12.30%) falls in the range reported earlier [14,8,15].

The fat contents of the raw flours ranged from 2.18 to 17.64% with corn (2.18%) having the lowest amount and soybean having the highest amount (17.64%). However, the fat content (4.11%) of African breadfruit determined in this study falls below (11.45%) reported earlier [9].

The crude fibre content of the flours ranged from 1.77 to 5.56% with soybean (5.56%) having the highest value and corn flour (1.77%) having the lowest value. The crude fibre content of soybean and corn flours is in the range reported earlier [4, 5]. In carbohydrate value, corn flour had the highest value (82.27%) followed by African breadfruit flour (71.67%) and soybean flour (28.02%) had the lowest amount. The carbohydrate value for corn flour reported in this work is high compared to 76.8% reported earlier [1]. The variation could be attributed to species, processing method, storage conditions among others. While for African breadfruit flour, the falls in the range earlier reported [9].

3.2 Proximate Composition and Energy Values of the Extrudates Compared with Some Selected Pasta Products

The proximate and the energy values of the extrudates in comparison with some selected commercial pasta (whole wheat spaghetti, enriched macaroni and pasta corn) is shown in Table 2. The protein content of the extruded blends and the commercial pasta were significantly ($p<0.05$) different from each other. However, the extruded blends were found to be significantly ($p<0.05$) high in protein than the commercial pasta. This suggests that, the extrudates constitute protein dense food products that could be a good tool in addressing prevalent cases of protein insufficiency in developing nations.

The fat contents of the commercial pasta were significantly ($p>0.05$) different from each other. However, the extruded blends were significantly ($p<0.05$) high in fat than the commercial pasta. Extruded blend I had 7.60% fat content. This could be attributed to whole soybean flour inclusion in the blend. Use of defatted soybean significantly brought down the fat content to 3.16% in extruded blend II. High fat contents

Table 1. Proximate composition of the raw materials

Proximate (%)	Africa breadfruit	Soybean	Corn
Moisture	9.20[a]±1.00	9.69[a]±0.38	8.45[a±]0.29
Crude protein	12.30[b]±1.00	42.65[a]±0.07	8.59[c±]0.41
Fat	4.11[b]±1.00	17.6[a]±0.13	2.18[c]±0.19
Crude fibre	1.55[c]±0.05	6.46[a]±0.11	5.19[b]±0.25
Ash	1.95[b]±0.10	5.56[a]±0.15	1.77[b]±0.07
Carbohydrate	71.67[b]±1.16	28.02[c]±0.78	82.27[a]±0.29

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same row are significantly different (p<0.05)

Table 2. Proximate and energy values of the extrudates compared with some commercial pasta products

Proximate (%)	Extruded blend I	Extruded *blend II	Spaghetti whole wheat	Macaroni enriched	Pasta corn
Moisture	9.70[a]±0.58	10.10[a]±0.58	-	-	-
Crude protein	24.50[a]±2.00	23.90[a]±1.00	11.00[b]± 1.00	12.00[b]±1.00	5.00[c]±1.00
Fat	7.60[a]±1.00	3.16[b]±1.00	1.00[c]± 0.20	1.00[c]±0.20	1.00[c]±0.20
Crude fibre	4.50[c]±1.00	4.60[c]±1.00	18.00[a]±1.00	7.00[b] ±1.00	19.00[a]±1.00
Ash	5.15[a]±1.00	5.07[a]±1.00	-	-	-
Carbohydrate	54.10[a]± 1.00	5 4.60[a]±1.00	26.54[c]±2.00	30.86[b]±2.00	27.91[bc]±1.00
Energy (Kcal)	382.80[a]±10.00	379.06[b] ±10.00	124.00[d]±2.00	158.00[c]± 2.00	126.00[d]±2.00

*Source: *[15]*

*Values are means and standard deviations of three determinations; Values not followed by the same superscript in the same row are significantly different (p<0.05); Key: *with defatted soybean flour; - = Not reported*

would make the extrudates prone to the development of rancidity which would affect the sensory attributes, consumer acceptability as well as the nutrient quality of the products during storage.

The fibre contents of the commercial pasta were significantly (p<0.05) high than the extruded blend. Pasta corn (19.00%) had the highest value while extruded blend I (4.50%) was the lowest. For high physiological functions of the extrudates, there is need for the dietary fibre content to be supplemented. The extrudates were rich in ash content signifying that the extrudates are rich in mineral elements over the three commercial products.

The moisture contents of the extrudates 9.30% and 10.10% in blends I and II were not significantly (p>0.05) different from each other. The low moisture content is an indication that, the extrudates would have stable shelf life during storage. However, further moisture removal via oven drying could give the extrudates more stable shelf life during storage.

The carbohydrate contents of the extrudates 54.10% and 54.60% for blends I and II respectively were significantly (p<0.05) high than the commercial pasta. Whole wheat spaghetti (26.54%) had the lowest value while extruded blend II (54.60%) had the highest value. The implication here is that, the extrudates are better sources of carbohydrate than the three commercial products.

The energy values of the extrudates (Figs. 1 and 2) 382.80 Kcal/100 g and 379.06 Kcal/100 g for blends I and II were significantly (p<0.05) high than the commercial pasta. Whole wheat spaghetti (124 Kcal/100 g) had the lowest value while extruded blend I (382.80 Kcal/100 g) had the highest value. One gram of the extrudate is capable of supplying 1/4[th] of the energy reserve (1600 Kcal) of a well-nourished 70 Kg healthy adult for a day (24 h.) [16].

3.3 Mineral Composition of the Extrudates Compared with Some Pasta Products

Table 3 compared the mineral content of the extrudates with some commercial pasta products (pasta corn, whole wheat spaghetti and enriched macaroni). The magnesium content of extruded blends I and II and whole wheat spaghetti were not significantly (p<0.05) different from each other. However, pasta corn (36.00 mg/100 g) was significantly (p<0.05) high in magnesium than the remaining commercial pasta and extruded blends I and II. However, enriched macaroni (18.00 mg/100 g) had the lowest value.

Fig. 1. Extruded blend I

Fig. 2. Extruded blend II

Table 3. Mineral composition of extrudates compared with some commercial pasta products

Mineral (mg/100 g)	Extruded blend I	Extruded *blend II	Pasta corn	Spaghetti whole wheat	Macaroni enriched
Magnesium	$32.60^{b}\pm20.00$	$32.10^{b\pm}10.00$	$36.00^{a}\pm1.00$	$30.00^{b}\pm1.00$	$18.00^{c}\pm1.00$
Phosphorus	$255.20^{a}\pm5.00$	$248.80^{b}\pm2.00$	$76.00^{d}\pm1.00$	$89.00^{c}\pm1.00$	$58.00^{e}\pm1.00$
Iron	$7.20^{a}\pm1.00$	$7.60^{a}\pm1.00$	$0.25^{b}\pm0.01$	$1.06^{b}\pm0.02$	$1.28^{b\pm}0.10$
Zinc	$7.20^{a}\pm1.00$	$6.80^{a}\pm1.00$	$0.63^{b}\pm0.10$	$0.81^{b}\pm0.10$	$0.51^{b}\pm0.10$
Molybdenum	$0.10^{a}\pm0.02$	$0.10^{a}\pm0.02$	-	-	-
Manganese	$8.30^{a}\pm1.00$	$9.20^{a}\pm1.00$	$0.15^{c}\pm0.01$	$1.38^{bc}\pm0.10$	$0.32^{b}\pm0.01$

*Source: **[17].*

*Values are means and standard deviations of three determinations; Values not followed by the same superscript in the same row are significantly different (p<0.05). Key: *with defatted soybean flour; - = Not reported*

Extruded blends I and II were significantly ($p<0.05$) high in phosphorus, iron, copper, zinc and manganese contents than the commercial pastas. The phosphorus content of the extrudate will supply the recommended daily needs of 700 mg in both children and adults [18]. High minerals determined could be attributed to the contribution of the three test ingredients (African breadfruit, soybean and corn flours). The increase in certain minerals in extruded products is attributed to the nutrient contribution of the test ingredients, screw wear of the extruder and the accumulation of these minerals in the water used in raw material preconditioning during extrusion cooking [19-21,5]. The result of the work shows that the extrudates are better enriched in both major and trace mineral elements. It can be deduced that, the extrudates constitute high density nutrient food products that could be helpful addressing severe mineral deficiencies.

4. CONCLUSION

Extrudates produced in this study showed better proximate and mineral contents. This implies that the product could serve as a beneficial tool in addressing nutrient inadequacies. This calls for advancement of the product for wider acceptability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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