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Chemical Properties of Flour Blends Produced from ACHA (*Digitaria Exilis*), African Breadfruit (*Treculia Africana*) and Soybeans Protein Concentrate (*Glycine Max*)

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ABSTRACT

Chemical properties of composite flour samples from two varieties of acha fortified with soybean concentrate and breadfruit flour were studied. Acha and soybean protein concentrate flours were blended (%, w/w) at ratios 100:0, 90:10, 85:15, and 80:20, 5% breadfruit flour was added to each blend as a constant and 100% of each of the two varieties of acha flour containing 5% breadfruit flour were used as the control samples. Mineral and vitamin contents of the flours blends were determined. The results of the mineral composition showed average values of (134.51, 42.29, 142.41, 1.08 and 0.85) mg/100g for calcium, magnesium, potassium, iron and zinc contents. The vitamin contents showed that 80WAF:20SBC:5BFF recorded the highest value for vitamin B_1 (0.12 mg/100g) and vitamin B_3 (1.69 mg/100g). 100BAF:5BFF recorded highest value for vitamin B_2 (1.36 mg/100g) and vitamin A (80.09 mg/100g), while 80BAF:20SBC:5BFF recorded the least value for vitamin B_2 (0.76 mg/100g) and vitamin A (60.59 mg/100g). Increase in vitamins B_1 and B_3 and decrease in vitamins B_2 and A were recorded with increasing concentration of soybean protein concentrate and decreasing concentration of acha flours. The findings from this study were comparable with the results from similar products from previous studies.

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Introduction

Composite four can be described as a mixture of several flours obtained from root, tuber, cereal and legume, with or without the addition of wheat four, which is created to satisfy specific functional characteristics and nutrient composition. The composite flours from cereals such as acha are known to be rich in protein and minerals [1]. Acha (*Digitaria exilis*), a traditional cereal crop from West Africa, is popular because it is well adapted to local conditions and has good nutritional and culinary properties [2]. Acha, one of the oldest and richest cereals of West Africa, is unknown to many people and neglected by research and extension services. Adapted to poor soils and limited water supply, acha is an excellent dry areas crop which grows and produces where other crops fail [3]. The major traditional foods from acha include: thick (Tuwo) and thin (Gwete and kunu) porridge (eaten with different kinds of stew and vegetables), steamed product (burabusko) and alcoholic beverages [4]. It could be boiled like rice (acha jollof) and is also used in the form of "couscous" in some countries in West Africa [4]. Acha is known to be easy to digest, and is traditionally recommended for children, old people and for people suffering from diabetes or stomach diseases [5]. Acha does not contain any glutenin or gladines proteins which are the constituents of gluten, making it suitable for people with gluten intolerance [5,6]. Acha is reported to have a high pentosan (3.3%), hence, a high water absorption capacity that could be utilized in baking [7]. Acha is rich in micronutrients like iron and iodine (28.5mg/100ml and 22.9mg/100ml respectively) [8].

Soybean (*Glycine max*) an important oil seed belonging to the family leguminosae and sub-family papillionnideae. It is one of the protein rich legumes consumed around the world and used as enrichment in many food formulations especially in Africa [9]. Soybean contains about 40% protein; it is higher than other legumes in protein. The protein of soybean yields all the essential amino acids in adequate amount except methionine and cystine which are deficient [9]. It is an excellent source of calcium, iron, magnesium, potassium, iron, phosphorus and vitamins like thiamine, riboflavin, niacin, folic acid and fair source of carotene and vitamin D [10]. Soybean is used in the dry form as soy-powder, soy milk, soy protein concentrate or isolate and texturized form, soy-ogi and soy-garri. Addition of soybean flour and cereal based products could be a good option to overcome the world protein calories malnutrition problem [11,12].

African breadfruit (Treculiaafricana) is a legume which has fruit heads. It is a known and valued food in the diet of many Nigerians. The southern people of Nigeria, especially the Igbos prepare it using different method of traditional preparations and the consumption may vary depending on food habits, ethnic background, culture and traditions [13]. Breadfruit has been reported to be a rich source of vitamins and minerals such as phosphorous, copper, magnesium, potassium, calcium, iron, and manganese depending on the cultivar [14]. Ascorbic acid and high contents of carotenoids which are bioactive compounds can be obtained from breadfruit. Breadfruit undergoes physiological deterioration after harvesting. The fruit can be processed into flour as a way of reducing post-harvest losses and increasing the utilization of breadfruit, which is more shelf stable [15].

There is need for the fortification of our traditional swallow meal which is mostly low in protein, micronutrients and high in carbohydrate. This fortification will prevent development of certain diseases and health disorders resulting from high carbohydrate consumption. The utilization of locally available nutritious seeds ensures food security and sustainability. These composite flours can also be used in the production of some foods, like in baking and production of complementary foods. Therefore, this study was carried out to determine the effect of inclusion of soybeans protein concentrate on the chemical properties of composite flours from blends of acha, african breadfruit and soybeans protein concentrate.

Materials and Methods

Source of Raw Materials

Two different varieties of *Acha* (brown and white) and soybean samples were purchased from Saborn Gari Central Market, Kano State, Nigeria. While whole African breadfruit seeds were purchased at Oyibo market, Old Aba Road Port Harcourt, River state, Nigeria.

Plate 1: White and Brown Varieties of Acha

Plate 2: Soybean Seeds

Plate 3: Raw Whole Breadfruit Seeds

Sample Preparation and Processing

The preparation and processing of the samples were carried out at the Grifeon Projects Laboratory, Umuahia, Abia State. The samples were sorted to remove, debris, stones and spoiled grains. After which each is of them were processed in to flours.

Production of Acha Flour

Acha flour was produced from the brown and white varieties of acha according to the method described by Olapade and Aworh [16]. The grains were cleaned by manually removing of extraneous materials like chaff, stone and stalks. This was followed by washing in portable water and stones removed by sedimentation. The washed grains were dried in an oven at 55°C then milled using attrition mill, sieved through 425 μm mesh screen and packaged in air tight zip lock nylon bags that were labeled and stored at 4°C for subsequent use. The flow chart for the process is as shown in Figure 1.

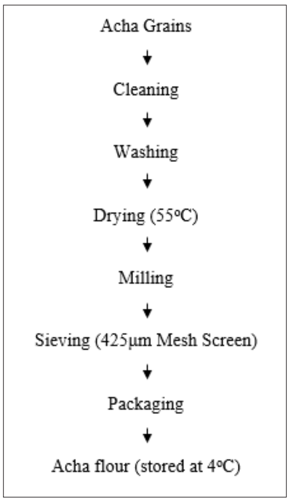

Figure 1: Flow Chart for the Production of Acha Flour

Production of Breadfruit Flour
The roasted breadfruit seed flour was prepared as described by Akubor et al. [17]. The raw and sorted breadfruit seeds were roasted in acid washed sand (140°C, 20min), sieved to remove the sand and milled in a laboratory mill. After Milling, it was sieved with a 200 nm mesh sieve to obtain the roasted breadfruit flour (RBF). The flow chart for the process is as shown in Figure 2.

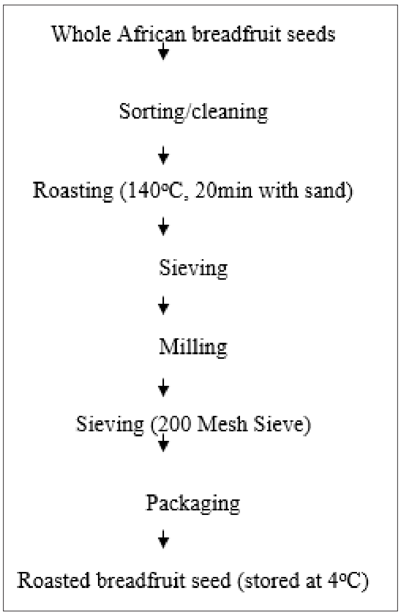

Figure 2: Flow Chart for the Production of Whole Breadfruit Seeds Flour

Production of Soybean Flour
The Soybean seeds were sorted to remove pebbles, stones and other extraneous materials. They were washed and steeped for 10 hours. The steeped soybean seeds were drained and pre-cooked for 15 minutes at 100°C after which they were manually dehulled (by rubbing in between the palms) and the hulls was removed by flushing with clean water. The dehulled soybean seeds was dried in the cabinet dryer at 70°C for 4 hours and milled into soybean flour.

Production of Defatted Soybean Flour
The soybean flour was defatted using the Soxhlet apparatus and ethanol according to the method described by Lusas and Rhee [18]. The flour samples were wrapped and suspended in a Soxhlet apparatus and refluxed for 12 h with ethanol and subsequently dried at room temperature. The defatted soybean flour was stored in jut bags at 37°C until use.

Production of Soybean Concentrate
Soybean concentrate was prepared from the defatted soybean flour using the standard method described by Lusas and Rhee [18]. The defatted soybean flour was mixed properly with distilled water in the ratio of 10:1 soybean flour/water. About 40% Citric acid was added to the mixture to bring the pH to 4.5 and the temperature elevated to 40°C for 30min while the mixture was stirred for proper mixing. The mixture was then centrifuged at 15,000rpm for 15mins. The supernatant was separated and the protein/fiber was neutralized to a pH of 7 using 0.3N NaOH and dried and stored as the soybean protein concentrate. The flow chart for the production process was as shown in Figure 3.

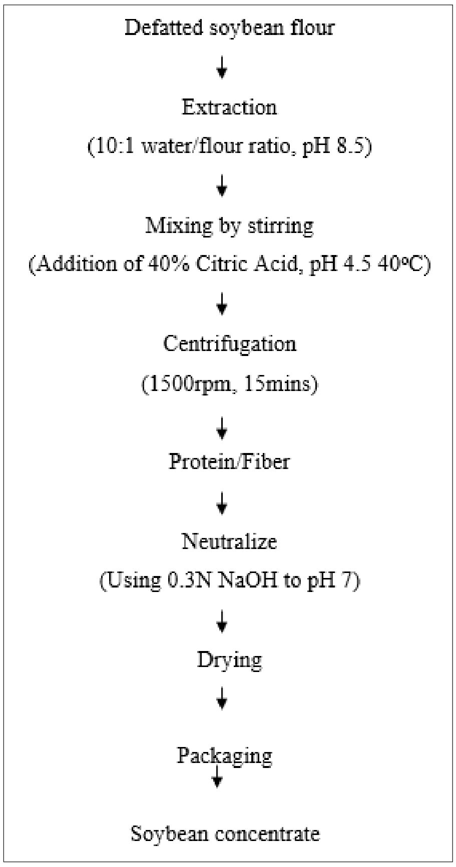

Figure 3: Flow Chart for the Production of Soybean Concentrate

Formulation of the Composite Flour
Whole breadfruit seed flour (5%) was added to each blend as a constant. Each of the two varieties of acha flours (100%) containing 5% whole breadfruit seed flour was used as control. The blends were thoroughly mixed using a blender and the samples were packed in jut bags. The formulation of the composite flour was summarized in Table 1.

Table 1: Formulation of Acha Flour/ Soybean Concentrate Composite Flour

Variety	Blends	BSF	SBC
BAV	BAS1 BAS2 BAS3 BAS4	100 90 85 80	0 10 15 20
WAV	WAS1 WAS2 WAS3 WAS4	100 90 85 80	0 10 15 20

Keys: BAV= brown *acha* variety, WAV= white *acha* variety, BSF = breadfruit seed flour and SBC = soybean concentrate, BAS = brown *acha* flour and soybean concentrate blends, WAS = white *acha* flour and soybean concentrate blends, BAS1- BAS4 are brown *acha* flour-based blended samples, while WAS1-WAS4 are white *acha* flour based blended.

Determination of Mineral Contents
Calcium, zinc, potassium, iron and magnesium contents of the samples were all determined using the method described by AOAC as reported by Verma and Srivastav [19,20]. A diacid mixture comprising 2 parts of nitric acid and 1 part of per-chloric acid was

used to digest 2 g each of the rice varieties. The digested samples were transferred to a 100 ml volumetric fask and made up the volume with distilled water. Using atomic absorption spectrophotometer (AAS) (Thermofisher iCE FIOS Atomic absorption Spectrometer) with different cathode lamps, the samples and the standards of elements made from dissolving pure metals were analyzed. The concentrations of respective elements were determined.

Determination of Vitamin Contents
Thiamine, riboflavin, niacin and vitamin A contents of the samples were determined according to method described by Onwuka [21].

Data Analysis
The replicated experimental data was analyzed for Analysis of Variance (ANOVA) at 0.05 level of significance and Pearson correlation coefficient at 0.05 level of significance using one- way ANOVA. All the data was presented in mean± standard error of mean and alphabetic mean ranking in case of significant difference observed based on Duncan Multiple Range Test.

Results and Discussion
The mineral composition of the composite flour samples are shown in Table 2. The calcium content of the composite flour samples ranged from 60.77 – 178.56 mg/100g. Sample A1 (100BAF:5BFF) had the least value (60.77 mg/100g) while sample B4 (80WAF:20SBC:5BFF) had the highest value (178.56 mg/100g). There were no significantly ($p>0.05$) differences among samples A3 (85BAF:15SBC:5BFF), B2 (90WAF:10SBC:5BFF) and B3 (85WAF:15SBC:5BFF). The calcium contents of the composite samples increased as the addition of soybean concentrate increased, this is an indication that soybean is a good source of calcium. The calcium content of the composite flour samples were much higher than the values 4.13 – 6.67 mg/100g reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed, 4.14 – 5.30 mg/100g reported by Olorode et al. for chemical, phytochemical and functional properties of selected seeds' flours and 29.63 – 45.07 mg/100 reported by Edet et al. for composite flour (blends of rice (oryza sativa), acha (digitaria exilis) and soybeans (glycine max) [22-24]. Calcium is by far the most important mineral that the body requires and its deficiency is more prevalent than many other minerals, it helps in the formation of strong bone and teeth [25]. Calcium content of the flour samples as well as their products would be able to supply calcium for both children and elderly people for strong bone and body development.

The magnesium content of the composite flour samples ranged from 23.57 – 61.15 mg/100g. Sample A1 (100BAF:5BFF) had the least value (23.57 mg/100g) while sample B2 (90WAF:10SBC:5BFF) had the highest value (61.15 mg/100g). Sample B2 (90WAF:10SBC:5BFF) vary ($p<0.05$) significantly from other samples. The magnesium content of the composite flour samples were much higher than the values 5.15 – 5.70 mg/100g reported by Oluwafunmilayo et al. for nutritional, phytochemical, functional and antioxidant properties of acha, chia and soycake flour blends but lower than 110 – 136 mg/100g reported by Edet et al. for composite flour (blends of rice (oryza sativa), acha (digitaria exilis) and soybeans (glycine max) [24,26]. Magnesium plays crucial role in lipid membrane stabilization, replication and metabolic processes. Magnesium is essential for all biosynthetic processes including glycolysis, formation of cyclic AMP, energy dependent membrane transport and transmission of the genetic code. Magnesium is also required for maintenance of electrical potentials of nerve and muscle and for the transmission of signals across neuromuscular junctions [27].

The potassium content of the composite flour samples ranged from 125.28 – 168.77 mg/100g. Sample A2 (90BAF:10SBC:5BFF) had the least value (125.28 mg/100g) while sample A4 (80BAF:20SBC:5BFF) had the highest value (168.77 mg/100g). There were significant ($p<0.05$) differences among the samples. The potassium content of the composite flour samples were lower than the values 184.37 – 1279.32 mg/100g reported by Tivde et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours but higher than 11.00 – 12.00 mg/100g reported by Oluwafunmilayo et al. for nutritional, phytochemical, functional and antioxidant properties of acha, chia and soycake flour blends [26,28]. Potassium, in particular, is essential for regulating body fluid balance and transmitting nerve impulses [29]. A high intake of potassium is linked to lowering blood pressure because it helps reduce sodium intake. Diets low in sodium but high in potassium and magnesium are associated with reduced rates of cardiovascular diseases [30]. This study emphasizes the potential health benefits of these composite flour blends, particularly their mineral content, which can contribute to better health results when incorporated into diets.

The iron content of the composite flour samples ranged from 0.92 – 1.34 mg/100g. Sample A2 (90BAF:10SBC:5BFF) had the least value (0.92 mg/100g) while sample B3 (85WAF:15SBC:5BFF) had the highest value (1.34 mg/100g). There were significant ($p<0.05$) differences among the samples. The iron content of the composite flour samples were higher than the values 0.50 – 0.65 mg/100g reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed but lower than the values 3.45 – 18.81 mg/100g reported by Tivde et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours and vary from the values 2.35 – 6.30 reported by Oluwafunmilayo et al. for nutritional, phytochemical, functional and antioxidant properties of acha, chia and soycake flour blends [22,26,28]. Iron is said to be an important element in the diet of pregnant women, nursing mothers, infants convulsing patients and elderly to prevent anaemia and other related diseases. The recommended daily allowance of iron for men is 7 mg /day and 12 – 16 mg/day for women during pregnancy [31].

The zinc content of the composite flour samples ranged from 0.75 – 0.96 mg/100g. Sample B1 (100WAF:5BFF) had the least value (0.75 mg/100g) while sample A1 (100BAF:5BFF) had the highest value (0.96 mg/100g). Significant ($p<0.05$) differences exist among the samples. The zinc content of the composite flour samples were lower than the values 1.45 – 3.55 mg/100g reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed, 2.90 – 7.80 mg/100g reported by Oluwafunmilayo et al. for nutritional, phytochemical, functional and antioxidant properties of acha, chia and soycake flour blends but vary from 0.76 – 15.40 mg/100g 100g reported by Tivde et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours [22,26,28]. Minerals are crucial for the human body, playing vital roles in cellular enzyme activity, nerve responses, muscle contraction, and blood clotting [32]. The presence of these minerals implies that the samples from this study could be utilized as sources of essential nutrients. Minerals, which are essential nutrients are said to be present in small amounts in the body or in several parts per million [33]. They are essential because each of them plays important role in metabolic processes of the body and their absence can cause deficiency symptoms [33]. The essential mineral elements of nutritional importance are the macro (major) elements such as Ca, P, K, Na, and Mg. The micro (trace) elements are Fe, Zn, Cu, Mn, and Co [34].

Table 2: Mineral Composition of the Composite Flours Samples

Samples (mg/100g)	Calcium	Magnesium	Potassium	Iron	Zinc
Sample A1 100BAF:5BFF	60.77^{f}±1.41	23.57^{d}±0.86	135.66^{e}±0.08	1.07^{c}±0.01	0.96^{a}±0.01
Sample A2 90BAF:10SBC:5BFF	138.64^{c}±1.41	49.01^{b}±0.86	125.28^{h}±0.68	0.92^{f}±0.02	0.83^{c}±0.03
Sample A3 85BAF:15SBC:5BFF	159.98^{b}±1.41	35.56^{c}±0.85	142.81^{d}±0.01	0.96^{e}±0.01	0.77^{d}±0.01
Sample A4 80BAF:20SBC:5BFF	120.88^{d}±1.41	35.75^{c}±0.86	168.77^{a}±0.04	0.93^{ef}±0.01	0.82^{c}±0.02
Sample B1 100WAF:5BFF	99.38^{e}±0.00	36.16^{c}±0.00	132.77^{f}±0.04	1.29^{b}±0.01	0.75^{d}±0.01
Sample B2 90WAF:10SBC:5BFF	158.72^{b}±1.41	61.15^{a}±0.86	149.61^{c}±0.01	1.06^{c}±0.01	0.89^{b}±0.01
Sample B3 85WAF:15SBC:5BFF	159.16^{b}±0.00	48.27^{b}±0.00	129.56^{g}±0.08	1.34^{a}±0.02	0.93^{ab}±0.01
Sample B4 80WAF:20SBC:5BFF	178.56^{a}±1.41	24.81^{d}±0.86	154.78^{b}±0.02	1.03^{d}±0.01	0.84^{c}±0.01

Values show the mean of duplicate analysis and ± standard deviation. Figures with different superscript down the column are significantly different ($p<0.05$).
Keys: Group BAF = Brown acha flour, WAF = White acha flour, BFF = Bread fruit flour, SBC = Soybean concentrate

The vitamin composition of the composite flour samples are shown in Table 3. The vitamin A content of the composite flour samples ranged from 60.59 – 80.09 mg/100g. Sample A4 (80BAF:20SBC:5BFF) had the least values (60.59 mg/100g) while sample A1 (100BAF:5BFF) had the highest value (80.09 mg/100g). There were significantly ($p<0.05$) differences among samples. The vitamin A contents of the composite samples decreased as the quantity of acha decreased, this is an indication that acha could be a good source of vitamin A. The vitamin A content of the composite flour samples were much higher than the values 6.23 – 12.56 mg/100g reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed and 0.12 – 18.29 mg/100g reported by Tivde, et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours but vary from the values 11.13 – 83.05 mg/100g reported by Mbaeyi-Nwaoha and Uchendu for blends of acha and fermented soybean paste (okara) but vary from the findings [22,28,35]. Vitamin A is very essential for growth, reproduction, good vision, healthy skin, hair and nail and to balance energy level in the human body. The deficiency of vitamin A in the body causes keratomalacia (night blindness) [36]. Vitamin A plays an beneficial roles in bone growth, cell division and cell differentiation (IOM, 2001), and also regulate the immune system, which helps to fight off infections by producing white blood cells that destroy harmful bacteria and viruses [37].

The thiamine (B_1) content of the composite flour samples ranged from 0.07 – 0.12 mg/100g. Samples A1 (100BAF:5BFF) and B1 100WAF:5BFF had the least values (0.07 mg/100g) while sample B4 (80WAF:20SBC:5BFF) had the highest value (0.12 mg/100g). Samples A3 (85BAF:15SBC:5BFF), B2 (90WAF:10SBC:5BFF), B3 (85WAF:15SBC:5BFF) and B4 (80WAF:20SBC:5BFF) differ ($p<0.05$) significantly from other samples. The vitamin B_1 contents of the composite samples increased as the addition of soybean concentrate increased, this is an indication that soybean could be a good source of vitamin B_1. The vitamin B_1 content of the composite flour samples were lower than the values 6.23 – 12.56 mg/100g reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed, 8.00 -10.04 mg/100g reported by Mbaeyi-Nwaoha and Uchendu for blends of acha and fermented soybean paste (okara) and 0.54 – 2.50 mg/100g reported by Tivde, et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours [22,28,35].

The riboflavin (B_2) content of the composite flour samples ranged from 0.76 – 1.36 mg/100g. Sample B4 (80WAF:20SBC:5BFF) had the least values (0.76 mg/100g) while sample A1 100BAF:5BFF had the highest value (1.36 mg/100g). Samples A2 (90BAF:10SBC:5BFF), B1 (100WAF:5BFF), B2 (90WAF:10SBC:5BFF) and B3 (85WAF:15SBC:5BFF) differ ($p<0.05$) significantly from other samples. The vitamin B_2 contents of the composite samples decreased as the quantity of acha decreased, this is an indication that acha could be a good source of vitamin B_2. The vitamin B_2 content of the composite flour samples were lower than the values 3.07 – 5.88 mg/100g reported by reported by Esther et al. for chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed higher than the values 0.04 – 0.55 mg/100g reported by Mbaeyi-Nwaoha and Uchendu for blends of acha and fermented soybean paste (okara) but vary from the findings 0.15 – 12.32 mg/100g of Tivde, et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours [22,28,35]. Riboflavin (B2) is responsible for maintaining healthy blood cells, plays an important role in the conversion of food into energy and in fat and protein metabolism. Hence, infants consuming complementary food containing A. brasiliana will have healthy blood cells, healthier vision and skin as well as improved fat and protein metabolism [38].

The niacin (B_3) content of the composite flour samples ranged from 0.50 – 1.69 mg/100g. Sample A1 (100BAF:5BFF) had the least values (0.50 mg/100g) while sample B4 (80WAF:20SBC:5BFF) had the highest value (1.69 mg/100g). There were significantly ($p<0.05$) differences among samples. The vitamin B_3 contents of the composite samples increased as the addition of soybean concentrate increased, this could be an indication that soybean could be a good source of vitamin B_3. The vitamin B_3 content of the composite flour samples vary from the values 0.53 – 2.85

mg/100g reported by Mbaeyi-Nwaoha and Uchendu for blends of acha and fermented soybean paste (okara) and 0.07 – 6.43 mg/100g reported by Tivde, et al. for proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours [28,35].

These vitamins are naturally occurring bioactive compounds which have high likeness towards heat and light. Usually, normal room temperature itself is enough to cause the compound to break down [39]. Thiamin, riboflavin, and niacin play key roles as co-enzymes in energy yielding processes. The recommended dietary allowance (RDA), that is adequate intake, is 1.1 to 1.2 mg for thiamin, 1.1 to 1.3 mg for riboflavin, and 14 to 16 mg for niacin. They help metabolize carbohydrates, fats and oils. Deficiency of the three vitamins may result in brain damage, poor nervous coordination and disorder in the skins and gastro-intestinal (GI) tracts of affected persons [40].

Considering the findings from this study, the samples that are comparable with the recommended dietary allowance (RDA) should be considered as it will give consumers with the daily vitamin required. This implies that infants consuming these foods will have an improved appetite, a healthier nervous system and a higher release of energy from the complementary foods as these are the major functions of vitamin B1 (thiamin) in the body [38].

Table 3: Vitamin Composition of the Composite Flours Samples

Samples (mg/100g)	Vitamin B_1	Vitamin B_2	Vitamin B_3	Vitamin A
Sample A1 100BAF:5BFF	$0.07^b±0.00$	$1.36^a±0.00$	$0.50^g±0.01$	$80.09^a±0.01$
Sample A2 90BAF:10SBC:5BFF	$0.08^b±0.00$	$1.18^b±0.03$	$0.81^d±0.00$	$78.21^c±0.43$
Sample A3 85BAF:15SBC:5BFF	$0.10^a±0.00$	$1.08^c±0.04$	$1.14^c±0.01$	$70.31^e±0.34$
Sample A4 80BAF:20SBC:5BFF	$0.11^a±0.00$	$0.76^e±0.00$	$1.51^b±0.02$	$60.59^h±0.86$
Sample B1 100WAF:5BFF	$0.07^b±0.00$	$1.18^b±0.03$	$0.52^f±0.01$	$79.97^b±0.01$
Sample B2 90WAF:10SBC:5BFF	$0.10^a±0.02$	$1.17^b±0.00$	$0.78^e±0.01$	$73.32^d±0.01$
Sample B3 85WAF:15SBC:5BFF	$0.11^a±0.00$	$1.16^b±0.03$	$0.10^h±0.02$	$68.78^f±0.01$
Sample B3 85WAF:15SBC:5BFF	$0.12^a±0.00$	$0.87^d±0.00$	$1.69^a±0.02$	$63.06^g±0.01$

Values show the mean of duplicate analysis and ± standard deviation. Figures with different superscript down the column are significantly different ($p<0.05$).
Keys: Group BAF = Brown acha flour, WAF = White acha flour, BFF = Bread fruit flour, SBC = Soybean concentrate

Conclusions

Composite flour samples formulated from acha fortified with soybean concentrate and whole breadfruit seed flour poses micronutrients that are higher than most flours formed from a single cereal or leguminous plant material. This study has shown that increases in vitamins B_1 and B_3 and decrease in vitamins B_2 and A were recorded with increasing concentration of soybean protein concentrate and decreasing concentration of acha flours. The presence of these minerals and vitamins imply that the samples from this study could be utilized as sources of essential nutrients. The overall quality of the composite flour samples indicates that they are suitable for both infant food formulations and functional foods for both young and elderly people requiring special foods for their health benefits.

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Author Contributions

Chinedu Ogbuele, Titus Nwabueze and Stella Ubbor designed the work; Chinedu Ogbuele did the write up and carried out the research and analysis; all authors reviewed the manuscript

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Data Availability

The authors declare that the data supporting the findings of this study are available within the paper.

Declarations Ethics Approval and Consent to Participate

Not applicable.

Consent For Publication

Not applicable.

Competing Interests
The authors declare no competing interests.

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