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Nutritional, Sensory and Anti-Nutritional Properties of Aadun Enriched With Groundnut and Crayfish

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Abstract

Nutrition transition has led to the advent of western foods and snacks characterised by high calorie and fat, resulting in gradual neglect of utilization of indigenous snacks in Nigeria. Enriched indigenous snacks can improve nutrient intake of consumers. *Aadun,* made from roasted corn flour, palm oil and spices, and sold as street snack is often used during naming ceremonies and traditional marriages. However, it is fast losing recognition; hence the need to popularise its usage. The study was carried out to improve the nutrient content and sensory attributes of *Aadun* by enriching it with groundnut and crayfish. Yellow maize, groundnut, crayfish, dried pepper, sugar and salt were purchased from Bodija Market in Ibadan, Nigeria. The maize was roasted at 160^{0}C for about 25 mins, cooled, milled and sieved. Dry pepper, onion, sugar and salt were added to palm oil and heated for about 3 mins, followed by addition of the roasted maize flour. The mixture was transferred into a bowl and stirred vigorously to form a firm paste (*Aadun*). Part of the *Aadun* was enriched with groundnut and crayfish at ratio 80:20 *Aadun*:groundnut, 80:20 *Aadun*:crayfish, and 80:10:10 *Aadun*:groundnut:crayfish. The four samples were analysed using the official methods of AOAC. An 100g of *Aadun* samples contained between 2.8-3.1g moisture, 10.0-22.7g protein, 34.7-40.6g fat, 21.0-34.0g carbohydrates, 730.33-939.00mg potassium, 521.33-754.00mg calcium, 401.33-523.67mg phosphorus, 4.44-5.14mg zinc, 3863.73-3896.60µg β-carotene, and 492.13-523.83kcalories of energy. Addition of groundnut and crayfish to *Aadun* significantly increased both macro and micronutrient content of the enriched products ($p<0.05$). *Aadun* enriched with groundnut, and mixture of groundnut and crayfish rated higher in sensory attributes than unenriched one. Enriching *Aadun* with groundnut and crayfish produced nutrient-dense and more acceptable products, hence, their production and consumption need to be promoted.

Keywords: *Aadun*; Crayfish; Enriched Maize Snack; Groundnut; Indigenous Snack

Introduction

A snack is a light meal or a portion of food often smaller than a regular meal, generally taken between meals; and generally enjoyed and consumed by all age groups **[1];** and can be eaten at any time of the day. Snacking is a way for people to obtain energy for their daily activities. Westernized snacks commonly consumed in most urban settlements include meat pies, scotch eggs, egg roll, sausage rolls, biscuits, buns, puff puff, plantain and potato chips, peanuts, and coconut chips. Most of these foods are high in energy but low in macro and micronutrients, and are referred to as empty calorie or junk foods which are dangerous to health **[1].**

In Nigeria, both staple and non-staple foods are used to produce locally made traditional snacks. These food items include maize, millet, sorghum, beans, groundnut, soybean, and they are used either as sole component or as a mixture of one or more of these crops. A wide variety of traditional/

indigenous snacks and appetizers which contribute to the overall dietary nutrient intake of consumers exist. These snacks have a long history of consumption especially among the low-income populace **[2].** They include *kulikuli* (Peanut ball), *Donkwa* (Maize- peanut ball, *Robo* (Melon seed ball), *Kokoro*, *Aadun* and *Masa* (Nigerian muffin) among several others **[1].** Among these, *Aadun*, which translates to "sweetness", is a savory snack of Yoruba origin; mostly consumed among the Yoruba who live mainly in the South-western part of Nigeria **[3].** It is a snack prepared from maize (*Zea mays*) which constitutes about 80% of the total composition **[4].** It is made from a combination of roasted corn flour, palm oil and spices **[5, 6].** A variation of this snack contains fried red cowpeas, *suya* spices, alligator pepper, and soybean **[1, 7, 8];** and defatted African oil bean seed flour **[6].**

Aadun is sold primarily as a street snack **[3],** and is often presented at festive functions like naming ceremonies and traditional marriages **[5];** signifying that the child and the home being celebrated will be as sweet as the '*Aadun*' snack. Its attractive brownish-orange colour and smooth taste are considered by many consumers as the quality attribute required of *Aadun* **[5].** It is served as a snack item and sometimes served with local cereals. It is commonly served in banana leaves which also contribute to its taste and attractiveness.

There is a relationship between the consumption of food or snacks and a person's nutritional status. Malnutrition develops when the body does not get the right amount of the macro- and micro-nutrients it needs to meet daily nutritional requirements, maintaining healthy tissues and organ functions. The problem of poor access to nutritious foods/snacks and diets of adequate quality affects not only the poorest of the poor, but also marginal populations in developing, transition, and developed countries **[9].** These populations consume excessive amounts of energy-dense, nutrient-poor foods, which lead to increased risks of overweight, obesity and related chronic diseases **[10, 11].**

A variety of snack foods widely consumed by Nigerians are made of low-protein cereals with lysine and tryptophan as limiting amino acids **[12].** Most often, snack foods do not provide nutrients in adequate quantities needed by the body. This may be due to their composition or due to the production process they go through. Whatever is responsible for their poor nutritional content, it is necessary to ensure that every food consumed by an individual contains required nutrients in adequate amount; more so, many people now work outside their homes and are becoming more dependent on snacks for the supply of part of their daily nutritional requirements.

Nutrition transition has led to the advent of Western foods and snacks characterised by high calorie and fat content, resulting in gradual neglect of the utilization of indigenous snacks in Nigeria. Most traditional snacks are made from minimally processed local foodstuffs, and are relished by the people living the traditional lifestyle, including the urban dwellers. It is therefore necessary to produce acceptable snacks that are possessing good nutritional quality that can be useful in meeting part of nutrient needs of consumers to alleviate nutrient deficiencies. Various studies have been carried out on nutritional, physicochemical properties and sensory attributes of *Aadun* products. These studies include the process technology, chemical composition and quality of *Aadun* snack **[5];** quality assessment and safety of street vended *Aadun* **[3];** and fungi, biodeterioration and contamination of Aadun samples **[4].** Efforts have also been made at enriching or fortifying *Aadun* snacks by supplementing the maize component with cashew kernel **[1],** defatted African oil bean seed flour **[6],** soybean **[7],** and groundnut, crayfish and **soybean [8].** However, majority of these studies did not consider the presence and effects of antinutrients, and possible nutrient contribution of the *Aadun* products. It is in line with this idea that this study was conducted to develop varieties of *Aadun* enriched with groundnut and crayfish to improve the nutritive value of the traditional snack, and evaluate its nutrient, sensory and anti-nutritional properties.

Materials and Methods

Sample Collection and Preparation

Yellow maize (*Zea mays indentata),* groundnut (*Arachis hypogea),* crayfish *(Euastacus spp),* dried pepper, sugar and salt were purchased from Bodija Market in Ibadan, Oyo State. Bodija market was purposively chosen because it is a major market in Ibadan which serves as depot of various kinds of food items from various parts of the country, and therefore, serves as a good representation of food sources from Nigeria.

Yellow maize grain (1.5 kg) was cleaned, washed with tap water and dried. The dried grain was roasted in an earthen pot at 160^0C for 25 minutes to give a nice brown colour. The roasted maize grain was allowed to cool to room temperature, milled and sieved with a 40-mesh sieve to obtain flour and grits. Five hundred (500 mg) grammes of sorted and cleaned crayfish was sun dried, milled and sieved with 30 mm particle size sieve. Also, 500 g of clean, sorted groundnut was rinsed with tap water, dried, roasted and then milled to fine groundnut paste.

The *Aadun* samples were prepared in the Dietetic kitchen of the Department of Human Nutrition and Dietetics, University of Ibadan. The maize flour, groundnut paste and crayfish flour were prepared into *Aadun* according to the methods described by Uzor *et al.* **[13],** and Iombor *et al.* **[14]** by standardizing the recipes collected from local producers of *Aadun* in Ibadan **[5].** Enriched *Aadun* was prepared by replacing portions of maize flour with either groundnut paste or crayfish powder at 20% (i.e. Maize: groundnut blend 80: 20, and maize: crayfish blend 80: 20) inclusion level respectively; and by a combination of maize, groundnut and crayfish at 10% groundnut: crayfish inclusion levels (i.e. Maize: Groundnut: Crayfish at 80: 10: 10, **[7],** (Table 1). Various samples of *Aadun* were produced as indicated below.

Preparation of *Aadun*

Local *Aadun* was prepared by using dry ground chilli pepper (1 tablespoon), sugar (1 tablespoon) and a pinch of salt added to 1 milk tin of palm oil in a pot and heated for about 3minutes. The roasted maize flour (250 g) was then added to the heated palm oil with the ingredients, mixed thoroughly, and removed from the source of heat almost immediately. The mixture was transferred into a bowl and stirred vigorously to form a firm paste (to incorporate air) and produce *Aadun*. The paste was allowed to set for about an hour and then moulded to desired shapes and sizes and wrapped in aluminium foil. This product was labelled as Sample 1.

Another sample of *Aadun* was prepared by replacing part of maize flour with groundnut paste at 80:20 w/w inclusion level by mixing the finely milled groundnut paste with the milled and sieved maize flour prepared as in Sample 1 above to give groundnut-enriched *Aadun* (Sample 2). The third sample of *Aadun* was prepared as above by replacing another portion of maize flour with dried crayfish powder at 80:20 w/w inclusion level to give crayfish-enriched *Aadun* and labelled as Sample 3. The fourth sample of *Aadun* was prepared by replacing 20% of maize flour with 10% groundnut paste and 10% crayfish (80:10:10 Maize:Groundnut:Crayfish) w/w, and prepared as in Sample 1 above. The product was labelled as Sample 4. The standardized recipes used are shown in (Table 1) below.

Ingredients	Sample 1	Sample 2	Sample 3	Sample 4
Maize flour (g)	250	200	200	200
Groundnut paste (g)	-	50	-	25
Crayfish flour (g)	-	-	50	25
Dry chilli pepper	1 tablespoon	1 tablespoon	1 tablespoon	1 tablespoon
Sugar	1 tablespoon	1 tablespoon	1 tablespoon	1 tablespoon
Salt	Pinch	Pinch	Pinch	Pinch
Palm oil	1 milk tin	4 tablespoons	12 tablespoons	6 tablespoons

Table 1: Recipe for the production of *Aadun*.

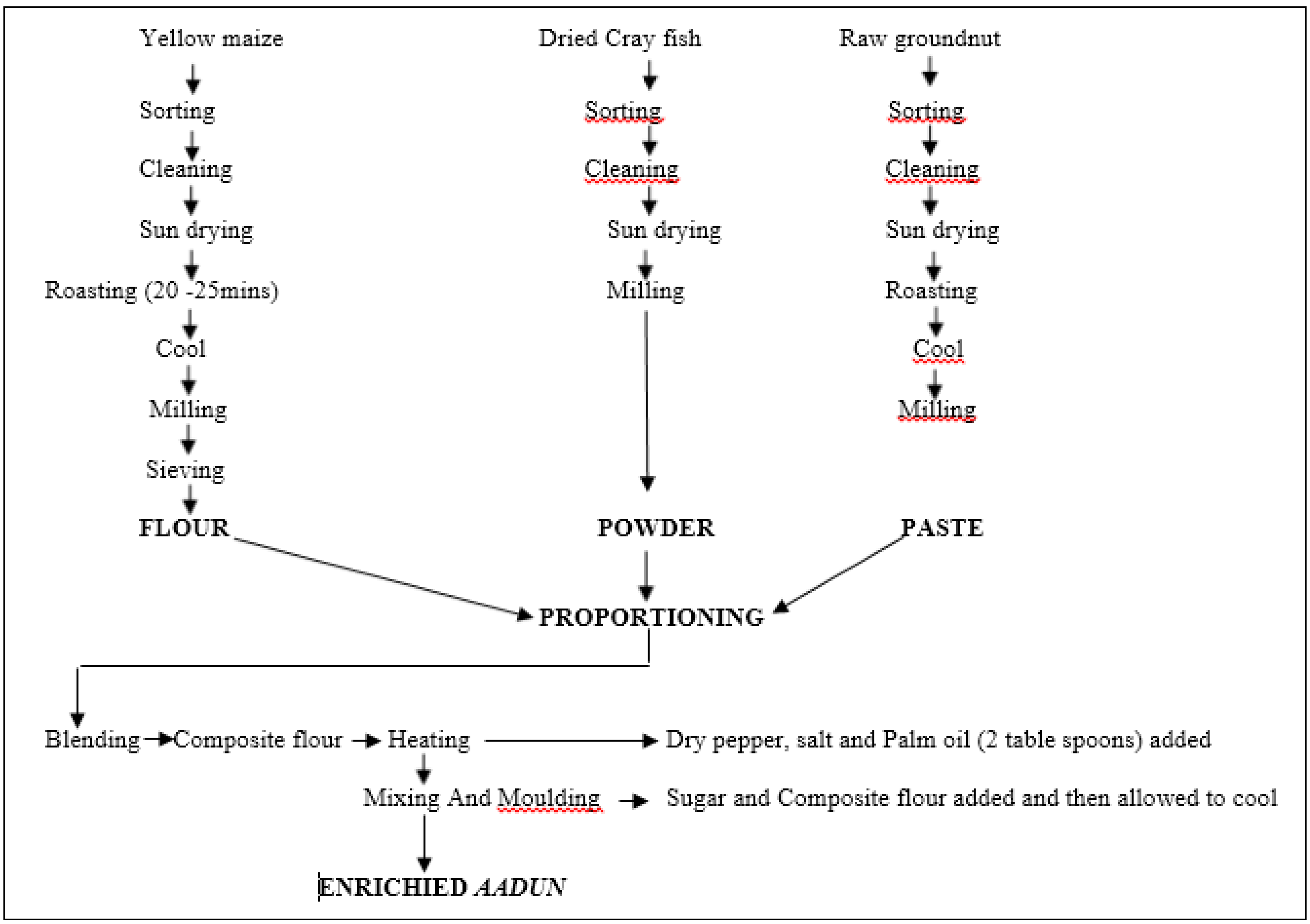

Figure 1: Flow chart for production of Crayfish and Groundnut enriched *Aadun*.

Chemical Analysis

Proximate Composition

The proximate composition of the *Aadun* products was determined using the standard methods of Association of Official Analytical Chemists **[15]**. The moisture content of the samples was determined by air oven method (Plus 11 Sanyo Gallenkamp PLC UK) at 105^{0}C for 4 hours. The crude protein was determined using micro-Kjeldahl method (Method No 978.04), crude lipid was determined by Soxhlet extraction method (Method No 930.09). The ash content was determined through incineration in muffle furnace at 550^{0}C for 4 hours (Method No 930.05). Total carbohydrate content was obtained by difference. Gross energy of the samples was determined using ballistic bomb calorimeter.

Mineral Content Determination

Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer/spectronic20 **[15]** (Method 975.11). Phosphorus was determined by vanado-molybdate colorimetric method **[15]** (Method 975.16). Calcium, magnesium, iron, zinc, manganese, and copper were determined by atomic absorption spectrophotometric method (Buck Scientific, Norwalk) and compared with absorption of standards of these minerals **[15]** (Method 975.23).

Vitamin Content Determination

Beta-carotene Determination: The beta-carotene content of the samples was determined through ultraviolet absorption measurement at 328 nm after extraction with chloroform. Calibration curve of vitamin A acetate was made and sample vitamin A concentration estimated as microgram (μg) of vitamin A acetate.

Thiamine (Vitamin B_1) Determination: Thiamine content of the samples was determined by weighing 1g of sample into 100 ml volumetric flask with addition of 50 ml of 0.1M H_2SO_4 and boiled in a boiling water bath with frequent shaking for 30 minutes. Five milliliters (5 ml) of 2.5M sodium acetate solution was added and flask set in cold water to cool contents below 50^{0}C. The flask was stoppered and kept at 45-50^{0}C for 2 hrs and thereafter made up to 100 ml mark. The mixture was filtered through a No. 42 Whatman filter paper, discarding the first 10 ml. Ten milliliters (10ml) was pipetted from remaining filtrate into a 50 ml volumetric flask, and 5 ml of acid potassium chloride solution was added with thorough shaking. Standard thiamine solutions were prepared and treated same way. The absorbance of the samples as well as that of standards was read on a fluorescent UV Spectrophotometer (Cecil A20 Model, USA) at 285 nm.

Riboflavin (Vitamin B_2) Determination: One (1 g) gramme of each sample was weighed into a 250 ml volumetric flask, 5 ml of 1M HCl was added, followed by the addition of 5 ml of dichloroethene. The mixture was shaken and 90 ml of de-ionized water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 mins to extract all the riboflavin. The mixture was then cooled and made up to volume with de-ionized water. It was then filtered, discarding the first 20 ml of the aliquot. Two milliliters (2 ml) of the filtrate obtained was pipetted into another 250 ml volumetric flask and made up to mark with de-ionized water. Samples were read on the fluorescent spectrophotometer at a wavelength of 460 nm. Standard solutions of riboflavin were prepared and readings taken at 460 nm. The sample riboflavin was obtained through calculation.

Niacin (Vitamin B_3) Determination: Five (5 g) grammes of sample was extracted with 100 ml of distilled water and 5 ml of this solution was drawn into 100 ml volumetric flask and made up to the mark with distilled water. Standard solutions of niacin were prepared and absorbance of sample and standard solutions was measured at a wavelength of 385 nm on a spectrophotometer, and niacin concentration of the sample estimated.

Determination of Pantothenic Acid (Vitamin B_5): Pantothenic acid content of the sample was determined by extracting 1g of sample with distilled water, filtered and 5ml of aliquot of the sample filtrate thoroughly mixed with 5ml of 12% KBr and 10ml of $KMnO_4$ solutions. The mixture was warmed in a boiling water bath for 10minutes, cooled in ice for 5 minutes and 20% freshly prepared H_2SO_3 solution added drop wise to obtain colourless solution. To the colourless solution, 10 ml of 2, 4 - dinitrophenyl hydrazine (5 g/l) was added and mixed thoroughly. The mixture was then heated on a steam bath for 15 minutes and cooled to room temperature to obtain yellow precipitate. The precipitate was dried for 30 minutes in an oven at 100 ^{0}C and dissolved in hot pyridine solution with thorough mixing to form homogenous suspension. The suspension was filter thorough a Whatman No 42 filter paper into a 50 ml volumetric flask and made up to mark with pyridine solution. To this solution was added 50 ml distilled water, followed by the adding 5ml of 5M NaOH solution. The absorbance of the sample and standard solutions of panthothenic acid were read on a spectronic21D spectrophotometer at 570 nm, and sample content calculated in μg /100 g of sample.

Pyridoxine (Vitamin B_6) determination: The vitamin B_6 content of the samples was determined by extracting 1 g of sample with 0.5 g of ammonium chloride, 45 ml of chloroform and 5 ml of absolute ethanol. The mixture was thoroughly mixed in a separating funnel by shaking for 30mins, and 5 ml of distilled water added. The chloroform layer containing the pyridoxine was filtered into a 100 ml volumetric flask and made up to the mark with chloroform. Standard solutions of 0-10 ppm of vitamin B_6 were prepared and treated in a similar way as samples; and their absorbance measured on Cecil 505E spectrophotometer at 415 nm. The amount of vitamin B_6 in the sample was then calculated.

Cyanocobalamin (Vitamin B_{12}) determination: Cyanocobalamin content of the samples was determined by extracting 1 g of sample with distilled water with shaking for 45 min, followed by filtering the mixture. The first 20 ml of the filtrate was rejected, and another 20 ml filtrate collected. To the collected filtrate, 5 ml of 1% Sodium dithionite solution was added. Standard cyanocobalamin solutions (0-10 μg/ml) were prepared, and absorbance of sample as well as standards was read on spectronic21D spectrophotometer at 445 nm. Amount of sample cyanocobalamin was then estimated through calculation.

Ascorbic acid Determination: Ascorbic acid in the samples was determined by titrating the aqueous extract of each sample with solution of 2, 6 - dichlorophenol-indophenol dye to a faint pink end point.

Tocopherol (Vitamin E) determination: One gram of sample was weighed into a 250 ml conical flask fitted with a reflux condenser wrapped in aluminium foil, and refluxed with 10 ml of absolute alcohol and 20 ml of 1 M alcoholic sulphuric acid for 45 min. The resultant solution was cooled for 5 min, followed by addition of 50 ml of distilled water and then transferred into a separating funnel covered with aluminium foil. The unsaponifiable matter in the mixture was extracted with 5 × 50 ml diethyl ether. The combined extract was washed free of acid and dried over anhydrous sodium sulphate. The extract was later evaporated at a low temperature and the residue obtained immediately dissolved in 10 ml absolute alcohol. Aliquots of solutions of the sample and standard were transferred to a 20 ml volumetric flask, 5 ml absolute alcohol added, followed by a careful addition of 1 ml conc. HNO_3 and placed on a water bath at 90°C for exactly 30 min from the time the alcohol begins to boil. Rapid cooling under running water follows. The absorbance of sample solution was read at 470 nm **[15]** (Method 1893).

Anti-nutrient Determination: Phytate was determined by titration with ferric chloride solution **[16]**; while trypsin inhibitory activity was determined on casein and comparing the absorbance with that of trypsin standard solutions read at 280 nm **[17]**. Oxalate content of the samples was determined by extraction of the samples with water for about three hours and standard solutions of oxalic acid prepared and read on spectrophotometer (Spectronic20) at 420 nm. The absorbance of the samples was also read at 420 nm, and amount of oxalate estimated.

The tannin content of the samples was determined by extracting the samples with a mixture of acetone and acetic acid for five hours, measuring their absorbance and comparing the absorbance of the sample extracts with the absorbance of standard solutions of tannic acid at 500 nm on spectronic20 **[18]**. Saponin was also determined by comparing the absorbance of the sample extracts with that of the standard at 380 nm **[17]**. All determinations were carried out in triplicate.

Sensory Evaluation: Sensory evaluation of the samples was carried out for consumer acceptance and preference using 30 untrained judges, comprising of students and staff of the University of Ibadan community, Ibadan who were familiar with the consumption of Aadun **[5]**. A nine (9)-point Hedonic scale (with one and nine representing "extremely dislike" and "extremely like", respectively) was used to assess the samples' colour, taste, odour, texture, appearance and general acceptability. The panelists were provided with water to rinse their mouths in-between sample evaluation, and were instructed to rinse their mouth with water before tasting another sample.

Data analysis: The data obtained for chemical composition were presented using means and standard deviations of triplicate determinations, and sensory values were calculated using the Microsoft Excel 2007 package. One-way analysis of variance (ANOVA) was used to test for significant differences in the nutrient, anti-nutrient and sensory properties of the samples.

Results

The proximate composition of the samples is presented in **(Table 2)**. Locally-made *Aadun* was very low in moisture content, low in crude protein, high in ash, carbohydrate and crude fibre and very high in crude lipid and gross energy content (Sample 1). Partial substitution of the maize flour with groundnut, crayfish or groundnut and crayfish resulted in significant increase in the moisture content of the products, with the crayfish-enriched *Aadun* having the highest value and groundnut with crayfish enriched *Aadun* having the lowest value ($p<0.05$). Enriching the locally-made *Aadun* with groundnut, crayfish or the mixture of the two led to significant increase in its crude protein and ash content, with significant reduction in crude lipid, fibre, carbohydrate and gross energy content of the products (Samples 2, 3, and 4) ($p<0.05$). Sample 1 had the highest value for lipid, crude fibre, carbohydrate and gross energy content, Sample 3 was highest in moisture, while Sample 4 had the highest value for crude protein and ash content. There was no significant difference in the carbohydrate content of Samples 1 and 2 ($p>0.05$).

The locally-made *Aadun* was very rich in potassium, calcium and phosphorus, and rich in magnesium, sodium and zinc. Enrichment generally led to increase in mineral content of the enriched samples (Samples 2, 3, and 4). Sample 4 was highest in all the mineral content, while Sample 1 was lowest in all the minerals except magnesium, in which Sample 2 had the lowest value **(Table 3)**. Significant differences existed among all the mineral content of the four samples ($p<0.05$).

Parameter	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	2.78±0.03a	2.94±0.03b	3.07±0.03c	2.88±0.03d
Crude Protein	10.01±0.25a	14.48±0.11b	16.85±0.07c	22.74±0.10d
Crude Lipid	40.63±0.03a	36.83±0.02b	34.67±0.02c	37.95±0.03d
Crude Fibre	7.85±0.03a	7.45±0.02b	7.26±0.02c	7.15±0.03d
Ash	2.41±0.02a	2.55±0.03b	2.72±0.04c	3.10±0.03d
Carbohydrates	36.32±0.23a	35.75±0.10a	35.43±1.84b	26.18±0.09c
Gross Energy (Kcal/)	523.83±087a	521.53±3.15a	492.13±0.45b	517.69±0.78c

*Values are means and standard deviations of three determinations (n = 3)
Values with the same superscript on the same row are not significantly different (p> 0.05).
Sample 1 = Locally made Aadun;
Sample 2 = Local Aadun enriched with groundnut;
Sample 3 = Local Aadun enriched with crayfish;
Sample 4 = Local Aadun enriched with groundnut and crayfish.

Table 2: Proximate Composition of *Aadun* 'As eaten' (g/100g)*.

Parameters	Sample 1	Sample 2	Sample 3	Sample 4
Sodium	264.67±2.08 a	277.33±2.08b	288±.67±2.52c	313.67±2.52d
Potassium	730.33±1.53a	821.00±3.00b	885.33±1.53c	939.00±2.00d
Calcium	521.33±3.51a	626.67±2.52b	678.67±2.52c	754.00±3.00d
Magnesium	391.62±2.52a	368.33±3.27b	381.62±3.51c	424.33±1.15d
Phosphorus	401.33±4.73a	425.33±2.08b	440.33±1.53c	523.67±2.52d
Zinc	4.44±0.00a	4.62±0.00b	4.93±0.01c	5.14±0.00d
Copper	0.54±0.02a	0.76±0.02b	0.88±0.03c	0.97±0.02d
Manganese	1.14±0.02a	1.37±0.01b	1.54±0.03c	1.73±0.02d
Selenium(µg/)	0.46±0.02a	0.61±0.02b	0.70±0.02c	0.78±0.01d

*Values are means and standard deviations of three determinations (n= 3)
Values with the same superscript on the same row are not significantly different (p> 0.05).

Table 3: Mineral Composition of *Aadun* 'As eaten' (mg/100g)*.

In **(Table 4)**, the locally made *Aadun* (Sample 1) was very rich in β-carotene but low in water soluble vitamins. Addition of groundnut and crayfish led to significant reduction in the β-carotene content of the products (p<0.05); the reduction being much pronounced in the crayfish sample. However, the enriched *Aadun* samples (Samples 2, 3, and 4) had higher values of water-soluble vitamins compared to the unenriched product (Sample 1), (p<0.05). There was no significant difference in value of vitamin E content of Samples 1, 3 and 4 (p>0.05). Groundnut enriched *Aadun* had highest value for all the water-soluble vitamins, followed by groundnut and crayfish enriched sample (p<0.05).

All the *Aadun* products were very low in antinutrients studied **(Table 5)**. Tannin was not detected in all the products at the level of determination. Significant differences were observed in the values of oxalate and saponin content of all the samples (p<0.05). There was no significant difference in the phytate content of Samples 1 and 2 (p>0.05).

In **(Table 6)**, unenriched *Aadun* product (Sample 1) scored highest in colour and texture, groundnut enriched *Aadun* product (Sample 2) rated highest in aroma, taste and general acceptability. Groundnut and crayfish enriched product (Sample 4) scored higher than either groundnut or crayfish enriched *Aadun* products in colour, while crayfish-enriched *Aadun* product (Sample 3) scored least in all the parameter studied, with no significant difference in aroma and taste compared with locally made crayfish (p<0.05). All the products were rated well above average.

As indicated in **(Table 7)**, the Aadun snacks can contribute meaningfully to both macro- and micronutrients intake of consumers, as the snack can be consumed as in-between meal.

Parameter	Sample 1	Sample 2	Sample 3	Sample 4
β-Carotene (µg/)	3896.60±0.17a	3874.30±0.20b	3863.73±0.15c	3885.56±0.15d
Vitamin B1	0.20±0.02a	0.25±0.02b	0.16±0.02c	0.24±0.02b
Vitamin B2	0.06±0.01a	0.12±0.01b	0.04±0.01c	0.11±0.01d
Vitamin B3	2.77±0.04a	3.32±0.04b	2.61±0.02c	3.06±0.02d
Vitamin B5	0.35±0.02a	0.59±0.02b	0.31±0.04c	0.37±0.02d
Vitamin B6	0.44±0.02a	0.67±0.02b	0.39±0.02c	0.51±0.02d

Vitamin C	4.28±0.03a	5.34±0.03b	4.61±0.02c	4.52±0.04d
Vitamin E	0.06±0.00a	0.07±0.00b	0.06±0.00a	0.06±0.01a
*Values are means and the standard deviations of three determinations (n = 3) Values with the same superscript on the same row are not significantly different (p> 0.05)				

Table 4: Vitamin composition of *Aadun* 'As eaten' (mg/100g)*.

Parameter	Sample 1	Sample 2	Sample 3	Sample 4
Phytate	0.07±0.01^{a}	0.07±0.01^{a}	0.04±0.00^{b}	0.06±0.01^{c}
Oxalate	0.04±0.00^{a}	0.05±0.00^{b}	0.03±0.06^{c}	0.05±0.06^{b}
Tannin	0.00±0.01^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Saponin	0.09±0.01^{a}	0.11±0.01^{b}	0.08±0.00^{c}	0.10±0.01^{d}
*Values are means and standard deviations of three determinations (n= 3) Values with the same superscript on the same row are not significantly different (p>0.05).				

Table 5: Anti-nutrient composition of *Aadun* (mg/100g)*.

Parameter	Sample 1	Sample 2	Sample 3	Sample 4
Colour	6.94±1.67^{a}	5.74±2.22^{b}	6.06±1.82^{c}	6.35±1.82^{d}
Aroma	5.84±1.88^{a}	7.00±1.21^{b}	5.00±2.24^{c}	5.81±1.82^{a}
Taste	6.19±1.67^{a}	7.71±1.27^{b}	5.26±2.42^{c}	6.42±1.71^{a}
Texture	6.94±1.36^{a}	6.55±1.69^{b}	6.06±1.50^{c}	6.19±1.54^{d}
Acceptability	6.03±1.96^{a}	6.90±1.62^{b}	5.48±1.93^{c}	6.35±1.98^{d}
*Values are means and standard deviations (n = 30) Values with the same superscript on the same row are not significantly different (p>0.05).				

Table 6: Sensory evaluation of *Aadun* products*****.

Nutrient	RDA/AI*	1	%RDA	2	%RDA	3	%RDA	4	%RDA
Energy (kcal)	2300	523	22.74	521	22.65	492	21.39	517	22.48
Protein (g)	65	10	15.38	14	21.54	16	24.62	22	33.85
Calcium (mg)	1200	521	43.42	626	52.17	678	56.5	754	62.83
Potassium(mg)	2500	730	29.2	821	32.84	885	35.4	939	37.56
Phosphorus (mg)	700	401	57.29	425	60.71	440	62.86	523	74.71
Magnesium (mg)	420	391	93.10	368	87.62	381	90.71	424	100.95
Zinc (mg)	11	4	36.36	4.62	42	4.93	44.82	5	45.45
RE (μg)	1000	649	64.9	645	64.5	643	64.3	647	64.7
Vitamin B$_1$ (mg)	1.2	0.20	16.67	0.25	20.83	0.16	13.33	0.24	20
Vitamin B$_2$ (mg)	1.3	0.06	4.61	0.12	9.23	0.04	3.08	0.11	8.46
Vitamin B$_3$ (mg)	16	2.77	17.31	3.32	20.75	2.61	16.31	3.06	19.13
Vitamin B$_5$ (mg)	5	0.51	10.2	0.59	11.8	0.31	6.2	0.37	7.4
Vitamin B$_6$ (mg)	1.7	0.44	25.88	0.67	39.41	0.39	22.94	0.51	30
Vitamin C (mg)	90	4.28	4.76	5.34	5.93	4.61	5.12	4.52	5.02
*** Source: Insel et al. 2007 RDA = Recommended Dietary Allowance AI = Adequate Intake; RE = Retinol Equivalent; 1 μg RE = 6 μg β-carotene 1 = Sample 1; 2 = Sample 2; 3 = Sample 3; 4 = Sample 4**									

Table 7: Possible Contribution to Recommended Nutrient Intake of Adults.

Discussion

In **(Table 2)**, the moisture content of the locally made *Aadun* was very low (Sample 1), indicating a high dry matter content and good keeping quality. The low moisture content of the sample is desirable because high moisture content is unacceptable in *Aadun*, as this may predispose the product(s) to microbial growth due to high water activity **[19]**. All the values obtained for proximate composition of all Aadun products were within the values reported for *Aadun* by Idowu et al. **[3]**. The protein content of the Sample (100% maize flour *aadun*) was within the range reported by Idowu *et al.* **[3]**. The high lipid content of the sample is believed to be due to lipid content of maize and the added palm oil. This is suggestive that the snack will be high in gross energy, as 1 gramme of fat contributes 9 kilocalories of energy. The *Aadun* snack was high in crude fibre, which is believed to be due to the use of whole maize grain that is high in fibre. The values of the crude fibre were however lower than the range reported by Idowu *et al.,* **[3]**). The high crude fibre value of the snack is an added advantage, as it is likely to be a good source of dietary fibres, which are known to promote satiety, reduce overeating, modulate nutrient absorption and aid digestion among other benefits **[20, 21]**.

The high ash content of the sample is indicative of its being high in mineral content, especially macro-minerals **[22, 23]**. The carbohydrate content of the snack was moderate and of complex carbohydrate, hence, the consumption of the snack will not lead to any sudden surge in blood glucose level as does other empty calorie snacks which contain refined sugars. The value of the carbohydrate was similar to the one reported by Idowu *et al.,* **[3]**. Its energy content can satisfy the consumers' immediate energy need and reduce the urgent need for consumption of other foods. Foods that are high in lipid and fibre tend to give sense of satiety and prevent the urge to consume staple foods within a short period of time **[24]**.

Addition of groundnut and crayfish increased the moisture, protein, and ash content of enriched products of *Aadun* (Samples 2, 3, and 4), with reduction in the products' crude lipid, fibre, carbohydrate and gross energy content of the products. This observation is similar to the findings of Apata et al. **[8]**. The little increase observed in the moisture content of the enriched samples is similar to the trend observed by Shakpo and Osundahunsi **[25]**. The observed increase in protein content of the enriched samples were believed to be due to addition of groundnut and crayfish flours. This is similar to the observation of Shakpo and Osundahunsi, who also found protein content to increase as a result of cowpea substitution in maize: cowpea flour blends **[25]**, Amodu *et al*. who fortified Aadun and Kokoro with soybean flour **[7]**; and Apata et al. who substituted maize with groundnut, crayfish and soybean to fortify *Aadun* **[8]**.

The high fat content of the enriched snacks is believed to be a result of the palm oil added during its production, as well as the oil from groundnut and the crayfish. The sources of the oil/fat are however healthy, as they contain substantial amount of unsaturated fatty acids. The high fat content may however predispose the snack to rancidity and low shelf life, particularly where the ambient temperature is low and humidity is high **[26, 3]**.

There was a significant increase in the ash content of the enriched samples. The increase in the ash content of the products could make them a good source of minerals. The reduction in calorie content of the enriched samples is due to reduction in the added palm oil and carbohydrate content.

The locally produced *Aadun* (Sample 1) was very rich in essential macro minerals **(Table 3)**. This finding is in line with the observation of Chikwendu **[27]** in the study of the chemical composition of *Akara* produced from ground bean and maize blends. The high potassium content can be beneficial to people with hypertension **[28]** and those who suffer from excessive excretion of potassium through the body fluids. Sodium is needed in the body for regulation of fluids and blood pressure. The potassium:sodium ratio (2.76) of the snack qualifies it as good snack for the hypertensive. The high content of calcium and phosphorus is beneficial because they form the dense, hard material of the teeth and bones; while magnesium plays an important role in carbohydrate metabolism **[29]**. Enrichment increased all the mineral content of *Aadun* samples (Samples 2, 3, and 4), thereby making them good source of these minerals. The trace mineral contents of the products were appreciable, and will improve the metabolic activities in the body.

In **(Table 4)**, the snack was very rich in β-carotene (Sample 1) but low in water-soluble vitamins, especially vitamins B_1, B_2, B_5 and C. The low content of these water-soluble vitamins might be due to their loss during the course of product preparation, as many of them are heat labile **[24]**. The β-carotene of the enriched products were also very high, showing that both the snack and its enriched products could serve as good source of improving the provitamin A intake of its consumers. The high β-carotene content of the samples was believed to be due to addition of palm oil during the preparation of *Aadun*, which has been found to contain high concentration of β-carotene. The reduction in the β-carotene content of the enriched samples could be as a result of the reduction in the quantity of palm oil that was used, suggesting that the groundnut did not contain β-carotene, nor the crayfish possess vitamin A. The high β-carotene content coupled with presence of vitamins C and E in the *Aadun* samples is an indication that it can be a good source of antioxidants, which are important in the prevention of chronic diseases.

The antinutrient contents of the samples were relatively low. Antinutrients are generally known to reduce the bio-availability of nutrients in the body. High levels of phytates in human nutrition decrease the availability of some minerals **[30]**. Consumption of high levels of oxalate causes corrosive gastroenteritis, shock, low plasma calcium, high plasma oxalates and renal damage **[31]**. However, the levels of phytate and oxalate in the samples were very low as to have any antagonist effect(s) on the nutrients or consumers, indicating that the consumption of the products as snack is safe.

The locally made *Aadun* (Sample 1) was relished by the sensory evaluators in all the parameters studied **(Table 6)**. The enriched sample with groundnut (Sample 2) scored highest in aroma, taste, and acceptability. This is believed to be a result of contribution from groundnut which itself is relished as a snack. The crayfish-enriched sample (Sample 3) scored least in all the parameters. This might be due to the peculiar taste, odour and colour of the crayfish which is usually used as an additive in soups and sauces. Overall, enrichment produced acceptable *Aadun* samples, as none of them was rejected or scored poorly by the panelists; with Sample 2 being the most acceptable one.

Conclusion

Aadun is a good and healthy snack which is nutrient dense. It can serve as a good source of energy, protein, healthy oil, essential minerals and antioxidant vitamins. Addition of groundnut and crayfish to enrich the locally made corn-based snack, *Aadun,* resulted in a more nutrient dense snack. Enrichment significantly increased most of the proximate and mineral content of the *Aadun* samples. The antinutrient content of the samples was very low, suggesting that *Aadun* samples were safe for consumption with good chances of nutrient uptake and utilization in the body when consumed. The enriched samples were acceptable to the judges, since none of the samples was rejected by them. However, the most acceptable sample based on general acceptability score was the groundnut-enriched sample. The products can serve as healthy and appropriate in-between meal; and if consumed often, will contribute greatly towards meeting human macro- and micro-nutrients requirements needed for normal growth and promotion of good health and longevity.

Promotion of these products through enlightenment and nutrition education for the local producers and vendors of the snack is necessary to enhance improved nutrient intake and optimal nutrition for the low- and middle- income earners who are the major consumers of *Aadun*. Food Technologists can also help to design a way to enrich this product and improve preservation and packaging without reducing its nutrient availability.

Conflict of Interest Statement

The Authors declare that there is no conflict of interest about this manuscript, as it was self-sponsored by the Authors, and has not been submitted for publication elsewhere.

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