



Research Article

Proximate Composition of Sorghum, Soya Bean and Cashew Nuts
Complementary Food Blends

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Malnutrition is a serious health condition that affects millions of people worldwide. Commercially available complementary foods are too expensive for low-income families or average families. Consequently, nursing mothers often depend on traditional, complementary foods, which are inadequate in energy density, proteins and micronutrients. Many indigenous and unexploited legumes and nuts, such as soya beans and cashew nuts, significantly improve the protein quality of complementary foods. This study was conducted to determine the proximate composition of sorghum, soya beans and cashew nuts blends. The complementary food blends from sorghum, soya beans and cashew nut were compared with checkers' Custard. Sorghum was subjected to sprouting and fermentation techniques while soya beans and cashew nuts were roasted. Using the Pearson square method, the complementary food blends were blended in different ratios to give six formulations. They include RSVM: 65 parts raw sorghum: 35 parts vitamin and mineral supplements, PSVM: 65 parts processed sorghum: 35 parts vitamin and mineral supplement, PSC: 85 parts processed sorghum: 15 parts cashew nuts, PSSB: 52 parts processed sorghum: 48 parts soya beans, PSSBC: 45 parts processed sorghum: 45 parts soya beans: 10 parts cashew nuts and PSCSBVM: 45 parts processed sorghum: 10 parts cashew nuts: 30 parts soya beans: 15 parts mineral and vitamin supplements. Data obtained were subjected to Analysis of Variance (ANOVA), and Duncan's multiple range test was used to compare the means. The results of the moisture content of the complementary food blends showed a significant ($P < 0.05$) decrease. RSVM (4.17 ± 0.02), PSVM (4.57 ± 0.01), PSC (4.57 ± 0.01), PSSB (5.03 ± 0.04), PSSBC (5.04 ± 0.04) and PSCSBVM (4.47 ± 0.01). Protein content of RSVM (17.2 ± 0.01), PSVM (18.2 ± 0.01), PSC (16.8 ± 0.01), PSSB (21.3 ± 0.01), PSSBC (23.1 ± 0.01) and PSCSBVM (25.8 ± 0.03) met the RDA for infants 6-12 months while the commercial complementary food blends (6.63 ± 0.02) was inferior to the complementary food blends and the RDA. The fat content of PSCSBVM (6.20 ± 0.06) was close to the RDA (10.25) for infants (6-12 months). Checkers' Custard (0.50 ± 0.02) was below the RDA. The fat content of RSVM (4.03 ± 0.04), PSVM (3.50 ± 0.01), PSC (3.93 ± 0.02), PSSB (2.06 ± 0.07) and PSSBC (2.35 ± 0.03) was below the RDA and not comparable to PSCSBVM. The calculated energy content of the complementary food blends PSCSBVM (364.92 ± 0.62) was comparable to PSSBC (365.32 ± 0.20 kcal/100g) and was close to the RDA (400 kcal/100g) for infants 6-12 months.

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INTRODUCTION

One of the primary underlying causes of death for many children worldwide is childhood malnutrition (Murray & Lopez, 1997). According to (Grantham-Mcgregor *et al.*, 2007), deficient nutrition during childhood can result in subpar intellectual performance, little earnings in maturity and insufficient care for the offspring of later generations. The average family cannot afford supplementary foods that are commercially available in developing nations (Onweluzo & Nwabugwu, 2009). As a result, nursing women frequently rely on traditional dietary supplements, which are frequently deficient in micronutrients, protein and energy density. How these traditional weaning foods are prepared and given to the child frequently raises their risk of getting sick (Caulfield *et al.*, 1999). Although there are numerous indigenous and unexploited legumes such as soya beans and nuts such as cashew nuts, these raw materials are locally available, accessible, affordable, highly nutritious, and quickly processed. When correctly complemented with indigenous carbohydrate sources, the ingredients would provide affordable, high-quality complementary foods to help reduce protein-energy malnutrition (PEM) and increase infant nutrition.

Nigerian communities, both rural and urban, suffer from protein-energy malnutrition, which can be attributed to strict economic measures and insufficient food production and supply, particularly to foods high in protein and micronutrients. Complementary feeding is when an infant is introduced to other sources of nourishment besides breast milk. As the child transitions from a liquid milk-based diet, they are progressively introduced to semi-solid foods which are readily digestible, have a high concentration of nutrients per unit of volume, and are not bulky (Onweluzo & Nwabugwu, 2009). The infant might be introduced to the family diet gradually over several months. Contrarily, with abrupt weaning, the newborn is immediately served meals with the family. The drawback of this approach is that the infant may not be able to eat more adult food to support their nutritional needs (Onofiok & Nnanyelugo, 1998).

Nuts have been a staple in the diets of many nations and civilizations because of their

enormous diversity of flavours and unique taste. Due to its distinctive nutritional makeup, tree nuts have also been associated with several health benefits in recent years. Edible nuts are reported to have an abundance of monounsaturated and polyunsaturated fatty acids (UFAs), as well as a wide range of amino acids, vitamins, phytosterols, minerals, and a significant amount of fibre. Including nuts in a balanced diet has been associated with a reduced risk of cardiovascular disease and mortality (Kris-Etherton *et al.*, 2001; Ros *et al.*, 2010), particularly in cases of stroke (Estruch *et al.*, 2013), it also decreased risk of metabolic syndrome (Fernández-Montero *et al.*, 2013); (Mitjavila *et al.*, 2013) and diabetes (Kendall *et al.*, 2011). In addition, nuts have been shown in several studies to increase bone mineral density, promote mental health (Carey *et al.*, 2012); (Herbison *et al.*, 2012) and decrease blood pressure (Rivas *et al.*, 2013); (Sanhueza *et al.*, 2013). Nut consumption over an extended period has also been linked to a lower risk of weight gain and obesity (Bes-Rastrollo *et al.*, 2009).

Glycine max (L) merr, a germ belonging to the *Leguminosae* or *Fabaceae* family, is the source of soya beans. The soya bean is called the 20th century's "super legume" or the "Golden bean." It is an excellent source of high-quality proteins, fibres, and unsaturated fatty acids. In extremely minute concentrations, saturated fatty acids are present in soya beans, while trans fatty acids are absent. Soya beans contain omega-3 and omega-6 fatty acids, such as alpha-linolenic acid (7–8% of total fat) and linoleic acid (56 % of total fat). Iron, phosphorus, magnesium, vitamin B2 (riboflavin), and folate are abundant in cooked soya beans. It is among the best vegetarian sources of complete protein since it has every important amino acid that a person's diet needs. According to (Rivas *et al.*, 2013), frequent soya bean food preparations include "edamame" (whole soya bean), soya flour, soya milk, "tofu" (fermented soya bean paste), soya bean oil, soya bean lecithin, and soya sauce.

Sorghum has poor organoleptic properties and low nutritional value (Moshia, 1990). Lysine and all amino acids containing sulphur are lacking (FAO, 1990). Sorghum has a high mineral content, but its dietary value is primarily determined by its chemical constituents; it

contains a significant quantity of unfavourable antinutritional factors like tannin, phytic acid, polyphenol and trypsin inhibitors, which should be avoided (Elsheikh *et al.*, 2000). Therefore, to increase the dietary quality of Sorghum and competently make use of its whole prospective as an individual diet, eliminating or inactivating such antinutritional chemicals is essential; one option to address this issue is through food processing technologies such as sprouting.

MATERIALS AND METHODS

Materials

Sources of Cashew nuts, Soya beans and Sorghum

The cashew nut, soya beans, and Sorghum were obtained at Maiduguri Monday Market and were identified and authenticated by a seed breeder at the University of Maiduguri, Borno State, Nigeria.

Source of Commercial Complementary Food

The commercial complementary food, Checkers' custard®, was purchased from a supermarket (Gumalti store) in Maiduguri, Borno State.

Methodology

Preparation of Cashew nut

Nuts that were healthy and dry were steamed for 45 minutes at 115°C. After being precooked, the nuts were divided into equal halves using a manually operated dehuller and allowed to cool for 48 hours at room temperature. The almonds inside the shells were extracted using tiny blades, and they were oven-dried for two hours at 85 °C. The nuts were chilled, ground, and sieved to produce fine flour by AOAC (2012) after being dried at 65 °C for six hours to reduce the moisture content to 5–6 %.

Preparation of Soya beans

Soya beans were sorted to remove any extraneous objects. After weighing it, it was submerged in tap water for roughly 30 seconds to help with the grain's dehulling, which was accomplished with a mortar and pestle. To make fine flour, the dehulled soya beans were roasted in a frying pan for three to four minutes, then ground and sieved.

Preparation of Sorghum

Sorghum was sorted to remove extraneous objects and broken grains. Two sections of the Sorghum were separated. Fine flour was obtained by washing, drying, milling, and sieving the initial portion. The remaining

Sorghum was soaked in water, the water was poured out, the Sorghum was put in a plastic bucket, and it was spread out on a grease-free tray to sprout for 72 hours. The sprout was kept in a sterile tray and dried for three days.

For 72 hours, the sprout was submerged in water around three times its weight in volume. To create fine flour, the fermented grain was cleaned, let to dry in the sun for three days, and then ground and sieved (Kulkarni *et al.*, 1991).

Formulation of the Complementary Food Blends

The complementary food blends were formulated using cashew nuts, soybean beans, and Sorghum in the following ratios. The Pearson square method is used to determine the ratio.

1. 65 parts of Unprocessed (raw) Sorghum and 35 parts of vitamin and mineral supplement, i.e. 65:35 RSVM.
2. 65 parts of Processed Sorghum and 35 parts of vitamin and mineral supplement. i.e. 65:35 PSVM.
3. 85 parts of Processed Sorghum and 15 parts of Cashew Nuts, i.e. 85:15 PSC
4. 52 parts of Processed Sorghum and 48 parts Soya Beans, i.e 52:48 PSSB
5. 45 parts of Processed Sorghum, 45 parts of Soya Beans and 10 parts of Cashew Nuts, i.e. 45:45:10 PSSBC
6. 45 parts Processed Sorghum, 10 parts Cashew Nuts, 30 parts Soya Beans and 15 parts vitamin and mineral supplement, i.e. 45:10:30:15 PSCSBVM

Determination of Proximate Analysis.

The following methodology for each of the stated parameters is provided below. Proximate analysis was performed by standard procedures described by AOAC (2012) to determine the moisture content, ash content, crude protein, crude fibre, fat content, as well as carbohydrate composition (nitrogen-free extract) of the samples:

Determination of Moisture Content (Oven Dry Method)

Principle

This process is based on moisture loss while drying at 105 °C in the oven. In addition to water, additional volatile materials at 105 °C will also be lost.

Procedure

A spotless silica flat dish was cooled in desiccators and dried in an oven. Weighing the chilled dish (W1). A five-gram sample was added, evenly distributed over the dish, and precisely weighed (W2). Using a pair of tongs, the dish and its contents were placed into an air

oven set at 105 °C to dry for three hours. Before being weighed, the dish was placed inside a desiccator and allowed to cool. The dish was weighed after being placed back in the oven for 30 minutes and allowed to cool in the desiccators. This process was repeated until a consistent weight was reached (W3).

$$\text{Moisture content} = \frac{(W2 - W1)}{(W2 - W1)} \times 100 \quad (1)$$

Where W_1 = weight of dish alone

W_2 = weight of dish + sample

W_3 = final content weight of dish + sample

Determination of Ash Content (Gravimetric method)**Principle**

In the oven, the food's organic content burned out. Ash, which is made up of inorganic components in the form of their oxides, was the leftover.

Procedure

After being cleaned, lit, and allowed to cool (in a desiccator), a silica dish was weighed (W1).

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} \times 100 \quad (2)$$

Determination of Fibre Contents (AOAC, 2012)

After weighing two grams (2 g) of the sample, it was put into a 250 ml fast conical flask, 100 ml of the digestion mixture was added and refluxed for 45 minutes while being shaken occasionally. A light suction was used to filter the mixture through ashless filter paper. Following a wash with 100 mL of boiling water, 50 mL of alcohol, and 50 mL of petroleum ether, the sample's filter ;

$$C = b - a \quad (3)$$

$$F = e - d \quad (4)$$

$$\% \text{ crude fibre} = \frac{C - F}{2g} \times 100 \quad (5)$$

b= weight of paper +residue

a= weight of paper alone

C=b-a = weight of residue

e= weight of dish + ash

d= weight of dish alone

Five grams of the test material (labelled W2) were precisely weighed and placed straight into the silica dish. The weighed sample was put in a muffle furnace with a temperature setting of 500°C and turned until the ash turned grey, using a pair of tongs to remove it. The dish containing the ash was taken out of the furnace and allowed to cool in a desiccator prior to being weighed (W3).

paper was dried at 100 degrees Celsius to maintain its weight. Weighing the filter paper allowed us to determine the residue's weight.

After adding the residue, the crucible was weighed and ashed at 600 degrees Celsius for four hours in a muffle furnace. The crucible was then removed and allowed to cool in a desiccator before being weighed again. The relationship below was used to compute the proportion of crude fibre:

F=e-d=weight of ash

C-f = weight of crude fibre

Determination of Fat content (Soxhlet Extraction Method)

Principles:

Fat is measured using a gravimetric method from a dry powdered material continuously extracted using a mild organic solvent (petroleum ether, 40–60°C).

Procedure:

Using a weighing dish, five grams (5g) of the sample were precisely weighed (W). Before the extractor was installed on the flat bottom flask, it was weighed (W₁). After carefully transferring the weighed sample into the thimble, the thimble

was held halfway inside the extractor. After being cleaned with petroleum ether, the weighing dish was placed within the thimble. Cotton wool was used to plug the thimble before completely submerging it in the extractor. After that, the solvent was added until it filled the flask to about two-thirds of its capacity, and the extraction process continued for five hours. After the extraction process, the solvent was evaporated over a water bath at 60 degrees Celsius, and the residue was dried. After cooling, the flask and residue were weighed (W₂).

$$\% \text{ Fat} = \frac{(W_2 - W_1)}{W} \times 100 \quad (6)$$

Where: W = weight of sample
W₁ = weight of flat bottom flask
W₂ = weight of flask and residue

Determination of Protein Content (Kjeldahl method)

Principle

This approach would incorporate nitrogen from proteins, alkaloids, nucleic acids, etc., instead of nitrogen from nitrites and nitrates. With the aid of a catalyst, concentrated sulfuric acid oxidized the organic materials, converting the nitrogen to ammonium sulphate.

Protein determination involves three major stages; they include:

- Digestion
- Distillation
- Titration

Digestion of sample

Twenty millilitres (20 ml) of sulphuric acid were added to a digesting tube (Kjedahl digestion tubes) containing two grammes (2 g) of material. After being connected, the digester was left to operate for three hours. Fifty millilitres (50 ml) of 40% NaOH will be added, and distilled water will be used to get up to 100 ml.

Distillation

Three droplets of bromocresol and methylene indicator were introduced to a conical flask containing five millilitres (5 ml) of 2% borate.

Five millilitres (5 ml) of the digested sample through the funnel were put into the distillation flask, and twenty (20 ml) of 40% NaOH was added. Every intake was shut off. 75 cc of the distillate was collected into the conical flask, which held the borate and mixed indicators after being positioned at the distillation unit's extended tube (output). 1M HCl was used as the standard titration solution.

Standardization of HCl

A solution containing five millilitres (5 ml) of ammonium was pipetted and distilled using about 15 ml of 40% NaOH solution. The ammonia that had been released was gathered in a conical flask together with four drops of mixed indicator and five millilitres (5 ml) of 2% boric acid. The usual 0.1m HCl was used to titrate the ammonia solution. The acid factor that will be used to calculate the crude protein content is the amount of HCl needed for the titration.

The percentage protein was calculated using the formula:

$$\% \text{ Protein} = \frac{A \times N \times F \times 14.007}{\text{weight of sample} \times \text{aliquot}} \quad (7)$$

Where; A= Volume of the acid used
N =Molarity of the acid
F=Factor 6.25

Determination of Carbohydrate Content (By difference)

Differences found after deducting total crude protein, fat, ash, and crude fibre from total dry matter were used to calculate the carbohydrate (nitrogen-free extract) content (AOAC, 2012).

Determination of total Energy Content (Formula Method)

The total energy value was determined according to the method of Mohgoub (1999) using the formula:

Total energy (Kcal/100g) = (% available carbohydrate x 4)×(% protein x 4) + (% fat x 9)

DATA ANALYSIS

Every determination was made three times. Using IBM SPSS statistic version 21.0, the obtained data were subjected to Analysis of Variance (ANOVA), and the means were compared using Duncan's multiple range test. Acceptable significance was set at (P<0.05).

RESULTS

Table 1: Proximate Composition of Raw and Processed Sorghum, Soya beans and Cashew nut

Components (%)	Samples					
	Sorghum		Soya beans		Cashew nut	
	Unprocessed	Processed	Unprocessed	Processed	Unprocessed	
Processed						
Moisture	4.61±0.03 ^b	5.78±0.02 ^a	6.37±0.02 ^a	4.21±0.02 ^b	4.20±0.01 ^a	2.70±0.01 ^b
Ash	2.18±0.03 ^a	0.50±0.01 ^b	4.91±0.01 ^b	5.03±0.01 ^a	4.01±0.02 ^a	3.04±0.03 ^b
Protein	6.97±0.01 ^a	7.77±0.04 ^a	35.1±0.02 ^a	30.6±0.70 ^b	39.0±0.04 ^b	31.5±0.25 ^a
Fat	2.03±0.03 ^a	1.51±0.02 ^a	29.4±0.21 ^b	32.4±0.20 ^a	29.9±0.40 ^b	33.6±0.01 ^a
Fibre	1.17±0.02 ^a	0.99±0.01 ^b	4.58±0.03 ^a	3.16±0.03 ^b	1.99±0.01 ^b	2.72±0.02 ^a
Carbohydrate (nitrogen-free extract)	83.1±0.05 ^a	83.5±0.06 ^a	19.6±0.18 ^b	24.6±0.71 ^a	30.9±0.45 ^a	26.4±0.20 ^b
Total Energy (Kcal/100g)	376.31±1.97 ^a	378.47±0.21 ^a	483.77±1.19 ^b	512.33±1.06 ^a	508.43±1.78 ^b	534.34±0.13 ^a

Values with different superscript along the row are significantly (P<0.05) different Values are recorded as mean ± SEM, n=3

Table 2: Proximate Composition of Complementary Food Blends

Component s (%)	Complementary Food Blends							
	RSVM	PSVM	PSC	PSSB	PSSBC	PSCSBV M	STD	RDA
Moisture	4.17±0.02 ^e	4.57±0.01 ^c	4.57±0.01 ^c	5.03±0.04 ^b	5.04±0.04 ^b	4.47±0.01 ^d	7.43±0.02 ^a	-
Ash	8.78±0.03 ^d	7.84±0.02 ^e	9.29±0.03 ^b	8.96±0.02 ^c	10.6±0.02 ^a	5.42±0.01 ^f	0.99±0.06 ^g	-
Protein	17.2±0.01 ^e	18.2±0.01 ^d	16.8±0.01 ^f	21.3±0.01 ^c	23.1±0.04 ^b	25.8±0.03 ^a	6.63±0.02 ^g	12-44
Fat	4.03±0.04 ^b	3.50±0.01 ^c	3.93±0.02 ^b	2.06±0.07 ^e	2.35±0.03 ^d	6.20±0.06 ^a	0.50±0.02 ^f	10-25
Fibre	5.53±0.02 ^e	6.39±0.01 ^c	5.62±0.01 ^d	6.53±0.02 ^b	6.61±0.01 ^a	6.53±0.02 ^b	0.81±0.01 ^f	-
Carbohydrate (nitrogen-free extract)	60.3±0.01 ^b	59.6±0.03 ^d	59.8±0.02 ^c	56.1±0.06 ^e	50.0±0.01 ^g	51.6±0.03 ^f	83.6±0.03 ^a	-
Total Energy(Kcal/100g)	346.4±0.39 ^a	342.5±0.0 ^{7a}	341.9±0.21 ^a	328.3±0.31 ^a	365.7±39.1 ^a	364.9±0.62 ^a	265.4±0.2 ^{0b}	-

Value are mean ± SEM, n=3

Values with different superscript along the row are significantly different (P<0.05)

RSVM- 65 parts of unprocessed (raw) sorghum and 35 parts of vitamin and mineral supplements

PSVM- 65 parts of processed sorghum and 35 parts of vitamin and mineral supplements

PSC- 85 parts of processed sorghum and 15 parts of cashew nut

PSSB- 52 parts of processed sorghum and 48 parts of soya beans

PSSBC- 45parts of processed sorghum, 45 parts of soya beans and 10 parts of cashew nuts

PSCSBVM- 45 parts of processed sorghum, 10 parts cashew nut, 30 soya beans and 15 parts vitamin and mineral supplement

STD- Checkers' Custard®

RDA- Recommended Dietary Allowance

DISCUSSION

Proximate Composition

The high moisture content observed in processed sorghum could result from the processing methods (sprouting and fermentation). This result varied slightly from that stated by (Raihanatu *et al.*, 2011). The stated difference could be due to differences in cultivars and environmental factors. The low moisture content of processed soya beans and processed cashew nuts is an advantage because it allows seed to be stored longer (Ogbemudia *et al.*, 2017). The decreased ash content of processed sorghum and processed cashew nut might be due to processing. However, the percentage ash content falls within the ranges (5-10 %). (Lokuruka, 2010) reported that soya beans have an ash content of about 5 %, supporting this research's findings. A protein content of 35.11 % was obtained in unprocessed soya beans, and this tallies with the finding of (Ogbemudia *et al.*, 2017), who

reported similar values of 37.69 %. The processed sorghum had more protein content than the unprocessed sorghum. The complementary food blends had a lower moisture content than the commercial complementary food, checkers' custard®. The results of the proximate composition obtained in this study were similar to those reported by (Oppong *et al.*, 2015). All the complementary food blends' moisture content was within the acceptable limit of not more than 10%. The moisture content of a food is influenced by the type of food, food variety and the storage condition (Oppong *et al.*, 2015). The low moisture content of the complementary food blends enhances its storage stability by preventing mould growth and reducing biochemical reactions (Singh, *et al.*, 2005). Consequently, complementary food blends with low moisture content will have a good shelf life (Modu *et al.*, 2012). Ash content indicates a food's mineral content (Kavitha &

Parimalavalli, 2014). The ash content of the complementary food blends (5.42 % to 10.63 %) was above the commercial complementary food (0.99 %). This suggests that the complementary food blend PSSBC (10.63 %) could be a better source of minerals than the other complementary blends. The percentage crude protein content of the complementary food blends ranged from 16.80 % to 25.75 %. The protein content of PSCSBVM and PSSBC reported in this study was higher than that of the other blends. This is because the presence of soya beans and cashew nuts in the formulation considerably increased the protein content. Checkers' custard® had the lowest protein content compared with all the complementary food blends. The fat content of the complementary food blends ranged from 2.06 to 6.20 %, which was generally low. This might be due to the science that cereals, legumes and tubers store energy as starch rather than lipids (Iwe *et al.*, 2016). The fat content of checkers custard® is 0.50 %, lower than all the sample blends. The fat content of the complementary food blends and the Checkers' custard® did not reach infants' RDA value (10-25 %). The complementary food blend PSCSBVM (6.20 %) was close to the RDA value. The fibre content of checkers' custard® (0.81 %) was the lowest compared to all the complementary food blends. PSSBC had the highest crude fibre content (Oppong *et al.*, 2015).

CONCLUSION

The processing methods adopted in this study (combined sprouting/fermentation of sorghum, toasting of soya beans and cashew nuts) considerably reduced the antinutrients and improved the nutrient quality. The complementary food blends, PSCSBVM and PSSBC, have adequate protein quality and can be used to reduce the problems of protein-energy malnutrition, which is widespread in developing countries.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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