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Research Article

Proximate assessment and bioassay of breakfast cereals produced from blends of acha (Digitaria exilis), mungbean (Vigna eadiata) and cashew nut (Anarcadium occidentale Linn) flours

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ABSTRACT

Breakfast cereals were formulated from blends of acha, fermented mungbean and cashew nut (undefatted and defatted) flours. The undefatted and defatted cashew nut flours were used at different levels of substitution (10, 20, 30, 40 and 50 %) with the best blend of acha and mungbean (80:20) flour which was determined by sensory evaluation. Breakfast cereals were produced by toasting (170 oC) a dry heat treatment process to gelatinize and semi-dextrinize the starch in order to generate dry ready to eat products. The samples were subjected to proximate and bioassay analyses. The breakfast cereal was used for a four week bioassay study using eighty four (84) healthy male albino rats weighing 60 - 90 g. The proximate composition showed: crude protein 10.24-20.10 %, moisture content 6.01-8.07 %, crude fat 3.60-24.51 %, crude fibre 4.02-7.07 %, ash 3.39-4.80 % and carbohydrate 46.4-68.08 %. Feed intake was measured daily while weight gain was measured weekly. Results after the study showed; feed intake 234.22 – 344.55 g, weight gain 34.14 – 80.25 g, feed efficiency 0.14-0.25 and protein efficiency 0.99-1.89. Feeding experiment showed positive increase in weight when the rats were fed the formulated breakfast products. This implies that the

products could support growth. No adverse growth rate was observed. Feed intake was also acceptable and compared well with the stable diet for rats. Feed efficiency of the samples compared well with the control diet.

INTRODUCTION

Breakfast is the nutritional foundation or the first meal of the day. It is considered the most vital meal of the day. According to Sharma and Caralli (2004), breakfast cereal is defined as any food obtained by swelling, roasting, grinding, rolling or flaking any cereal. Despite being consumed dry in the early hours of the morning, breakfast cereals provide a good source of energy, which is a vital requirement of the human body. Nonetheless, the value of breakfast cereal is undeniable in this age of fast living, rapid urbanization, and above all, a health-conscious society (Janvekar, 2010). Ready-to-eat breakfast cereals are gradually displacing most conventional breakfast diets in most developing countries. They are popular among urban dwellers because of their convenience, nutritional value, increased income, status symbol, and job demands (Usman, 2012). Breakfast cereals now offer a variety of options for meeting today's recommendations for people of all ages to improve their whole grain intake. Cereals, on the other hand, are the most common breakfast products (Sharma and Caralli, 2004).

Acha (*Digitaria exilis*) is a West African grass also known as fundi, fonio, hungry rice, fonio blanc and petit mil. Acha, though neglected, is probably the oldest African cereal (Ayo and Nkama, 2004). Acha could not keep up with the latest international cereals, which were made particularly convenient for consumers by the use of mills and processing, due to a lack of interest and support from authorities (mostly non-African colonial authorities, missionaries, and agricultural researchers). The old grains languished and were primarily used as a food source for the poor and in rural areas (Ayo and Nkama, 2004). The acha cereal grain has been named one of the world's most fascinating plants. The proteins in acha grains (8–11 %) are not easily extractable. Their digestibility, on the other hand, outperforms sorghum and millet. Due to its rich in methionine and cysteine content, acha is considered one of the most nutritious grains (Jideani, 1997; Jideani et al., 1994). It may have essential functional properties due to the high levels of residue protein in it. Acha is also a delicious cereal that is regarded as one of the best in the world (NRC, 1996). The acha can benefit greatly from this combination of nutrition and flavour.

Mung bean (*Vigna radiata*), also known as green gram, is a tropical legume that is primarily grown in Asia and also Nigeria. Mungbean is a great source of high-quality protein and one of the cheapest and richest plant protein sources (Akaerue and Onwuka, 2010). It is high in amino acids, especially lysine and thus can be used to complement human diets that are primarily focused on cereals.

Cashew nut meal has recently been approved for use in poultry, especially layers, in addition to human consumption. Cashew seeds' main products are the kernels, which have nutritional and economic value as confectionary nuts (Ogungbenle, 2014). The nuts have long played an important part of the meals of many cultures and civilisations, because of their great nutritional content, their broad variety of taste and distinct flavours and high energy value.

Researchers and policymakers overlook many of the underutilized food crops native to third-world countries, especially Nigeria. These underutilized crops, on the other hand, may have a lot of potential particularly in terms of improving food quality and thus people's nutrient intake. One of the best ways to minimize nutritional, environmental and financial vulnerability in times of change is to increase the use of underutilized crops (Pasiecznik and Jaenicke, 2009).

From the foregoing, it is clear that some of these locally available cereals and legumes, which are cultivated in large quantities, can be used to formulate products, thus highlighting the raw materials' other utility potentials (Mbaeyi, 2005). As a result, the aim of this project was to formulate a breakfast cereal with acha, mungbean and cashew nut flour in its defatted and undefatted form. This would be accomplished by fermenting the legume (mungbean) in order to impart those desirable qualities. This project aims to raise public awareness about the nutritional benefits of defatted and undefatted cashew nut flour and to provide useful information on how to use it effectively in a variety of food applications

MATERIALS AND METHODS

Procurement of raw materials

The grains of acha (*Digitaria subtilis*) were purchased at the Ogbete market in Enugu State. Mungbean (*Vigna radiata*), cashew nut (*Anacardium occidentale Linn*) were purchased from Obollo-afor market while salt, and sugar were purchased from Ogige Market in Nsukka, Enugu State, Nigeria.

Sample preparation

At the beginning acha grains, mungbean seed and cashew kernels were properly sorted and cleaned to extract stones, weeviled seeds, and other foreign matter.

Processing of acha into flour

With a slight modification, the procedure mentioned by Agu et al., (2015) was used. 5 kilograms of cleaned and sorted acha were thoroughly washed and drained. To make the flour, the acha was dried in a hot air oven, milled, and sieved through a 1mm pore size sieve. The flour was stored in a transparent airtight container until it was required. Figure 1 depicts the flow diagram for the development of acha flour.

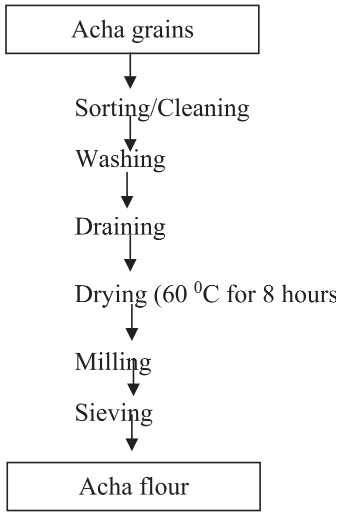

Figure 1. Flow diagram for acha flour production. (Agu et al., 2015)

Processing of mungbean into flour

The procedure described by Enwere (1998) was used with minor modifications. 5 kilograms of mungbeans were cleaned, sorted, and thoroughly washed with clean water before being fermented for 12 hours, then boiled for 30 minutes, cooled and dehulled. To make flour, dehulled mungbeans were dried in a hot air oven, milled and sieved through a 1mm pore size sieve. The flour was held in a clear, airtight container until it was required. Figure 2 depicts the flow diagram for the processing of mungbean flour.

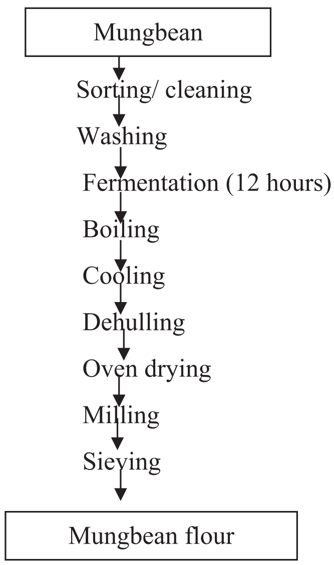

Figure 2. Flow diagram for production of mungbean flour. (Enwere, 1998)

Processing of cashew nut into flour

The modified methods of Badje et al., (2018) was used. A total of 10 kilograms of cashew kernels were cleaned, sorted for discolored kernels and insect damage, and divided into two equal parts. The cashew kernels were milled separately using a blender. One portion of the flour was sieved through a 0.4mm sieve and left as undefatted flour. The defatted flour was made from the remaining part. By continuous maceration for 30 minutes, the flour was de-oiled twice using an apolar solvent (hexane) and the flour/solvent ratio (w:w). The supernatant containing the oil and hexane mixture was removed after 24 hours of incubation, and the remaining cakes were collected in a muslin cloth and pressed. The defatted oil cakes were air dried to remove the solvents, then oven dried for 1 hour at 65 °C to remove all of the solvents. The defatted flour is then held at room temperature in an airtight jar. The flow diagram for the production of cashew nut flour is shown in Figures 3 and 4.

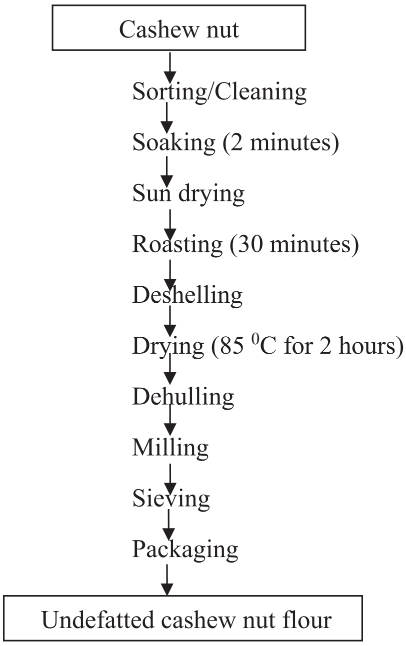

Figure 3. Flow Chart for production of undefatted cashew nut flour. (Badje et al., 2018)

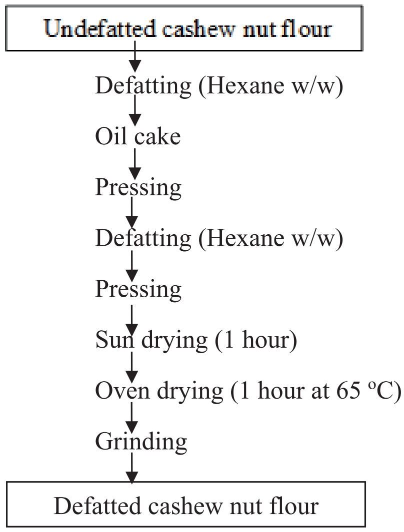

Figure 4. Flow chart for production of defatted cashew nut flour. (Badje et al., 2018)

Product formulation and production of breakfast cereals

The best blend of acha and mungbean flour was determined using sensory evaluation after composite flour was formulated by mixing acha and mungbean flour. The composite flour (made of acha: mungbean flours) was mixed with graded levels of undefatted and defatted cashewnut flour (100:0; 90:10; 80:20; 70:30; 60:40; 50:50), sugar, salt, and water to make 11 breakfast cereal samples and toasted at 170 °C with continuous stirring till dried products were obtained (Figure 5). A control sample was produced from 100 % acha and mungbean composite flour as shown in Table 1.

Production of Breakfast Cereals

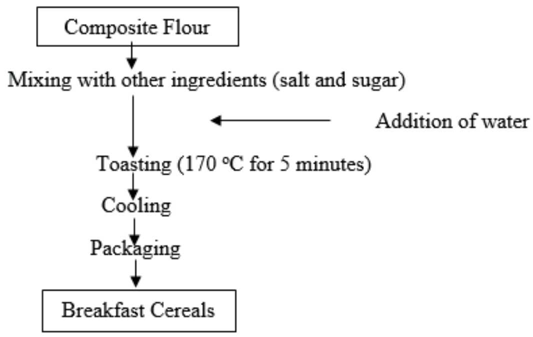

Figure 5. Flow chart for the production of breakfast cereal. (Usman, 2012)

Analysis of Samples

The proximate composition of the blended samples were examined using AOAC, 2010. A bioassay was done using albino rats to determine the bioavailability of protein in comparison with a control (commercial product).

Proximate Analysis of the Samples

Determination of Moisture Content

Clean crucibles were dried for 1 hour in a hot air oven at 100 oC and then cooled in a desiccator to achieve a constant weight. Two grams of each of the samples were weighed into the different crucibles and dried for four hours at 105oC to ensure that the weights were constant. Loss in weight of the samples were recorded and the moisture content was calculated as:

$$\%\ \text{Moisture Content} = \frac{\text{weight loss}}{\text{Sample weight}} \times \frac{100}{1}$$

Determination of crude fat

A Soxhlet extractor was mounted, along with a reflux condenser and a 500 ml round bottom flask. A labeled thimble was used to measure two grams of the sample. The round bottom flask was filled with petroleum ether (300 ml), and the extractor thimble was plugged with cotton wool. After allowing the Soxhlet apparatus to reflux for about 6 hours, the thimble was removed. Petroleum ether was collected for re-use. The flask was dried for 1 hour at 105 °C in an oven, then cooled in a dessicator before being weighed. The percentage fat was calculated as:

$$\%\ \text{Fat} = \frac{\text{Weight of fat}}{\text{Sample weight}} \times \frac{100}{1}$$

Determination of crude protein

After putting 2 g of the sample in a Kjeldhal flask, the flask was filled with anhydrous sodium sulphate (5 g of Kjeldhal catalyst). In addition to a few boiling chips, concentrated sulphuric acid (H2SO4; 25 ml) was added. In a fume chamber, the flask was heated until a clear solution was obtained. The clear solution was moved into a 250 ml volumetric flask and filled up to the mark with distilled water after cooling at room temperature.

Distillation: The apparatus was set up after cleaning the distillation unit volume. A 100 ml conical flask was filled with five milliliters (5 ml) of 2 % boric acid solution and three drops of methyl red indicator. 5 ml of the sample digest was pipetted into the apparatus and washed down with distilled water after placing the conical flask under the condenser. In addition, 5 ml of 60 % NaOH was added to the digest. 100 ml of the sample was stored in the receiving flask after it was heated. The content was titrated with

Table 1. Composite flour formulations for breakfast cereals made from acha, mungbean, undefatted and defatted cashew nut flour blends

Sample	Sample Code	Code Ratio	Percentage
ACMB	AC+MB	100: 0	100% AC + MB, 0%DCN/UCN
$AMDN_1$	AC+MB: DCN	90: 10	90 % AC+ MB, 10 % DCN
$AMDN_2$	AC+MB: DCN	80: 20	80 % AC + MB, 20 % DCN
$AMDN_3$	AC+MB: DCN	70: 30	70 % AC + MB, 30 % DCN
$AMDN_4$	AC+MB: DCN	60: 40	60 % AC + MB, 40 % DCN
$AMDN_5$	AC+MB: DCN	50: 50	50 % AC + MB, 50 % DCN
$AMUN_1$	AC+MB: UCN	90: 10	90 % AC + MB, 10 % UCN
$AMUN_2$	AC+MB: UCN	80: 20	80 % AC + MB, 20 % UCN
$AMUN_3$	AC+MB: UCN	70: 30	70 % AC + MB, 30 % UCN
$AMUN_4$	AC+MB: UCN	60: 40	60 % AC + MB, 40 % UCN
$AMUN_5$	AC+MB: UCN	50: 50	50 % AC + MB, 50 % UCN

AC= Acha; MB= Mungbean; DCN= Defatted Cashew nut Flour; UCN= Undefatted Cashew nut Flour

0.04 M H_2SO_4 and the desired end point, which was pink in color was achieved. The nitrogen percentage was determined using the following formula:

$$\% = \frac{T \times 14.01 \times 0.01 \times \text{dilution factor}}{2.0 \times 1000} \times \frac{100}{1}$$

Where, T= Titre value;

2 .0 g = Weight of the sample;

0.01 = Molarity of HCl;

14.01 = Atomic mass of nitrogen;

% protein = % N × 6.25

Where; 6.25 = Conversion factor of protein.

Determination of total ash

Two grams of well-blended samples were weighed into a shallow ashing dish (crucible) that has been ignited, cooled in a desiccator, and weighed after reaching room temperature. The crucibles and their contents were heated to 550 oC in a muffle furnace. The ashing took 8 hours to complete. The ashed samples were removed from the muffle furnace, moistened with a few drops of water to expose un-ashed carbon, dried in the oven at 100 oC for four hours. The crucibles were removed from the muffle furnace, cooled in a desiccator, and weighed after reaching room temperature. Percentage ash was calculated using the expression:

$$\%\ \text{Ash} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of crude fibre

3 grams of the sample was placed in a 50 ml beaker, fats were extracted with petroleum ether by stirring, settling, and decanting three times. Before being transferred to a 60 ml dried beaker, the sample was air dried. After adding 200 ml of 1.25 H_2SO_4, a few drops of anti-foaming agent were added to the beaker. This beaker was placed on the digestion apparatus using a pre-adjusted hot plate and boiled for 30 minutes with frequent rotating of the beaker in order to prevent solid adhesion to the sides of the beaker. The mixture was allowed to settle for 1 minute before being filtered through a Buchner funnel. The insoluble substance was washed away with boiling water without breaking the suction until it was acid free. The residue was then rinsed back into the original flask with a wash bottle containing 200 ml NaOH solution. It was quickly boiled for another 30 minutes with the same precautions as before. It was filtered under suction after 30 minutes after being allowed to stand for 1 minute. The residue was washed with boiling water first, then 1 % HCl acid, and then boiling water again until it was acid-free. It was then moved to an ash dish and dried at 100 °C to a constant weight after being washed twice with alcohol and three times with ether. This dried residue was incinerated at 600 oC for 30 minutes before cooling in a desiccator and being weighed. The fibre content was calculated as a difference between the incinerated residue and the oven dried residue and expressed in percentage as shown:

$$\%\ \text{Crude fibre} = \frac{\text{weight after oven dried} - \text{weight after incineration}}{\text{Total weight of sample taken}} \times \frac{100}{1}$$

Determination of carbohydrate content (by difference)

The carbohydrate content was calculated using the difference method.

$$\%\ \text{Carbohydrate} = 100 - \%\ (\text{moisture} + \text{protein} + \text{ash} + \text{crude fibre})$$

Bioassay

The breakfast cereal was used for 28 days bioassay study using 84 healthy male albino rats weighing 60 - 90 g. The rats were divided into twelve groups (seven per group) including a control group. The albino rats were housed in well ventilated cages containing wood shaving for bedding. The rats were allowed to acclimatize for seven days and were maintained with the breakfast cereal and tap water under room temperature.

Determination of feed and water intake

Feed intake was determined using the slightly modified method described by Kamau et al., (2017). The quantity of feed and water consumed was calculated daily based on quantity of feed and water supplied the day before and the quantity left after 24 hours.

Determination of weight gain/growth rate

Weight gain was determined by slightly modifying the method described by Kamau et al., (2017). Body weights were taken before starting dosing, once every seven days, and on the last day of the study. A digital top loader balance was used to determine the body weights. The difference between the original and final body weight was used to calculate weight gain.

Feed Efficiency Ratio (FER)

The feed efficiency ratio was calculated using the formula suggested by FAO (2011). Feed efficiency ratio was expressed as:

$$\text{FER} = \frac{\text{weight gain (g)}}{\text{feed intake (g)}}$$

Protein Efficiency Ratio (PER)

The Protein Efficiency Ratio (PER) was calculated using the formula suggested by FAO (2011). Protein efficiency ratio was expressed as:

$$\text{PER} = \frac{\text{feed intake (g)}}{\text{gram of proteinin diet(g)}}$$

Experimental design and data analysis

Experimental design and data analysis was carried out in accordance with the method described by Onuh et al., (2019). The experiment was designed using a totally randomized method (CRD). Statistical Product for Service Solution (SPSS) version 23.0 was used to analyze the data using one-way analysis of variance (ANOVA) and Duncan multiple range test (p=0.05) to separate the means.

RESULTS AND DISCUSSION

Plates 1 – 4 show the single flours from acha, mungbean and cashew nut (defatted and undefatted) flours. The formulated breakfast cereals are presented in Plates 5 – 10.

Plate 1: Acha flour

Plate 2: Mungbean

Plate 3: Undefatted cashew nut flour

Plate 4: defatted cashew nut flour

Plate 5: Sample ACMB

Plate 6: Sample AMDN2

Plate 7: Sample AMDN3

Plate 8: Sample AMDN5

Plate 9: Sample AMUN1

Plate 10: Sample AMUN5

KEY:

ACMB = 80 % acha and 20 % mungbean flour

AMDN2 = 80 % ACMB and 20 % defatted cashew nut flour

AMDN3 = 70 % ACMB and 30 % defatted cashew nut flour

AMDN5 = 50 % ACMB and 50 % defatted cashew nut flour

AMUN1 = 90 % ACMB and 10 % undefatted cashew nut flour

AMUN5 = 50 % ACMB and 50 % undefatted cashew nut flour

Proximate composition of the formulated breakfast cereals from acha, mungbean, defatted and undefatted cashew nut flours

Tables 2 and 3 show the proximate composition of the raw materials and formulated samples. The results showed some significant changes at $p<0.05$.

The proximate composition of acha, mungbean and cashew nut flours is shown in Table 2. The moisture content varied between 4.41 and 8.05 %. The moisture content of the different flours were significantly different ($p>0.05$). Mungbean flour had the highest moisture value (8.05 %) and is lower than the values obtained by Mbaeyi-Nwaoha and Odo (2018) and that obtained by Oburuoga and Anyika (2012); 12.33 and 10.74%, respectively. The moisture content of acha flour is 7.22 %, and is significantly different from the moisture content of the defatted and undefatted cashew nut flours. The lowest moisture content was found in defatted cashew nut flour (4.41 %). This was consistent with the values obtained by Badje et al., (2018) and Emelike et al., (2015) for defatted cashewnut flour (4.2 and 4.4 %). This indicated that defatting reduced the moisture content of raw materials. The different flours with lower moisture content (less than 14%) could have a lower risk of bacterial activity and mould growth, which could cause undesirable changes (Ihekoronye and Ngoddy, 1985).

The amount of ash in the samples ranged from 2.10 to 4.60 %. The highest value (4.60 %) was found in undefatted cashew nut flour, while the lowest (2.10 %) was found in acha flour. The ash content for mungbean and acha flour was comparable to the values (3.23 and 2.25 respectively) reported by Oburuoga and Anyika (2012). The ash content of defatted cashew nut flour (2.71 %) was significantly lower ($p<0.05$) than that of undefatted flour (4.60 %).

The percentage of protein in the samples ranged from 7.05 to 31.04 %. The protein content of acha flour was the lowest (8.05 %). This was comparable to the value obtained by Ayo and Johnson (2018). Mungbean flour had a protein content of 22.08 %. This was higher than the values reported by Setyaningsih et al., (2019) who reported 18.42 % and Mbaeyi-Nwaoha and Odo (2018) who reported 18.92 %, but lower than that reported by Oburuoga and Onyika (2012) which was 31.31 %.

When compared to the undefatted sample (20.78 %), the protein content of the defatted flour (31.04 %) is significantly ($p<0.05$) higher.

According to Aremu et al., (2005), the crude protein content of raw cashew kernels was higher than that of bambara ground nut (11.6 %) and kersting's groundnut (12.9 %). Omosuli et al., (2009) recorded a higher value (27.31 %) for roasted and defatted cashew nut flour. The disparity between these reports may be a result of methods used in processing the cashew nut and the type of raw material.

The crude fat content of acha and mungbean flours were 2.07 and 2.51 %, respectively. This low-fat content could be probably due to the fact that acha and mungbean flours were obtained from cereal and legume which are known to contain little fat. Defatting significantly ($p<0.05$) decreased the crude fat content of cashew nut flour to 19.69 % from 41.37 % in the undefatted sample. These values were comparable with those observed by Badje et al., (2018); Emelike et al., (2015) and Ogungbenle (2014). It is possible that the differences in these reports are due to the processing methods used, variations in raw materials and chemicals used for evaluation.

Crude fibre content ranged from 1.74 and 6.36 %. Acha flour had a crude fibre content of 4.29 % while mungbean flour had a crude fibre content of 6.11 %. When compared to the undefatted sample, the crude fiber content of defatted flour (6.36 %) was significantly ($p<0.05$) different (1.73 %). Owing to the removal of fat, defatted samples have a higher flour volume per unit weight than undefatted samples, leading to the rise in fibre content of the defatted samples (Omowaye-Taiwo et al., 2014).

The carbohydrate content of acha flour was 77.25 % and therefore significantly ($p<0.05$) different than the other flours. Mungbean flour had 57.72 % carbohydrate content. Setyaningsih et al., (2019) reported similar results for mungbean flour (66.25 %) and Ayo and Johnson, (2018) reported similar results for acha flour (81.60 %). The carbohydrate content of the defatted flour 35.78 % and the undefatted flour 26.07 % differed significantly ($p<0.05$). This indicates that the various flours are healthy sources of energy and are capable of meeting the body's daily energy requirements.

Proximate composition of the formulated breakfast cereals from acha, mungbean, defatted and undefatted cashew nut flours

Table 3 shows the proximate composition of formulated breakfast products made from acha, mungbean, defatted, and undefatted cashew nut flours.

The moisture content of the formulated breakfast cereals ranged from 6.01 to 8.07 %. The highest value (8.07 %) was observed in the product containing 10 % undefatted cashew nut flour (AMUN1) while the least value (6.01 %) was observed in the sample containing 50 % defatted cashew nut flour (AMDN5). The moisture content of the samples were significantly different ($p<0.05$). A decrease in moisture content was observed as the addition of undefatted and

Table 2. Proximate composition (%) of acha, mungbean, defatted and undefatted cashew nut flours (dry basis)

Sample	Moisture	Ash	Fat	Protein	Crude Fibre	Carbohydrate
ACH	$7.23^{c}\pm0.19$	$2.10^{a}\pm0.25$	$2.07^{a}\pm0.07$	$7.05^{a}\pm0.11$	$4.29^{b}\pm0.05$	$77.25^{d}\pm0.03$
MBN	$8.05^{d}\pm0.09$	$3.52^{c}\pm0.13$	$2.51^{b}\pm0.08$	$22.03^{c}\pm 0.19$	$6.11^{c}\pm 0.18$	$57.72^{c}\pm 0.02$
UCN	$5.45^{b}\pm0.10$	$4.60^{d}\pm0.04$	$41.37^{d}\pm0.18$	$20.78^{b}\pm0.21$	$1.74^{a}\pm0.06$	$26.07^{a}\pm0.48$
DCN	$4.41^{a}\pm0.16$	$2.71^{b}\pm0.11$	$19.69^{c}\pm0.10$	$31.04^{d}\pm0.27$	$6.36^{c}\pm0.16$	$35.78^{b}\pm0.27$

Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly ($p<0.05$) different. ACH = Acha flour, MBN = Mungbean flour, UCN = Undefatted cashew nut flour, DCN = Defatted cashew nut flour.

defatted cashew nut flours increased. This was in agreement with the works done by Badje et al., (2018) and Ojinnaka and Agubulom (2013) who made bread from defatted cashew nut/ wheat composite flour and wheat/cashew paste cookies, respectively.

The fat content of the formulated breakfast cereals ranged from 3.60 (ACMB) to 24.51 % (AMUN5). There were significant ($p<0.05$) differences in the fat content of the samples. The lowest value (3.60 %) for fat was recorded in the sample (ACMB) without cashew nut flour addition. This could be due to low fat values observed in acha and mungbean flours. The highest value (24.51 %) was recorded in the sample with 50 % undefatted cashew nut flour (AMUN5). As the amount of undefatted and defatted cashew nut flours was increased, the fat content of the samples increased. This could be due to the high fat content of the undefatted (41.37 %) and defatted (19.69 %) cashew nut flours.

Crude protein content of the samples ranged from 10.24 to 20.10 %. The crude protein content of the samples was significantly ($p<0.05$) different. The protein content of sample AMUN1 (10 % undefatted cashew nut flour) was the lowest (10.24 %), while sample AMDN5 (50 % defatted cashew nut flour) had the highest. With the addition of undefatted cashew nut flour, the protein content of the formulated products increased. This could be due to the fact that cashew nuts contain a significant amount of protein. With the addition of defatted cashew nut flour, the protein content of the samples increased as well. This increase in protein was, however, significantly ($p<0.05$) higher than that observed in the undefatted cashew nut flour samples. This could indicate that the presence of

Table 3. Proximate composition (%) of the formulated breakfast cereals from acha, mungbean, defatted and undefatted cashew nut flour blends

Sample	Moisture	Ash	Fat	Protein	Crude Fibre	Carbohydrate
ACMB	7.58^{f}± 0.21	3.39^{a}±0.39	3.60^{a}±0.39	11.61^{c}±0.05	5.74^{d}±0.08	68.08^{k}±0.26
AMDN$_1$	7.32^{ef}±0.27	3.39^{a}±0.25	6.11^{b}±0.06	13.89^{f}±0.04	5.82^{de}±0.06	63.48^{j}±0.49
AMDN$_2$	7.23^{de}±0.05	3.61^{ab}±0.11	7.92^{c}±0.06	14.98^{g}±0.15	5.96^{ef}±0.08	60.31^{h}±0.00
AMDN$_3$	6.92^{c}±0.13	3.82^{bcd}±0.02	9.92^{d}±0.23	17.01^{h}±0.03	6.06^{f}±0.05	56.28^{f}±0.16
AMDN$_4$	6.54^{b}±0.06	4.01^{cd}±0.04	11.82^{f}±0.01	18.61^{i}±0.03	6.78^{g}±0.10	52.24^{d}±0.02
AMDN$_5$	6.01^{a}±0.04	4.15^{de}±0.04	13.09^{g}±0.13	20.10^{j}±0.0.3	7.07^{h}±0.05	49.81^{b}±0.19
AMUN$_1$	8.07^{g}±0.03	3.48^{ab}±0.02	10.85^{e}±0.03	10.24^{a}±0.04	5.70^{d}±0.09	61.40^{i}±0.47
AMUN$_2$	7.86^{g}±0.06	3.71^{abc}±0.03	13.68^{h}±0.14	11.04^{b}±0.09	5.05^{c}±0.05	58.66^{g}±0.13
AMUN$_3$	7.40^{ef}±0.08	4.12^{de}±0.08	17.09^{i}±0.23	11.61^{c}±0.03	4.77^{b}±0.11	55.00^{e}±0.26
AMUN$_4$	7.03^{cd}±0.13	4.46^{e}±0.04	20.71^{j}±0.09	12.99^{d}±0.11	4.15^{a}±0.05	50.68^{c}±0.05
AMUN$_5$	6.89^{c}±0.11	4.80^{f}±0.04	24.51^{k}±0.02	13.39^{e}±0.04	4.02^{a}±0.06	46.40^{a}±0.01

Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly ($p<0.05$) different. ACMB= Breakfast cereal made from 80% Acha and 20% Mungbean flour, AMDN1= Breakfast cereal made from 90% ACMB + 10% Defatted cashew nut flour, AMDN2= Breakfast cereal made from 80% ACMB + 20% Defatted cashew nut flour, AMDN3= Breakfast cereal made from 70% ACMB + 30% Defatted cashew nut flour, AMDN4= Breakfast cereal made from 60% ACMB + 40% Defatted cashew nut flour, AMDN5= Breakfast cereal made from 50% ACMB + 50% Defatted cashew nut flour, AMUN1= Breakfast cereal made from 90% ACMB + 10% Undefatted cashew nut flour, AMUN2= Breakfast cereal made from 80% ACMB + 20% Undefatted cashew nut flour, AMUN3= Breakfast cereal made from 70% ACMB + 30% Undefatted cashew nut flour, AMUN4= Breakfast cereal made from 60% ACMB + 40% Undefatted cashew nut flour, AMUN5= Breakfast cereal made from 50% ACMB + 50% Undefatted cashew nut flour.

oil in the sample causes some protein globules to demobilize (Ogungbenle, 2014). As a result, the removal of fat contributed to an increase in other nutritional parameters like crude protein (Ogungbenle, 2014). This suggests that the sample should be taken defatted, particularly for adults and children who require less fat and more protein.

The ash content of the formulated breakfast cereals showed significant ($p<0.05$) differences with values ranging from 3.39 to 4.80 %. Kanu et al., (2009) observed lower values (1.3-2.3 %) in a porridge-type breakfast cereal made from pigeon pea and sesame seed.

The crude fibre content of formulated breakfast cereals ranged from 4.02 to 7.07 %. The crude fiber content of the samples differed significantly ($p<0.05$). As the amount of undefatted cashew nut flour added increased, the crude fiber content decreased. This could be due to the low crude fiber content observed in the undefatted cashew nut flour. The crude fiber content of the formulated breakfast cereals, on the other hand, increased as addition of defatted cashew nut flour increased. This could be due to the increased crude fiber content of the cashew nut flour as a result of defatting.

The carbohydrate content of the formulated breakfast cereals differed significantly ($p<0.05$), varying from 46.40 to 68.08 %. The carbohydrate content of sample ACMB (80 % acha and 20 % mungbean flour) was the highest (68.08 %). This could be because acha flour, which is a cereal, has a high starch content. Sample AMUN5 (50

Table 4. Effect of the formulated breakfast cereal on the feed intake

Sample	Week 1	Week 2	Week 3	Week 4	Total Feed Intake(g)
RCHW	81.44^{bcd} ±11.27	76.46^{efg}±18.67	74.78^{bcd}±13.57	90.52^{ef}±6.98	323.20
ACMB	74.76^{bc} ±18.72	64.67^{bcde}±7.93	66.31^{abc}±11.99	78.12±9.48	283.86
$AMDN_1$	91.99^{cd}±8.57	85.79^{g}±16.40	78.85^{cd}±17.51	87.92^{ef}±8.75d	344.55
$AMDN_2$	91.62^{cd}±11.23	75.29^{defg}±16.22	64.09^{ab}±11.26	81.45^{cdef}±13.43	312.45
$AMDN_3$	86.20^{bcd}±15.85	69.75^{cdef}±5.10	82.28^{d}±9.51	83.17^{cdef}±13.82	321.40
$AMDN_4$	93.14^{d}±9.81	82.12^{fg}±10.65	71.99^{abcd}±12.33	91.90^{f}±7.18	339.15
$AMDN_5$	79.74^{bcd}±15.89	49.25^{a}±7.49	66.86^{abc}±8.05	77.47^{bcd}±13.37	272.71
$AMUN_1$	74.82^{bc}±21.09	62.44^{abcd}±11.83	76.42^{bcd}±11.07	68.70^{ab}±8.20	282.38
$AMUN_2$	76.88^{bcd}±12.72	67.12^{bcde}±9.61	70.30^{abcd}±10.76	84.22^{cdef}±10.85	298.52
$AMUN_3$	75.24^{bc}±12.99	65.11^{bcde}±4.70	63.18^{ab}±10.70	72.53^{abc}±12.31	276.06
$AMUN_4$	70.0^{ab}±9.74	61.08^{abc}±10.16	58.89^{a}±11.79	67.69^{ab}±8.12	257.66
$AMUN_5$	55.82^{a}±15.64	54.40±8.21^{ab}	60.08±8.85^{a}	63.92±7.83^{a}	234.22

Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly ($p<0.05$) different. ACMB= Breakfast cereal made from 80% Acha and 20% Mungbean flour, AMDN1= Breakfast cereal made from 90% ACMB + 10% Defatted cashew nut flour, AMDN2= Breakfast cereal made from 80% ACMB + 20% Defatted cashew nut flour, AMDN3= Breakfast cereal made from 70% ACMB + 30% Defatted cashew nut flour, AMDN4= Breakfast cereal made from 60% ACMB + 40% Defatted cashew nut flour, AMDN5= Breakfast cereal made from 50% ACMB + 50% Defatted cashew nut flour, AMUN1= Breakfast cereal made from 90% ACMB + 10% Undefatted cashew nut flour, AMUN2= Breakfast cereal made from 80% ACMB + 20% Undefatted cashew nut flour, AMUN3= Breakfast cereal made from 70% ACMB + 30% Undefatted cashew nut flour, AMUN4= Breakfast cereal made from 60% ACMB + 40% Undefatted cashew nut flour, AMUN5= Breakfast cereal made from 50% ACMB + 50% Undefatted cashew nut flour, RCHW= Rat chow

% undefatted cashew nut flour) had the lowest (46.40 %) carbohydrate content. This could be due to the high fat content observed in the sample.

Effect of formulated breakfast cereals on feed intake

The effect of the formulated breakfast cereals on the feed intake of the rats is shown in Table 4 which shows the results of the average weekly feed intake of the experimental animals. The experimental animals consumed between 234.22 and 344.55 g of feed in total. It was observed that the groups fed with samples AMDN1 (90 % ACMB and 10 % defatted cashew nut), AMDN4 (60 % ACMB and 40 % defatted cashew nut) and the commercial control diet consumed more food than the other groups. Rats fed samples AMUN4 (60 % ACMB and 40 % undefatted cashew nut) and AMUN5 (50 % ACMB and 50 % undefatted cashew nut) were observed to have consumed the least quantity of food. This could be due to the fact that samples AMUN4 and AMUN5 had higher portions of the undefatted cashew nut flour and cashew due to its high fat content could increase satiety thereby reducing rate and volume of food consumed. The quantity of food consumed and the composition of the food are factors that determine the nutrition of the consumer (Ikujenlola et al., 2015).

Effect of formulated breakfast cereals on the weight gain/growth rate

Table 5. Effect of the formulated breakfast cereals on weight (grams) gain of the rats

Sample	Initial Weight (g)	Week 1	Week 2	Week 3	Week 4	Weight Gain
RCHW	71.23^{a}±5.98	93.12^{ab}±6.59	115.16^{de}±2.98	194.68 ^{e}±9.64	151.48^{e}±7.68	80.25
ACMB	73.84^{ab}±5.26	86.49^{a}±6.81	95.32^{a}±3.29	102.47^{a}±4.13	107.98^{a}±2.73	34.14
AMDN$_1$	72.31^{ab}±9.08	94.62^{b}±9.62	122.73^{e}±13.33	136.42^{d}±13.61	145.45^{de}±12.90	73.14
AMDN$_2$	72.04^{ab}±8.17	91.93^{ab}±8.91	114.47^{de}±8.48	124.58^{b}±9.76	132.92^{bc}±9.32	60.88
AMDN$_3$	73.03^{ab}±8.47	96.91^{b}±9.2	112.98^{de}±9.45	121.24^{b}±9.20	127.27^{b}±9.59	54.24
AMDN$_4$	72.98^{ab}±11.18	98.09^{b}±10.06	123.05^{e}±12.35	132.01^{cd}±12.3	139.57^{bc}±9.04	66.59
AMDN$_5$	70.60^{a}±5.54	92.20^{ab}±7.87	116.14^{de}±10.26	124.68^{bc}±9.00	132.37^{bc}±9.04	61.77
AMUN$_1$	68.73^{b}±31.80	77.87^{ab}±35.66	110.47^{cd}±8.67	118.47^{b}±8.23	123.23^{b}±9.00	54.50
AMUN$_2$	68.14^{a}±2.69	83.79^{a}±3.12	100.44^{ab}±3.48	106.12^{a}±3.41	109.85^{a}±4.41	41.71
AMUN$_3$	69.91^{a}±7.37	87.64^{ab}±7.39	108.38^{bcd}±6.42	118.85^{b}±11.55	125.82^{b}±11.99	55.91
AMUN$_4$	68.39±4.24^{a}	85.52±7.11^{a}	95.76±6.07^{a}	102.86±5.74^{a}	107.35a±6.11^{a}	38.96
AMUN$_5$	67.34±3.57^{a}	83.33±6.30^{ab}	101.64±6.01^{abc}	105.66±4.94^{a}	110.27±5.83^{a}	42.93

Values are means ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly (p<0.05) different. ACMB= Breakfast cereal made from 80% Acha and 20% Mungbean flour, AMDN1= Breakfast cereal made from 90% ACMB + 10% Defatted cashew nut flour, AMDN2= Breakfast cereal made from 80% ACMB + 20% Defatted cashew nut flour, AMDN3= Breakfast cereal made from 70% ACMB + 30% Defatted cashew nut flour, AMDN4= Breakfast cereal made from 60% ACMB + 40% Defatted cashew nut flour, AMDN5= Breakfast cereal made from 50% ACMB + 50% Defatted cashew nut flour, AMUN1= Breakfast cereal made from 90% ACMB + 10% Undefatted cashew nut flour, AMUN2= Breakfast cereal made from 80% ACMB + 20% Undefatted cashew nut flour, AMUN3= Breakfast cereal made from 70% ACMB + 30% Undefatted cashew nut flour, AMUN4= Breakfast cereal made from 60% ACMB + 40% Undefatted cashew nut flour, AMUN5= Breakfast cereal made from 50% ACMB + 50% Undefatted cashew nut flour, RCHW = Rat chow

Table 5 shows the effect of the formulated breakfast cereals on the weight gain/growth rate of the rats. The mean weight gain of the animals ranged between 34.14 – 80.25 g. All the formulated diets supported positive weight gain throughout the feeding trial except the control diet (rat chow), which showed a decrease in weight in the last week of the feeding trial. This could mean that the formulated diets support growth as shown by the increase in weight.

The highest weight gain over the period of investigation was recorded for the control diet with an average total weight gain of 80.25 g while the second-best diet was sample AMDN1 (90 ACMB and 10 % defatted cashew nut) with an average weight gain of 73.14 % while sample ACMB (80 acha and 20 % mungbean) had the least weight gain (34.14 %).

In addition, it was observed that the samples incorporated with the defatted cashew nut flour showed higher weight gain than those incorporated with the undefatted cashew nut flour. This may indicate that removing the fat led to an improvement in other nutritional parameters such as crude protein (Ogungbenle, 2014) and, as a result, increased the growth rate of the test animals.

Effect of the formulated diet on the feed and protein efficiency of the diets

The Feed Efficiency Ratio (FER) of the diets are presented in Table 6. The values vary from 0.12-0.25. The feed efficiency of the formulated diets compared well with the control diet. The rats fed rat chaw had the highest feed efficiency. This could be due to the fact that rat chaw is a stable

Table 6. Food intake, protein intake and body weight gain of rats for the assessment of FER and PER

Samples	Feed Intake (g)	Protein Intake (g)	Weight Gain (g)	FER	PER
ACMB	283.86	32.95	34.14	0.25	1.03
$AMDN_1$	344.55	47.89	73.14	0.21	1.53
$AMDN_2$	312.45	49.63	60.88	0.19	1.22
$AMDN_3$	321.40	54.64	54.24	0.17	0.99
$AMDN_4$	339.15	63.08	66.59	0.20	1.06
$AMDN_5$	272.71	54.81	61.77	0.23	1.13
$AMUN_1$	282.38	28.80	54.50	0.19	1.89
$AMUN_2$	298.52	32.84	41.71	0.14	1.27
$AMUN_3$	276.06	32.02	55.91	0.20	1.75
$AMUN_4$	257.66	33.43	38.39	0.15	1.15
$AMUN_5$	234.22	31.36	42.93	0.18	1.37
RCHW	323.20	42.02	80.25	0.25	1.19

ACMB= Breakfast cereal made from 80% Acha and 20% Mungbean flour (ACMB), AMDN1= Breakfast cereal made from 90% ACMB + 10% Defatted cashew nut flour, AMDN2= Breakfast cereal made from 80% ACMB + 20% Defatted cashew nut flour, AMDN3= Breakfast cereal made from 70% ACMB + 30% Defatted cashew nut flour, AMDN4= Breakfast cereal made from 60% ACMB + 40% Defatted cashew nut flour, AMDN5= Breakfast cereal made from 50% ACMB + 50% Defatted cashew nut flour, AMUN1= Breakfast cereal made from 90% AMB + 10% Undefatted cashew nut flour, AMUN2= Breakfast cereal made from 80% ACMB + 20% Undefatted cashew nut flour, AMUN3= Breakfast cereal made from 70% ACMB + 30% Undefatted cashew nut flour, AMUN4= Breakfast cereal made from 60% ACMB + 40% Undefatted cashew nut flour, AMUN5= Breakfast cereal made from 50% ACMB + 50% Undefatted cashew nut flour, RCHW= Rat chow food for rats. Sample AMDN5 (50 % ACMB and 50 % defatted cashew nut) had the highest (0.23) feed efficiency amongst the formulated diets while sample ACMB (80 % mungbean and 20 % acha flour) had the least (0.12) feed efficiency. The feed efficiency ratio measures the ability of a food to sustain growth.

Table 6 shows the Protein Efficiency Ratio (PER) of the formulated breakfast cereals and the control diet. The protein efficiency ratio of the formulated diets varies between 0.99 -1.91. Sample AMDN3 (70 % ACH and 30 % MBN) had the least (0.99) PER. This could be due to lower protein quality in the diet. Table 6: Protein Efficiency Ratio (PER) of the formulated breakfast cereals

The control diet had the highest (1.91) PER. The PER values of the formulated diets (0.99–1.89) did not match those recorded in the literature for casein (2.5), whole egg (3.8) and cow's milk (2.0) as reported by Okoye (1992). This might be due to the fact that proteins from animal sources have a higher biological value and, as a result, a higher PER than proteins from plant sources. Anti-nutritional factors in the diet may have hindered successful protein utilization (Nassar and Sousa, 2007).

CONCLUSION

This study showed that an acceptable breakfast product of adequate nutritional value could be produced from graded portions of acha, mungbean and cashew nut (defatted and undefatted) flours. Producing breakfast cereals with cashew nut improved the proximate composition especially the protein content (up to 20.10 %). The fat content of the formulated breakfast products improved as the amount of cashew nut flour added was increased. This could lead to rancidity thereby affecting the shelf stability of the product. Feeding trial showed positive increase in weight when the rats were fed the formulated breakfast products, this implies that the products could support growth. No adverse growth rate was observed. Feed intake was also acceptable and compared well with the stable diet for rats. Feed efficiency of the samples compared well with the control diet. Protein efficiency was not up to other protein standards but compared well.

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