PHYSICAL, ELECTROLYTES AND LIPID PROFILE OF RATS FED WITH COMPLEMENTARY BLENDS PRODUCED FROM MALTED AND FERMENTED ACHA *(Digitaria exilis)* FLOUR SUPPLEMENTED WITH SOYBEANS *(Glycine max)* FLOUR

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Abstract:

Malting and fermentation are required to enhance the nutritional value of food. These simple and basic technologies were applied on acha grains there after supplementing it with soybeans *(Glycine max)*. For the blends formulation, material balancing was employed to obtain the right ratios that adhered to the prescribed dietary intake. Unmalted, unfermented acha and soybeans (UMUFAS), malted unfermented acha soybeans (MUFAS), malted fermented acha soybeans (MFAS), and unmalted fermented acha soybeans (UMFAS) were the labels for the blends. Thirty-five (35) wister strain of albino rats were grouped into 7 groups of 5 rats per cage and were fed with the formulated blends. Nestle Cerelac, Umalted unfermented acha flour (UMUFA) and soybeans flour serve as controls. Rats in different groups were place under the same conditions and were fed with about seven hundred and fifty (750g) to eight hundred (800g) of food for 28 days. Analysis of variance (ANOVA) was used to establish any significant difference in the analytical data for formulated and control diets at ($p<0.05$). The results showed that the formulated diets are nutritionally lower than Nestle Cerelac in support of animal's weight gain. The result indicate that rats fed with (MFAS) had 91.35g while animals fed with (UMUFAS) had 51.93g. These are the highest and lowest weight gain among the formulated blends. The electrolytes results obtained shows that Na^+ range from 136.40 UMUFA to 144 MFAS, K^+ 4.50 soybeans to 5.34 cerelac, HCO_3^- 22.60 UMUFA, soybeans to 27.40 MUFAS and Cl^- 98.60 soybeans to 105 MFAS all in mmol/L. The total cholesterol ranges between 2.26 UMUFA to 3.62 soybeans, HDL 0.89 acha to 1.49 MFAS, triglyceride 0.47 UMUFA to 1.26 cerelac and 1.04 cerelac to 2.18 MUFAS LDL all in mmol/L. The electrolytes and lipid profile of formulated diets were within similar range when compared to the commercial control Nestle Cerelac.

Key words: Acha, soybeans, complementary blends, malting, fermentation, physical, electrolytes and lipid profile.

Introduction

Infancy and the early years of childhood require enough nourishment for a child's healthy growth and mental development (Sudik *et al*., 2019). It is advised that healthy, well-nourished moms exclusively breastfeed their full-term infants for the first six months of life (Abiose *et at.*, 2015). However, beyond six months, breast milk is unable to supply the infant's nutritional and caloric needs. As a result, complementary foods that can meet the developing child's nutritional needs can be introduced (Abiose *et al*.,2015). Infants are given complementary food in addition to breast milk in an effort to supplement the nutrients and calories that the breast milk has previously lacked or inadequate. Like many other developing nations, Nigeria has developed a variety of supplementary foods that are offered to newborns in different settings (Awogbenja *et al.*, 2020, Abiose *et al*.,2015). It is well recognized that complementary foods made from cereals lack several important amino acids necessary for infants' healthy development and growth (Solomon, 2005a). Lysine and tryptophan, two of the necessary amino acids, are in insufficient supply in regular maize, but a novel hybrid variety called Quality Protein Maize (QPM) provides a respectable amount of these amino acids (Awogbenja *et al.*, 2020, Abiose *et al*., 2015). Protein-energy malnutrition among children in underdeveloped nations has been linked mostly to poverty and poor child feeding practices (Sudik *et al.*, 2019). Since they couldn't afford the more expensive, fortified, nutritious proprietary complementary meals, the majority of nursing women in underdeveloped nations chose unsupplemented cereal porridges prepared from maize, sorghum, and millet as complementary foods (Sudik *et al*., 2019).

Nutritional density, food safety, storage stability, palatability, and convenience of supplemental foods for infant mixes may all be improved by food processing methods including fermentation and germination(Adeoti, 2018). Cereal fermentation and germination are accessible and popular processing methods in Africa (Adeoti, 2018). Fermentation enhances the nutrient of foods through biosynthesis and bioavailability of vitamins and essential amino acids, reduction of antinutrients, improving the protein quality and fibre digestibility (Abiose *et al*., 2015, Mohammed *et al*., 2021). Many components in the food that are in bound forms are released during germination, enhancing the food's bioavailability of those nutrients as well as its acceptability and energy density (Abiose *et al*., 2015).

According to Suleiman and Muhammad (2015), acha (Digitaria exillis) is a cereal grain of the gramineae family that is also known as fonio or hungry rice. Because of their diminutive size, Acha are typically consumed whole (Ja *et al*., 2018). The grain is a good source of dietary fiber when consumed as whole grain, and it also has related nutraceutical benefits that make it perfect for those who are health-conscious and who are dealing with obesity and disorders like diabetes (Ja *et al.*, 2018, Babarinde *et al.*, 2020a). Acha has the potential to significantly contribute to whole grain diets, wellness,

economic status improvement, and could play an important role in food security in developing economy of a nation like Nigeria(Ja *et al.*, 2018).

The soybean (Glycine max (L.) Merrill) has become the miracle crop of the twenty-first century (Desissa, 2017). Soybeans (Glycine max), which have a good balance of amino acids, are a cheap source of high-quality proteins (Guzeler and Yldrm, 2016). Soybean is a good source of vitamins, minerals, and the various amino acids required to repair damaged bodily tissue (Zegeye *et al*., 2019). Protein concentration in soybeans is highest, at 40%. (Subroto *et al*., 2021) Adding locally available, high-protein legumes to cereals increases the protein content of cereal-legume combinations because cereals normally contain little protein.

Aim of the research

The aim of this research is to evaluate the physical, electrolytes and lipid profile of rats fed with complementary blends produced from malted and fermented acha *(digitaria exilis)* flour supplemented with soybeans *(glycine max)* flour.

Materials and Methods

Experimental food samples

The study was conducted using formulations of acha (*Digitaria exilis*) (cereal) and soybeans (*Glycine max*) (legumes) supplementary flour. Nestle Cerelac was used as the commercial control. The entire foodstuffs used in formulating the supplementary diets was purchased from local market (Terminus) in Jos, Plateau.

Preparation of acha and malted acha flours

The procedure for the production of acha flour was carried as follows: Whole (undehulled) acha grain were washed in 5% (w/v) sodium chloride (NaCl) solution to disinfect the grains. The washed grain was dried under natural sunlight in a confined environment and was dehulled and washed. The washed acha grains were dried, milled and sieved using 0.2mm mesh. The procedure for the production of malted acha flour is as follows: Malting was carried out using the method described by (Gernah, *et al*.,2012b) as shown in Fig. 1. Adequate quantity of whole acha grains were washed in 5% (w/v) sodium chloride (NaCl) solution to disinfect the grains. The grains were then soaked in tap water at room temperature (30 + 20C) using a ratio of 1:3 (w/v grain: water), in a plastic bucket. The steep water was changed every 3 hours for a total steeping time of 6 hours, followed by draining in a plastic basket and the grains were spread in a single layer on a moistened jute bag and allowed to germinate at room temperature (30 + 20C) for 48 hours, while spraying with water at intervals of 12 hrs. The non - germinated and germinated grains were removed after 48 hours dried in a confined environment covered with polythene with sunlight as source of drying. The dried malted acha was dehulled and winnowed. The winnowed acha grain was washed and dried on the sunlight and was then milled into flour and was sieved using 0.2mm particle size.

The resultant acha and malted acha flours were then packaged in low density dark - coloured polyethylene bags, stored in 500ml plastic containers with airtight lids at room temperature (30 +20C) and utilized for product formulation and analysis within 24 hours.

Preparation of fermented acha flours

Fermented acha flour were obtained by accelerated natural lactic acid fermentation using the method described by Genah *et al* (2012a) as shown in Fig. 1. One hundred and twenty gram(120g) each of acha and malted acha flours were mixed with 80ml of distilled water and subjected to natural fermentation in a covered 500ml glass beaker at room temperature (30 + 20C) for 24 hours. 50% of the fermented mixture was used as starter culture for a new fermentation cycle. The pH and titratable acidity (an index of lactic acid bacteria activity) were monitored during acha fermentation. The fermentation process was continued concentrates were dried using natural sunlight in a confined environment, milled and sieved into fine particle size sieved using 0.2mm mesh. The fermented acha and malted fermented acha flours were then packaged in low density dark - coloured polyethylene bags, stored in 500ml plastic containers with airtight lids at room temperature (30 +20C) and utilized for product formulation and analysis within 24 hours.

Soybean processing

Soybeans were sorted for stones, rot and other physical defects. The sorted beans were washed and soaked in distilled water 1:5 w/v for 15 hrs (Asfaw Tufa, 2016). The soaked beans were placed in a sieve and allowed to drain. Blanched for about 20 min. The hulls were removed manually, washed repeatedly using distilled water. The dehulled beans were dried using tray dryer. Soybeans were milled into flour and sieved through 0.2mm mesh size screen. The soybeans flours was packaged in low density dark - coloured polyethylene bags, stored in 500ml plastic containers with airtight lids at room temperature (30 +20C) and utilized for product formulation and analysis within 24 hours.

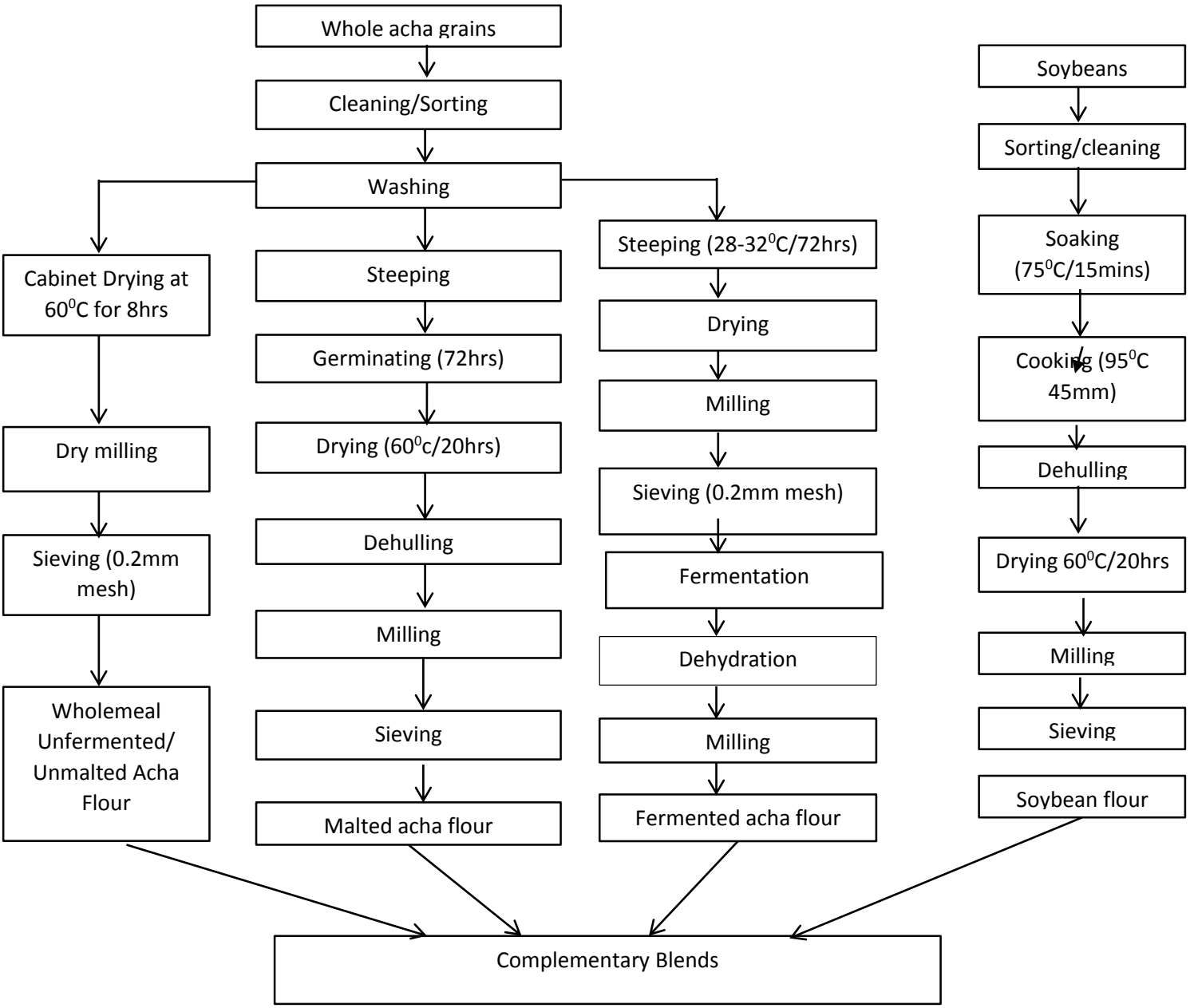

Figure 1: Flow chart showing blends formulations
Source:(Temitope, 2017**,** Gernah *et al.*, 2012b**,** Ogori *et al.*, 2020**,** Zegeye *et al*., 2019)**.**

Formulation of the experimental blends
Four different food formulations were made by blending the different acha flours with the soybeans flour to obtain 16g protein and 9g fat/100g. This was achieved by material balancing from their respective proximate compositions (Gernah *et al*., 2012a &b).
Diet 1 -Unmalted, Unfermented Acha and Soybeans (UMUFAS)
Diet 2 - Malted Unfermented Acha and Soybeans (MUFAS)
Diet 3- Malted Fermented Acha and Soybeans (MFAS)
Diet 4- Unmalted, Fermented Acha and Soybeans (UMFAS)

Ethical clearance

The study protocol was approved and ethic clearance was given by the Ethical Committee for Laboratory Animals of Department of Pharmacology, Faculty of Pharmaceutical Sciences, University of Jos Nigeria with reference number: F17-00379.

Animals

Male Winter-strain weanling rats weighing between 20 – 50g was purchased from the Animal House of the University of Jos, and the animals were used in this studies. The rats were randomly distributed into seven groups (7) groups of 5 rats each during feeding. They were keep in metabolic cages made of Perspex sheets. The rats were allowed to stabilize on the normal laboratory feed for 3 days and starved for one day before feeding with the experimental diets commenced.

Animal grouping

During the feeding experimentation, rats were apportioned the diets as follows:

Group A- Nestle Cerelac (commercial control)
Group B - Acha
Group C- Soybeans
Group D - Acha and soybeans (UMUFAS)
Group E - Malted Unfermented Acha and soybeans (MUFAS)
Group F- Malted Fermented Acha and soybeans (MFAS)
Group G- Unmalted, Fermented Acha and soybeans (UMFAS)

Animal feeding

Just before every feeding, known quantity of each diet was mixed thoroughly with enough boiling water to a thick paste and allowed to cool before feeding to the animals. Rats were given feed and water ad libitum for 28 days. Faeces and urine was collected separately to avoid mixing with the feed. Daily records of urine, feed, water and weights of rats were kept. The total food intake of the rats was determined by recording the food left after daily intake. Weight gain was achieved by weighing all rats individually at interval of 3 days.

Slaughtering and collection of blood samples

At the 28th day of the feeding experiment period, each rat was anaesthetized with chloroform inside a dessicator before slaughtering. A portion of whole blood was collected from each rat into sample bottles and sample bottles containing EDTA (1mg/ml) for parameters that required the use of whole blood. The bottles were immediately capped and the content mixed gently for about 1 min by repeated inversion thereafter used for various haematological studies. The remaining blood samples was allowed to clot for 20 minutes, before centrifuging at 3000rpm for 15 minutes in a refrigerated centrifuge, (to obtain serum for parameters determined in sera). Serum was carefully transferred with pasteur pipettes into clean, dry labeled light-shielded sample bottles and stored frozen until required.

Determination of protein quality

Protein quality indices were determined using standard methods. The nitrogen content of the faeces was determined by the standard Kjeldhal method (Laganà *et al.*,2019). From the values of Mean Daily Feed Intake (MFDI) and Mean Daily Weight Gain (MDWG) obtained, Protein Efficiency Ratio (PER) and Feed Conversion Efficiency (FCE) were calculated using approved formulae.

$$\text{Mean daily food intake(MDFI)} = \frac{\text{Total Quantity Consumed}}{\text{Numberr of Days of Feeding}}$$

Mean Daily Weigh Gain (MDWG)

$$= \frac{\text{Total weight Gain}}{\text{Number of Day of Feeding}}$$

$$\text{Protein Efficiency Ratio (PER)} = \frac{\text{Weight Gain}}{\text{Total Protein Intake}}$$

$$\text{Feed Conversing Efficiency (FCE)} = \frac{\text{Daily Feed Intake}}{\text{Daily Weight Gain}}$$

Determination of HDL, TC, TG and LDL

Total cholesterol concentration, serum HDL-cholesterol and triacylglyceride were done using Randox diagnostic reagent kits. LDL-cholesterol was estimated using Friedewald formula (Luka *et al.*, 2017)**.**

Determination of serum sodium (Na^+), potassium (K^+), chloride (Cl^-) and serum bicarbonate (HCO_3^-).

The different biochemical methods for determination of Na+, K+ and Cl- using standard biochemical procedures and principles were employed as stated in (Ovuakporaye *et al.*, 2020). Sodium was determined based on method of Maruna. Sodium was precipitated as the triple salt, sodium magnesium uranyl acetate, with the excess uranium being reacted with ferrocyanide to produce chromophore whose absorbance varies indirectly with the concentration of sodium in the test sample. Potassium was determined based on method of describe by (Luka *et al.*, 2017)**.** The amount of potassium (K+) was determined by using sodium tetraphenylboron, a specifically prepared mixture to produce a colloidal suspension. Chloride was estimated using the method described by described by Skeggs and Hochestrasser and serum bicarbonate (HCO_3^-) using(Mohd Nasir *et al.*, 2010).

Statistical analysis

All data and results with statistical analysis were subjected to analysis of variance (ANOVA). Each determination was carried out in triplicate and results were reported as an average value (mean ± standard deviation). Data was analyzed by Analysis of Variance (ANOVA) model using SPSS Version 20. Statistical significance was set at $p<0.05$.

Results and discussion

Water, food intake and urine excreted during feeding trial

The water intake, feed consumed and urine excreted during feeding trial is presented on Table 1, 2 and 3. The significant difference was obtained at $p>0.05$. Difference was observed between the controls in total water intake, total food consumption and total urine excreted as compared to the formulated blends. The total water intake ranged between 1242.60ml and 430.23ml for CERELAC and UMUFA respectively, the total food consumed was highest in CERELAC (781.47g) and lowest in SOYBEANS (299.87g) and the total urine excreted ranges from 388.51 to 1038.90ml for UMUFA, UMUFAS respectively.

The water intake in UMUFAS, MUFAS, MFAS and UMFAS is significantly lower than CERELAC, high when compared to UMUFA (normal acha flour) and SOYBEANS flour with the exception of MUFAS which is low when compared to soy beans. The food consumed in each group ranges as 781.47, 593.77, 299.87, 658, 546.33, 591.20 and 591.85g for CERELAC, ACHA, SOYBEANS, UMUFAS, MUFAS, MFAS and UMFAS respectively. The rate of food consumption in UMUFAS, MUFAS, MFAS and UMFAS is significantly lower than CERELAC, higher than UMUFA (normal acha flour) in UMUFAS and high when compared to SOYBEANS flour in all the food samples. The total urine excreted in

each group is 641.67, 388.51, 525.70, 1038.90, 837.50, 416.40 and 428.27 ml for CERELAC, ACHA, SOYBEANS, UMUFAS, MUFAS, MFAS and UMFAS respectively. The total urine excreted was found different and lower in UMUFAS, MUFAS and higher in MFAS and UMFAS when compared to CERELAC. Urine excreted was also found high in all the samples when compared to UMUFA (normal acha flour) and high in UMUFAS, MUFAS and low in MFAS and UMFAS when compare with SOYABEANS flour. Factors affecting lower intake of water include dry matter content or the physical form of the diets. Therefore, lower intake of water by the experimental animal fed with UMUFA could be due to the physical form of the formulated diet. This agreed with the findings of Babarinde *et al* 2020b. Animals fed with CERELAC had the highest food consumption while animals fed soybeans ate lowest. This might probably be because of its palatability and this is in agreement with Solomon (2005b). It was observed that the malted and fermented food formulations were consumed less in comparison to the unmalted and unfermented blends. This could be related with the fact that sour characteristics of the fermented products affected their intake by the experimental rats. According to Gernah *et al*(2012a) it has been established that rats prefer a diet with some sweet taste and may consume higher quantities of such diets. Thus, the unfermented diet was sweeter and therefore was consume more.

Table 1: Average and total water intake by experimental rats for 28 days

Treatment groups	Average water intake(ml)	Total water intake(ml)
CERELAC	248.60±0.057	1242.60±0.057
NORMAL ACHA	86.23±0.088	430.23±0.088
SOY BEANS	145.43±0.088	726.43±0.088
UMUFAS	173.30±0.152^{adf}	866.00±0.577^{adf}
MUFAS	110.95±0.011^{ade}	554.75±0.057^{ade}
MFAS	157.60±0.057^{adf}	788.00±0.288^{adf}
UMFAS	222.73±0.088^{adf}	1114.60±0.057^{adf}
p-values	<0.0001	<0.0001

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
[a]Values are significantly low when compared with cerelac ($p < 0.05$)
[b]Values are significantly high when compared with cerelac ($p < 0.05$)
[c]Values are significantly low when compared with normal acha ($p < 0.05$)
[d]Values are significantly high when compared with normal acha ($p < 0.05$)
[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$)

Table 2: Average and total feed consumed by experimental rats for 28 days

Treatment groups	Average feed consumption(g)	Total feed consumption (g)
CERELAC	155.70±0.057	781.47±3.417
NORMAL ACHA	118.82±0.044	593.77±0.011
SOY BEANS	59.98±0.005	299.87±0.011
UMUFAS	131.30±0.057^{adf}	658.00±0.577^{adf}
MUFAS	109.33±0.033^{acf}	546.33±0.088^{aef}
MFAS	118.30±0.057^{acf}	591.20±0.115^{aef}
UMFAS	118.38±0.005^{acf}	591.85±0.014^{aef}
p-values	<0.0001	<0.0001

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
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[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$)

Table 3: Average and total urine excreted by experimental rats for 28 days

Treatment groups	Average urine excreted(ml)	Total urine excreted (ml)
CERELAC	128.50±0.115	641.67±0.088
NORMAL ACHA	77.53±0.088	388.51±0.008
SOY BEANS	105.15±0.008	525.70±0.057
UMUFAS	207.79±0.008^{bdf}	1038.90±0.008^{bdf}
MUFAS	167.51±0.008^{bdf}	837.50±0.003^{bdf}
MFAS	83.21±0.005^{ade}	416.40±0.305^{ade}
UMFAS	85.13±0.088^{ade}	428.27±0.145^{ade}
p-values	<0.0001	<0.0001

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
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[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$)

Weight changes and efficiency ratios in the rats during feeding trial

Table 4 and 5 shows the weight change and efficiency ratios of rats recorded during the feeding period of 28 days. Rats fed with CERELAC control diet recorded the highest weight gain/growth rate followed by rats fed with MFAS. Rats fed UMUFA had the lowest growth rate. There was no mortality recorded in any group. The efficiency ratios determined include: Protein Efficiency Ratio (PER), Food Conversion Efficiency (FCE) and also Mean Daily Food Intake (MDFI), Mean Daily Weight Gain (MDWG). The results ranges from 14.01 soybeans to 41.13 cerelac (MDFI), 1.11 UMUFA to 10.35 cerelac (MDWG), 0.67 soybeans to 13.71 cerelac (PER) and 3.98 cerelac to 13.31 UMUFAS for (FCE). The significant difference between the formulated and control diets were determined at ($p < 0.05$). The weight changes computed shows that weight change in group fed with CERELAC is significantly higher in weight than all other groups. Animals fed with the formulated blends in all the groups gain more weight when compared to animals that were fed on UMUFA (normal acha flour). The weight changes of animals across in relation to group fed with SOYABEANS flour shows that animals fed with formulated diets had significant weight gain. When values of the formulated blends were compared with the controls in efficiencies, CERELAC showed higher weight gain, protein intake as well as better food and protein efficiency ratios significantly at ($p<0.05$) while the formulated blends had better efficiencies than UMUFA, SOYABEANS significantly at ($p<0.05$). Incorporating soybean flour into the blend significantly ($p<0.05$) improved the protein efficiency ratio of various products. This is an indication that complementary blends of cereals and legumes gives a better quality than the individual crop. The growth performance of the formulated and control diets is in line with report given by Adeoti (2018) who shows rats fed with ogi-fermented moringa seeds diet (ogi-fermented moringa seed flour) and (ogi-germinated moringa seeds flour) was significantly higher than ogi-raw moriga seeds flour and basal (BAS) diets.

Table 4: Weight changes in the rats during feeding

Treatment groups	Initial weight (g)	Final weight (g)	Differences (g)	Total weight gain in group(g)
CERELAC	43.05±1.263	82.36±0.638	39.31±1.676	196.54±8.372
NORMAL ACHA	32.00±0.756	36.34±0.888	4.37±0.165	21.88±0.829
SOY BEANS	31.26±0.607	37.11±0.915	5.84±0.368	29.21±1.840
UMUFAS	38.58±0.406^{adf}	48.96±0.742^{adf}	10.38±0.368^{adf}	51.93±1.843^{adf}
MUFAS	32.66±0.751^{adf}	50.20±0.757^{adf}	17.53±0.866^{adf}	87.66±4.333^{adf}
MFAS	30.04±0.014^{ace}	48.20±0.115^{adf}	18.27±0.153^{adf}	91.35±0.765^{adf}
UMFAS	35.63±0.233^{adf}	52.91±0.233^{adf}	17.37±0.066^{adf}	86.86±0.318^{adf}
p-values	<0.0001	<0.0001	<0.0001	<0.0001

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
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[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$

Table 5: Mean daily food intake, mean daily weight gain, protein efficiency ratio and food conversion efficiency of experimental animals per group

GROUP	MDFI(g)	MDWG(g)	PER	FCE
CERELAC	41.13±0.033	10.35±0.450	13.71±0.593	3.98±0.168
NORMAL ACHA	31.41±0.016	1.11±0.060	2.01±0.088	28.30±1.582
SOYBEANS	14.01±0.916	1.50±0.115	0.67±0.044	9.54±1.358
UMUFAS	34.68±0.033^{adf}	2.68±0.116^{adf}	2.53±0.089^{adf}	13.31±0.523^{bcf}
MUFAS	28.91±0.016^{acf}	4.58±0.216^{adf}	4.63±0.216^{adf}	5.44±0.634^{bce}
MFAS	31.23±0.016^{acf}	4.78±0.044^{adf}	4.58±0.044^{adf}	6.52±0.061^{bce}
UMFAS	31.26±0.016^{acf}	4.57±0.015^{adf}	3.95±0.028^{adf}	6.83±0.023^{bce}
p-values	<0.0001	<0.0001	<0.0001	<0.0001

KEY: MDFI = MEAN DAILY FOOD INTAKE, MDWG = MEAN DAILY WEIGHT GAIN, PER = PROTEIN EFFICIENCY RATIO, FCE = FOOD CONVERSION EFFICIENCY.
Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
[a]Values are significantly low when compared with cerelac ($p < 0.05$)
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Blood lipid profile

Table 6 shows the lipid profile in blood of rats fed with the experimental diets. The lipid profile analysed were Total cholesterol (TC), High density lipoprotein (HDL), Triglyceride(TG) and Low density lipoprotein (LDL). Significant difference was determined between the formulated blends and the controls at ($p < 0.05$).

Total plasma concentration of cholesterol and triglycerides can give a clear insight into hyperlipidaemia arising either from excessive dietary intake or genetic disorders. High dietary intake of saturated fat for instance has been shown to initiate LDL-Cholesterol synthesis by the liver. The result from the experiment shows that total cholesterol ranges between 2.26 UMUFA to 3.62 soybeans, HDL 0.89 acha to 1.49 MFAS, triglyceride 0.47 UMUFA to 1.26 cerelac and 1.04 cerelac to 2.18 MUFAS LDL all in mmol/L. The acceptable range humans for total cholesterol is 2.9 to 6.0 mmol/L, HDL 0.9 to 2.12mmol/L, tryglyceride 0.5 to 17 mmol/L and LDL ranges from 1.6 to 3.63mmol/L. The above values indicate that the food given to the animals would not pose any risk of hyperlipidemia or even be a cardio vascular risk factor.

Table 6: Some lipid profile in the blood of rats fed with the formulated and control diets

GROUP	TC(mmol/L)	HDL(mmol/L)	TG(mmol/L)	LDL(mmol/L)
CERELAC	2.50±0.114	1.34±0.117	1.26±0.201	1.04±0.062
UMUFA	2.26±0.092	0.89±0.034	0.47±0.022	1.10±0.017
SOYBEAN	3.62±0.037	1.45±0.097	0.76±0.050	1.72±0.117
UMUFAS	2.90±0.122^{bde}	0.99±0.049^{ade}	1.04±0.092^{adf}	1.46±0.097^{bde}
MUFAS	3.56±0.107^{bde}	1.18±0.053^{ade}	0.76±0.050^{adg}	2.18±0.048^{bdf}
MFAS	3.28±0.149^{bde}	1.49±0.105^{bdf}	1.14±0.107^{adf}	1.59±0.030^{bde}
UMFAS	2.82±0.124^{bde}	1.03±0.005^{ade}	0.62±0.080^{ade}	1.70±0.121^{bde}
p-values	<0.0001	<0.0001	<0.0001	<0.0001

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
[a]Values are significantly low when compared with cerelac ($p < 0.05$)
[b]Values are significantly high when compared with cerelac ($p < 0.05$)
[c]Values are significantly low when compared with normal acha ($p < 0.05$)
[d]Values are significantly high when compared with normal acha ($p < 0.05$)
[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$)

Some electrolytes in the blood of rats fed with the formulated and control diets

The result of electrolyte fed with the formulated blends and the control for 28 days is presented on Table 7. The electrolytes determined is stated as follows: sodium, potassium, bicarbonate and chloride. The differences between the formulated and control samples were determined at ($p < 0.05$).

This study showed that the electrolyte (sodium, potassium, chloride and bicarbonate) concentration in the formulated blends and control diet were comparable. Electrolytes leave and enter the cell membranes through ion channels and are important for muscle contraction. Electrolyte balance is maintained by oral intake of electrolyte containing substances. In human's electrolyte homeostasis may be controlled by hormones such as antidiuretic hormone aldosterone and parathyroid hormones (Adeoti, 2018).

Table 7: Some electrolytes in the blood of rats fed with the formulated and control diets

GROUP	Na^+ (mmol/L)	K^+(mmol/L)	$HCO3^-$ (mmol/L)	Cl^-(mmol/L)
CERELAC	142.00±0.948	5.34±0.116	25.60±0.509	104.60±0.927
UMUFA	136.40±0.509	5.10±0.141	22.60±0.678	103.60±0.927
SOYBEAN	136.80±0.583	4.50±0.249	22.60±0.509	98.60±0.509
UMUFAS	143.00±0.707[bdf]	5.26±0.276[adf]	25.20±0.374[adf]	104.00±0.707[adf]
MUFAS	140.00±1.140[adf]	5.00±0.192[acf]	27.40±0.927[bdf]	103.20±0.860[acf]
MFAS	144.00±1.414[bdf]	5.02±0.174[acf]	25.60±0.972[gdf]	105.00±1.140[bdf]
UMFAS	140.60±0.678[adf]	4.60±0.114[acf]	25.20±0.663[adf]	103.80±0.860[adf]
p-values	<0.0001	0.0307	0.0002	0.0004

Values are expressed as mean ± SEM, n = 5.
If p value is less than or equal to 0.05, mean values are statistically significant.
[a]Values are significantly low when compared with cerelac ($p < 0.05$)
[b]Values are significantly high when compared with cerelac ($p < 0.05$)
[c]Values are significantly low when compared with normal acha ($p < 0.05$)
[d]Values are significantly high when compared with normal acha ($p < 0.05$)
[e]Values are significantly low when compared with soybean ($p < 0.05$)
[f]Values are significantly high when compared with soybean ($p < 0.05$)
[g]Value is not statistically significant ($p < 0.05$)

Conclusion

The research demonstrated that the experimental complementary foods were characterized with essential nutrients, energy, ability to support growth and affordable even though the commercial diet had a better growth support rate than other formulated diets. The combination of soybean with acha in blend food formulations can improve their protein and micronutrient quality. The experiment also show that the formulated diet has no negative effect on lipids and electrolytes. Therefore, it is considered to be safe for consumption. It can be concluded that the use of acha and subjecting it to processing techniques such as malting and fermentation has positive impact on food quality, functionality which could provide adequate nutrients for the prevention of protein-energy malnutrition in infants.

Conflict of interest

The authors declare that there is no conflict of interest report in this work.

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