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Pasting, functional, microbial and sensory evaluation of complementary food blends produced from malted and fermented acha *(Digitaria exilis)* flour supplemented with soybeans flour *(Glycine max)*

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Abstract
Pasting, functional, microbial and sensory properties of complementary food blends produced from malted and fermented acha *(Digitaria exilis)* flour and supplemented with soybeans flour *(Glycine max)* was carried out. Acha (*Digitaria exilis*) flours and soybeans *(Glycine max)* flour were used in preparation of complementary diets. The appropriate ratios of combination of the flours were achieved through material balancing. Four products blends were formulated and named as Unmalted unfermented acha soybeans (UMUFAS), Malted unfermented acha soybeans (MUFAS), Malted fermented acha soybeans (MFAS) and Unmalted fermented acha soybeans (UMFAS). Standard chemical method was used to determine the functional properties, Visco analyzer RVA was used to determine the pasting properties of the blends. Microbiological analysis of the complementary blends was carried out. A 9-point hedonic scale (1-deslike extremely, 9-like extremely) was used to rate the sensory attributes of colour, taste, aroma, texture and overall acceptability of the products. Analysis of variance (ANOVA) was used to establish any significant difference in the analytical data for formulated and control diets ($p<0.05$). The functional properties results show that there were significant differences ($p < 0.05$) in water absorption capacity, bulk density, water absorption capacity, swelling capacity and reconstitution index among the formulated food blends. The result for pasting property indicate that there were significant differences ($p < 0.05$) among the formulated blends. Peak viscosity, final viscosity, setback, pasting time and trough were found higher in samples that were fermented. Microbiological analysis of composite flours was focused on the search for flora of contamination and pathogenic microorganisms. The load (CFU/g) of the microorganism are below the microbiological standards and are safe for consumption. The sensory results show that there was no significant difference in appearance or colour, taste, aroma and general acceptability for all the food formulations. The unfermented products were better than the fermented products in all the attributes, while the values for NESTLE CERELAC which is the contol were higher than all the food formulations but did not show any significant difference ($p < 0.05$).

Keywords: acha, soybeans, complementary food blend, malting and fermentation

Introduction

The full potential of healthy growth and development in children is attributed with an adequate nutrition of the child within the first 1000 days [1]. The consequences of poor nutrition include illness such as common childhood diarrhea, global malnutrition, stunting (a state of an adult being shorter than potential height), and micronutrient deficiencies. Hence, the introduction of protein and energy rich complementary foods to the children is very critical at this stage in order to prevent the challenges of good nutrition faced by the children of 6–23 months in most developing countries [1, 2]. Complementary foods play a vital role on child growth and development since it complements for both nutritional and developmental needs of the infant when breast milk alone is no longer sufficient [3].

Acha (Digitaria exilis) is a cereal crop of West African origin that can be relied upon during the time of food scarcity or famine due to its short cropping cycle, vital nutritional values and health benefits [4, 5]. Research has shown that the methionine content of Acha grain is twice that of egg protein [5]. The nutraceutical potentials of acha (fonio and iburu) is due to their antioxidant, phenolic, and cholesterol-lowering properties [6]. Acha is recommended to remedy some health challenges. Acha improve blood clotting in women after child birth and also stimulate milk production in breastfeeding women [5].

Soybean (Glycine max (L.) Merrill) has become the miracle crop of the 211st century [7]. Soybeans (Glycine max) are cheap source of high-quality proteins with a good balance of amino acids [8]. It is a triple beneficiary crop, which contains about 40% proteins, possessing high level of essential amino acids except methionine and cystine, 20% oil rich in poly unsaturated fatty acids specially omega-6 and omega-3 fatty acids, 6 to 7% total minerals, 5 to 6% crude fibre and 17 to 19% carbohydrates [7]. Soybean crops provide one of the world's most important sources of protein and oil [9]. The digestibility value of soy protein is 91.41% [8]. Soybean has a good source of vitamins and mineral and supply adequate amount of different amino acids required for repairing the damaged body tissue [8]. It could be an essential part of functional foods and could be used for enrichment of product quality [8].

Fermentation is used to enhance the bioaccessibility and bioavailability of nutrients from different crops, improves organoleptic properties as well as extending the shelf life [10]. It makes food safe by not only inhibiting growth of pathogenic bacteria due to antimicrobial activity of lactic acid but also detoxifies aflatoxin [11]. These desirable

benefits has made fermentation to be considered as an effective way to reduce the risk of mineral deficiency among populations, especially in developing countries where unrefined cereals and/or pulses are highly consumed [12].

Malting is the term used for the preparation of a brewing raw material, employing a controlled germination of grain in moist air [13]. Malting aims to convert or modify the physical structure of the grain and allow synthesis or activation of a series of enzymes such that the final product [13, 14]. During the malting process, hydrolytic enzyme production and/or release is maximized leading to cell-wall degradation and protein solubilization with minimal starch breakdown [13].

Germination and fermentation of cereals are affordable and widely practiced processing method in Africa. The combination of different traditional processing methods such as milling, soaking, drying, dehulling, roasting fermentation, germination, blanching in the production of complementary food with addition of protein from other sources has been observed to improve the nutrient content, palatability, and bioavailability of micronutrients in plant-based diets as well as decrease or remove anti-nutritional factors in food[15].

Since cereals such as acha are generally low in protein, supplementation of acha with locally available legume such as soybeans that is high in protein is a necessity to help solve the problem of malnutrition in developing countries such as Nigeria.

Materials and Methods

1. Materials

1.1. Experimental food samples

The study was conducted using formulations and analysis of acha (cereal) and soybeans (legumes) supplementary flour. These foodstuffs are staples readily available in Plateau State. These formulations were carried out to ascertain the nutritional components of acha when fermented and malted and to encourage mothers on the significance of local fermentation and malting to prepare diets within their household which is nutritious enough to meet the nutritional requirement of infant, children and the entire household. The foodstuff used are acha grains (*Digitaria exilis*) and soya beans (*Glycine max*). Nestle Cerelac was used as the control.

2. Methods

2.1. Technology and preparation of products formulation

The entire foodstuffs to be used in formulating the supplementary diets was purchased from local markets in Jos, Plateau State, in adequate quantities and processed as follows:

2.2. Preparation of unmalted and malted acha flours

The procedure for the production of Unmalted 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 [16] 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.

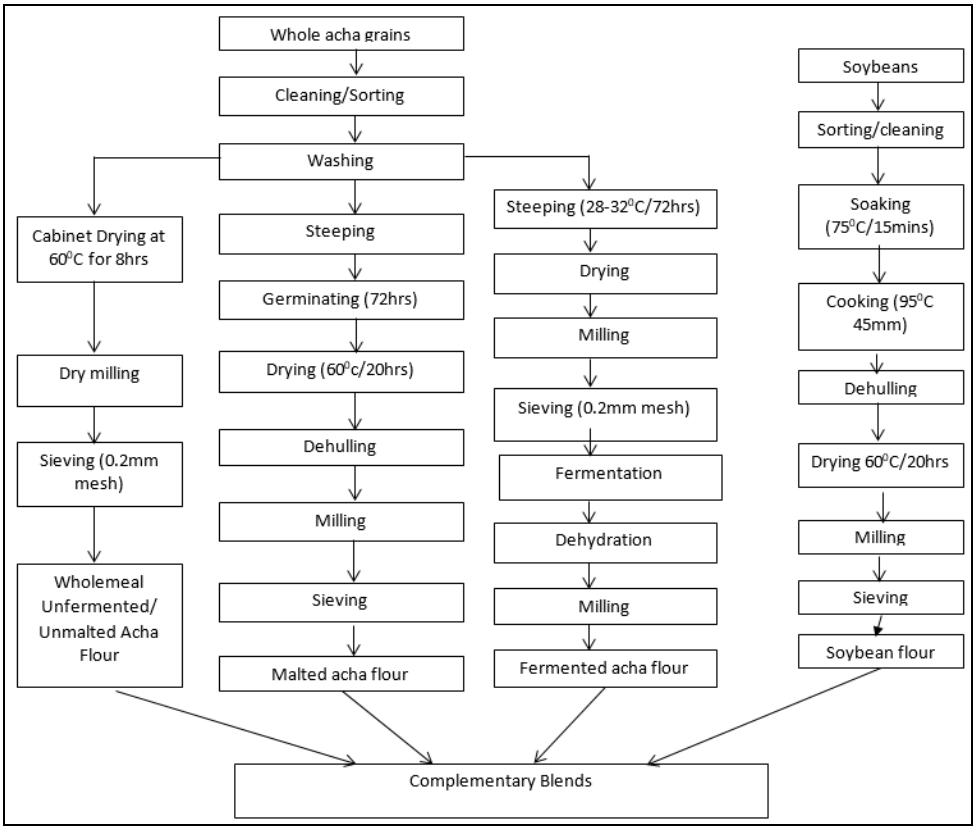
The resultant unmalted acha and malted acha flours were then packaged in low density dark - coloured polyethylene bags, stored in 500ml plastic containers with airtight lids at room temperature (30 +20C) and utilized for product formulation and analysis within 24 hours.

2.3. Preparation of fermented acha flours

Fermented acha flour were obtained by accelerated natural lactic acid fermentation using the method described by [17] as shown in Fig. 1. In this process 120.0g each of unmalted 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. At the end of this period, 50% of the fermented mixture was used as starter culture for a new fermentation cycle. During this process, the pH and titratable acidity (an index of lactic acid bacteria activity) were monitored. 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 unmalted 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

2.4. Soybean processing

Soybeans were sorted for stones, rot and other physical defects. The beans were then washed and soaked in distilled water 1:5 w/v for 15 hrs according to method proposed by [18]. The soaked beans were then placed in a sieve and allowed to drain. They were then blanched for about 20 min. The hulls were removed manually, then the beans were washed repeatedly using distilled water. The dehulled beans were then dried using tray dryer. Soybeans were milled into flour and sieved through 0.2mm mesh size screen. The soybeans flours was 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.



Source: [19], [16], [20], [21].

Fig 1: Flow chart showing blends formulations

2.5. 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 [16].

Diet 1-Unmalted, Unfermented Acha: Soybeans (UMUFAS)

Diet 2 - Malted Unfermented Acha: soybeans (MUFAS)

Diet 3- Malted Fermented Acha: soybeans (MFAS)

Diet 4- Unmalted, Fermented Acha: Soy beans (UMFAS)

2.6. Preparation of gruels

Gruels was prepared from the food formulations using the method described by [18]. Gruels were prepared from both controls and formulated food samples by mixing 20g of each sample dissolved in 400ml tap water and boiled at 92 ºC for about 10 to 15min.The boiled gruels were allowed to cool to about 40ºC– 42ºC.

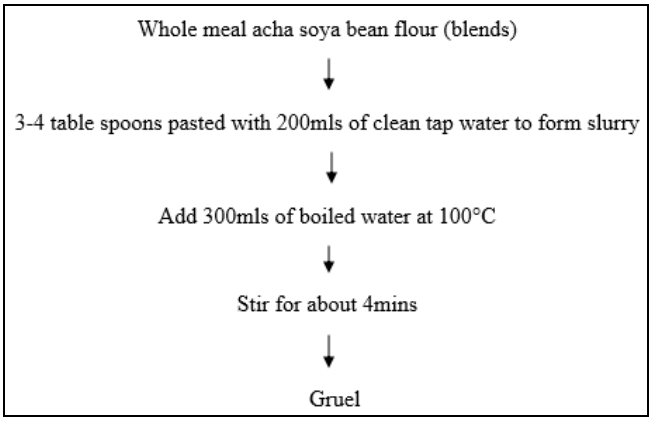


Fig 2: Flowchart showing gruel preparation

3. Determination of Pasting Properties

The pasting properties were determined by methods as describe by [22]. Pasting properties were determined with the Rapid Visco Analyzer (RVA). 3.0g of the flour sample was weighed and dispensed into the test canister. 25.0 ml of distilled water was dispensed into the canister. The Visco Analyzer was switched on and the pasting performance of the flour was automatically recorded on the graduated sheet of the instrument.

4 Functional Properties

The functional properties of the blends were assessed by determining the values of these parameters - bulk density, water absorption capacity, oil absorption capacity and viscosity. The functional properties of the blends were determined by the method described by [22, 23].

4.1. Water/oil absorption capacity

Water and oil absorption capacities of the flour samples by weighing (20 g) of each flour samples and hydrated with 100 mL of distilled water at 25°C for 1 h with manual stirring at 10-min intervals. The excess water was drained with a Whatman No. 2 filter paper with slight suction. The water/oil absorption capacity was calculated as follows:

$$\text{WAC} = \frac{\text{Weight gain upon hydration}}{\text{Dry weight}} \times 100$$

4.2. Bulk density

A 50 g flour sample was put into a 100-mL measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g /ml) was calculated as weight of flour (g) divided by flour volume (ml).

4.3. Reconstitution Index / time
10 grams of each sample flour was spread on the surface of 50 ml of distilled water at room temperature in a cylinder, the time taken for the flour to completely disperse was recorded as the reconstitution time while the weight of flour reconstituted at the bottom of the cylinder was calculated against the 10g flour to obtain the reconstitution index.

4.4. Viscosity
Viscosity was determined of each flour by heating at 100 ºC for 10 min. The determination was done with torsion viscometer according to the manufacturer's instructions.

4.5. Swelling capacity
One gram of the flour sample was mixed with 10 mL distilled water in a centrifuge tube and heated at 80°C for 30 min. This was shaken continuously during the heating period. After heating, the suspension was centrifuged at 1000g for 15 min. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as:

$$\text{Swelling capacity} = \frac{\text{Weight of precipitate/paste}}{\text{Weight of dry flour}}$$

5. Microbiological Analysis of the Complementary Blends
The total aerobic, yeast, mould, Enterobacteriaceae and Staphylococcus counts of the food formulation were determined according to the method found in [17], [24]. According to this methods, one mil each of randomly selected dilutions was prepared on appropriate agar media by spread-plate method for isolation and enumeration of microorganisms. Aerobic bacteria, staphylococci yeast, mould and enterobacteriaceae were cultivated and enumerated on Plate Count Agar (PCA) (Oxoid England), mannitol salt agar (MSA, Oxoid) and MacConkey agar (Oxoid). Plates were incubated at 30 °C for 48 hrs, morphological characteristics on plates examined and the number of colony forming units (CFU) for each morphotype recorded separately. Potato dextrose agar (SDA, Oxoid) containing 50 mg/L chloramphenicol and 50mg/L chlortetracycline, to inhibit bacterial growth, was employed for the cultivation of fungi. Incubation was at 25 ºC for 3 to 5 days. Lactic acid bacteria (LAB) were grown on de Man Rogosa and Sharpe (MRS) agar (Oxoid) incubated under anaerobic conditions in an Anaerobic Gas-Pack system at 30°C for 48–72 h. Colonieswere counted and recorded as logarithms of the numbers of colony forming unit per gram (cfu/g). Pure isolates were stocked for further characterization.

5.1. Identification of isolates
Bacterial isolates were examined for Gram's reaction, catalase production and sporulation (incubation in nutrient broth plus 50 mg/l MnCl2 for 7 days). Presumptive LAB isolates on MRS agar were examined for Gram's reaction, catalase production, gas production from MRS-broth containing inverted Durham tubes and growth at 15°C and 45°C in MRS broth [24]. Cell morphology and motility were examined by microscopic observation of cells grown in broth for 24 h [24].

6. Sensory Evaluation
Sensory evaluation of gruels produced from the food formulations was performed by affective testing [25]. The panelists consist of 20 women (mostly mothers) who are regular users of commercial complementary foods. A 9-point hedonic scale (1-deslike extremely, 9-like extremely) was used to rate the sensory attributes of colour, taste, aroma, texture and overall acceptability of the products. The panelists judged the samples, which was presented to them at random, commercial bottle water (swan) was used for mouth rinsing in between evaluations [26]. The gruels from the formulated products was prepared in distilled water and stored in insulated food flasks (Eleganza Nigeria Plc; Lagos), from where they were served to the panelists. Fifty (50) ml of each gruel was served hot (70-800 C) in 100ml colourless, transparent plastic cups, which were coded and colourless transparent spoons were supplied for eating the gruels. The results were subjected to analysis of variance at 5% level of significance and means were separated using the Duncan Multiple Range Test.

7. Statistical Analysis
All data and results with statistical analysis will be 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. Fisher's Least Significance Difference (LSD) was used for multiple mean comparison tests. Statistical significance was set at $p<0.05$.

Results
1. Functional Properties of the formulated blends
The functional properties of the formulated blends are presented on Table 1. The functional properties explain how food ingredients behave during preparation and cooking. The functional property impact the finished food products in terms of texture, appearance, structure and taste. The effect of malting and fermentation is indicated in the formulated food blend and the ranges of the results are shown below. The properties analysed include water absorption capacity, bulk density, water absorption capacity, swelling capacity, reconstitution index and viscosity at ambient temperature was determined and values obtained ranged from 67.63UMFAS to 80.63 UMUFAS, 0.58 MFAS to 0.85 UMUFAS, 71.37 MFAS to 83.37 UMUFAS, 16.51 MUFAS to 20.47 UMUFAS, 84.67 UMUFAS to 86.59 MFAS and 397.45 UMFAS to 402.30 UMUFAS for water absorption capacity, bulk density, water absorption capacity, swelling capacity, reconstitution index and viscosity at ambient temperature. Significant difference was determined at ($p<0.05$) among the formulated diets.

Table 1: Functional Properties of the formulated blends

Samples	Oil absorption Capacity (%)	Bulk Density (%)	Water Absorption Capacity (%)	Swelling Capacity (%)	Reconstitution index (%)	Viscosity @ ambient temp (cp)
UMUFAS	80.63^{d}±0.01	0.58^{a}±0.01	83.37^{d}±0.02	16.51d±0.03	84.67^{a}±0.04	389.48^{a}±0.22
MUFAS	72.97^{c}±0.02	0.65^{b}±0.01	80.38^{c}±0.02	16.73^{c}±0.01	85.69^{bc}±0.07	397.45^{b}±0.14
MFAS	70.26^{b}±0.01	0.73^{c}±0.02	79.54^{d}±0.03	16.94^{b}±0.02	86.15^{c}±0.02	398.78^{c}±0.24
UMFAS	67.63^{a}±0.01	0.85^{d}±0.01	71.37^{a}±0.02	20.47^{a}±0.02	86.59^{d}±0.02	402.30^{d}±0.15

Values are mean ± Standard deviation of triplicate replicates. Means with different superscripts on the same column are significantly different at $p < 0.05$.
Key
UMUFAS: Unmalted,unfermented acha soybeans
MUFAS: Malted,unfermented acha soybeans
MFAS: Malted fermented acha soybeans
UMFAS: Unmalted fermented acha soybeans

2. Pasting Properties

Pasting properties of the formulated blends is presented on Table 2. Pasting property is one of the most important properties that influence quality in the food industry because pasting property affect texture and digestibility of food. The effects of fermentation and malting were shown on the formulated blends which bring about either increase on decrease on a specific pasting property and the ranges of the results is stated as follows: the peak viscosity was highest in UMFAS 189.31 and lowest in UMUFAS 162.34. The variation in the peak viscosity could be because of the amylose contents of the flour samples [27]. Final viscosity was highest in UMFAS 246.54 and lowest in UMUFAS 181.293, the setback ranges between 54.62UMUFAS and 68.27UMFAS, Breakdown range from 9.65UMUFAS to 11.61 MFAS. [27] reported that high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross- linking properties. Pasting time ranges between 6.45 UMUFAS and 7.65 UMFAS, pasting temperature range between 65.44 UMFAS and 68.44UMUFAS and trough ranges from 152.69 UMUFAS to 178.27 UMFAS. Significant difference was determined at ($p<0.05$) among the formulated diets.

Table 2: Pasting properties

Samples	Peak viscosity (RVU)	Final viscosity (RVU)	Set back (RVU)	Breakdown (RVU)	Pasting time(Min)	Pasting temp (°C)	Trough (RVU)
UMUFAS	$162.34^{a}\pm0.29$	$207.31^{a}\pm0.01$	$54.62^{a}\pm0.40$	$9.65^{a}\pm0.031$	$6.45^{a}\pm0.04$	$68.44^{a}\pm0.05$	$152.69^{a}\pm0.02$
MUFAS	$176.58^{b}\pm0.01$	$225.7^{b}\pm0.01$	$60.42^{b}\pm0.02$	$11.30^{b}\pm0.03$	$7.13^{b}\pm0.01$	$67.31^{b}\pm0.01$	$165.28^{b}\pm0.04$
MFAS	$187.31^{c}\pm0.02$	$243.28^{c}\pm0.02$	$67.58^{c}\pm0.02$	$11.61^{b}\pm0.06$	$7.31^{c}\pm0.06$	$66.15^{c}\pm0.07$	$175.70^{c}\pm0.02$
UMFAS	$189.13^{d}\pm0.02$	$246.54^{d}\pm0.02$	$68.27^{d}\pm0.02$	$10.86^{c}\pm0.80$	$7.65^{d}\pm0.02$	$65.44^{d}\pm0.02$	$178.27^{d}\pm0.03$

Values are mean ± Standard deviation of triplicate replicates. Means with different superscripts on the same column are significantly different at $p < 0.05$.
Key
UMUFAS: Unmalted,unfermented acha soybeans
MUFAS: Malted,unfermented acha soybeans
MFAS: Malted fermented acha soybeans
UMFAS: Unmalted fermented acha soybeans

3. Microbiological Quality of Various Formulations

The total aerobic, yeast, mould, Enterobacteriaceae and total Staphylococcus aureus counts of the formulated blends are presented on Table 3. Malting and fermentation resulted in significant ($p<0.05$) increase in microbial load of the food formulations. The total aerobic counts, ranges from $1.20x10^{2}$ CFU/g in MFAS to $2.7x10^{2}$ CFU/g in UMUFAS, yeast and mould count range between $1.70^{a}\times10^{1}$ cfu/g UMUFAS and $5.86^{d}\times10^{1}$ cfu/g UMFAS, there was no growth of yeast in MUFAS, MFAS. Yeast count in UMUFAS, UMFAS was $1.66^{b}\times10^{1}$,$1.90^{c}\times10^{1}$ cfu/g respectively. The only growth observed in entrobacteriacae was found in UMUFAS $7.80^{b}\times10^{1}$fu/g c. There was no growth recorded in Total staphylococcus aureus count in any of the formulated blend. The fungal/ bacteria isolates in the formulated blends are named as follows; UMUFAS: yeast cell, klebsiella aerogenes, staphylococcus spp. MUFAS: yeast cell, staphylococcus spp. MFAS: are yeast cells, mucor spp, staphylococcus spp. UMFAS: yeast cells, mucor spp, bacillus spp, staphylococcus spp

Table 3: Microbiological Quality of Various Formulations

Samples	TAC (cfu/g)	YMC (cfu/g)	YC (cfu/g)	EC (cfu/g)	Tsac (cfu/g)
UMUFAS	$2.70^{a}\times10^{2}$	$1.70^{a}\times10^{1}$	$1.66^{b}\times10^{1}$	$5.80^{b}\times10^{1}$	0.00
MUFAS	$2.63^{a}\times10^{1}$	$2.80^{b}\times10^{1}$	0.00^{a}	0.00^{a}	0.00
MFAS	$1.20^{a}\times10^{2}$	$3.90^{c}\times10^{1}$	0.00^{a}	0.00^{a}	0.00
UMFAS	$1.30^{a}\times10^{2}$	$5.86^{d}\times10^{1}$	$1.90^{c}\times10$	0.00^{a}	0.00

Values are mean ± Standard deviation of triplicate replicates. Means with different superscripts on the same column are significantly different at $p < 0.05$.

Key

UMUFAS: Unmalted,unfermented acha soybeans
MUFAS: Malted,unfermented acha soybeans
MFAS: Malted fermented acha soybeans
UMFAS: Unmalted fermented acha soybeans
TAC: Total Aerobic Count, YMC: Yeast and Mould Count, YC: Yeast Count, EC: Enterobacteriaecae Count, Tsac: Total Staphylococcus Aureus Count

4. Sensory Properties

The sensory scores for the different formulated acha and soybeans product in comparison with NESTLE CERELAC are provided on Table 4. The results for appearance ranges from 6.60 (UMUFA) to 7.60 (MFAS), the aroma ranges from 6.55(UMUFA) to 7.50 (UMUFAS), the taste ranges from 6.35(UMUFA) to 7.55 (UMUFAS) and the general acceptability ranges from 6.55(UMUFA) to 7.70 (MUFAS). The NESTLE CERELAC has a general acceptability of 7.85. In the formulated blend, the blends made from UMUFAS had the highest score while the UMUFA had the lowest score in general acceptability. The sensory scores for the NESTLE CERELAC was not significantly different ($p < 0.05$) in comparison with the formulated products.

Table 4: Sensory Scores for Various Formulated Products

Samples/Attributes	Appearance	Aroma	Taste	General Acceptability
UMUFAS	7.50±1.14[a]	7.50±1.19[a]	7.55±1.09[a]	7.65±1.22[a]
MUFAS	7.55±0.99[a]	7.20±1.64[a]	7.35±1.26[a]	7.70±1.21[a]
MFAS	7.60±1.35[a]	6.95±1.76[a]	6.95±1.46[a]	7.30±1.83[a]
UMFAS	6.95±1.73[a]	6.95±1.31[a]	7.00±1.29[a]	7.10±1.58[a]
NESTLE CERELAC	7.85±1.30[a]	7.90±1.11[a]	7.65±1.26[a]	7.85±1.34[a]
UMUFA	6.60±2.54[a]	6.55±2.50[a]	6.35±2.32[a]	6.55±2.43[a]

Values are mean ± Standard deviation of triplicate replicates. Means with different superscripts on the same column are significantly different at $p < 0.05$.

Key

UMUFAS: Unmalted, unfermented acha soybeans

MUFAS: Malted, unfermented acha soybeans

MFAS: Malted fermented acha soybeans

UMFAS: Unmalted fermented acha soybeans

NESTLE CERELAC

UMFAS: Unmalted fermented acha

Discussion

1. Functional Properties of the Formulated Blends

Functional properties of food materials are very important for the appropriateness of diet, particularly, for the growing children [28]. There were significant differences ($p < 0.05$) in water absorption capacity, bulk density, water absorption capacity, swelling capacity and reconstitution index among the formulated food blends. This report is similar to report given by [28]. Bulk density is a function of flour wettability which influences packaging design and could be used in determining the required type of packaging material. The higher the value the better the sample reconstitutes in water and gives a fine constitutes during mixing [29]. The lower loose bulk density implies that less quantity of the food samples would be packaged in constant volume thereby ensuring an economical packaging. It was observed that bulk density decrease with malting and fermentation.

According to [17], the decrease in bulk density might as result of malting and fermentation which soften the seeds, thus making milling easier, with smaller particle sizes than unmalted grains, hence this bring about reduction in bulk density. The significance of this is that the less bulky flours will have higher nutrient density, since more flour can be packaged in the same given volume [17]. However, the packed bulk densities would ensure more quantities of the food samples being packaged, but less economical. Nutritionally, loose bulk density promotes easy digestibility of food products, particularly among children with immature digestive system [28]. The decrease in bulk density with malting and fermentation in the formulated products is in line with report given by [17, 30].

The swelling capacity is an important factor used in determining the amount of water that food samples would absorb and the degree of swelling within a given time. The swelling index of the formulated blends were highest in the unmalted samples and lowest in the malted and fermented samples. The swelling of starch granules leads to disruption of some of the intermolecular hydrogen bonds, thus allowing more water to enter and enlarge the granules. The malted and fermented flours, whose starches had already been dextrinized, could not swell as much [28], [17].

The water absorption capacity is an index of the maximum amount of water that a food product would absorb and retain [28]. The reduction of water absorption capacity with malting and fermentation is similar to report by report by [30]. Lower water absorption capacity is desirable for making gruels in which more flour can be added per unit volume of the gruel. This would help to increase the energy density and nutrient content of the infant foods [31]. There was also increase in water absorption capacity and reconstitution index with malting and fermentation. The increase in water absorption capacity and reconstitution index with malting and fermentation could be due to increased solubility as a result of the increase in amount of soluble sugars present in the malted and fermented flours. This means that the malted and fermented formulations, which had better water absorption capacity, were easier to reconstitute in water when needed [17].

According to [28] microbial activities of food products with low water absorption capacity would be reduced. Hence the shelf-life of such product would be extended. This implies that the fermented food formulations will have less microbial activity in comparison to the unmalted, unfermented formulations and therefore the fermented formulations will have a more stable shelf life than the unfermented formulations. The ability of protein in flours to physically bind with water is a determinant of its water absorption capacity. Soybean with a better quality protein tended to absorb more water than groundnut [29]. It was observed that oil absorption capacity decreases in formulated diet that contain malted and fermented acha. Oil absorption capacity is an important functional property that enhances mouth feel while retaining the flavour of foods [32].

2. Viscosity

Viscosity at ambient temperature among the formulated food blends were determined. The significant reduction ($p<0.05$) in viscosity with malting and fermentation could be due to breakdown or degradation of starch granules, other macromolecules such as polysaccharides and polypeptides to smaller units, such as dextrins and peptides respectively by the enzymes mobilized during the germination and fermentation process. This process cause the decrease of starch swelling while cooking [33]. Fortification with soy flours strengthens starch granules. These observations are in conformity with reports by [17] on effects of malting and fermentation on maize fortified with defatted sesame seed. The reduction in viscosity with malting and fermentation could be nutritionally advantageous since for equal volumes, germination and fermentation would permit the addition of higher quantities of food solids to the gruels in comparison to UMUFAS formulation. This report is similar to report given by [34, 33].

3. Pasting Properties

Pasting properties of the formulated blends is presented on Table 4.8. Cereals forms paste when reconstituted with hot water hence its amylographic viscosities are important in assessing the suitability of its application as functional

ingredients in food and other industrial products [35]. Pasting properties are regarded as one of the most important indices in the evaluation of starch [36]. There were significant differences ($p < 0.05$) among the formulated blends. Peak viscosity, final viscosity, setback, pasting time and trough were found higher in samples that were fermented. This implies that fermentation increases the stated parameters. UMFAS, MFAS had greater values than UMUFAS, MUFAS this is agreement with report by [37]. Results also shows that malting increases the above parameters than unmalted, unfermented formulated blends. Breakdown was lowest in UMUFAS and highest in MFAS. Pasting temperature was lowest in UMFAS and highest in UMUFAS, this implies that fermentation and malting decreases pasting temperature and viscosities increase on sprouting of the cereals [35]. The observation in the pasting properties in the formulated blends is similar to the report by [36, 38].

The setback viscosity is usually regarded as an index of retrogradation tendency of the paste prepared from a starchy food and the higher the value, the greater the retrogradation tendency. The low setback values indicate low rate of starch retrogradation and syneresis. The peak viscosity often correlates with quality of end product and also provides an indication of the viscous. Therefore, the observed variation in setback values has a strong implication on the variability of retrogradation tendency of the weaning food paste during storage. The pasting time is usually regarded as an indication of the total time taken by each blend to attain its respective peak viscosity. Thus, weaning food blends with a lower pasting time will cook faster than that with a higher peak time. The pasting temperature provides an indication of the minimum temperature required to cook a given sample, which can also have implications on energy usage [39, 37]. This indicates that the final viscosities are important in determining the ability of the sample materials to form gel during processing while setback indicates gel stability and potential for retrogradation [40]. Peak viscosity is a measure of the ability of starch to form a paste on cooking [25, 41]. Peak viscosity is an indicative of the strength of paste, which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling. High peak viscosity (PV) indicates high swelling power and corresponds to high thickening power of the samples starch. Peak viscosity relates to the final product quality [27]. Breakdown and Trough viscosities reflect the stability of the paste. The peak and final viscosities of the formulated diets did not follow the same trend that was observed in [31] whose formulated diet reduced with germination.

4. Microbiological Composition

Microbiological analysis of composite flours was focused on the search for flora of contamination and pathogenic microorganisms. The load (CFU/g) of the microorganism are below the microbiological standards. These low values can be related to environmental and water hygiene that was maintained during experiment. The enumerated organisms were: the total aerobic, yeast, mould, Enterobacteriaceae and total Staphylococcus aureus gave values below microbiological standards. The standards are $<10^5$, $<10^3$, $<10^4$, <10 and $<10^2$ for the total aerobic, yeast, mould, Enterobacteriaceae and total Staphylococcus aureus respectively as stated by [42, 43]. The significant increase in microbial load observed with malting and fermentation is consistent with the findings of [17]. Significant difference ($p<0.05$) in microbial load of the malted and fermented food formulations were determined.

The micro-organism in the formulated blends identified were yeast cell, klebsiella aerogenes, staphylococcus spp., mucor spp. and bacillus spp. The bacillus counts in the formulated products could be due to the high heat resistance of these microorganisms which could result in survival of blanching and drying processes used in product formulation and consequent growth in the less inhibitory low acidity medium. Malting and fermentation gives rise to enormous increases in mucor, staphylococcus, yeasts and bacilli as well as potential pathogenic and toxinogenic species. UMFMAS and MFAS with pH value of 3.72 and 3.20 respectively did not support the growth of micro-organism in comparison with and UMUFAS which have pH of 5.66 which encouraged growth of more microorganisms. This implies that pH has great influence on microbial growth. The consumption of these formulated flours cannot present a danger to the health of the child because most of the enumerated microorganism in the food formulations can be destroyed during cooking. This report is in agreement with what is found in [44].

5. Sensory Properties

There was no significant difference in appearance or colour, taste, aroma and general acceptability for all the food formulations. The unfermented products were better than the fermented products in all the attributes, while the values for NESTLE CERELAC were higher than all the food formulations but did not show any significant difference ($p < 0.05$). NESTLE CERELAC was preferred followed by MUFAS, UMUFAS, MFAS, UMFAS and UMUFA formulations in that order. There were general comments on the sourness of the fermented products and the fermented products (UMFAS and MFAS) were still acceptable to panellists. This could be due to the fact that fermented (sour) gruels are common in local diets. The sour taste in fermented products might be due to the action of lactic acid bacteria which results in hydrolysis of starch to organic acids. This is in line with the lower pH and higher titratable acidity in fermented products.

Conclusion

At the end of this research, it can be seen that the use of acha and subjecting it to processing techniques such as malting and fermentation has positive impact on food quality and functionality. The blends formulated from unmalted, malted and fermented acha flour enriched with soy beans has great nutritional impact. The blends formulated in this study are recommended for complementary feeding especially for rural and poor urban mothers to feed their infants and children during the complementary feeding period when mix properly in appropriate ratios.

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