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EVALUATION OF THE QUALITY OF MALTED ACHA-SOY BREAKFAST CEREAL FLOUR

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ABSTRACT

Breakfast cereals are increasingly in demand for health reasons and are primarily made from different cereal grains. Acha (*Digitaria exilis* Stapf) cereal grain and malted soybean flours (MSFs) were used in the ratio 100:0, 90:10, 80:20, 70:30, and 60:40 to produce five Acha-soy breakfast cereal (ASC) products. Acha grains were cleaned, washed, dried, milled and sieved through 600 µm sieve to obtain wholemeal flour. The soybean was soaked (24 hr), drained, germinated (96 hr), dried using cabinet drier at 60^{o}C for 8 hr, devegetated, winnowed, dry milled and sieved to obtain flour. The quality of ASC flour products was assessed in terms of proximate analysis, energy content and microbial analysis. Significant differences ($p<0.05$) existed in all the proximate and energy compositions. There was a general increase in protein, fat and ash contents as the proportion of malted soybean increased while crude fibre, moisture and carbohydrate contents decreased. The energy contents increased with increase in the proportion of malted soybean. Microbial analysis showed no count at first week for both bacteria and fungi. Microbial growth began during the second week after production and increased with storage time. Sensory evaluation was conducted on gruel (thin porridge) made from ASC products. There were significant differences ($p<0.05$) in aroma, flavour, texture and overall acceptability amongst the products. A general decrease existed in the mean scores of the breakfast gruel in all the parameters monitored with increase in MSF. Whole meal Acha breakfast gruel (100%) had the highest mean values except in flavour while ASC gruel (60:40%) had the lowest mean value in all the parameters. Gruel made from 10 and 20% MSFs had the best sensory qualities. These results showed the potential utilization of this unique cereal grain (Acha/fonio) in enriched breakfast cereal production targeting diabetic individuals and the efforts made to introduce a semi-finished Acha product in the market.

Key words: Proximate, Sensory, Microbiological qualities, breakfast, Cereal flour, Gruel, Acha, Malted soybean

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INTRODUCTION

Breakfast cereal (or just cereal) is a food made from processed grains that is often eaten as the first meal of the day. On average a typical traditional cereal is high in carbohydrate and fibre, low in fat, void of essential proteins and vitamins that the body needs. On the other hand, it is mostly rejected by a group of individuals with certain health problems. For this reason, it is necessary to produce an instant Acha (*Digitaria exilis* Stapf) and malted soybean breakfast cereal which would provide a better balanced nutritional value. Grain crops play a significant role in the human diet [1]. Indigenous communities all over the world are familiar with a large diversity of flora and fauna that provide sustenance in form of food and medicine. The 'Plants For a Future' [2] website lists more than 7000 underutilized species with both culinary and medicinal values. Acha cereal grain has been listed as one of the interesting plants of the world [3]**.** Cereal grains are used as breakfast in different forms [4].

Legumes have been highly recommended as a cheap source of protein in upgrading the nutritional quality of cereal products. However, the level of their usage is limited due to their characteristic flavour or functionality [5]. Acha/fonio is a good source of calories and other nutrients, [6,7] but its protein is of lower nutritional quality than those of legumes because it is deficient in essential amino acids such as lysine and threonine [8,9]. However, it is free from gluten, hence would be favoured by gluten sensitive people. Legumes contribute significantly towards protein, mineral and B-complex vitamin needs for people in developing countries. Hence, fortification of Acha flour with inexpensive staples, such as legumes, helps in improving the nutritional quality of Acha products [10]. Dhingra and Jood [11] reported that development and consumption of such functional foods not only improves nutritional status but also helps those suffering from degenerative diseases associated with today's changing life style and environment.

Malted grains are seen in a number of foods at natural health food stores. The concept behind the use of malted grains is that the enzymes produced during malting convert starch into more digestible maltose and increase the absorption rate of vitamins and minerals during digestion. In effect the malting process 'predigests' grains [12]. It is known that germination increases free limiting amino acids and available vitamins with modified functional properties of seed components [13,14].

Acha-wheat flour has been fortified with soybean flour to improve the nutritional value of biscuit [15]. Acha and malted soybean have been used in the production of bread and biscuits [16]. Furthermore, research shows that the essential nutrients missed at breakfast are not compensated for during the other meals of the day, making the choice of what we eat in the morning even more important. To give consumers the full freedom of choice, the breakfast cereal industry provides a wide variety of breakfast cereals, ranging from conventional breakfast cereal to oat flakes and varieties of puddings. In combination with appropriate nutritional and educational information, breakfast cereals can play important roles in improving the diet and the nutritional status of the people.

The objectives of this research are (1) to produce instant whole meal Acha and malted soybeans composite breakfast cereal (ASC), (2) to evaluate the effect of the added malted

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soybean on the chemical and sensory quality of the breakfast cereal, and (3) to determine the microbiological quality of the ASC products under ambient temperature (29 ± 3^{o}C).

MATERIALS AND METHODS

Source of materials

The consumable materials as well as the grain samples, yellow type soybean (*Glycine max*) and Acha (*Digitaria exilis* Staph) grains, were purchased from Muda Lawal market, Bauchi, Nigeria. The major reasons that necessitated the choice of these grains were the high nutritional value of soybean, affordability to consumers and the yield and availability of white acha. The chemicals used were of analytical grade.

Production of wholemeal acha and malted soybeans flours

Acha (*D. exilis*) grains (3000 g) were sorted to remove tiny stones and foreign materials and washed with clean tap water three times for 20 min. The Acha grains were drained and cabinet dried at 60^{o}C for 8 hr (Figure 1) before milling using a hammer mill (Bremmer, Germany). The whole meal flour was packaged in polyethylene bags and stored in a refrigerator at 4-6^{o}C till needed.

Malted soybean flour was produced using the method of Iwe, [18] as shown in Figure 1. Soybean seeds (2000 g) were sorted, cleaned, washed and soaked overnight in a stainless steel bucket containing clean tap water. The soybeans were spread on a clean jute bag and covered to screen from direct sun light. Water containing small amount of calcium hypochlorite ($CaClO_4$) to discourage the growth of microorganisms [18], was sprinkled twice a day at the intervals of nine (9) hr. The seeds were allowed to germinate for 96 hr at room temperature and cabinet dried at 60^{o}C for 8 hr, devegetated by hand rubbing, winnowed and milled into flour using hammer mill (Bremmer, Germany). The flour was sieved with the aid of a 425 µm sieve (Endecotts Ltd, London, England) to obtain a uniform particle size of flour which was packaged in polyethylene bag and stored at 4-6^{o}C till needed.

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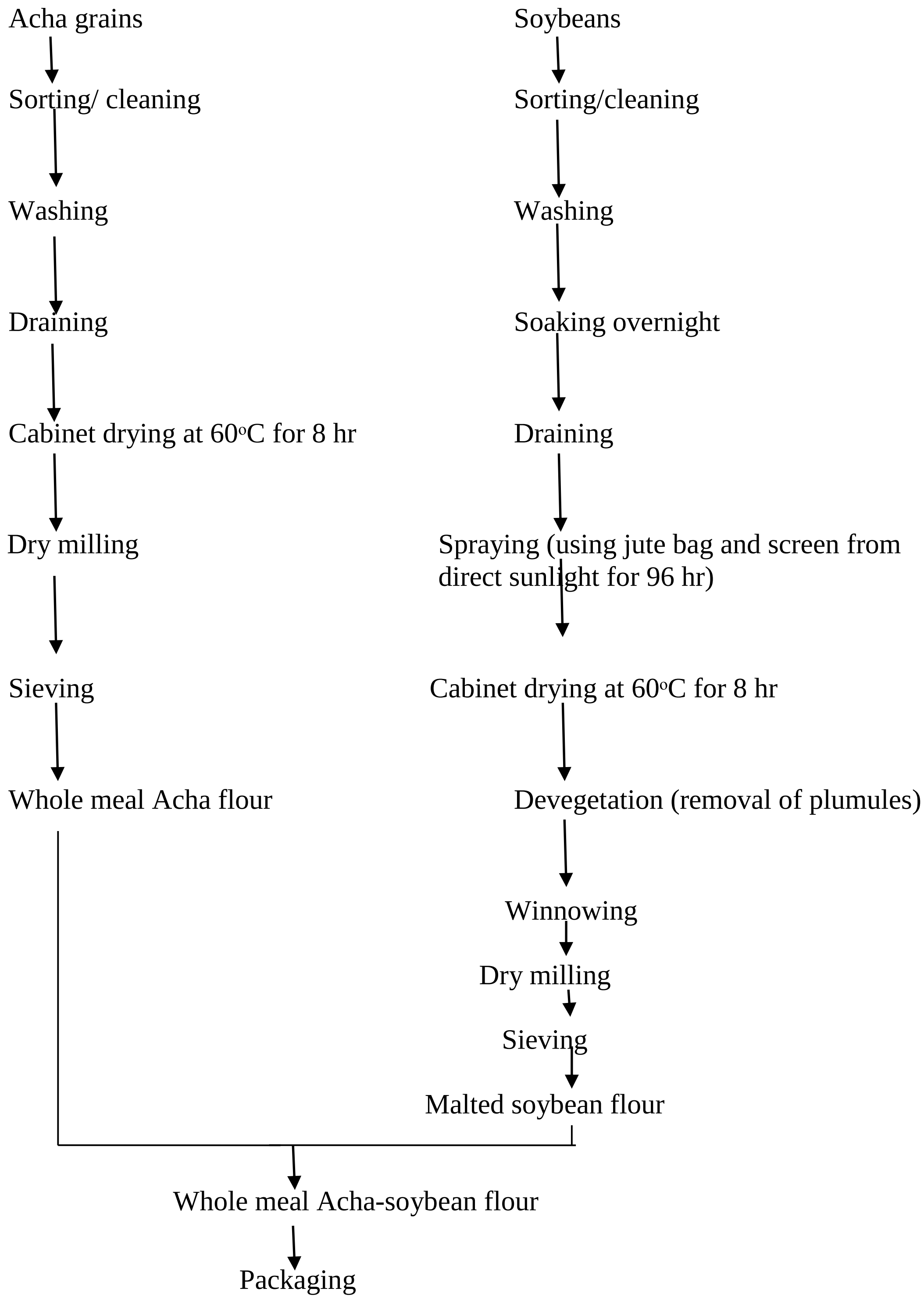

Figure 1: Flow chart of whole meal Acha-malted soybean flour

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Production of whole meal Acha and malted soybean composite flour

Five value-added breakfast flours were produced from the wholemeal Acha and malted soybeans flours in different proportions of 100:0%, 90:10%, 80:20%, 70:30% and 60:40% respectively as shown in Table 1. The proportions chosen are similar to those investigated in a previous study by Ayo *et al.* [16].

Acha-soy breakfast gruel

Based on preliminary preparations, about 3 to 4 tablespoons of the composite breakfast flour was pasted with 200 ml of clean tap water. Boiled water of about 300 ml was added with initial vigorous stirring followed by intermittent stirring for about 4 min, to obtain a desirable consistency (Figure 2).

Proximate composition of Acha-soy breakfast cereal (ASC) flour

The quality of ASC instant flour was assessed in terms of proximate composition and energy content. The moisture (925.09B), protein (979.09), fat (920.39C), ash (923.03), crude fibre (962.09E) contents were determined by the AOAC method, [19]. The available carbohydrate was determined by difference: Carbohydrate = 100 – (% moisture + % protein + % fat + % ash + % crude fibre) following the method of FAO [20]. Energy content was determined as described by Marero *et al.* [21].

Sensory evaluation of whole meal Acha-soy breakfast gruel

The Acha-soy breakfast gruel was compared to 100% whole meal Acha (control) and assessed by a twenty-member taste panel. The panelists were selected randomly from the department of Food Science and Technology, Federal Polytechnic, Bauchi Nigeria based on their familiarity with the product. Panelists had to commit to participation throughout the evaluation period. The products were evaluated for colour, texture, flavour, aroma and overall acceptability [16]. A nine-point Hedonic scale from 9 (like extremely) to 1 (dislike extremely) was used. The scores were statistically analysed using analysis of variance. The products, appropriately coded (ACF = 100% whole meal Acha flour, MSA = 90:10% whole meal Acha/malted soy flour, TSG = 80:20% wholemeal Acha/malted soy flour, AZR = 70:30% whole meal Acha/malted soy flour and JMA = 60:40% whole meal Acha/malted soy flour) and of the same quantity (10 ml) and temperature ($29 \pm 3^{o}C$) were placed in white plastic plates. The panelists rinsed their mouths with bottled water after tasting each sample [22]. Test samples were served randomly to panelists in different booths under fluorescent light.

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Whole meal Acha-malted soybean flour

↓

Three to four tablespoons pasted with 200 ml of clean tap water

to form slurry

↓

Add 300 ml of boiled water at 100^{o}C

↓

Stir for about 4 min

↓

Gruel

Figure 2: Flow process for the constitution of whole meal Acha and malted soy gruel

Microbiological analysis of the Acha-soy breakfast cereal (ASC) flour

The pour plate method of knowing and counting the number of viable bacteria, mould and yeast present in the sample was adopted as described by Jideani and Jideani [23]. The ASC sample (2 g) was used for the enumeration. Quarter strength of peptone water solution was prepared by dissolving 3 g of peptone in 200 ml of distilled water. The nutrient agar and potato dextrose agar were used for bacteria and mould respectively. Serial dilution was carried out on the ASC flour products before plating for bacteria and mould on appropriate media.

Statistical analysis

The proximate and sensory results obtained were subjected to analysis of variance and Duncan multiple range tests [24] was used to separate means where significant differences existed. The software used for the statistical analysis was MINITAB ver. 17.

RESULTS

Proximate and energy compositions of Acha-soy breakfast flour

The proximate composition of the various proportions of ASC flour is shown in Table 2 with 100% whole meal Acha flour serving as control. The percent protein, fat and ash contents of the breakfast meals ranged from 6.92 - 19.60, 2.74 - 12.45 and 1.02 - 2.46 respectively with 60:40% ASC flour having the highest percentages. The energy content (Kcal/100 g) increased from 361.46 - 422.39 with increase in malted soybean flour (MSF). The crude fibre contents increased from 0.86 - 2.46% with increase in the amount of MSF in the resulting composite flour. The moisture and carbohydrate contents of the ASC flour products decreased from 9.35 - 5.05% and 77.28 - 57.99%, respectively.

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Sensory evaluation of the Acha-soy breakfast gruel

The sensory evaluation of the fortified breakfast (ASC) gruel was compared to the control gruel (100% whole meal Acha flour) as shown in Figure 3. There was no significant difference ($p > 0.05$) in colour for all the ASC gruels while significant difference ($p < 0.05$) existed in aroma, flavour, texture and overall acceptability. The mean values for colour, aroma and flavour ranged from 6.90 to 7.40, 4.84 to 6.55 and 4.95 to 6.60, respectively while texture and overall acceptability ranged from 5.70 to 7.30 and 3.20 to 7.50, respectively.

Microbiological analysis of the Acha-soy breakfast flour

The bacteria/fungal counts of the flours done at an interval of one week over a period of five weeks are shown in Table 3. The microbial analysis for first week after production showed no growth of bacteria, mould and yeast. Microbial growth began at the second week after production with the range of 1.3×10^3 - 1.5×10^4 cfu/g for bacteria and 1.6×10^3 - 1.6×10^4 cfu/g for fungi. There was increase in microbial load with the range of 3.4×10^2 - 3.8×10^4 cfu/g for bacteria and 4.7×10^2 - 3.6×10^4 cfu/g for fungi at the fifth week.

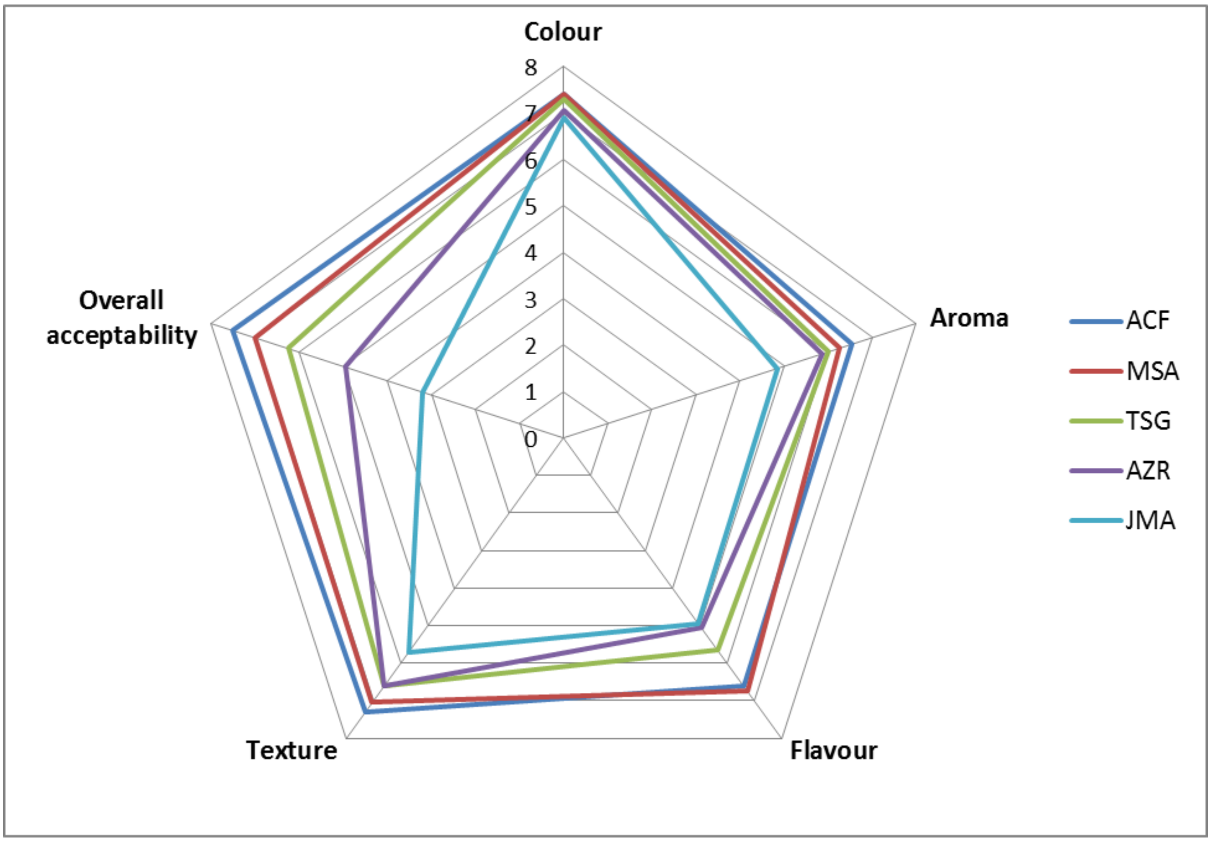

Figure 3: Spider plot of sensory evaluation of whole meal Acha-malted soybean breakfast gruel. ACF = 100% whole meal Acha flour, MSA = 90:10% whole meal Acha/malted soy flour, TSG = 80:20% wholemeal Acha/malted soy flour, AZR = 70:30% whole meal Acha/malted soy flour and JMA = 60:40% whole meal Acha/malted soy flour

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DISCUSSION

Proximate and energy compositions of Acha-soy breakfast flour

Significant differences ($p<0.05$) existed among the ASC samples. The protein contents of the breakfast flours increased with increase in malted soybean flour (MSF). The incorporation of legumes into cereal meals has been reported to result in a higher protein quality than if administered as only cereal meal [25]. According to Berns [26], consumption of breakfast cereals containing soybean product discourages the accumulation of cholesterol.

The fat content in the breakfast meals showed a significant level of increase with increase in MSF in the formulations. This showed that the breakfast flours were high energy products because of the fat content. This increase was due to the addition of MSF, soybean being a good source of oil [18]. The flours being rich in fat provided the energy requirements for bodily activities as computed in the data by FAO [27] and FAO/WHO [28].

The ash content of the ASC products increased with increase in MSF. Ash content indicates the presence of mineral matter in food. It is a non-organic compound that constitutes the mineral content of food. It aids in the metabolism of other compounds such as protein, fat and carbohydrate [29]. This increase could be due to more mineral content of soy as compared to Acha grain [9].

The crude fibre contents were low as compared to 5.69% for the 100% wholemeal Acha flour (control). It is known that whole grains are good source of dietary fibre and are used in the prevention and treatment of constipation, cardiovascular diseases and hypertension [30]. The health benefits of whole grain Acha products are now widely recognized and considered to result from the presence of bioactive components, including dietary fibre and phytochemicals [31].

The decrease in moisture content could be due to increase in protein content as a result of MSF, and protein has more affinity to moisture than carbohydrate [32]. This could be an advantage to the keeping quality and shelf-life of the flours. There is less microbial growth when moisture is less available.

The 100% whole meal Acha flour had the highest percentage carbohydrate content of 77.28. The substantial carbohydrate content of whole meal Acha has made it a complement to the diet for diabetic individuals. It has been found that consumption of whole Acha grains by diabetic patients helps them recover due to its low glycemic index [33]. The whole grain Acha is rich in fermentable carbohydrate that reaches the gut. Whole grain breakfast cereal has been shown to be more effective than wheat bran breakfast cereal as a prebiotic, increasing faecal bifido bacteria and *lactobacilli* in human subjects [34]. The energy content (Kcal/100 g) of the ASC products showed that the products are rich in energy.

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Sensory evaluation of the Acha-soy breakfast gruel

There was a general decrease in the mean scores of the breakfast gruel in all the parameters monitored with increase in MSF. Whole meal Acha breakfast gruel (100%) had the highest mean value in all the parameters monitored except in flavour while ASC gruel (60:40%) had the lowest mean value in all the parameters.

The 10 and 20% substitution of malted soybean breakfast gruels compared favourably with 100% whole meal Acha breakfast gruel (control) in all the sensory properties measured. This is an indication that the adjustment was acceptable to the consumers. Fliedell *et al* [35] reported sensory diversity of Fonio/Acha (*D. exilis*) landraces from West Africa and concluded that sensory variability offers to processors, who intend to promote this tiny cereal both in the sub-region and beyond, the possibility to choose adapted landraces to develop new products.

As stated by Kipkoriony and Jaja, [36] the answer to the question of long-term food security lies in diversity of approaches and resources, among which exploring the wild for alternative crops remains a mostly untapped frontier. Acha, like some other overlooked alternative, is the option of going back to the partially domesticated species that have a long history of usage as food, medicine, and raw material. These plants are resilient, well adapted to local environments, and still retain highly diverse genetic bases and unique characteristics. Moreover, overcoming malnutrition and food insecurity with local resources, like Acha/Fonio cereal grain, means protecting and promoting the use of local resources against importation of low-priced processed foods from subsidized production in industrialised countries [37]; and finding appropriate end users can contribute much to support farmers in developing countries in planting these indigenous crops.

Microbiological analysis of the Acha-soy breakfast flour

There was a general increase in microbial load with storage time under ambient temperature (29 ± 3^{o}C). This increase could be due to the composition of the product with regard to increased protein content of the fortified breakfast cereal flours. From the result, it could be concluded that mould and yeast are the possible spoilage organisms associated with the product at moisture content below 10% level. Bacterial growth in the product was as a result of handling, suggesting the need for the adoption of standard microbiological safety procedure in production and setting microbial specifications for the products.

CONCLUSION

Acceptable breakfast cereal-soy flours were formulated from whole meal Acha and malted soybean flours. Analysis carried out showed that the fortified Acha breakfast cereal flour is rich in protein, fat, ash and energy. The 10% and 20% substitution of malted soybean breakfast gruels compared favourably with 100% whole meal Acha breakfast gruel (control) in all the sensory properties measured. The formulation of the breakfast cereal flour has provided another means of utilizing Acha/Fonio (*D. exilis*) cereal grain and soybean. The breakfast cereal flour produced has low microbial load and is estimated to have a projected shelf life of one year at 29 ± 3^{o}C with 77% relative humidity. Statistics published by the UN Population Division (2007) show that the estimated world human population is expected to reach 8.5 billion by 2025 and projected 9.2 billion by 2050. These estimates require concomitant increase in food production, supply and processing especially in developing economies in order to meet world demand and to minimize malnutrition.

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Table 1: Formulation (%) of whole meal Acha and malted soy instant gruel

Whole meal Acha-malted soy blends	Whole meal Acha flour	Malted soy flour
ACF	100	-
MSA	90	10
TSG	80	20
AZR	70	30
JMA	60	40

ACF = 100% whole meal Acha flour, MSA = 90:10% whole meal Acha/malted soy flour, TSG = 80:20% whole meal Acha/malted soy flour, AZR = 70:30% whole meal Acha/malted soy flour and JMA = 60:40% whole meal Acha/malted soy flour.

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Table 2: Proximate (%) and energy compositions of whole meal Acha and malted soybean flour

Sample code	Whole meal Acha flour (%)	Malted soy flour (%)	Crude protein	Fat	Ash	Crude fibre	Moisture	Carbohydrate	Energy kcal/100 g
ACF	100	-	$6.92^{e} \pm 0.24$	$2.74^{e} \pm 0.34$	$1.02^{d} \pm 0.04$	$5.69^{a} \pm 0.38$	$6.36^{b} \pm 0.27$	$77.28^{a} \pm 0.71$	$361.46^{d} \pm 0.74$
MSA	90	10	$9.07^{d} \pm 0.21$	$5.17^{d} \pm 0.16$	$1.21^{d} \pm 0.03$	$2.46^{b} \pm 0.13$	$9.35^{a} \pm 0.79$	$72.74^{b} \pm 1.03$	$373.77^{c} \pm 1.91$
TSG	80	20	$12.16^{c} \pm 0.22$	$8.53^{c} \pm 0.39$	$1.48^{c} \pm 0.13$	$1.65^{c} \pm 0.14$	$5.17^{c} \pm 0.10$	$71.01^{c} \pm 0.93$	$409.45^{b} \pm 0.67$
AZR	70	30	$15.10^{b} \pm 0.30$	$11.24^{b} \pm 0.48$	$2.10^{b} \pm 0.08$	$0.99^{d} \pm 0.09$	$5.17^{c} \pm 0.05$	$65.40^{d} \pm 0.33$	$423.16^{a} \pm 1.80$
JMA	60	40	$19.60^{a} \pm 0.41$	$12.45^{a} \pm 0.34$	$2.46^{a} \pm 0.11$	$0.86^{d} \pm 0.09$	$5.05^{c} \pm 0.06$	$59.48^{e} \pm 0.23$	$428.77^{a} \pm 2.40$

Means with the same letter along a column showed no significant difference at ($p > 0.05$). Values are means ± Standard deviation of two determinations.

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Table 3: Total bacteria/mould count for whole meal Acha-malted soybean breakfast meal

Sample code	Whole meal Acha flour (%)	Malted Soybean flour (%)	Weeks (cfu/g)				
	Bacteria count		**1**	**2**	**3**	**4**	**5**
ACF	100	0	NG	1.3×10^2	2.0×10^2	2.4×10^2	3.4×10^2
MSA	90	10	”	1.0×10^4	2.0×10^4	2.6×10^4	3.4×10^4
TSG	80	20	”	1.2×10^4	2.8×10^4	3.2×10^4	3.3×10^4
AZR	70	30	”	1.3×10^4	3.4×10^4	3.8×10^4	3.4×10^4
JMA	60	40	”	1.5×10^4	3.4×10^4	3.4×10^4	3.8×10^4
	Fungal count						
ACF	100	0	NG	1.6×10^2	2.1×10^2	3.0×10^2	4.7×10^2
MSA	90	10	”	1.4×10^4	2.0×10^4	2.8×10^4	3.4×10^4
TSG	80	20	”	1.3×10^2	2.4×10^4	3.2×10^4	3.4×10^4
AZR	70	30	”	1.2×10^4	2.2×10^4	3.4×10^4	3.5×10^4
JMA	60	40	”	1.6×10^4	2.6×10^4	3.5×10^4	3.6×10^4

NG = No growth

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