Development and Production of High Protein and Energy Density Beverages from Blends of Maize (*Zea mays*), Sorghum (*Sorghum bicolor*) and Soybeans (*Glycine max*) for School Aged Children: Effect of Malting Period on Selected Proximate Parameters and Sensory Qualities of Developed Beverages

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Abstract

A simple process technology for producing high protein and energy density beverage from blends of malted yellow maize, white sorghum and soybeans was developed and produced in this study. The cereals grains were subjected to malting for a period of 48 hours and 72 hours, kilned and milled into flour (270µm). Malt extract was obtained by reconstituting the flour in water (45^{0}C). Also, soymilk was obtained from soybeans and both the malt extract and the Soymilk were then blended at ratio 1:2 respectively. Food additives such as food flavor and sweetening agents (glucose syrup and table sugar) were incorporated into the blend to enhance sensory scores of the developed soy-malt beverages. The results show that malting period had a significant effect ($p \leq 0.05$) on the proximate parameters and sensory qualities of the developed beverages. The developed beverages crude protein ranged between 12.30% to 17.80%, fat content ranged from 2.63% to 10.13%, ash content ranged between 1.25% and 5.30% while the energy content ranged from 135.40 and 166.52kcal. Based on the overall sensory acceptability, sample from 72 hours maize malt and soymilk was the most preferred sample.

Keywords: Beverage drink, cereal malt, soymilk, proximate analysis, sensory qualities

Introduction

The consumption of cereal based food products from maize (*Zea mays*), sorghum (*Sorghum bicolor*), millet (*Pennisetum typhoideum*), rice (*Oryza sativa*) etc is very common and popular worldwide especially in developing African countries where they constitute a major source of their staple food (Gernah *et al.*, 2011).
With the world total production figure being put at 784 million tons of cereals in 2007 (FAO, 2009), these crops particularly maize and sorghum are widely grown and produced in significant quantities per annum in most of the developing African countries in which Nigeria produces 53,000,000 metric tonnes of maize and 8,000,000 metric tonnes of sorghum per annum respectively. Nigeria was reported to have come fifth and second respectively in terms of annual world production figures of maize and sorghum relative to other producing countries (FAOSTAT, 2005; USDA, 2005). Essentially, these crops constitute a major source of carbohydrate and energy for these countries. The maize grains are rich in carbohydrate and do contain significant quantities of other compositions (Ingbian and Oduyela, 2010). Sorghum is an important sources of vitamin B-complex and some other minerals like phosphorous, magnesium, calcium and iron. The protein quality of sorghum is also very similar to that of maize with lysine as the limiting amino acid but rich in methionine (FAO, 1995).

Soybean (*Glycine max*) is an important legume reported to have contained large amount of protein along with other nutrients (IITA, 1990). The protein is high in lysine but low in methionine (Ogazi *et al*., 1996; Omueti *et al*., 2000). However, Nigeria produces about 592,000 metric tonnes of soybeans annually and accounts for 95% of production in Africa (FAO, 2009).

Due to the prevailing unfavourable economic conditions in most developing countries of the world, Africa and Nigeria in particular where over 40% of the population live below poverty line (Nzeagwu and Nwaejike, 2008), the incidence of protein-energy malnutrition among different age groups particularly children with an estimated 400million children being reported to be malnourished worldwide is highly prevalent and on the increase on a daily basis (Oji, 1994; Oosthuizen, 2006; Agiriga and Iwe, 2009). This may be attributed to the ever increasing populace being fed predominantly on their staple food crops (maize, sorghum, cassava, etc) which have been reported to be poor sources of protein (FAO, 1995; Labadarious *et al.,* 2005) particularly in terms of amino acid balance but are rich sources of carbohydrate particularly starch. However, empirical data have shown that there is a strong positive relationship between good nutrition and mental, physical and cognitive development in children generally as well fed children are strong and healthy, they also posses increased intellectual capacity and high ability for scholastic performance with reduced mortality rate and diseases (Chandhari, 2008).

Malting has been shown to be one of the most effective and convenient ways for improvement of nutritional value of cereals (Adeyemo *et al.,* 1992; Akpapunam *et al.,* 1996; Gernah *et al.,* 2011); and currently there is a growing interest in the formulation of food products using the combination of composite blends of malted cereals and legumes as a way of improving nutritional quality of the product suitable for children (Agu and Aluya, 2004).

The appropriate processing of cereals (of which malting is inclusive) and soybeans, as well as the formulation of intermediate products into nutrient blends that will complement each other particularly in terms of the essential amino acids have been reported by several authors (Uwaegbute *et al*., 1998; Alabi and Anuonye, 2007). Also, the use of legume flour to improve the protein quality of cereal and tuber flour in different food formulations have been studied and reported by various researchers (Iwe, 2001; Nnam, 2003; Agiriga and Iwe, 2008). The developed formulations range from production of enriched breakfast meals, biscuits to non-alcoholic beverages. The consumption of cereal based beverage among all age groups is very common in Nigeria and some West African countries for its thirst quenching and filling properties (El-Mahmood and Doughari, 2007). However, the need to formulate and develop a high protein and energy density beverage for school age children cannot be over emphasized as it is hoped that it will help to alleviate the endemic problem of protein-energy malnutrition among the school age children as most processed and packaged beverage available in Nigeria could not be classified as protein and energy rich product. They are generally good source of energy with very little micronutrients.

The aim of this study therefore was to formulate and produce high protein and energy beverage from indigenous crops suitable for school aged children.

Materials and Methods

Materials Used

Yellow maize, white sorghum and soybeans were obtained from local market in Lagos Nigeria. Other raw materials used include granulated sugar, food flavor and potable water.

Product Formulation and Production

Production of Soymilk

The soybean was produced using modified method of Gandhi, (2009) with little modifications. Wholesome soybeans obtained from a local market in Lagos were cleaned to remove stones, dirts and washed. The soybeans were then pressure cooked with 0.1% Sodium bicarbonate for 15minutes, drained, manually dehulled and subsequently wet milled (1000g of cooked soybeans to 250mls of water) into paste using heavy duty blender (Waring blender, Model CB15, Serial No - 556973). Milk was then extracted from the paste by filtration through Muslin cloth using one part of paste to four parts of water. The extracted Soymilk was then stored in a stainless steel vessel with lid prior to use.

Micro-malting of Maize and Sorghum

The cereals were manually cleaned to remove stones and dirts. The cereals were washed in 5% (w/v) sodium chloride (NaCl) solution to suppress the growth of mould and then steeped in portable water at room temperature (30 ± 2^0C) in a ratio of 1:3 (w/v) grains to water in a plastic container. The water was changed every 3hrs (to prevent fermentation) for a total period of 9hrs after which the cereals were drained and subjected to malting period of 48hrs and 72hrs using the modified method of Ayernor and Ocloo, (2007).

After 48 and 72hrs of germination, the germination was arrested by kilning in the cabinet dryer at 45^{0}C for 24hrs and subsequently de-rooted manually prior to dry milling into flour(270µm) using Apex Hammer mill (Model No: 114S2/FLP) to obtain maize and sorghum malt flour.

Malt Extraction

Extraction of malt from the malted grains was accomplished by the addition of 2.5litres of water at 42-45^{0}C to 1kg of each malted flour with stirring for 15-20minutes for each malt flour produced in this study.

Product Formulation

The product formulation/recipe used in this study is as shown in Table 1. Added food flavour and table sugar were incorporated into the blends to enhance the organoleptic qualities of the developed beverages which are referred to as Soy-malt in this study.

Tables 1: The product formulation/recipe for the developed beverage drink

S/N	Ingredients	Soy-maize malt beverage Quantity	Soy-sorghum malt beverage Quantity	Soy-maize -sorghum malt beverage Quantity
1	Maize malt extract	300mls	-	150mls
2	Sorghum malt extract	-	300mls	150mls
3	Soymilk	600mls	600mls	600mls
4	Sugar	50g	50g	50g
5	Flavour (Strawberry)	0.27mls	0.27mls	0.27mls

The developed products were coded as B1, B2, B3, B4, B5 and B6 depending on the period of germination of the cereals used as shown below.
B1 represents Soy-maize malt beverage using 48hrs malt.
B2 represents Soy-maize malt beverage using 72hrs malt.
B3 represents Soy-sorghum malt beverage using 48hrs malt.
B4 represents Soy-sorghum malt beverage using 72hrs malt.
B5 represents Soy-maize-sorghum malt beverage using 48hrs malt.
B6 represents Soy-maize-sorghum malt beverage using 72hrs malt.

Methods

Proximate composition of raw materials, intermediate and finished products

Proximate analysis of the various raw materials and intermediate products were determined using established procedure of Association of Official Analytical Chemist (AOAC) (2000). Crude protein, fat, crude fibre and carbohydrate were determined in the raw materials and intermediate products. Some specific proximate parameters such as crude protein, crude fat, ash and energy were determined in the finished products.

Sensory Characteristics of Developed Beverages

The sensory evaluation of the developed beverage was performed using the method of Iwe, (2002). The scoring was based on a 9- point hedonic scale ranging from 1 (extremely like) to 9 (extremely dislike) and 5 (neither like not dislike).

Statistical Analysis

All statistical analyses were performed using SPSS version 15.0. Mean separation was carried out using Duncan Multiple Range test and Analysis of Variance ANOVA was conducted on the mean values to determine the significance of any differences between samples.

Results

Table 2 shows the proximate analysis of raw materials as well as the malted grains used in this study. The proximate composition of the samples ranged from 10.43% to 10.65% for crude protein, 3.00% to 3.17% for fat, 2.23% to 2.33% for ash, 2.07% to 2.17% for crude fibre, 10.28% to 10.70% for moisture and 71.35% to 71.84% for carbohydrate.

Table 2: Proximate analysis of raw and malted grains

Sample	Treatment	PARAMETERS (%) Crude Protein	Fat	Ash	Crude Fibre	Moisture	Carbohydrate
White Sorghum	Raw	10.44^{bc}	3.07^{c}	2.33^{a}	2.08^{a}	10.33^{c}	71.84^{a}
	Malted (48hrs)	10.51^{b}	3.00^{d}	2.28^{ab}	2.07^{a}	10.30^{c}	71.75^{b}
	Malted (72hrs)	10.65^{a}	3.02^{d}	2.26^{b}	2.13^{a}	10.47^{b}	71.47^{c}
Yellow Maize	Raw	10.34^{c}	3.22^{a}	2.23^{ab}	2.17^{a}	10.28^{c}	71.70^{b}
	Malted (48hrs)	10.38^{c}	3.17^{b}	2.29^{b}	2.15^{a}	10.65^{a}	71.35^{c}
	Malted (72hrs)	10.45^{bc}	3.14^{b}	2.28^{b}	2.10^{a}	10.70^{a}	71.42^{d}

*Values are average of triplicate determination

Table 3 presents the proximate composition of the soymilk used in the formulation of the developed soy-malt drink.

Table 3: Proximate analysis of the Soymilk

S/N	Parameter	Soymilk Composition (wb) (%)
1.	Moisture	92.40
2.	Crude Protein	3.38
3.	Crude Fat	1.50
4.	Crude Fibre	0.02
5.	Ash	0.50
6.	Carbohydrate	2.20

*Values are average of triplicate determination

Table 4 shows some selected proximate composition of the developed Soy-malt beverage. The crude protein, fat, ash and energy ranged from 12.30% to 17.80%, 2.63% to 10.13%, 1.25% to 5.30% and 135.40 kcal to 172.75 kcal respectively.

Table 4: Some selected proximate parameters of developed Soy-malt beverages

Sample Code	Parameters Crude Protein (%)	Fat (%)	Ash (%)	Energy (kcal)
B1	17.80^{a}	10.13^{a}	5.30^{a}	161.42^{d}
B2	15.38^{b}	9.80^{b}	3.25^{c}	166.52^{c}
B3	14.38^{c}	2.63^{f}	1.25^{f}	138.60^{e}
B4	13.24^{e}	8.15^{c}	2.79^{d}	172.75^{a}
B5	12.30^{f}	7.03^{d}	2.34^{e}	169.76^{b}
B6	13.38^{d}	6.49^{e}	5.17^{b}	135.40^{f}

*Values are average of triplicate determination

Figure 1 below presents the sensory characteristics of the developed Soy-malt beverage with added flavouring agent.

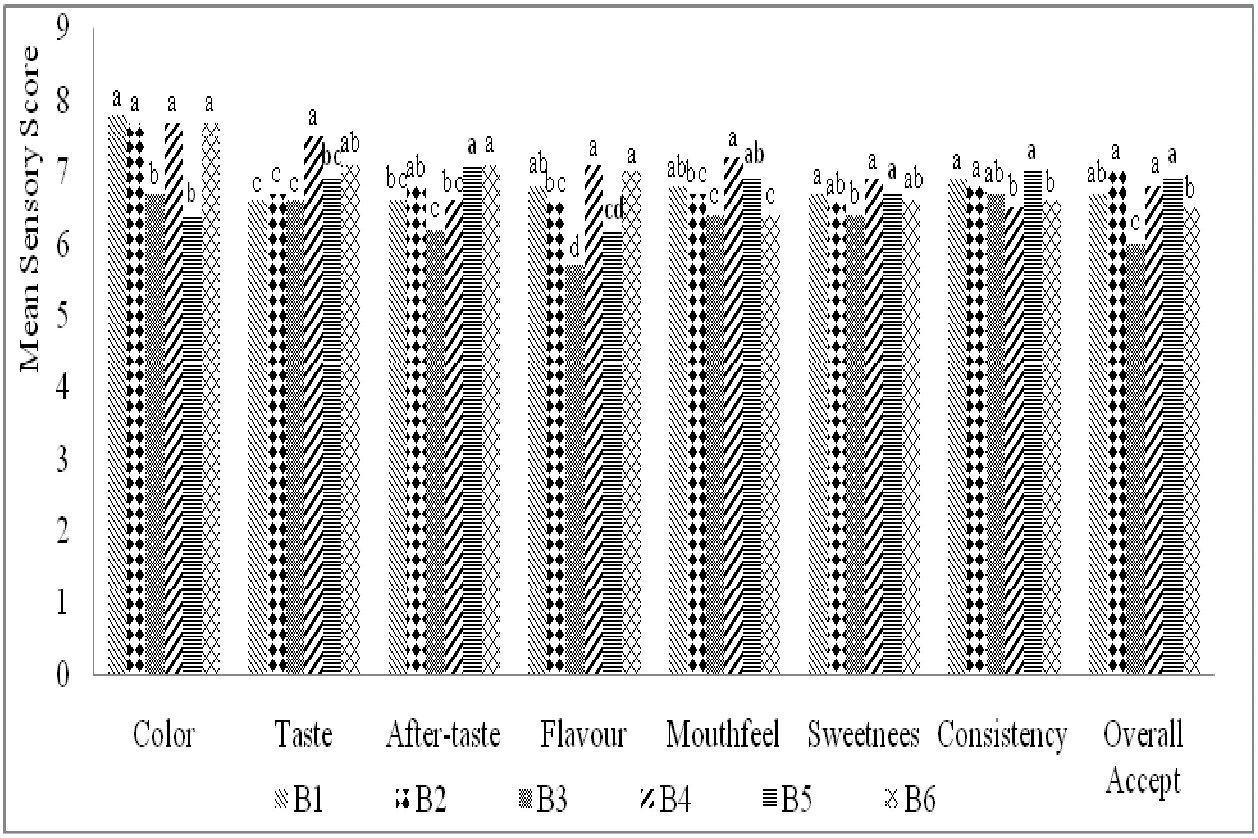

Fig 1: Sensory characteristics developed soy-malt beverage

Note: Values with a different letter on the bars are significantly different (p≤0.05) for a given sensory characteristics.

Discussion

Proximate composition of raw and malted cereal grains

The results of the proximate composition of the raw and malted cereal grains showed that maize and sorghum contained appreciable level of crude protein, low levels of fat, crude fibre and ash but high levels of carbohydrate which have been similarly observed by previous workers (Dewar *et al*., 1997; El-Hkier and Hamid, 2008; Gernah *et al,* 2011). Malting generally induces important beneficial biochemical changes in cereal grains. Soaking generates softening and increases water availability (Enwere, 1998). The enzymes produced during germination leads to the hydrolysis of starch and proteins with release of sugar and amino acids. Proteolytic enzymes improves amino acid availability particularly lysine, methionine and tryptophan that are lacking in cereals. This may be responsible for the progressive increase in the crude protein values recorded from the raw cereals (sorghum and maize) grains to the seventy-two hours malted cereal (Sorghum and Maize) grains that was observed in this study with sorghum showing higher value for each malting period.

Generally, malting of the grains resulted in significant (p≤0.05) increase in crude protein. This is probably due to breakdown of protein compounds into peptides and amino (Ade-Omowaye *et al*., 2006) showing that the biochemical reactions occurring during malting also affects the protein among other molecules in the germinating grains. Previous workers have reported that during malting protease enzymes were produced which possibly acted on the protein to produce peptides and amino acids from protein (Kirk-Uthmar, 2007).

Akpapunam and Dedeh, (1995) reported that during malting, the first 48hrs are actually the period preceding sprouting during which the growth process and metabolic activities of the grains are suspended at maturation, dehydration and storage of the grain are resumed under favourable conditions of moisture and temperature.

Conversely, there was significant decrease between raw and malted cereals ($p \leq 0.05$) in crude fat, ash and carbohydrate during the germination period. This might probably be attributed to malting losses incurred as a result of dry matter loss, mainly due to the growth and respiration of the embryo and the enzymic activities in the grains (Abiodun, 2000). There was a progressive decrease in the fat content of the raw materials to the seventy-two hours malted sorghum and maize grains. This could be traceable to development and production of lipase enzymes during malting which probably act on the fat (or lipids) to produce fatty acids in the malted products. The extent of the different enzyme activities in the malted products in the study is however not determined in this study. Also, malting affects the carbohydrate molecules in the germinating grains through the action of amylase enzymes produced during the malting process by reducing the carbohydrate to maltodextrins and low molecular weight sugars (Kirk-Uthmar, 2007).

Generally, the changes in the raw materials brought about by malting of the cereal grains involved production of which amylases (reported to increase digestibility of the grains), proteases and lipases which play a major role in the biochemical changes observed in the malted cereal grains (Stevens *et al.*, 2004). It appears as if malting did not have a pronounced effect on the crude fibre content of the malted products ($p \leq 0.05$) in this study. However, the crude fibre appears to have progressively increased from the raw sorghum grain to the seventy-two hours malted sorghum grains while the reverse situation was obtained for the maize grain.

The moisture content of the malted grains shows that there is a gradual increase in the moisture content of both cereals with increase in malting period with seventy-two hours malted maize showing highest moisture content. This probably is as a result of addition of water to the grains during the malting process with seventy-two hours malt having more water due to the prolonged period of water addition. This effect of malting on the moisture content on sorghum and maize is nearly comparable to those results obtained by Yousif and Magboul, 1972. Results indicated that in both cereal grains (Maize and Sorghum) the moisture content increased with increasing malting period as compared with non-malted grains. The proximate analysis result of the soymilk is in agreement with the report of Gesinde *et al.*, 2008, however higher moisture content was reported in their findings. This as well as varietal differences may be responsible for the small variation in the other values obtained.

The proximate analysis of the developed beverages in this study showed that the beverages in this study contain appreciable level of protein and are good source of energy which are expected due to the starting raw materials. A similar observation has earlier been reported by Omueti *et al*., (2000). White Sorghum and Yellow Maize are very good sources of carbohydrate (particularly starch), energy with little content of protein, ash and fat. On the other hand, soybean is a very good source of protein, fat and minerals (IITA, 1990).

Sensory quality of developed products

Sensory characteristics of the developed products showed that the Soy-malt beverage that contained Soymilk and Maize malt was the most acceptable product followed by the Soy malt beverage that contains Soymilk and blends of equal quantities of seventy-two hours old White Sorghum and Yellow Maize malt. The least acceptable product was however made from blends of soymilk and 72hrs old malted white sorghum.

Conclusion

In terms of overall acceptability, sample B2 has the highest sensory score, but it does not have any significant difference with samples B5, B4 and B1. The study shows that it is possible to develop and produce nutritious beverages from blend of cereals and legumes suitable for different age groups particularly for school aged children in developing African countries where hunger and protein-energy malnutrition is increasing on a daily basis.

Further Work

There is still need to subject the developed beverage to different quality evaluation, mineral and vitamin content analysis. Also, amino acid and fatty acid content as well as rat feeding study to ascertain the protein digestibility, biological value, net protein utilization as well as toxicological study still need to be investigated.

Acknowledgement

The authors wish to acknowledge the Federal Institute of Industrial Research, Oshodi, Lagos, Nigeria for providing fund and laboratory facilities to conduct the study.

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