Original Paper

Microbial, pH, Titratable Acidity, Functional and Sensory Properties of Weaning Food Blends Formulated from Maize, Cowpea, Bambaranut and Groundnut

Bintu B.P.[1], Falmata A.S.[1], Maryam B.K.[1], Raihatu M.A.[1], Chellube Z.[1], Hauwa H.[1] & Modu S.[1*]

[1] Department of Biochemistry, Biological Sciences and Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069, Maiduguri, Nigeria

[*] Modu S., Department of Biochemistry, Biological Sciences and Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069, Maiduguri, Nigeria

Abstract

This study investigated the microbial, sensory evaluation and functional properties of cereal/legume complementary weaning food blends using yellow maize, cowpea, bambaranut and groundnut. Yellow maize was fermented to produce "Akamu", cowpea, bambaranut and groundnut were roasted. The weaning food blends were formulated as follows: MCBG: 60 (g) yellow maize: 20(g) cowpea: 10(g) bambaranut: 10(g) groundnut, MCB; 60(g) yellow maize: 20(g) cowpea: 20(g) bambaranut, MCG: 60(g) yellow maize: 20(g) bambaranut: 20(g) groundnut and MBG: 60(g) yellow maize: 20(g) bambaranut: 20(g) groundnut. Standard laboratory methods were used to determine the parameters. The yellow maize (Improved variety), cowpea, bambaranut and groundnut were obtained from Lake Chad Research Institute (LCRI) Maiduguri. Data obtained were subjected to analysis of variance (ANOVA) and Duncan's multiple range test was used to separate the means. A decrease in pH with an increase in titratable acidity was observed during the production of "Akamu" from yellow maize. The weaning food blend MCBG showed a significant decrease in viscosity, water absorption capacity and bulk density than MCB, MCG and MBG. Predominant micro organisms isolated during the production of Akamu and the weaning food blends were lactobacillus, saccharomyces cerevisae, and streptococcus lactics. Results of the sensory evaluation showed that MCBG had the highest overall acceptability than the three weaning food blends MCB, MCG and MBG.

Keywords

weaning food, pH, cereal/legume blend, fermentation/roasting

1. Introduction

Children in must developing countries are introduced directly to the regular house diet of cereal foods inadequate complementary food is a major cause for the high incidence of child malnutrition, morbidity and mortality (Ijarotimi, 2012) Protein malnutrition among infants in low income countries is an important public health problem and can be related to the composition of the complementary foods introduced after the breast feeding period (Falmata et al., 2014). According to World Bank (2013) malnutrition when it is served can cause premature death, permanent disability and fragility in face of many deadly diseases. Among different types of malnutrition protein energy malnutrition affects more than one half of the world's population especially infants at weaning age (Laminu et al., 2014). It has been recognized that high densed with pathogenic microbiological parameters weaning foods is an etiological factor of protein energy malnutrition (Saleh, 2015).

In many developing countries, traditional weaning foods are prepared mainly from cereals like maize, millet and sorghum, which are usually in protein quantity and quality. This coupled with the high cost and viscous nature of commercial available complementary foods as well as the poor hygiene of food handlers and major constraints in providing children with adequate nutrients (Gernah et al., 2012). It is therefore, desirable to study ways and means of developing less costly but nutritious complementary weaning foods using our local available cereals and legumes through simple techniques (Elemo et al., 2011). These food staples can be fermented to increase the nutrient content, reduce bulk water absorption capacity, improve their shelf life and be generally acceptable to infants at weaning age.

The objective of the study is to formulate a weaning food blends from yellow maize, cowpea, bambaranut and groundnut flours and to assess their pH, titratable acidity, functional microbiological and sensory properties.

2. Materials and Methods

2.1 Materials

Sources of Yellow Maize, Cowpea, Bambaranut and Groundnut

The yellow maize (Improved variety), cowpea, bambara nut and groundnut were obtained and authenticated by a seed breeder/plant taxonomist in the Lake Chad Research institute, and Department of Biological Science, University of Maiduguri respectively.

Source of Commercial Weaning Foods

The commercial weaning foods maize based Cerelac and wheat based Frisogold were purchased from a supermarket in Maiduguru, Borno State. It is recommended for infants of 6 months and above and it is a product of Nestle Nigeria plc.

2.2 Methods

Preparation of "Akamu"

The Akamu (ogi) was prepared by the method described by Akingbala et al. (1981). One hundred (100 g) of maize (cereal) was cleaned and steeped into 200 ml of distilled water in a 1:2 ratio for 72 hours.

At the end of the 72 hours, the top water was decanted and 200 ml of distilled water was added and milled into a slurry. The slurry was then sieved through a nylon cloth to separate the bran. The filtrate was then allowed to settle for 24 hours and the top water decanted. The akamu was sun-dried to a constant weight and was packed into airtight container and stored at $4^{0}C$ until used for weaning food formulation and analysis.

Preparation of Cowpea

One hundred (100 g) of the cowpea was cleaned and soaked in distilled water for 5 minutes. The cowpea was dehulled (using a mortar and pestle) and washed to remove the husk. It was then sun-dried to a constant weight roasted and ground into a fine powder as described by Theodore et al. (2007).

Preparation of Bambaranut

One hundred (100 g) of dry bambara nut was cleaned, roasted and milled into a fine powder after which it was sieved using a sieve as described by Theodore et al. (2007).

Preparation of Groundnut

One hundred (100 g) of groundnut was cleaned of dirt, roasted and dehulled. The dehulled groundnut was milled as described by Davies (2009).

Formulation of the Weaning Diets

Cereal / legume diets were formulated using yellow maize, cowpea, bambara nut and groundnut in the following ratios;

1. 60 parts of Yellow Maize, 20 parts of Cowpea, 10parts of Bambaranut and 10 parts of groundnut. i.e., 60:20:10:10-MCBG.

2. 60 parts of Yellow Maize, 20 parts of Cowpea, 20 parts of Bambaranut. i.e., 60:20:20-MCB.

3. 60 parts of Yellow Maize, 20 parts of Cowpea, 20 parts of Groundnut. i.e., 60:20:20-MCG.

4. 60 parts of Yellow Maize, 20 parts of Bambaranut, 20 parts of Groundnut. i.e., 60:20:20-MBG.

pH and Titratable Acidity (TA)

During 72 hours of fermentation, pH and titratable acidity were measured. The pH of the supernatant was taken using a pH meter. For the titratable acidity, 10ml of sample was measured into a 50 ml beaker of phenolphthalein indicator was added and titrated against 0.1N NaOH (Egnan et al., 1981).

Calculation

Titratable acidity (g/100) $= \frac{V \times N \text{ meq.wt}}{1000 \times V}$ x 100

Where

V = volume of sodium hydroxide

N = Normality of sodium hydroxide

Meq. Wt = Mill equivalent weight of standard

Functional Properties

Water Absorption Capacity (WAC)

One gramme (1 g) of each diet was weighed into a centrifuge tube and 10 ml of distilled water was added. Samples were vortexed for 5 minutes and allowed to stand for 15 minutes at room temperature

62

before centrifuging (10,000 x C) for 5 minutes Excess water was allowed to drain by inverting the tube over absorbent paper. The weight of sample bound to water was determined by difference (Lin & Humbent, 1974).

Apparent Viscosity

Viscosity was determined by the methods of Bhattachanga et al. (1986). Viscosity (AV) was determined by placing twenty grams (20 g) of the sample in measuring cylinder of 100 ml of water in a boiling water bath of 75^0C -80^0C. The slurry was constantly stirred and until boiling which was continued for five minutes. The slurry was cooled to room temperature 23^0C-25^0C and their viscosity was measured with a cannon viscometer.

Bulk Density

The bulk density was determined using the method of Okezie and Bello (1988). Ten grams (10 g) of the sample material were placed in a 25 ml graduated cylinder and packed by gentle tapping of the cylinder on a bench top ten times from a height of 5-8 cm. The final volume of the test material was recorded and expressed as g/ml.

Microbiological Analysis

Microbiological analysis was determined according to the method described by Harrigan and McCaine (1976). Appropriate dilution of samples was enumerated for counts of bacteria and yeasts using nutrient agar, MacConkey agar, sabourraud dextrose agar and blood agar base. Inoculated plates was incubated at appropriate time and temperature combinations. Colonies of respective microbial types appearing in inoculated plates was counted and expressed as colony forming units (cfu/g). Colonies of bacteria and yeasts was isolated and subcultured to obtain pure cultures.

Media Preparation

Nutrient agar

This is a general purpose medium which may be enriched with 10% blood or other biological fluid. It supports the growth of a wide range of microorganisms and contains sufficient nutrients for the organisms.

Procedure

Twenty grams (20 g) of nutrient agar (oxoid) was weighed and dissolved in 1.0 L of distilled water in a clean conical flask. It was brought to boil to dissolve completely and then sterilized by autoclaving at 121^0C for 15 minutes. It was allowed to cool to 50-55^0C and them poured aseptically into sterile Petri dishes and allowed to set.

MacConkey agar

This is a differential medium for the isolation of coliforms and intestinal pathogens in water, dairy products and biological specimens.

Procedure

Fifty grams (52 g) of McConkey agar was weighed into 1.0 L of distilled water in a clean conical flask. This was brought to boil to dissolve completely and sterilized by autoclaving at 121^oC for 15 minutes.

It was aseptically poured into sterile Petri dishes. The surface of the gel was dried before inoculation.

Blood agar base

Forty two grams (42 g) of nutrient agar was dissolved in 1.0 L of distilled water; it was dissolved and sterilized in an autoclave at 121^oC for 15 minutes. On cooling 10 ml of blood was added and poured aseptically into sterile Petri dishes.

Sabouraud dextrose agar

This is a general purpose medium for the cultivation of yeasts and moulds.

Sixty five grams (65 g) of SDA was suspended in 1.0L of distilled water was boiled to completely dissolve and autoclaved at 121^0C for 15 minutes and then cooled and aseptically poured into Petri dishes.

Determination of Total Viable Count

After inoculation, the plates was incubated at 37^0C for 24 hours. The colonies obtained was counted on an electric colony counter (Gallen kamp Colony counter).

Isolation and identification

A loopful of the sample was smeared over one corner of the solidified medium which was sufficiently dried. A ninchrome wire loop will be sterilized over a spirit lamp then cooled and used to make parallel streaks from the main inoculums. The plates was then incubated at 37^0C for 24 hours.

The colonies was separated from one another based on the difference of colony monopoly. One of the separated colonies was taken using a sterilized wire loop and inoculated in another media then incubated for 24 hours at 37^0C. Colonies was obtained on the medium after 24 hours.

Sensory Evaluation

A 10% (w/v) of the weaning food blends were cooked and evaluated by 50 nursing mothers using a nine point Hedonic Scole (Appendix I) as described by Land and Shepard (1988). The mean scores were analysed by Duncan's Multiple Range Test.

Statistical Analysis

All determinations were carried out in triplicates. All data collected were subjected to analysis of variance and Duncan multiple range test was used to compare the means using SPSS 11.0 software. Significance was accepted at p≤0.05.

3. Results

3.1 pH and Titratable Acidity

The results of pH and titratable acidity (TA) recorded during the fermentation of maize for "Akamu" production is presented in Table 1. Fermentation was found to cause a sharp decrease in pH with time. The change in pH from zero to 72 hours resulted in a pH drop from initial pH of 6.30±005 to 3.00±0.11 at 72 hours. The titratable acidity increased from 0.30±0.05 to 4.73±0.02 during the 72 hours period of maize fermentation. Both pH and TA are time dependent and the respective differences are statistically significant (p<0.05).

Table 1. pH and Titratable Acidity (TA) at 72 Hour Fermentation of Maize

Parameters	Time (hours)			
	0	24	48	72
pH	6.30 ± 0.05^a	4.65 ± 0.21^b	3.31 ± 0.05^c	3.00 ± 0.11^d
Titratable Acidity (TA)	0.30 ± 0.05^d	0.65 ± 0.03^a	3.60 ± 0.06^c	4.73 ± 0.02^b

Values are recorded as mean $\pm$ SD of three determinations. Means in the same row with different superscripts are significantly different (p<0.05).

3.2 Functional Properties of the Raw and Processed Maize, Cowpea Bambaranut and Groundnut and the Weaning Food Blends

Functional properties of the raw and processed maize, cowpea, bambaranut and groundnut are presented in Table 2. The functional properties of the weaning food blends are presented in Table 3.

Apparent Viscosity

There was a significant (p<0.05) difference in the apparent viscosity of raw and processed cowpea, bambara nut at 30 shear rate. No significant difference (p<0.05) was observed between the raw and processed maize and groundnut at 30 shear rate.

Signifciant differences (p<0.05) were observed in the apparent visicosity of the weaning food blends MCBG, MCB, MCG and MBG. MCG (1452.70 cps) exhibited the highest viscosity followed by MCB (1442.50 cps) and then MBG (1420.20 cps). The weaning food blend MCBG (1008.60 cps) exhibited the lowest viscosity

Water Absorption Capacity

The water absorption capacity of the raw and processed, maize, cowpea, bambaranut and groundnut exhibited significant (p<0.05) differences. Roasted groundnut had the highest water absorption capacity while fermented maize had the lowest water absorption capacity.

The water absorption capcity of the weaning food blends exhibited significiant differences (p<0.05). MBG (1.40 g/ml) is the highest followd by, MCG (1.30 g/ml), MCB (1-10 g/ml) and then MCBG (0.98 g/ml). MBG had the highest water absoption capcity while MCBG had the lowest water absorption capcity.

Bulk-Density

There was a significant(P<0.05) difference (p<0.05) in the bulk density of the raw and processed maize, cowpea, bambara nut groundnut and the weaning food blend. Raw groundnut had the lowest bulk density, while fermented maize had the highest.

The weaning food blend MCBG (1.20 g/ml) had lowest bulk density when compared with MCB (1.50 g/ml), MCG (1.60 g/ml) and MBG (1.80 g/ml) which were significantly higher than MCBG. MCB had the lowest bulk density followed by MBG and then MCG.

Table 2. Functional Properties of Raw and Processes Maize, Cowpea, Bambara Nut and Groundnut

Functional properties	SAMPLES							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Apparent viscosity 30 shear rate	1005.33 ± 0.28^a	1005.5 ± 0.10^a	999.9 ± 0.10^b	1016.0 ± 0.11^c	1002.2 ± 0.20^e	1007 ± 0.10^d	999.7 ± 0.10^b	999.2 ± 0.10^b
Water absorption capacity (g/ml)	2.00 ± 0.10^b	0.90 ± 0.10^g	1.42 ± 0.10^c	1.40 ± 0.10^d	1.00 ± 0.10^f	1.20 ± 0.05^h	1.30 ± 0.05^e	2.60 ± 0.01^a
Bulk density (g/ml)	1.60 ± 0.10^c	1.90 ± 0.05^a	1.60 ± 0.10^c	1.60 ± 0.05^c	1.80 ± 0.01^b	1.60 ± 0.05^c	0.10 ± 0.05^d	1.80 ± 0.10^b

Values are recorded as mean ± SD of three determinations. Mean in the same row with different superscripts are significantly ($p<0.05$) different.

Table 3. Functional Properties of the Weaning Food Blends

Functional properties	Weaning food blends			
	MCBG	MCB	MCG	MBG
Apparent viscosity 30 shear rate	1008.70 ± 0.10^a	1442.50 ± 0.020^c	1452.70 ± 0.07^b	1420.20 ± 0.10^d
Water absorption capcity (g/ml)	0.98 ± 0.02^d	1.10 ± 0.05^c	1.30 ± 0.10^b	1.40 ± 0.07^a
Bulk density (g/ml)	1.20 ± 0.02^d	1.50 ± 0.06^c	1.60 ± 0.10^a	1.80 ± 0.03^b

MCBG—60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambaranut and 10 parts of groundnut

MCB—60 parts of yellow maize, 20 parts of cowpea, 20 parts of Bambaranut

MCG—60 parts of yellow maize, 20 parts of cowpea, 20 parts of Groundnut

MBG—60 parts of yellow maize, 20 parts of Bambaranut, 20 parts of Groundnut

Total Bacterial Count and Microorganisms Isolated

The total bacterial count during the production of "Akamu" is presented in Table 4. The total bacterial count at 0 hour was 28 x 10^3 cfu/ml which then dropped to 20 x $10^{3,}$ 11 x 10^3, 8 x 10^3 at 24 hours, 48 hours and 72 hours fermentation of maize respectively. The bacterial count of the slurry after 24 hours was 6 x 10^3 cfu/ml, 5 x 10^3 for dried Akamu, 1 x 10^3 cfu/ml for MCBG, 3 x 10^3 cfu/ml for MCB, 7 x 10^3 cfu/ml for MCG and 3 x 10^3 cfu/ml for MBG.

The microorganisms isolated from "Akamu" production are shown in Table 5. *lactobacilus, Escherichia coli* and *Corynebacteria* appeared after 24 hours of maize fermentation. *Lactobacillus streptococcus lactic, Bacillus subtitilitis Saccharomyces cerevisae* appeared after the grain was milled into a slurry after 24 hours of fermentation. *Lactobacillus* and *Saccharomyces cerevisae* were present after the "Akamu" was sun dried to a constant weight ; *Saccharomyces Cerevisae* were detected in

66

MCBG, *Lactobacillus* in MCB, *Saccharomyces Cerevisae* and *Streptococcus Lactics* in MCG and *Saccharomyces cerevisae* and *Lactacillus* in for MBG.

Table 4. Total Bacterial Count during Production of "Akamu"

Samples	Total bacterial count (cfu/ml)			
Maize	0 hour	24 hours	48 hours	72 hours
Steep water	28×10^3	20×10^3	11×10^3	8×10^3
Slurry	-	6×10^3	-	-
Dried "Akamu"	-	5×10^3	-	-
MCBG	-	1×10^3	-	-
MCB	-	3×10^3	-	-
MCG	-	7×10^3	-	-
MBG	-	3×10^3	-	-

Table 5. Microorganisms Isolated During Production of "Akamu"

Sample	Microorganisms isolated		
Maize	24 hours	48 hours	72 hours
Steep water	*Lactobacillus* *Escherichia coli* *Corynebacteria* *Bacteria*	*Lactobacillus* *Streptoccus lactic* *E.coli*	*Lactobacillus* *Streptococcus lactics*
Slurry	*Lactobacillus, Streptoccus lactic Bacillus substilitis, Saccharomyces cerevisae*		
Dried "Akamu"	*Lactobacillus, Saccharomyces cerevisae*		
MCBG	*Saccharomyces cerevisae*		
MCB	*Lactobacillus*		
MCG	*Streptococcus lactics* *Saccharomyces cerevisae*		-
MBG	*Saccharomyces cerevisae* *Lactobacillus*		-

Sensory Evalaution of the weaning food blends

The sensory evaluation of the weaning food blends is presented in Table 6. No significant (p>0.05) differences were observed in the colour, odour, taste and overall acceptability of the formulated weaning food blends MCB, MCG and MBG. However, there was a significant (p<0.05) difference in the color, odour, taste, texture and overall acceptability of MCBG and the three weaning food blends, MCB, MCG and MBG.

Table 6. Sensory Evaluation of the Weaning Food Blends

Parameters	Weaning Food Blends			
	MCBG	MCB	MCG	MBG
Colour	8.3 ± 1.21^a	7.6 ± 2.50^b	7.5 ± 1.93^b	7.0 ± 1.91^b
Odour	8.1 ± 1.17^a	7.3 ± 2.48^b	7.3 ± 2.00^b	7.7 ± 0.98^b
Taste	8.6 ± 2.40^a	7.7 ± 2.56^b	7.6 ± 1.89^b	6.8 ± 2.41^b
Texture	8.2 ± 1.01^a	6.9 ± 2.44^b	7.0 ± 1.59^c	6.9 ± 1.12^b
Overall acceptability	8.00 ± 2.00^a	7.8 ± 2.52^b	7.6 ± 1.81^b	7.1 ± 2.14^b

4. Discussion

4.1 pH and Titratable Acidity (TA)

Fermentation was found to cause a gradual reduction in pH with time. The reduction in pH of maize during fermentation was similar to the result of other workers (Elyas et al., 2002; Nanson & Fields, 2011; Sanni et al., 1994). These results also agree with those obtained by Gieze (1994), who reproted that as a result of fermentation acidity increased and pH falls and this enhanced the keeping quality of fermented foods, by inhibiting microbial growth and also contributing to the flavour of processed maize. Nanson and Fields (2011) reported that lactic acid fermentation causes a rapid drop in pH of various food grains. Also in a related study, fermented dough is lowered due to the production of organic acids by the microflora; hetero fermentors were reported to convert glucose to equimolar mixture of lactic acid, ethanol and carbon dioxide (Singh et al., 2012).

Titratable acidity increased with time over the entire fermentation period from 0.30 ± 0.05 at 0 hour to 4.73 ± 0.02 at 72 hours of maize fermentation. This finding is in agreement with the work of Wakil and Kazeem (2012). The increase in acidity is of great significance as it was reported to reduce the incidence of diarrhoea in infants consuming fermented maize porridge (Mensah et al., 1990).

Functional Properties

Apparant Viscosity

The weaning food blend MCBG had a lower viscosity followed by MCB, MCG and then MBG. Decrease in apparant viscosity indicates increase in nutrient density. Nkama et al. (2001) made similar observations. The significant reduction in viscosity with fermentation could be due to breakdown of macromolecules such as polysaccharides and polypeptides to smaller units, such as dextrins and peptides respectively by the enzymes mobilized during fermentation (Gernah et al., 2012). Low viscosity weaning diet with a high nutrient content is a desirable characteristics of weaning food (Ariahu et al., 1996). During fermentation of cereals, microbial activity hydrolyses starch granules thereby resulting in reduced viscosity (Chavan & Kadam, 1989; Nout et al., 1998).

The action of microbial α- and β- amylases on the maize modify starch structures and results in low viscosity. This thereby leads to a reduction in dietary bulk which is an important factor in the aetiology

of protein -energy malnutrition (Mbata et al., 2009b).

Water Absorption Capacity

Water absorption capacity indicates the volume of water required to form a gruel with suitable consistency for infant feeding (Bintu et al., 2015; Sodipo & Fashakin, 2011). The result showed that the weaning food blend (MCBG) had lowest water absorption capacity followed by MCB, MCG and then MBG. Ijarotimi and Keshinro (2013) had similar findings. According to Ghavidel and Mehdi (2011), water absorption capacity gives an indication of the amount of water available for gelatinization. Lower absorption capacity is desirable for making thinner gruels. The process of fermentation provides a simple inexpensive means of increasing nutrient density by reducing bulk. Fermentation influenced the ability of the weaning food to absorb water (Ikujenlola & Fashakin, 2005). According to previous reports of Barac et al. (2010) and Ikujenlola and Adurotoye (2014) fermentation activates the inherent amylase enzymes in grains; these enzymes saccharify / dextrinify the starch in the grains to dextrins and maltose which absorbs little water when cooked. Weaning food blends with low water absorption capacity tend to have their microbial activities reduced (Imtiaz et al., 2011).

Bulk Density

The significant reduction in bulk density of the weaning food blend (MCBG) could be attributed to the fact that fermentation tend to soften the seeds thus making milling easier with smaller particle size than the unprocessed grains, hence the reduction in bulk density (Iwe, 2003). 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 (Gernah et al., 2012). The bulk density is a reflection of the load the flour samples can carry, if allowed to rest directly on one another (Wilhelm et al., 2004). Values obtained from this study were comparable with the values reported by (Singh et al., 2012).

Total Bacterial Count and Microorganisms Isolated

Fermentation of maize attracted a microflora of bacteria and yeast. Lactate bacteria and yeast were predominant in the fermented sample. This could be as a result of a symbiotic relationship between lactate and yeast. It is assumed that the lactic flora provide an acidic condition for growth which yeast provide sufficient growth factors which enhances growth of lactate flora (Bintu et al., 2015; Ikemefuna, 1998). The microorganisms that were predominant were *Lactobaciullus* and *Saccharomyces cerevisae*. This is in agreement with the findings of Abegaz et al. (2002), Mbata et al. (2009a), Serna-salde and Rooney (1995). Oyerekua (2011) observed species of *sacchoromyces cerevisae* in spontaneous lactic acid fermentation in cereals. The decrease of total bacterial counts in the weaning food blend might be due to mixed macro-flora of each cereal and legume that might also indicate a range of enzymes like glycoamylase which degrades starch and yeast and ferments parts of glucose thereby making lactic acid bacteria to co-exist with yeast in proto-cooperative manner. This agrees with the report of Nout (2009), Amodou et al. (2014) Fermentation has also been strongly suggested to have inhibition effects on the groups of microorganisms that can cause spoilage or food poisoning (Gernah et al., 2012).

Sensory Evaluation

The result of the sensory evaluation indicates that the colour, odour, taste, texture and overall acceptability of the weaning food blends, MCB, MCG and MBG, showed no significant differences. In the overall acceptability, the weaning food blend MCBG had a highest overall acceptability which indicates like very much followed by MCB, MCG and MBG. This indicates that MCBG was preferred over MCB, MCG and MBG.

5. Conclusion

Fermentation affected the microbiological composition and enhanced microbiological safety of the diet/blends by increasing dominance of lactic acid bacteria and inhibiting growth of pathogenic mciro-organisms and improved the nutrient density by reducing bulk. The sensory evaluation of MCBG was found to be superior in terms of over all acceptability than MCB, MCG and MBG.

References

Akingbala, J. O., Rooney, L. W., & Faubion, J. M. (1981). A laboratory procedure for the preparation of Ogi, A Nigerian fermented food. *Journal of Food Science*, *46*, 1523-1526. https://doi.org/10.1111/j.1365-2621.1981.tb04212.x

Amadou, I., Gounga, M. E., Shi, Y. H., & Le, G. W. (2014). Fermentation and heatmoisture treatment induced changes on the physicochemical properties of foxtail millet (*Setaria italica*) flour. *Food Bioprod Proc.*

Barac, M., Cabrilo, S., Pesic, M., Stanojevic, S., & Macej, O. (2010). Profile and functional properties of seed proteins from six pea (*Pisum sativum*) genotypes. *Int. J. Mol. Sci.*, *11*, 4973-4990. https://doi.org/10.3390/ijms11124973

Bhattachanya, M., Hynna, M. A., & Kaufman, R. E. (1986). Textural properties of extruded plant protein blend. *Journal of Food Science*, *51*(4), 989-993.

Bintu, B. P., Hajjagana, L., Falmata, A. S., Modu, S., & Shetima, Y. (2015). Studies on the evaluation of the nutritional quality chemical composition and rheological characteristics of a cereal of fortified with legume as a weaning of food blend. *International Journal of Biotechnology and of Food Science*, *3*(1), 1-9.

Chavan, J. K., & Kadam, S. S. (1989). Nutritional improvement of cereals by fermentation. *Critical Reviews in Food Science and Nutrition*, *28*(5), 352-399.

Daves, R. M. (2009). Physical properties of groundnut grains. *Research Journal Applied Science Engineering Technology*, *1*(2), 10-13.

Egnan, H., Kirk, K. R., & Way's, R. (1981). *Pearson's chemical analysis of food* (5th ed., p. 233). Church-hill Livingstone Edinburgh: London New York.

Elemo, G. N., Elemo, B. O., & Okafor, J. N. C. (2011). Preparation and nutritional composition of a complementary food formulated from germinated sorghum (*Sorghum bicolor*) and steam cooked cowpea (*Vigna unguiculata* Walp). *Am. J. Food Technol*, *6*(5), 413-421.

70

Falmata, A. S., Modu, S., Badau, H. D., Babagana, M., & Bintu, B. P. (2014). Formulation and evaluation of complementary weaning of food prepared from single and combined sprouted fermented local red sorghum (s.bicolor) variety blended with cowpea (vigna unguiculkata) and groundnut (*Arachis hypogea*). *International Journal of Biotechnology and Food Science*, *2*(8), 149-155.

Gernah, D. I., Ariahu, & Ingbian, E. K. (2012). Storage and shelf life prediction of food formulations from malted and fermented maize (zea mays L) of fortified with defatted sesame (sesamun indiucum L). *Nig. J. nutr. Sci.*, *32*(1), 45-54. https://doi.org/10.4314/njns.v32i1.67814

Ghavidel, R. A., & Mehdi, G. D. (2011). Processing and assessment of quality characteristics of composite Baby Food. *World Academy of Science Engineering and Technology*, *59*, 2041-2043.

Gieze, J. (1994). *Antimicrobial food safety Food Technology*, *48*, 102-110.

Harrigan, W. F., & McCaine, M. E. (1976). *Laboratory methods in Food and Dairy microbiology*. Academic Press London, NY, San Francisco.

Ijarotimi, O. S. (2012). Influence of germination and fermentation on chemical composition, protein quality and physical properties of wheat flour (*Triticumaetivum*). *J. Cereals Oilseeds.*, *3*(3), 35-47.

Ijarotimi, O. S., & Keshino O. O. (2013). Determination of amino acid, fatty acid, mineral functional and choking properties of germinated and fermented popcorn (zea mays Everta) flour. *European Journal and of Food Research and Review*, *2011*(2), 102-122.

Ikemefuna, C. O. (1998). Fermented foods. *Nutritional Quality of Plant Foods*, *2*, 160-198.

Ikujenlda, V. A., & Fashakin, J. B. (2005). Bioassay Assessment of a complementary diet prepared from vegetable proteins. *Journal of food Agriculture and Environment*, *3*(3-4), 20-22.

Imitaz, H., Burhanudd, N. M., & Gulzarm, A. (2011). Evaluation of weaning foods formulated from germinated wheat and Maybean from Banylades. *African Food Science*, *5*(17), 897-903. https://doi.org/10.5897/AJFS11.180

Iwe, M. O. (2003). *The science and technology of soybean chemistry nutrition processing, utilization rejoin communication services Ltd. Enugu Nigeria*.

Laminu, H. H., Sheriff, M., Bintu, B. P., & Muhammad, A. A. (2014). Evalution of the protein quality of composite meals produced from selected cereals and legumes of r infants. *Scholarly Journal of Agriculture Science*, *4*(11), 536 -542.

Land, D. G., & Sheperd, R. (1988). Scaling and ranking methods. In J. R. Piggott (Ed.), *Sensory Analysis of Foods* (pp. 155-185). Elsevier Applied Science, London.

Lin, M. J. Y., Humbert, E. S., & Sosulki, F. W. (1974). Certain functional properties of sunflower meal products. *J. food sci.*, *39*, 368-370. https://doi.org/10.1111/j.1365-2621.1974.tb02896.x

Mbata I. T., Ikenebomeh, M. J., & Ahonkai, I. (2009a). Studies on the microbiological nutrient composition and antinutrition contents of fermented maize flour of rtified with bambara groundnut (vigna subterranean L). *African Journal of food science*, *3*(6), 165-171.

Mensah, P. A., Tomkina, A. M., Drasar, B. S., & Harisson, T. J. (1990). *Fermentation of cereals of r*

reduction of bacterial contamination of weaning of food in Ghana lancet, *336*, 140-143. https://doi.org/10.1016/0140-6736(90)91660-3

Nanson, N. J., & Field, M. L. (2011). Influence of temperature on the nutrient value of lactic acid fermented corn meal. *Journal of food Science*, *49*, 958-959.

Nkama, I., Dagawanna, F. N., & Ndahi, W. B. (2001). Production composition and consumer acceptability weaning of foods of mixtures of pearl milet cowpea and groundnut. *Journal of Agricultural science*, *11*, 165-169.

Nout, M. J., Hautvast, F. V., & Hear, S. D. (2009). *Formulation and microbiological safety of cereal based weaning foods International Development Research Centre (IDRC) Ottawa, Canada* (pp. 245-260).

Okezie, B. O., & Bello, A. B. (1988). Physiochemical and functional properties of Winfed bean flour and isolates compared with soya isolates. *Journal of Food Science*, 450-454.

Saleh, S., Bintu, B. P., Modu, S., Ibrahim, M., Laminu, H. H., & Yagana, S. Y. (2015). Effects of fortification of rice with banjara beans and sesame on chemical composition mineral elements and vitamin contents of a complementary meal. *Ecronicon*, *1*(2), 35-40.

Sanni, A. I., Lonner, C., Mark hinder, I., Johansson, M. I., & Molin, G. (1994). Starter cultures for the production of Ogi: A fermented infant food from maize and sorghum. *Chemical microbiology technology de lebensmitted*, *16*(112), 29-33.

Serna-saldivar S., & Rooney, L. W. (1995). Structure and chemistry of sorghum and millets. In D. A. V. Dendy (Ed.), *Structure and chemistry of sorghum and millets* (pp. 69-124). St. paul MN USA. AM Assoc. cereal chem.

Singh, A., Yadav, N., & Sharma, S. (2012). Effect of fermentation on physicochemical properties and in vitro starch and protein digestibility of selected cereals. *International Journal of Agricultural and of Food Science*, *2*(3), 66-70.

Sodipo, M. A., & Fashakin. J. B. (2011). Physico-chemical properties of a complementary diet prepared from germinate maize, cowpea and pigeon pea. *Journal of Food Agriculture and Environment*, *9*, 23-25.

Theodore, I., Mbata, M. J., Ikeheboneh, I., & Ahonkai, S. (2007). Nutritional status of maize fermented meal by fortification with Bambara nut. *AJFAND*, *7*(2), 44-61.

Wakil, S. M., & Kazeem, M. O. (2012). Quality assessment of weaning of food produced from fermented cereal legume blend using starter. *International journal of Food Research*, *19*(4), 1679-1685.

Wilhelm, R. L., Dwayna, A. S., & Gerand, H. B. (2004). *Introduction to problem solving skills in food and processing engineering technology ASAE*.

World Bank. (2012). *Infant and Young Child Feeding: World Bank Nutrition*. Retrieved January 2013, from http://www.report.siteresources.worldbank.org/NUTRITION/Resources/Tool2-Chap5.pdf