Vol. 12(10) pp. 254-262, October 2018
DOI: 10.5897/AJFS2017.1586
Article Number: C9A41FF58519
ISSN: 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Weaning food fortification and improvement of fermented cereal and legume by metabolic activities of probiotics *Lactobacillus plantarum*

Adeyemo S. M.[1*] and Onilude A. A.[2]

[1]Food and Industrial Microbiology Unit, Department of Microbiology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.
[2]Microbial Physiology Unit, Department of Microbiology, University of Ibadan, Oyo State, Nigeria.

Received 3 March, 2017; Accepted 5 July, 2017

The provision of cheap, balanced and adequate nutritional composition for growing infants is a major challenge in Africa. Most weaning foods are usually cereal-based gruels fermented by lactic acid bacteria (LAB). The major nutrient they supply being carbohydrate, uncontrolled or inappropriate intake might cause growth retardation and malnutrition in growing children. The nutritional requirement of weaning infants could be supplied by supplementation with protein rich diets. Soybean is a cheap and available source of protein in Nigeria; but it also contain some complex sugars (raffinose) which is associated with abdominal discomfort in children of weaning age. This study is designed to use the probiotics LAB to improve the nutritional composition of weaning food blends. Lactic acid bacteria were isolated from Ogi (a fermented cereal gruel) using standard morphological and biochemical tests; their identities were confirmed with molecular methods. Nutritional and organoleptic attributes of the food blend were determined following Association of Official Analytical Chemist procedures. The data were subjected to statistical analysis at 5% level of significance. Fortification of the gruel with pre-treated soybeans improved the nutritional quality (Protein: 8.4 to 17.8 %; Fat: 3.6 to 12.9 %; Ash: 2.0 to 3.8%; Fe: 6.4 to 10.7mg/100g and Ca: 156.7 to 211.0mg/100g) during fermentation. Utilization of raffinose by probiotic Lactobacillus plantarum from local food sources reduced the complex sugars in soybeans. Nutritional qualities and organoleptic attributes of cereal gruels were improved by fortification with soybeans and fermentation.

Key words: Probiotics, complex sugars, Lactobacillus plantarum, fermentation, nutritional improvement, soybeans.

INTRODUCTION

Lactic acid bacteria (LAB) are a group of bacteria characterized by their ability to synthesize lactic acid. Typical LAB are gram-positive, non-sporing, catalase-negative, lacking cytochromes. They are anaerobic but

*Corresponding author. E-mail: adeyemotella@gmail.com.

tolerate little amount of oxygen. They can be rod or cocci and they produce lactic acid as the major end product of fermentative metabolism (Axelsson, 2004; Wall et al., 2007; Arimah and Ogunlowo, 2014). Proteinaceou bacteriocins are also produced by several LAB strains and provide an additional hurdle for spoilage and pathogenic microorganisms. Furthermore, lactic acid and other metabolic products contribute to organoleptic and textural profile of the food item (Makarova et al., 2006; Khalid, 2011; Kaškonienė et al., 2017).

The industrial importance of the LAB is further evidenced by their reputation as generally regarded to as safe (GRAS) status, due to their ubiquitous appearance in food and their contribution to humanhealth (Wall et al., 2007). LAB are characterized by an increased tolerance to a lower pH range which partially enables LAB to outcompete other bacteria in a natural fermentation, as they can withstand the increased acidity from organic acid production, for example, lactic acid and acetic acid (Wall et al., 2007; Adeyemo, 2012; Magala et al., 2017).

In many West African countries, exclusive breastfeeding is usually adequate up to three to four months of age, but after this period, it may become increasingly inadequate to support the nutritional demand of the growing infant. Thus, in a systematic weaning process, there is always the need to introduce soft, easily swallowed foods to supplement the infant's feeding early in life (Mariam, 2002; Ozogul and Hammed, 2017). In Nigeria, the usual first weaning food is called pap, *akamu*, *ogi* or *koko*, made from fermented cereal such as maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum* spp.). Such weaning foods are prepared traditionally by first hand-picking the dirt or stones in the cereal and washing with water. This is then followed by soaking in water, wet milling and fermentation (Oguntona and Akinyele, 1995; Adeyemo, 2012).

In Nigerian *Ogi*, maize, millet or sorghum grains are washed and steeped for 24 to 72 h during which they undergo lactic acid fermentation. They are then drained, wet-milled and finally sieved to yield fine smooth slurry with about 8% solid content and high water content (Oguntona and Akinyele, 1995). Such weaning foods are usually high in carbohydrate content and are of low nutritive value. They are characterized by low protein, low energy density and high bulk (Mariam, 2002; Yelnett et al., 2014; Carevic et al., 2016). Cereal-based diets have been found to be of lower nutritional value than animal-based ones and this forms the primary basis for most of the traditional weaning foods in West Africa.

The protein content of maize and guinea-corn is of poor quality, low in lysine and tryptophan. These two amino acids are indispensable to the growth of the young child. The problems inherent in the traditional weaning foods and feeding practices in West Africa predispose the infant to malnutrition, growth retardation, infection and high mortality (Nagai et al., 2012; Magala et al., 2017).

Legumes are rarely used for weaning because of their associated problems of indigestibility, flatulence, diarrhoea and discomfort in children (Hou et al., 2009). They may, however, be introduced later in life (after 6months) or be used as food blend to supplement or fortify the fermented cereal nutritionally.

Food fortification or supplementation is the public health policy of adding micronutrients (essential trace elements and vitamins) to foodstuff to ensure that minimum dietary requirements are met (Mariam, 2002; Nagai et al., 2012). Addition of micronutrients to staples and condiments can prevent large-scale deficiency disease and prevent the attended cases of malnutrition that is associated with using cereal based diet as weaning food .Several types of food supplements have been recognized including additives which repair a deficit to "normal" levels or additives which appear to enhance a food and supplements taken in addition to the normal diet (Mariam, 2002; Narwade et al., 2015).

A dietary supplement, also known as food supplement or nutritional supplement, is a preparation intended to provide nutrients, such as vitamins, minerals, fiber, fatty acids, proteins or amino acids that are missing or are not consumed in sufficient quantity in a person's diet. Some countries define dietary supplements as foods, while in others they are defined as drugs.

Soybean is one of such legumes that are used to supply additional nutrients and vitamins to cereal-based weaning food. It is rich in high level of dietary protein and it is easily accessible to the local populace (Wakil and Onilude, 2009). It has been used by several authors to formulate food blend that are rich in protein and used as weaning food in different part of Nigeria.It is thus able to supply the other nutrients that are lacking in such food. Also, formulated infant weaning foods from fermented blends of cereal and soybeans using *Lactobacillus plantarum* and other lactic acid bacteria have been formulated by different authors (Wakil and Onilude, 2009; Nagai et al., 2012; Magala et al., 2017).

Soybean utilization is, however, limited because it contains some anti-nutritional factors.There is also the presence of some oligosaccharides such as raffinose, stachyose and verbascose which possess flatulence-inducing properties in children (Hou et al., 2009; Adeyemo and Onilude, 2014; Carevic et al., 2016). This problem has been solved by various authors in the past by dehulling, cooking, wet or dry milling, addition of sugar and oil, use of chemicals, germination and fermentation.

Some of these processes, however, may alter the composition of the weaning food, some are time and energy consuming, while others may be expensive or difficult to preserve. Thus, there has been agitation over the years to look for simple fermentation technology approach in order to arrive at nutritionally adequate ready-to-feed weaning foods that can be preserved safely without getting contaminated (Nagai et al., 2012; Carevic et al., 2016).

Fermented foods are associated with 'good bacteria' referred to as probiotics. *L. plantarum*has however been named as one of those good, useful and safe bacteria. Probiotics, as defined in a FAO/WHO (2002) report, are 'live microorganisms which when administered in adequate amounts confer a health benefit on the host'. Robiotics are beneficial bacteria in that they favourably alter the intestinal microflora balance such as reconstruction of normal intestinal microflora after disorders caused by diarrhoea, antibiotic therapy and radiotherapy. It inhibits the growth of harmful bacteria, promote good digestion, boost immune function and increase resistance to infection (Waugh et al., 2009; Parvez et al., 2006; Makarova et al., 2006,Yelnett et al., 2014; Kaškonienė et al., 2017; Ozogul and Hammed, 2017).

Other physiological benefits of probiotics include removal of carcinogens, lowering of cholesterol, immune-stimulating and allergy lowering effect, synthesis and enhancing the bioavailability of nutrients. People with flourishing intestinal colonies of beneficial bacteria are better equipped to fight the growth of disease causing bacteria (Body Ecology., 2012; Ozogul and Hammed, 2017).

*L. plantarum*as a potential probiotics that shows antimicrobial activity by producing organic acids and bacteriocin. Some assayed strains of the organism showed safety with regard to haemolytic and gelatinase activity. They were able to produce exopolysaccharidesand some were able to utilise Fructooligosaccharide, all of which are characteristics attributed to probiotics. *L. plantarum* ferments raffinose and lactose efficiently and possesses alpha-galactosidase, beta-galactosidase and beta-phosphogalactosidase activities (Makarova et al., 2006; Bulhões et al., 2007; Yelnett et al., 2014; Kaškonienė et al., 2017; Ozogul and Hammed, 2017).

Problems usually arise from the wayweaning food is introduced to the child. While some mothers believe that additives such as milk should be added as supplement, others, especially from the low-income group, do not see a need for this at all. They do not make special effort to adequately prepare the child's weaning diet. And so, such are usually monotonous, boring, unhygienically prepared and lacking sufficient nutrient for the growth of the child (Mariam, 2002; Magala et al., 2017).

Another problem that is associated with weaning foods in West Africa is the problem of diarrhoea and diarrhoea-related diseases that are highest at this level, especially in children that are less than one year. At this stage, these foods are gradually introduced to supplement and succeed breast feeding. This also plays a major role in child's mortality and morbidity. This is because due to unhygienic and inappropriate preparation of weaning foods, episodes of diarrhoeal diseases are highest with the combination of nutrient malabsorption and malnutrition (Mariam, 2002; Ozogul and Hammed, 2017).

This approach would require knowledge about the nutritive values of a variety of local food commodities, indigenous to the affected communities. A number of cereals and legumes that are readily available in Nigeria have been found to have nutrient potentials that could complement one another if properly processed and blended (Mariam, 2002; Magala et al., 2017). Therefore, it is imperative that efforts to formulate composite blends and scientific studies are carried out to ascertain the nutritive adequacy of these locally available blends (cereal and legumes) for possible use as complementary foods with health benefits, especially by the rural and poor urban mothers during weaning period.

MATERIALS AND METHODS

Preparation of processed samples of soybeans and sterilization of samples

All the samples of soybeans used for this analysis were first surface-sterilized by cleaning in 1% sodium chloride solution for 5 min. It was rinsed several times with distilled water and allowed to dry in an oven at 50°C before further processing.

Preparation of samples

Raw

1 kg of soybeans was used at each time for the processing. The samples were picked manually to remove the dirts.It was milled into powder, sieved with a fine sieve to pass through 0.5 mm diameter sieve and stored in air tight plastic container for further use.

Cooked

One kilogram soybeans was added to distilled water (1:5,w/v) and cooked at 80°C on a hotplate (Hanna instruments 7010, UK). In all the cooking process, the level of cooking water was kept constant by the addition of boiling distilled water. It was dehulled and washed several times with distilled water to remove the seed coat; drained and later dried in the oven at 50°C. This was milled into powder and sieved with a fine sieve and later kept in airtight plastic container for further use.

Roasted

One kilogram soybeans was roasted in an oven (Hearson Willow model,UK) at 100°C, dehulled to remove the seed coat and milled into powder. It was sieved with a fine-sieve into fine powder and stored in airtight container until further use.

Proximate analysis

Moisture content, ash content, crude fat, protein, crude fibre, carbohydrate and total sugar were determined by the method of Horwitz and Latimer (2010).

Table 1. Analysis of *Ogi* samples only.

Parameter	***Ogi* only**		
	White maize	**Yellow maize**	**Brown(Sorghum)**
Moisture content (%)	*62.3±0.02	61.5±0.01	62.6±0.14
Protein (%)	3.2±0.10	3.5±0.10	3.9±0.50
Etherextract(fat) (%)	1.6±0.10	1.8±0.020	1.8±0.02
Ash (%)	1.3±0.05	1.3±0.02	1.5±0.01
Crude fibre (%)	1.3±0.05	1.3±0.02	1.7±0.02
Carbohydrates (by difference) (%)	30.3±0.02	30.6±0.02	28.5±0.02
Ascorbic acid (mg/100g)	3.5±0.03	3.8±0.05	4.2±0.05
Reducing sugar (%)	0.7±0.30	0.8±0.50	0.5±0.01
Total sugar (%)	1.2±0.15	1.1±0.20	1.1±0.01
Thiamine (mg/100 g)	0.4±0.50	0.7±0.02	0.3±0.02
Riboflavin (mg/100 g)	0.05±0.50	0.08±0.13	0.10±0.12
Niacin (mg/100 g)	0.5±0.05	0.6±0.10	0.5±0.20
Ca^{2+} (mg/100 g)	24±0.30	27±0.01	28±±0.01
Fe^{2+} (mg/100 g)	2.2±0.02	2.6±0.02	4.2±0.02
PO_4^{3-} (mg/100 g)	140±0.30	142±0.01	145±0.05

*All value recorded are means of replicatedetermination±SE

Determination of vitamins and minerals in food

Ascorbic acid, vitamins B (riboflavinand thiamine), niacin and the determination of iron, calcium and phosphate in food samples were determined by the method of AACC (2008).

Preparation of the cereal blend

The three samples of the fermented gruels *ogi* were used for the formulation-white, yellow and brown (sorghum) *ogi*. It was prepared in the ratio 1:3 with the various soybeans prepared in different ways, namely:-raw, cooked and roasted. It was allowed to ferment with *L. plantarum* and the proximate analysis, antinutritional and residual oligosaccharides (and their profiles)and reducing sugars (and their profiles) were determined as described earlier. The food blend produced was also served as samples to nursing mothers and the organoleptic attributes of the various food blends such as taste, colour, aroma, texture, flavour, odour, shelf life, acceptability and appearance were assessed with questionnaires.

Packaging of the weaning food blend

The method of Oguntona and Akinyele (1995) as modified by Adeyemo (2012) was used in the preparation of *ogi*. *Ogi* was made using clean fermented cereals.The maize cereal was fermented for five days, milled and sieved thereafter. It was allowed to settle and srored in a clean platic container. The water was changed regularly to make it as fresh as desired and retain the desired taste, aroma and flavour.

Soybean was prepared by hand picking stones and dirt. It was roasted at 100°C on a hotplate. It was broken into small pieces with a waring blender (Kenwood model, UK) to remove the seed coat , milled into powder and sieved through a 0.5 mm sieve. It was stored in air tight plastic container. It can also be sealed in nylon containers and stored at room temperature. *Ogi* can be stored by refrigeration or at room temperature. The fermenting water may be changed regularly. This allows further fermentation to take place.

The blend or formulationwas done when the meal was to be consumed. Three parts *ogi* sample was mixed with one part roasted soybeans and left forone hour before cooking.

RESULTS

The nutritional analysis of different varieties of *Ogi*is presented in Table 1 while the Analysis of Ogis samples fortified with raw and processed soybeans in ratio 3:1 is shown in Table 2. There was significant diference between the three samples. The protein content was 3.9% in *Ogi* from sorghum while the one from white maize was 1.6% and the one from yellow maize 1.8%. The crude fibre was 1.7% in sorghum and 1.3 in white and yellow maize respectively. The riboflavin content (mg/100 g) was 0.10 in sorghum and 0.05 and 0.05 in white and yellow maize respectively. Fe^{2+} content in mg/100 g was 4.2 in sorghum and 2.2 and 2.6 in white and yellow maize respectively. The phosphate content also follows the same trend. Analysis of Ogis samples fortified with raw and processed soybeans in ratio 3:1. This is shown in Table 2.

The nutritional composition of the weaning food blend was presented in Table 3. There was an increase in the nutritional composition when compared with the *ogi* samples only. There was an increase in the protein content (13.8%), fat content (6.8%) and ash content (2.2%) while there was a reduction in the carbohydrate

Table 2. Analysis of *Ogi*samples fortified with raw and processed soybeans in ratio 3:1.

Parameter	Raw soy			Roasted soy			Cooked soy		
	White maize	Yellow maize	Brown (sorghum)	White maize	Yellow maize	Brown (sorghum)	White maize	Yellow maize	Brown (sorghum)
Moisture content (%)	*63.9±0.02	64.9±0.25	64.6±0.05	64.2±0.50	64.6±0.15	63.7±0.03	65.1±0.03	64.2±0.03	65.5±0.02
Protein (%)	11.2±0.10	11.5±0.25	13.6±0.50	11.5±0.02±0.02	11.6±0.20	13.8±0.02	10.9±0.02	11.0±0.04	11.4±0.01
Ether extract (fat) (%)	5.9±0.10	6.1±0.13	6.0±0.25	6.3±0.25	6.5±0.04	6.8±0.04	5.4±0.12	5.5±0.05	5.6±0.05
Ash (%)	1.8±0.14	1.8±0.12	1.7±0.05	2.0±0.12	2.1±0.20	2.2±0.02	1.4±0.02	1.5±0.03	1.5±0.05
Crude fibre(%)	2.1±0.05	2.1±0.33	2.4±0.13	2.0±0.04	1.9±0.02	2.2±0.03	2.0±0.04	1.9±0.03	2.0±0.04
Carbohydrates (by difference) (%)	15.1±0.02	13.6±0.30	11.7±0.14	14.0±0.03	13.3±0.03	11.3±0.04	15.2±0.13	15.9±0.13	13.0±0.20
Ascorbic acid (mg/100g)	7.0±0.02	7.0±0.50	7.4±0.05	4.0±0.03	3.9±0.03	4.3±0.02	3.2±0.03	3.5±0.02	3.8±0.10
Reducing sugar(%)	0.7±0.13	0.8±0.05	0.8±0.02	0.3±0.10	0.3±0.30	0.6±0.25	0.3±0.02	0.2±0.13	0.3±0.03
Total sugar(%)	0.9±0.33	0.9±0.20	0.8±0.04	0.7±0.04	0.7±0.02	0.8±0.04	0.3±0.05	0.3±0.05	0.4±0.02
Thiamine (mg/100g)	0.8±0.02	0.9±0.02	0.7±0.12	0.4±0.04	0.4±0.13	0.7±0.50	0.6±0.04	0.7±0.02	0.5±0.02
Riboflavin (mg/100g)	0.1±0.020	0.10±0.20	0.11±0.02	0.03±0.0.12	0.03±0.03	0.15±0.30	0.09±0.02	0.09±0.13	0.10±0.05
Niacin (mg/100g)	1.5±0.30	1.6±0.01	1.9±0.12	1.3±0.20	1.3±0.13	1.5±0.04	1.1±0.03	1.1±0.02	1.3±0.20
Ca^{2+} (mg/100g)	83±0.25	82±0.01	76±0.01	88±0.01	88±0.01	92±0.05	86±0.50	87±0.55	80±0.03
Fe^{2+} (mg/100g)	3.5±0.50	3.6±0.14	4.4±0.10	3.2±0.55	3.2±0.13	3.8±0.04	3.1±0.50	3.2±0.02	3.2±0.03
PO_4^{3-} (mg/100g)	205±0.05	208±0.20	216±0.10	226±0.55	225±0.50	228±0.04	210±0.02	212±0.55	210±0.05

*All value recorded are means of replicate determination±SE

content. There was also an increase in the vitamin content thiamine, riboflavin and niacin (0.7, 0.2 and 1.5 mg/100 g) respectively. Analysis of variance shows a significant difference (p=0.05) in the sample before it was fortified with the roasted soybeans sample. The mineral content also increased significantly (p=0.05). Also, when the ingredients were fermented together, there was a further increase in the nutritionalcomposition.The protein content increased (17.8%), fat (12.%), ash (3.8%), iron (10.7 mg/100 g), calcium (211.0 mg/100 g) and phosphate (288 mg/100 g).

The vitamin content also increased significantly, thiamine, riboflavin, and niacin (0.7, 0.2 and 1.5 mg/100 g respectively). In a trial experiment for the choice of the best weaning food composition, recipe A which consisted of roasted soybean and sorghum *ogi* was preferred by the nursing mothers. This is shown in Tables 2 and 4. Few people prefer recipes B and C. Therefore, further work was done with sample A alone.This was also used as a criteria for selection of the best weaning food for infants. The mothers were taught to prepare the weaning food themselves through a community development programme and their feed back were assessed with a questionnaire.

The weaning food blend were evaluated for their taste, colour, aroma, texture, flavour, odour, shelf life, acceptability and appearance based on a 5-point hedonic scale representing 'well acceptable, acceptable, fairly acceptable, moderately acceptable and rejected; this is shown in Table 4. The Organoleptic attributes of the fermented cereal blend is shown in Table 4 and Figure 1. Sample A compared favourably with sample D, a commercially sold weaning food set up as control

The organoleptic attributes of the food blend is shown in Figure 1. Samples fermented with *L. plantarum* have pleasant odour, taste and aroma longer shelf life. The colour was creamy and was accepted by mothers. The market surveywas done among nursing mothers who were earlier

Table 3. Nutritional Analysis of the weaning food blend (Sorghum *Ogi*-fortified with roasted soybeans and fermented with *L.plantarum*).

Parameter	Sorghum *ogi* only	Sorghum *ogi* with roasted soybeans	Sorghum *ogi* with roasted soybeans and fermented with *L.plantarum*
Moisture content (%)	62.6±0.14	63.7±0.02	52.3±0.30
Protein (%)	3.9±0.50	13.8±0.15	17.8±0.30
Ether extract(Fat) (%)	1.8±0.02	6.8±0.20	12.9±0.02
Ash (%)	1.5±0.01	2.2±0.05	3.8±0.10
Crude fibre (%)	1.7±0.02	2.2±0.10	1.7±0.01
Carbohydrates (by difference) (%)	28.5±0.02	11.3±0.20	11.5±0.01
Ascorbic acid (mg/100g)	4.2±0.05	4.3±0.03	18.3±0.03
Reducing sugar (%)	0.5±0.01	0.6±0.10	1.6±0.20
Total sugar (%)	1.1±0.01	0.8±0.01	3.2±0.12
Thiamine (mg/100g)	0.3±0.02	0.7±0.02	1.8±0.13
Riboflavin (mg/100g)	0.10±0.12	0.2±0.03	1.0±0.50
Niacin (mg/100g)	0.5±0.20	1.5±0.50	2.7±0.03
Ca^{++} (mg/100g)	28±±0.01	92.0±0.05	211.0±0.02
Fe^{++} (mg/100g)	4.2±0.02	3.8±0.10	10.7±0.13
PO_4^{---} (mg/100g)	145±0.05	228.0±0.01	288.0±0.01

*All value recorded are means of replicate determinations± SE

Table 4. Organoleptic attributes of the fermented cereal blend.

Organoleptic attributes	Roasted Soybeans +sorghum *Ogi* (A)	Roasted soybeans + dried sorghum *Ogi* (B)	Roasted soybeans + sorghum*Ogi* fermented with L. *plantarum* (C)	Commercially sold weaning food(D)
Taste	Sweet	Sweet	Sweet	Sweet
Colour	Creamy	Creamy	Creamy	Creamy
Aroma	Acceptable	Fairly acceptable	Moderately acceptable	Acceptable
Texture	Acceptable	Fairly acceptable	Moderately acceptable	Acceptable
Flavour	Acceptable	Fairly acceptable	Moderately acceptable	Acceptable
Odour	Acceptable	Fairly acceptable	Moderately acceptable	Acceptable
Shelf life	2 months	2½ months	2 months	6months
Acceptability	Well accepted	Fairly acceptable	Moderately acceptable	Well Accepted
Appearance	Well accepted	Fairly acceptable	Moderately acceptable	Well Accepted

taught the recipe. It showed that mothers had different erroneous believes about factors responsible for the presence of gas production, bloating and flatulence in young infants. Their responses were favourable when the sample was compared with commercially sold weaning food set up as control.

Statistical analysis

The statistical analysis carried out include mean, standard deviation and standard error, anova and Duncan multiple range of variables using SAS package and bar chart.

DISCUSSION

Provision of healty, nutritionally adequate, cheap, easy-to- prepare weaning food with prolonged shelf life is major challenge in West Africa. Weaning food is usually required when breast milk alone cannot meet the nutritional requirement of a young child. Commercial weaning foods are available in the market butthey are usually very expensive and not within the reach of low income earners. Some of these weaning foods however

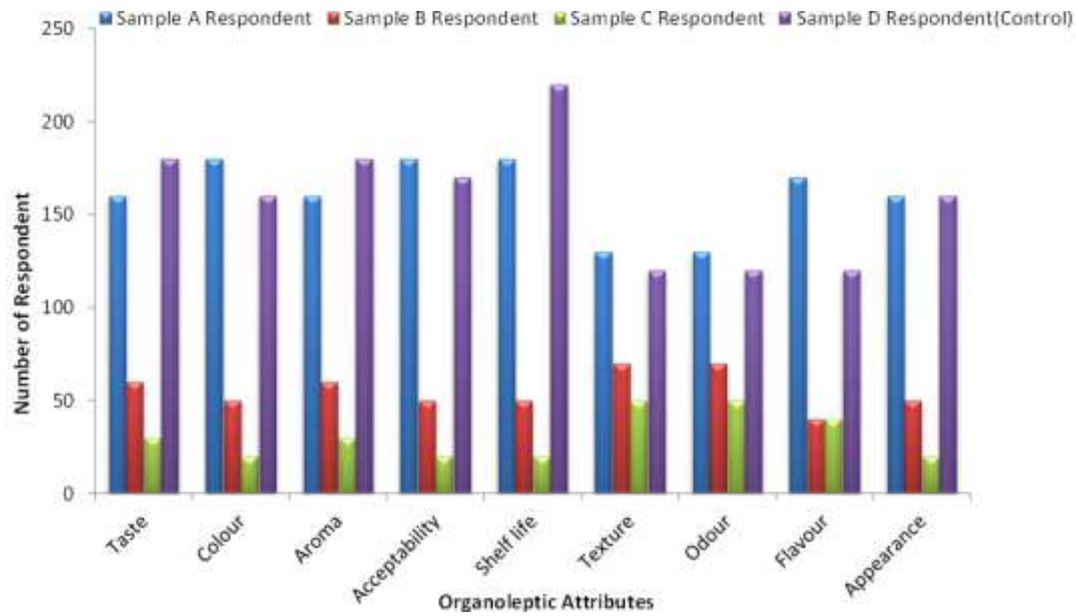

Figure 1. Survey carried out among nursing mothers on the organoleptic attributes of the weaning food blend. Sample A = Roasted soybeans+sorghum *Ogi;* Sample B = Roasted soybeans + dried sorghum*Ogi;* Sample C = Roasted soybeans + sorghum *Ogi* and Fermented *L. plantarum;* Sample D = Commercially sold weaning food (Control).

have their various challenges. Domestic preparation of some results in a combination of raffinose family of oligosaccharides that causes abdominal pain, bloating, gas formation and flatulence in young children, while some also contain some anti nutritional factors as a result of poor method of preparation. Others may not be prepared prepared hygienically which may result in series of diarrhoeal episodes in children. Some of these problems were addressed in this research with the metabolic and probiotics activities of *L. plantarum* through fermentation. This is in accordance with the work of Mariam (2002) and Macdonald et al. (2012) on problems preparation of a good weaning food and its associated.

The presence of raffinose oligosaccharide and some antinutritional factors in soybeans has limited its use as a good source of protein in Nigeria despite its several advantages (Oguntona and Akinyele, 1995; Nagai et al., 2012). Soyabeans can be consumed by adults and infants when the anti nutritional factors and Raffinose (RFO) have been removed successfully. This has been reported earlier by the authors Adeyemo and Onilude (2013, 2014).

Furthermore, the nutritional composition of soybeans was enhanced by fermentation using *L. plantarum.* Also, soybeans is not usually consumed raw except with some form of pre-treatment methods such as soaking, dehulling, milling, cooking and roasting (Onilude et al., 2004; Nagai et al., 2012). Fortification of sorghum *ogi* with roasted soybean improved the nutritional composition of the cereals. Cereals have been known to be deficient in lysine, but are rich in cystein and methionine. Legumes on the other hand are rich in lysine but deficient in sulphur containing amino acids. Thus by blending cereals with legumes, the overall protein quality was improved in the blend (Nagai et al., 2012; MacDonald et al., 2012).

On nutritional composition, the increase in the quality of the food blend by the addition of roasted soybeans flour was significant ($p<0.05$). The result was consistent with other report on the improvement in quality of corn protein by protein complementation or supplementation as determined by more traditional evaluation methods and as observed by other researchers like Onilude et al. (2004); Bulhões et al. (2007) and Wakil and Onilude (2009). There was an increase in protein, ash content, ascorbic acid, thiamine, riboflavin, niacin and mineral content. This is similar to the work of Nagai et al. (2012) who reported that when *ogi* was fortified with a high quality vegetable protein such as soybean flour, the fermented meal could serve as a major source of protein, especially in weaning foods for infant. They also opined that fortifying corn meal with defatted soybean caused a further improvement in the vitamin content of the food blend.

The formulation made in this research could easily serve as a good weaning formula with probiotics properties. The traditional fermentation of *ogi* which consist of metabolic activities of *L. plantarum* and inclusion of roasted soybeans which caused an increase in the protein content is however, a desirable quality. Even thou the development of weaning formulation in developing countries is a great challenge,this can be addressed by the use of such weaning food composition. In a similar observation, Macdonald et al. (2012) opined that the traditional fermentation which contribute an important role in food supply especially fermented cereal from indigenous raw materials play an important role on daily nutrition in developing countries.

The formulated blend meets the daily nutritional requirements of growing infants. This agrees with the nutritional composition and specification for home-prepared and commercially-processed food blends as laid down by PAG (2009) and recommended by FDA, FAO, WHO and UNICEF (Reports 1997-2012; 2007; 2000-2016). It is also able to supply the nutritional and energy requirement of a growing child and also confer health benefits on them as stated in the FDA report (2000-2016) while meeting the daily nutrient composition of the recommended standard for weaning when compared with commercially available ones.

This is also corroborated by the work of Wakil and Onilude (2009) who reported a significant increase in nutritional composition of fermented cereals when the fermentation time increases. Furthermore, the probiotics activities of LAB was able to increases the acidity of the fermenting cereal during the process by lowering of the pH and preventing the growth of spoilage microorganisms which is a characteristic of a good probiotics (Bulhões et al., 2007; Arimah and Ogunlowo, 2014; Ozogul and Hammed, 2017).

This corroborates the work of Adeyemo and Onilude (2014) which reported a reduction of galacto-oligosaccharide content of soybeans during fermentation with enzymatic activities.The reduction of RFO and other unwanted /toxic substances during fermentation and improvement of the nutritional composition of the food by *L. plantarum* is one of the attributes of a good probiotic that can be used as starter culture (Amankwah et al., 2012; Nagai et al., 2012).

In conclusion, cereals and legumes are abundant in West Africa Sub-region; thus these potentials can be harnessed to prepare adequate weaning foods for children. Preparation of weaning foods through fermentation should be as natural as much as possibleand carried out under strict hygienic condition. This will reduce diarrhoea, infection, kwashiorkor and high infant mortality rate. Also, preparation of adequate and well balanced weaning food is cheap, easy to prepare and has so many probiotic properties and health benefits. The Sustainable Development Goals (SDG) of the UN will be achieved as this will reduce the problem of poverty, malnutrition and infant mortality rate. The food blend can compete adequately with the commercially available infant weaning formula.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Adeyemo SM (2012). Raffinose Metabolism and Utilization by L. plantarumIsolates from indigenously fermented cereal gruels for Nutritional Improvement. Ph.D Thesis. University of Ibadan, Nigeria pp. 1-256.

Adeyemo SM, Onilude AA (2014). Reduction of Oligosaccharide content of soybeans by the action of L. plantarumisolated from fermented cereals. African Journal of Biotechnology 13(37):3790-3796.

Adeyemo SM, Onilude AA (2013). Enzymatic Reduction of Anti-nutritional Factors In soybeans by Lactobacillus plantarumIsolated from fermenting cereals. Nigerian Food Journal 31(2):84-90.

American Association of Cereal Chemist Approved Methods (AACC) (2008). Technological Handbook. Edited by M Carcea..10th ed. Methods. 44-40. The Association, St. Paul, MN, US.

Arimah BD, Ogunlowo OP (2014). Identification of Lactic Acid Bacteria from Nigerian Foods: Medical importance and comparison of their Bactericin activities. Journal of Natural Sciences Research 4(23):76-86.

Axelsson L (2004). Lactic Acid Bacteria - Classification and Physiology, in, S. Salminen and Avon Wright (eds.) Lactic Acid Bacteria. Microbiology and Functional Aspects, 2nd ed. Marcel Dekker, Inc, New York. pp. 1-72.

Body Ecology (2012). Lactobacillus Plantarum: The Key Benefits of this "Superstar" Probiotic & How to Get It In Your Diet. Available at: http://bodyecology.com/articles/lactobacillus_plantarum_benefits.php

Bulhões AC, Goldani HA, Oliveira FS, Matte UD, Mazzuca RB, Silveira TR (2007). Correlation between lactose absorption and the C/T-13910 and G/A-22018 mutations of the lactase-phlorizin hydrolase (LCT) gene in adult-type hypolactasia. Brazilian Journal of Medical and Biological Research 40(11):1441-1446.

Carevic M, Banjanac K, Ćorović M, Jakovetić S, Milivojević A, Vukašinović-Sekulić M, Bezbradica D (2016). Selection of Lactic Acid Bacteria strain for simultaneous production of alpha and beta galactosidases. Zaštita Materijala 57(2):265-273.

FAO/WHO (2002). Report of the International Conference on organic agriculture and food FAO/WHO Reports 2007, 2008,2009 and 2010. Available at: https://www.twn.my/title2/susagri/susagri003.htm

FDA/WHO/UNICEF (1997-2012). Reports Recommended Daily Dietary Reference Intakes 1997-2012. Available at: https://www.scribd.com/document/190516892/Scientific-Opinion-on-Nutrient-Requirements-and-Dietary-Intakes-of-Infants-and-YoungChildren

Horwitz W Latimer GW AOAC (2010). Official methods of analysis of AOAC International. Gaithersburg, MD: AOAC International, 2010. Available at: http://www.worldcat.org/title/official-methods-of-analysis-of-aoac-international/oclc/649275444

Hou A, Chen P, Shi A, Zhang B, Wang YJ (2009). Sugar variation in soybean seed assessed with a rapid extraction and quantification method. International Journal of Agronomy 2009:1-8.

Joint FAO (2007). WHO Working Group on Drafting Guidelines for the Evaluation of Probiotics in Food. Guidelines for the evaluation of probiotics in food: report of a Joint FAO/WHO Working Group on Drafting Guidelines for the Evaluation of Probiotics in Food, London, Ontario, Canada.

Kaškonienė V, Stankevičius M, Bimbiraitė-Survilienė K, Naujokaitytė G, Šernienė L, Mulkytė K, Malakauskas M, Maruška A (2017). Current state of purification, isolation and analysis of bacteriocins produced by lactic acid bacteria. Applied Microbiology and Biotechnology, 101(4):1323-1335.

Khalid K (2011). An overview of lactic acid bacteria. International Journal of Biosciences 1(3):1-13.

MacDonald AA, Evans SJ, Cochrane BO, Wildgoose JC (2012).

Weaning infants with phenylketonuria: a review. Journal of Human Nutrition and Dietetics 25(2):103-110.
Magala M, Kohajdova Z, Karovičová JO, Greifova M, Hojerova J (2017). Application of lactic acid bacteria for production of fermented beverages based on rice flour. Czech Journal of Food Science 33:458-463.
Makarova K, Slesarev A, Wolf Y, Sorokin A, Mirkin B, Koonin E, Pavlov A, Pavlova N, Karamychev V, Polouchine N, Shakhova V. (2006). Comparative genomics of the lactic acid bacteria. Proceedings of the National Academy of Sciences 103(42):15611-15616.
Mariam SB (2002). Nutritional value of three potential complementary foods based on Cereals andlegumes. African Journal of Food, Agriculture, Nutrition and Development 5(2):1-15.
Nagai T, Staatz JM, Bernsten RH, Sakyi-Dawson EO, Annor GA (2012). Locally processed roasted-maize-based weaning foods fortified with legumes: factors affecting their availability and competitiveness in Accra, Ghana. African Journal of Food, Agriculture, Nutrition and Development 9(9):1927-1944.
Narwade RB, Kasare JD, Choudhary RS (2015). Isolation, Screening and Characterisation of Lactobacilli from Cow milk. International Journal of Agriculture Innovations and Research 3(6):1635-1637.
Oguntona EB, Akinyele IO (1995). Nutrient composition of commonly eaten foods in Nigeria-Raw, processed and prepared. Food Basket Foundation, Ibadan, Nigeria. Available at: http://agris.fao.org/agris-search/search.do?recordID=XF2015022133
Onilude AA, Sanni AI, Ighalo MI (2004). Process upgrade and the microbiological, nutritional and consumer acceptability of infant wearing food from composite blends of cereals and soybean. Available at: http://agris.fao.org/agris-search/search.do?recordID=FI2005026377
Ozogul FF, Hamed IK (2017). The importance of Lactic acid bacteria for the prevention of Bacterial Growth and their biogenic amines formation.A review. Critical Reviews in Food Science and Nutrition 58(10):1660-1670.
Protein Advisory Group of the United Nations System (PAG) (2009). Protein Advisory Group of the United Nations System. Nutrition Bulletin. Available at: https://onlinelibrary.wiley.com/journal/14673010
Wakil SM, Onilude AA (2009). Microbiological and chemical changes during production of malted and fermented cereal – legume weaning foods. Advances in Food Sciences 31:139-145.
Wall TY, Bath MM, Britton RA, Jonsson HO, Versalovic JJ, Roos SA (2007). The early response to acidshock in Lactobacillus reuteriinvolves the ClpL chaperone and a putative cell wall-alteringesterase. Applied and Environmental Microbiology 73(12):3924-3935.
Waugh AW, Foshaug R, Macfarlane S, Doyle JS, Churchill TA, Sydora BC, Fedorak RN (2009). Effect of Lactobacillus plantarum 299v treatment in an animal model of irritable bowel syndrome. Microbial Ecology in Health and Disease 21(1):33-37.
Yelnett AT, Purnomo HG, Purwadii KT, Miran AY (2014). Biochemical characteristics of Lactic Acid Bacteria with proteo;ytic Activity and Capability as Starter ulture Isolated from spontaneous fermented Local goat Milk. Journal of Natural Sciences Research 4(10):137-146.