Original Research Article

SAFETY EVALUATION OF FONIO *(DIGITARIA EXILIS*)/ RICEBEAN (*VIGNA UMBELLATA*) BASED COMPLEMENTARY FOOD.

Abstract

Aims- This study evaluated the oligosaccharides, phytochemicals, dietary fiber, microbial count, pH and acidity of fonio *(Digitaria exilis*)/ricebean (*Vigna umbellata*) based complementary foods in order to ascertain the safety of the formulations.

Study design- A 3 by 4 by 4 factorial design was used**.**

Methodology- A 70:30 (treated fonio): (72 h sprouted and dehulled ricebean) blend containing 30 % peeled dried carrot and 30 % crayfish (FNBN) was formulated. A similar blend with additional 20 % milk (FNBP), a third blend containing unsprouted and undehulled ricebean (FNBU) and a fourth containing only treated fonio and sprouted ricebean (FNBM) were also formulated.

Results- The level of stachyose and raffinose in the diets ranged from 0.21±0.00 -0.40±0.02 % and 0.05±0.00 -0.10±0.01 % respectively. The levels of stachyose and raffinose in the sprouted samples (FNBP, FNBN and FNBM) were comparable ($p>0.05$) and low suggesting absence of flatulence. The residual phytochemicals in the formulations ranged from 0.160±0.00-0.28±0.00 % (alkaloid), 0.17±0.02-0.35±0.01 % (flavonoid) and 0.39±0.02-0.530±0.01 % (saponin). These low values indicate absence of allergy. The dietary fiber contents of the blends were lower ($p<0.05$) than the recommended 5 % for complementary food indicating that the digestive system of the infants can handle it. The low bacterial load and zero fungal growth observed in the products depict high level of hygiene and sanitary quality while the near neutral pH and low acidity suggest caution during handling and feeding of the infant. These conditions favour growth of spoilage and pathogenic microorganisms.

Conclusion- Results of the study show a high measure of safety of the formulations.

Keywords: Fonio, Ricebean, Complementary food, Formulation, Flatulence

1.0 Introduction

Breast milk is the ideal food for infants during the first six months of life. However, after the first six months of life breast milk may not adequately provide enough nutrients and calories for the infants to thrive (IFM,2008). Thus, other nutritious foods should be added to argument the breast milk. Asinobi (2007) reported that after the first six months of life, infants cannot thrive with the nutrients and calories provided by breast milk, so complementary foods needed to be introduced to argument energy and nutrient intake.

Complementary foods are foods other than human milk or infant formula provided to an infant or young child to provide nutrient and calories (RMFS, 2019) which are consumed between a time of exclusive breast milk or formula and time of family foods (Yeung, 2000). Complementary foods are consumed for a relatively short period of four to six months to about twelve months of age and constitute a large proportion or baby's diet and contribute a significant amount of nutrients that are necessary for growth and development. Complementary foods should therefore be safe, nutritionally adequate and appropriately fed in order to meet the young child's calories and nutrient need. According to Brown (1991), stunted growth or malnourishment or both can result if an infant does not receive adequate complementary foods due to deficiencies in protein, energy, calcium and micronutrients such as iron, zinc, iodine and vitamin A.

The principal cause of nutrient deficiencies in Children especially in resource poor communities is lack of affordable nutrient dense complementary foods. Though there are commercial fortified weaning foods that can address this issue, they are very expensive. This makes nursing mothers resort to traditional weaning foods which are characterized by high bulk and low energy/low nutrient density because of the nature of native or unmodified cereal foods that make them unsuitable for feeding of infants.

According to Ijeomah (2015), cereal proteins have low biological value (BV) because they are limited in some essential amino acids such as lysine which is the growth amino acid and sometimes tryptophan. Also, the digestibility of cereal protein is lower than that of animal protein besides the presence of other antinutrients such as trypsin inhibitor, phytic acid, haemagglutinins and cyanogenic glucosides.

The quality of cereal based complementary foods can be improved by complementation with legume, method of preparation such as malting, pressure cooking, fortification with micro-nutrients and enrichment with micro-nutrients (Ijeomah, 2015).

This study therefore was aimed at evaluating the Oligosaccharides (Stachyose and raffinose), phytochemicals, dietary fiber, microbial count, pH and acidity of a complementary food produced from fonio (*Digitaria exilis*) and ricebean (*Vigna umbellata*) fortified with carrot and crayfish, with a view of ascertaining the measure of safety of the formulations.

2.0 Materials and method

2.1 Sources of material

Fonio, ricebean, carrot, crayfish, sugar, vegetable oil, salt and milk were purchased from Ogbete main market Enugu, Enugu State. The chemicals and reagents used were of analytical grade and purchased from standard scientific chemical dealers.

2.2 Preparation of samples:

Five hundred grams (500 g) of fonio was cleaned, soaked in hot water (100±2^{o}C) for 10min and allowed to boil for 5 min. The boiled fonio was drained and dried in an oven at 35^{o}C for 12 h. Five hundred grams (500 g) of ricebean was cleaned, washed, steeped in water at ambient temperature (30±2^{o}C) overnight. The steeped ricebean was spread on a jute bag and sprouted for 72 h. At the end of the sprouting period, the grain was dehulled and the dhals boiled for 45min, drained and dried in an oven at 35^{o}C for 10 h. Unsprouted grain (250 g) was cleaned, washed, boiled for 45 min drained and dried in an oven at 35^{o}C for 10 h. Carrot (1kg) was washed, peeled, sliced into thin rings (1mm thick) blanched in hot water 100±2^{o}C for 10 min and dried in an oven at 35^{o}C for 10 h. Five hundred grams of crayfish was cleaned and dried in an oven at 35^{0}C for 10 min.

2.3 Formulation of samples

Samples were formulated to contain70 g treated fonio, 30 g sprouted and dehulled ricebean, 30 g dried carrot and 30 g crayfish. Milk, sucrose, vegetable oil and salt were added at 20 g, 5 g 5 ml and 1 g levels respectively (FIRRO, 2008). Figure 1 shows the flow chart for the production while table 1 shows the composition of fonio/ricebean based complementary foods fortified with carrot and crayfish.

Prepared fonio + malted ricebean dhals
+dried carrot slices+crayfish+sugar+salt

↓

Milling

↓

Sieving (250 um)

↓

Blending (with vegetable oil)

↓

Drying (35^{o}C for 10 min in an oven)

↓

Cooling

↓

Packaging (in a cellophane)

↓

Sealing (vacuum sealed)

Fig. 1. Flow chart for the production of fonio and ricebean based complementary food fortified with carrot and crayfish.

Table 1: Composition of fonio/ricebean based complementary food

Ingredient(g)	FNBN	FNBP	FNBM	FNBU
Processed fonio	70	70	70	70
Sprouted and dehulled ricebean	30	30	30	-
Untreated ricebean	-	-	-	30
Carrot	30	30	-	30
Crayfish	30	30	-	30
Sucrose	5	5	5	5
Vegetable oil (ml)	5	5	5	5
Salt	1	1	1	1
Milk	-	20	-	-

FNBN- Diet containing normal ingredient, FNBP – Diet that contained milk in addition, FNBM- Diet without carrot and crayfish and FNBU- Diet that contained untreated ricebean.

2.4 Analysis

2.4.1 The Oligosaccharides (Stachyose and raffinose) were determined by anthrone method (James, 1995).

2.4.2 The phytochemicals (alkaloid and flavonoid) were determined using the alkaline gravimetric method of Harborne (1976) while the saponin was determined using the double solvent extraction gravimetric method of Harborne (1976).

2.4.3 The dietary fiber was determined using the Spectrophotometric method described by James (1995).

2.4.4 The International Commission on Microbiological Specification (ICMSF, 2000) method was used for microbial count.

2.4.5 Porridge acidity was determined by the alkaline titrimetric method described by James (1995).

2.4.6 Porridge pH was determined using a pH meter (Jenway Model DG 5007), Germany.

3.0. Statistical analysis:

Data collected were subjected to one way analysis of variance (ANOVA) using SPSS version software package for social sciences (SPSS Inc. USA). Means were separated using Duncan's new multiple range text and significance was accepted at 5% probability level ($p<0.05$). Results were expressed as mean ± standard deviation (SD) of triplicate determinations.

4.0. Results and Discussion

The Oligosaccharides, phytochemicals, dietary fiber, microbial count and porridge acidity are shown in table 2. The total sugar content of the formulated diets was highest (5.94±0.02 %) in the sample that contained untreated ricebean (FNBU) relative to the levels in other diets which were comparable ($P>0.05$). This low values of free sugar invariably gave rise to the low values of stachyose (0.21±0.00-0.40±0.02 %) and raffinose (0.05±0.00-0.10±0.01 %) in the diets. All the samples (FNBP, FNBN, and FNBM) containing sprouted ricebean had comparable stachyose and raffinose values which may be as a result of soaking, dehulling and sprouting. These processes are known to reduce flatulence inducing oligosaccharides in grains (Nout and Ngoddy, 1997). The very low values of Stachyose and raffinose suggest absence of flatulence.

The residual phytochemicals in the formulations were very low ranging from 0.16±0.00-0.28±0.00 % (alkaloid), 0.17±0.02-0.43±0.01 % (flavonoid) and 0.39±0.02-0.53±0.01 % (saponin). The high values of residual phytochemicals observed in the sample containing untreated ricebean (FNBU) in relation to other samples may be due to the fact that ricebean used was neither soaked nor dehulled and phytochemicals have been reported to be concentrated in seed coats. Nout and Ngoddy (1997) reported that washing, soaking and dehulling may reduce phytochemicals. Phytochemicals (alkaloid and saponin) may induce allergies in infants while flavonoid may act as prooxidant when ingested in high amount.

The total dietary fiber contents of the diets varied. The sample that contained unsprouted and undehulled ricebean (FNBU) had the highest value (3.79±0.01 %) due probably to the presence of fonio and ricebean hulls. Significant ($P<0.05$) differences were observed in the insoluble dietary fiber contents of the formulated diets. The values ranged from 2.24±0.00 % in the unfortified sample (FNBM) to 3.12±0.01 % in the untreated sample (FNBU). Ricebean hulls may have accounted for the level of insoluble fiber observed in FNBU. According to Kulkarni et al. (1991) sprouting and dehulling decrease fiber contents of cereals and legumes. Little variations were observed in the

Table 2: Oligosaccharides, dietary fiber, microbial count, porridge acidity and porridge pH of the formulated diets.

Parameter	FNBP	FNBU	FNBN	FNBM
Oligosaccharides (%)				
Free sugar	$5.27^{a} \pm 0.03$	$5.94^{b} \pm 0.02$	$5.20^{a} \pm 0.02$	$5.24^{a} \pm 0.01$
Stachyose	$0.21^{a} \pm 0.01$	$0.40^{b} \pm 0.02$	$0.21^{a} \pm 0.00$	$0.21^{a} \pm 0.00$
Raffinose	$0.05^{a} \pm 0.01$	$0.10^{b} \pm 0.01$	$0.05^{a} \pm 0.00$	$0.05^{a} \pm 0.01$
Phytochemicals (%)				
Alkaloid	$0.22^{a} \pm 0.02$	$0.28^{b} \pm 0.00$	$0.24^{a} \pm 0.02$	$0.16^{c} \pm 0.00$
Flavonoid	$0.28^{a} \pm 0.02$	$0.35^{b} \pm 0.01$	$0.28^{a} \pm 0.01$	$0.17^{c} \pm 0.02$
Saponin	$0.43^{a} \pm 0.01$	$0.53^{b} \pm 0.01$	$0.43^{a} \pm 0.02$	$0.39^{c} \pm 0.02$
Dietary fiber (%)				
Total	$3.60^{a} \pm 0.01$	$3.79^{b} \pm 0.01$	$3.35^{c} \pm 0.01$	$3.28^{d} \pm 0.02$
Insoluble	$2.49^{a} \pm 0.02$	$3.12^{b} \pm 0.01$	$2.29^{c} \pm 0.01$	$2.24^{d} \pm 0.00$
Soluble	$1.11^{a} \pm 0.01$	$0.67^{b} \pm 0.03$	$1.06^{c} \pm 0.00$	$1.04^{c} \pm 0.00$
Microbial count CFU/g x10^{1}				
Bacteria	$3.2^{a} \pm 0.10$	$2.3^{b} \pm 0.02$	$2.5^{b} \pm 0.60$	$1.7^{c} \pm 0.10$
Fungi	NG	NG	NG	NG
Porridge pH and Acidity				

pH	$6.12^{a} \pm 0.02$	$6.20^{b} \pm 0.02$	$6.18^{b} \pm 0.02$	$6.25^{c} \pm 0.02$
Acidity	$0.76^{a} \pm 0.00$	$0.71^{b} \pm 0.01$	$0.73^{b} \pm 0.02$	$0.68^{c} \pm 0.03$

Value are means of triplicate determination ± standard deviation (SD). Means with different superscripts on the same row are significantly different *($p < 0.05$)*.

FNBN = Diet containing fonio, sprouted ricebean, carrot and crayfish, FNBP = Diet containing fonio,, sprouted ricebean, carrot, crayfish and milk, FNBM = Diet containing fonio, and sprouted ricebean only and FNBU = Diet containing fonio, unsprouted and undehulled ricebean, carrot and crayfish. NG = No growth.

soluble dietary fiber contents of the samples due to differences in the total and insoluble fiber contents. The dietary fiber contents were lower ($P<0.05$) than the recommended dietary fiber requirement (5 %) for complementary foods. This is an indication that the digestive system of infants can handle it. Low dietary fiber is one of the requirements for complementary food (Ainciburu, 2001) because the digestive system of infants is not developed enough to handle high amount of dietary fiber (Bamji et al., 2010).

Bacterial count of 3.2±0.10 CFU/gx10^1 obtained in the diet containing milk (FNBP) was higher ($p<0.05$) than that of other diets. The bacterial load (2.3±0.02 CFU/g x10^1) and (2.5±0.60 CFU/g x 10^1) of untreated (FNBU) and treated samples (FNBN) respectively did not differ significantly. The unfortified sample (FNBM) had the lowest bacterial load (1.7±0.10 CFU/g x 10^1). The high bacterial load in FNBP was expected because milk and crayfish are good sources of nutrient (nitrogen) for bacterial growth (Ezeama, 2008). There was no fungal growth. Microbial load is an indication of microbiological and sanitary quality of a product. It also depicts the level of hygiene employed in the production. The low bacterial load and zero fungal growth observed in the samples suggest a measure of safety.

The formulated diets had pH values near neutral (pH 7.0) with slight variations among the samples. Sample FNBP showed the lowest pH value (6.12±0.02) due probably to the presence of milk which according to Ihekoronye and Ngoddy (1985) is acidic. Samples FNBN (6.20±0.02) and FNBU (6.18±0.02) had pH values that did not vary significantly ($p>0.05$). The unfortified sample (FNBM) had the highest pH (6.25±0.02) which may be due to the fact that crayfish was not used in the formulation. Crayfish is an animal food with slight acidic pH (USDA, 2013). The titratable acidity (TTA) of the samples was very low and varied slightly among the samples. The TTA of samples FNBN (0.73±0.02 %) and FNBU (0.71±0.01%) did not differ significantly ($p>0.05$). Sample FNBP had the highest value (0.76±0.00%) while sample FNBM had the lowest acidity value (0.68±0.03%).

The near neutral pH and low acidity of the formulations suggest caution during handling and feeding of the infants as these conditions may favour the growth of spoilage and pathogenic microorganisms.

5.0 Conclusion

Considering the observed results, there is a high measure of safety in the formulation of the diets indicating safety of the diets.

References

Ainciburu, M. (2001). Complementary feeding, Department of Bromatology, Universidad de

Buenos Aires, Argentina.

Asinobi, C. (2007). Complementary food and complementary feeding for infants and young children of various age groups. Modalities and Techniques Institute of child health, University of Nigeria Teaching Hospital, Ituku, Enugu Pp. 97-126.

Bamji, M.S, Krishnawwamy, K. and Brahmam, G.N.V. (2010). Nutritional deficiency disorders. Textbook of Human Nutrition 3rd edition. Oxford and IBH publishing company Put. Ltd, New Delhi. Pp. 265-322.

Brown, K.H. (1991). The importance of dietary quality versus quantity for weanlings in less developed countries. A frame work for discussion. Food and Nutrition Bulletin 2:86-93.

FIRRO (2008). Recipe for the formulation of weaning food. Technical Information Bulletin for Industry. Federal Institute of Industrial Research, Oshodi, Lagos Vol 36 Pp. 44

ICMSF (2000). International Commission on Microbiology of Science and Food. Microbiological Analysis of Foods, Pp 286-297.

IFM (2008). International Food Monitoring http://www.IFM.Net/issue/ complementary foods. Accessed 3rd September, 2008.

Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated Food Science and Technology for the Tropics. Macmillian Publishers Ltd, London, Pp33-34.

Ijeomah, O.C. (2015). Production and Evaluation of fonio *(Digitaria exilis)*/ricebean (*Vigna umbellata*) based complementary food fortified with micronutrients rich foods. Ph.D thesis. Department of Food Science and Technology, University of Nigeria, Nsukka, Nigeria.

James, C.S. (1995). Analytical chemistry of foods. Blackie academics and professional. Chapman and Hall Ltd, London Pp 103-113.

Kulkarni, K.D, Kulkarni, D.N and Ingle, U.M (1991). Sorghum Malt based weaning food formulation. Preparation, functional properties and nutritive value. Food and Nutrition Bulletin, 13(4). The United Nations University.

Nout, M.J.R. and Ngoddy, P.O. (1997). Technological aspects of preparing affordable fermented complementary foods. Food Control (5/6); 279-287.

RMFS (2019). Reference Module in Food Science.

USDA (2013). United States Department of Agriculture Crayfish. http://www.USDA.crayfish. Accessed March 3rd 2012.

Yeung, D.C. (2000). In and Micronutrients: Complementary food fortification. H.J. Heinz Company, Corporate Nutrition, London, Pp 1-5.