American Journal of
Food Sciences and Nutrition
(AJFSN)

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AJP

American Journal of Food Sciences and Nutrition
ISSN 2789-3154 (Online)
Vol.4, Issue 1, pp 61 - 68, 2022
www.ajpojournals.org

Bioavailability of Nutrients in a Fonio (*Digitaria exilis*) Ricebean (*Vigna umbellata*) Based Complementary Food

Ijeomah, O.C[1] and Okpala, M. O[2.]

[1]Department of Food Science and Technology, Madonna University, Akpugo Campus, Enugu State, Nigeria

[2]Department of Food Technology, Federal Polytechnic, Oko, Anambra State, Nigeria

Corresponding Author's Email: **ijekuso@gmail.com**

Purpose: This study was carried out to assess the bioavailability of nutrients in a fonio/ricebean based complementary food.

Methodology: Treated fonio (*Digitaria exilis*)/sprouted (72h) ricebean (*Vigna umbellata*) composite were processed into four complementary diets. FNBN-70:30:30:30(Fonio: ricebean: dried carrot: crayfish). A similar blend containing in addition 20g of milk (FNBP), a third blend that contained unsprouted and undehulled ricebean (FNBU) and the fourth that contained only fonio and ricebean (FNBM) were also formulated. These were analyzed for antinutrients, phytochemicals and viscosity using standard methods.

Findings: There were slight variations in the trypsin inhibitor (1.16-1.78 Tiu/g), phytic (0.12-0.17%) and tannic acid (0.048-0.067%) contents of the samples. Cooking, soaking, sprouting and dehulling might have accounted for the observed low values of these antinutrients suggesting high bioavailability of the nutrients in the diets. The residual phytochemicals were equally low with sample FNBU having the highest values (alkaloid – 028%, flavonoid – 0.35%) and saponin 0.53%) among the samples which can be attributed to the non-sprouting and non-dehulling of the ricebean. The formulated diets showed low viscosities ranging from 84.21-85.77cP due probably to the thinning effect of amylases activated during sprouting. Decreased viscosity indicated increased nutrient density. The results showed high availability of the nutrients and low bulk/high nutrient density of the diets which showed suitability of the diets to argument nutrient and energy intake in children.

Recommendation: Fonio/ricebean complementary food should substitute commercial complementary food.

Keywords: *fonio, ricebean, complementary food, assessment, bioavailability.*

1.0 Introduction

Good nutrition in the first two years of life is crucial because it is when infants undergo rapid growth and it is a major determinant of healthy growth and development during childhood and of good health in adulthood. United Nations International Children's Emergency Fund (UNICEF) (2000) declared that after six months of exclusive breast feeding, energy and nutrient rich complementary foods should be continued up to two years or longer. Locally available foods such as fish, poultry and eggs should be included. According to Lancet (2008), the period from birth to two years of age is the "critical window" for the promotion of optimal growth, health and development. Lancet (2008) also reported that insufficient and inadequate quality of complementary foods, poor child feeding practices and high rate of infection have detrimental impact on health and growth in these important years. Even breastfed children declared Lancet (2008) will become stunted if they do not receive sufficient quantities of quality complementary foods after six months of age. He stated that 6% or six hundred thousand under five deaths can be prevented by ensuring optimal complementary feeding. Poor quality complementary foods characterized by high viscosity and low energy density and inappropriate feeding practices are part of the major causes of malnutrition in children especially in the second semester of the first year of life of children in the poor resource communities.

Complementary foods are prepared traditionally with local staples such as maize, sorghum, millet, rice, tapioca among others. The starchy nature of these foods make them bind so much water when prepared into a gruel of fluid consistency that will be suitable for the delicate mouth structures of infants. This dilution increases bulk and makes it more difficult for the infant to consume large quantity in one sitting while at the same time limiting the amount of nutrients that could have been derived from the gruel. On the other hand, if the solid in the gruel is increased to improve nutrient content, the gruel may be too thick and cause choking to the child.

Secondly, most cereals are limiting in some essential amino acids such as lysine and tryptophan making the protein of low biological value. Also digestibility of cereal protein is low partly due to inherent fibre and tannins that bind the proteins (Graham et at., 1980) besides the presence of other antinutritional factors such as trypsin inhibitor, phytic acids, haemagglutinins and cyanogenic glycosides (Okaka, 1997), Nout and Ngoddy, 1997) and phytochemicals such as alkaloids, flavonoids and saponins. The quality of cereal based complementary foods can be improved by complementation with legume, method of preparation such as malting or sprouting, cooking and fortification with micronutrients. According to Desikachar (1982), viscosity reduction to any desired level depending on the extent of germination makes sprouting especially suitable for young babies' foods. This process enhances phytase hydrolysis of phytin to available phosphate, elaboration of vitamin C and lysine in cereals and causes development of aroma during kilning. Pressure cooking softens the grains without nutrient loss. Washing, soaking, dehulling and sprouting reduce antinutrients and phytochemicals while sprouting breaks down starch to simple sugar, thereby decreases gruel viscosity.

Therefore, the aim of this study was to evaluate the antinutrients, phytochemicals and viscosity of fonio/ricebean based complementary food fortified with carrot and crayfish with a view of ascertaining the accessibility of the nutrients in the diets.

2.0 Materials and methods

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

2.3 Formulation of fonio/ricebean based complementary diets: Samples were formulated to contain70g treated fonio, 30g sprouted and dehulled ricebean, 30g dried carrot and 30g crayfish. Milk, sucrose, vegetable oil and salt were added at 20g, 5g 5ml and 1g 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 (250um)

↓

Blending (with vegetable oil)

↓

Drying (35^0C 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 antinutrients (trypsin inhibitor, phytic acid and tannins were determined by AOAC (2000) spectrophotometric method while hydrogen cyanide (HCN) was by modified alkaline picrate colorimetric method.

2.4.2 Phytochemicals (Alkaloids, flavonoids aid saponins) were determined using the method described by Harbone (1976).

2.4.3 Viscosity was determined by the method described by James (1995).

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 results of the proximate, vitamins and minerals of the various formulated diets were recorded on table 2. The level of trypsin inhibitor in the formulations ranged from 1.16Tiu/g to 1.78Tiu/g. The sample that contained milk (FNBP) had comparable trypsin inhibitor content with the sample that contained sprouted ricebean (FNBN) which differed from the levels in other samples. These low values may be attributed to cooking of the ricebean because according to Salunkhe et al. (1982), cooking destroys trypsin inhibitor. These observed low values indicates utilization without interference of the protein since trypsin inhibitor interferes with plant protein utilization. This agrees with Lopez et al. (2002).

There were slight variations in the phytic and tannic acid contents of the samples. The untreated sample (FNBU) had the highest amounts of phytic acid (0.17%) and tannic acid (0.067%) which can be attributed to the non-sprouting and non-dehulling of the ricebean. The Level of phytic acid in the unfortified sample (FNBM), sprouted sample (FNBN) and sample that contained milk (FNBP) were comparable ($P>0.05$) unfortified sample (FNBM) had the lowest tannic acid value (0.048%). This can be attributed to the non-fortification of the diet. Soaking, dehulling and sprouting might have accounted for the observed low values of phytic and tannic acid. According to Nout and Ngoddy (1997), soaking, dehulling and sprouting reduce these acids of the grain. These low values suggest high availability of nutrients in the diets especially the limiting amino acids such as lysine (Salunkhe et al., 1982). Lopez et al. (2002) made similar observation. Phytate binds calcium and other minerals in pigmented seeds (Lopez et al., 2002). Hydrogen cyanide (HCN) was not detected in the formulations except in the untreated sample (0.19kg/1kg). Non-detection of cyanide in the other samples may be probably due to dehulling and cooking of the raw materials. Glycosides are concentrated in the seed coat and peripheral tissues of legumes.

Table 2: Antinutrient, Phytochemical and Viscosity of the formulated diets.

ANTINUTRIENT	FNBP	FNBU	FNBN	FNBM
Trypsin inhibitor (Tiu/g)	$1.69^{a}\pm0.01$	$1.78^{b}\pm 0.01$	$1.67^{a}\pm 0.02$	$1.16^{c}\pm0.02$
Phytic acid (%)	$0.14^{a}\pm 0.02$	$0.17^{b}\pm 0.01$	$0.14^{a}\pm 0.02$	$0.12^{c}\pm0.01$
Tannic acid (%)	$0.065^{a}\pm 0.00$	$0.067^{b}\pm 0.02$	$0.062^{a}\pm0.001$	$0.048^{c}\pm0.002$
HCN (Kg/Kg)	ND	0.19 ± 0.01	ND	ND
Phytochemical (%)				
Alkaloid	$0.22^{a}\pm 0.02$	$0.28^{b}\pm 0.00$	$0.24^{a}\pm 0.02$	$2.16^{c}\pm0.00$
Flavonoid	$0.28^{a}\pm 0.02$	$0.35^{b}\pm 0.01$	$0.28^{a}\pm 0.01$	$0.17^{c}\pm0.02$
Saponin	$0.43^{a} \pm 0.01$	$0.53^{b} \pm 0.01$	$0.43^{a} \pm 0.02$	$0.39^{c} \pm 0.02$
Viscosity (cP)				
Viscosity	$84.72^{a} \pm 0.01$	$85.77^{b}\pm 0.02$	$84.74^{a}\pm 0.02$	$84.21^{c} \pm 0.02$

Values are means of triplicate determinations ± 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.

The residual phytochemicals (alkaloid, flavonoid and saponin) were very low ranging from 0.16-0.28% (alkaloid) 0.17-0.35% (flavonoid) and 0.39-0.53% (saponin) respectively. The least and highest values were observed in samples FNBM and FNBU respectively. Samples FNBP and FNBN had comparable values. Non-sprouting and non-dehulling of the ricebean in sample FNBU may have contributed to the slight high values. Alkaloids and saponins may induce allergies in infants while flavonoids may be prooxidant when ingested in high amount.

The viscosity of 5% (w/v) gruel made from the formulated diets ranged from 84.21-85.77cP. Diets formulated with sprouted ricebean had lower ($P<0.05$) viscosities than that formulated with unsprouted ricebean (85.77cP) due probably to the thinning effect of amylases activated during sprouting (Nkama et al., 2001). Viscosity decrease implies nutrient density increase. According to Ariahu et al. (1999), low viscosity and high nutrient content are desirable characteristics of complementary foods. Drapper (1994) reported that low energy density is one of the factors implicated in infant and young children malnutrition and Nout et al. (1988) said that low energy density is usually associated with complementary foods formulated from unmodified starch staples. Sprouting and boiling of the ricebean and precooking of the ricebean and precooking of the fonio evidently modified the rheological properties of these raw materials and is reflected in the product.

5.0. Conclusion

The results obtained from the study showed that the diets formulated have low bulk density, high nutrient density and the nutrients are bioavailable suggesting high-quality complementary foods.

6.0. Recommendation

Based on the results, it is recommended that the expensive commercial complementary foods be substituted with fonio/ ricebean based complementary food especially in the poor resource settings.

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