



Chemical Composition of Fonio (*Digitaria-Exilis*)/Ricebean (*Vigna Umbellata*) Based Complementary Food Fortified With Carrot and Crayfish

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Abstract

This study evaluated the proximate composition and micronutrient (vitamins and minerals) contents of fonio/ricebean based complementary food fortified with carrot and crayfish. Sprouted (72 h) and dehulled ricebean (*Vigna umbellata*) dhals and parboiled dried fonio (*Digitaria exilis*) (70:30) composite were fortified with 30% crayfish and 30% dried carrot (FNBN). A similar blend with additional 20% milk (FNBP). A third blend containing unsprouted and unde-hulled ricebean (FNBU) and a fourth containing only treated fonio and ricebean (FNBM) were formulated. The diets were analyzed for proximate composition and micro-nutrients using standard analytical methods. The diets had high crude protein and calorific contents: 13.80-21.70% protein and 401.56 kCal/g-415.91 kCal/g energy. The levels of iron (6.77-8.30 mg/100g) and zinc (4.32-4.85 mg/100g) in the diets were low. Raw materials and dehulling accounted for this. Plant foods are poor source of iron and zinc and dehulling removes those in the seed coats. Soaking and milling contributed to the low levels of B vitamins in the formulations: (thiamin (0.054-0.085 mg/100mg), riboflavin (0.043-0.060 mg/100g) and niacin (0.16-0.28 mg/100g)) due to leaching and thermal destruction. Further vitamin and mineral premix fortification is recommended.

Key words: Complementary food, fonio, ricebean, calorific value.

1.0 Introduction

Childhood under nutrition is a major health problem especially in resource poor communities. According to UNICEF (2000), approximately one third of children under five years of age in developing countries are stunted (low height for age) and large proportion are deficient in one or more micronutrients (vitamins and minerals). Martins (2004) reported that adult who were malnourished in early childhood have impaired intellectual performance and reduced capacity of physical work. Also, the reproductive capacity of women who were malnourished as children is affected, their infants may have low birth weight and they have complications in their deliveries (Martins, 2004).

Deficiency in energy or any of the essential nutrient can have dire consequences some of which are long lasting. Vitamins and minerals are vital to healthy development, disease prevention and wellbeing. According to Kreamer et al. (2015), micro nutrients except vitamin D are not produced in the body and must be derived from the diet. United Nations International Children's Emergency Fund (UNICEF) (2019) stated that even though micronutrients are needed in small amounts, it is important to consume the recommended amounts. According to Adu-Afarwuah et al. (2008), micronutrient deficiencies known as hidden hunger are common in infants and UNICEF (2019) reported that half of under five children worldwide suffer from hidden hunger while Vinodini (2003) noted that iron and zinc are the critical micronutrient in infant food needed for the prevention of long-term adverse effects of deficiency. But unfortunately, these minerals are low in plant foods. The more prevalent nutrient deficiencies among infants and preschoolers reported Yeung

(2000) are iron, vitamin A, iodine, protein, energy, riboflavin, calcium and vitamin D. Prolonged deficiency of essential vitamins and minerals can cause permanent damage to a child's growth (Micronutrient Initiative (2013). Food and Agricultural Organization/World Health Organization (FAO/WHO) (1992) reported that millions of children suffer from iron, iodine and vitamin A deficiencies. These problems are remarkably higher according to Yip (1989) in developing countries though infants in industrialized countries are not spared. Iron deficiency cuts across all borders and approximately 15 % of infants consume insufficient amount of dietary iron in industrialized countries (Yip, 1989).

Breast milk is the ideal food for infants during the first six months of life. It can totally satisfy the infant's nutritional requirement. International Food Monitoring (IFM) (2008) noted that breast milk contains still undiscovered substances that cannot be reproduced artificially and its overall nutrient composition is superior to any alternative including infant formula. After the first six months of life reported Asinobi (2007), infant's need for nutrient and calories exceeds that provided by breast milk hence complementary feeding becomes necessary to bridge this gap. Complementary foods are consumed for a relatively short period and they constitute a large proportion of the baby's diet and significant amount of nutrient that are necessary for growth and development. Therefore, they need to be nutritionally adequate, safe and appropriately fed in order to meet the young child's calories and nutrient need.

The causes of nutrient deficiencies in children are many but the principal one especially in the resource poor communities is lack of affordable nutrient dense complementary foods. Complementary foods are prepared traditionally with local staples such as maize, sorghum, millet, rice and tapioca among others. The starchy nature of these foods made them bind so much water when being prepared to yield gruel of fluid consistency that is suitable for the delicate mouth structures of infants. This dilution increase 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 nutrient that could have been derived from the gruel. On the other hand, if the solid in the gruel is increased to improve the nutrient content, the gruel may be too thick (viscous) and cause choking to the child.

Cereal proteins have low biological value (BV) because they are limited in some essential amino acids such as lysine the growth amino acid and tryptophan. Also, the digestibility of cereal protein is lower than that of animal protein apart from other antinutritional factors such as trypsin inhibitor, phytic acid, haemagglutinins and cyanogenic glucosides. Finally, the bulky and low energy/low nutrient density nature of native or unmodified cereal foods make them unsuitable for feeding of infants. These problems can lead to protein - energy malnutrition (PEM)(Ijeomah,2015).

Though there are commercial fortified complementary foods that can address under nutrition in infants and preschoolers, they are very expensive. Consequently, nursing mothers' resort to traditional complementary foods. Meanwhile there are many indigenous unexploited cereals and legumes which can be processed, adequately complemented with commonly available micro-nutrient rich foods that can be used to alleviate protein-energy malnutrition and hidden hunger thus improve infant nutrition.

The aim of this study is to evaluate the proximate composition and vitamin and mineral contents of a complementary food produced from fonio and ricebean fortified with carrot and crayfish with a view of ascertaining the possibility of using it to ameliorating protein, energy and micronutrient deficiencies in infants and pre-schoolers

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 Formulation of Samples

Samples were formulated to contain 70 g fonio, 30 g sprouted ricebean, 30 g carrot and 30 g crayfish, milk, sucrose, vegetable oil and salt were added at 20 g, 5g, 5 ml and 1 g level

respectively (FIRRO, 2008). Prepared fonio, malted ricebean dhals, dried carrot slices, crayfish, sugar and salt were mixed together and milled. The resultant flour was sieved using 2 mm sieve, blended with vegetable oil, dried in an oven at 35 °C for 10 min, cooled, packaged in a cellophane and vacuum sealed.

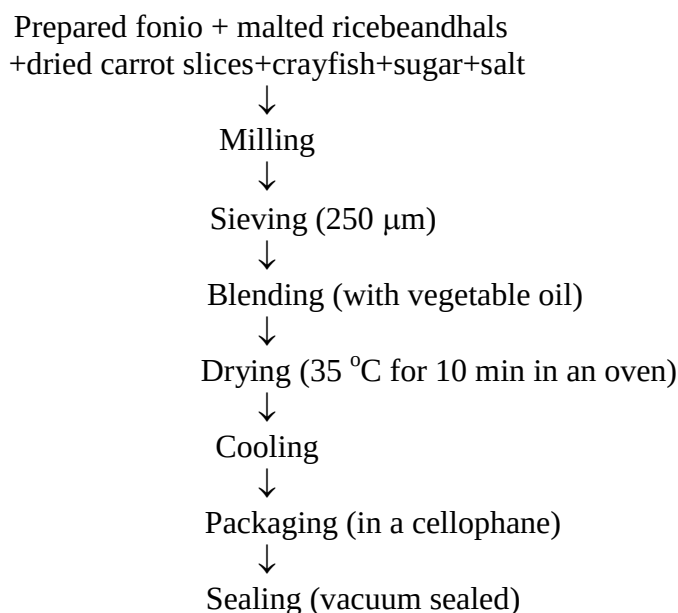


Fig 1. Flow chart for the production of fonio and ricebean based complementary food fortified with carrot and crayfish.

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

2.3. Analysis

2.3.1. The proximate composition was determined by AOAC (2010) standard method.

2.3.2. Determination of vitamins

Thiamine and riboflavin contents were determined using scalar analyzer method of AOAC (2000), niacin was determined using the method of AOAC (2000), the method of the Association of Vitamin Chemists (Kirk and Sawyer, 1998) was employed for the determination of vitamin A and E and vitamin C was determined using the titrimetric method of AOAC (2000).

2.3.3. Determination of minerals

The method described by Onwuka (2000) was used. The sample were ashed and digested. The digest, were used for mineral element determination. Calcium and Magnesium were determined by the titrimetric method of kirk and Sawyer (1998), Vanado-Molybdate colorimetric method of kirk and Sawyer (1998) was employed for phosphorous determination, flame photometry was used to determine the sodium content (AOAC, 2000) while atomic absorption spectrophotometric method (James, 1996) was used for iron and zinc determination. Iodine was determined using thiosulphate titrimetric method (Pearson 1976).

3.0. Statistical analysis.

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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 test and significance was accepted at 5 % probability level ($p < 0.05$). Results were expressed as mean $\pm$ standard deviation (SD) of triplicate determinations.

4.0 Results and Discussion.

The results of the proximate, vitamins and minerals of the various formulated diets are recorded on table 2. There were significant differences ($p < 0.05$) in protein among the various formulated diets. The crude protein content ranged from 13.80 % in unfortified diet (FNBM) to 21.70 % in the diet containing milk (FNBP). These values except 13.80 % which is comparable are higher than 14 g of protein recommended by International Food Monitoring (IFM, 2008). The values were also higher than 3-11 g and 10-15 g recommended by Lutter and Dewey (2003) per 100g fortified complementary food and FAO/WHO (1994) for commercial weaning food respectively. The observed protein value differed significantly from the value (8.70-10.50 g) reported by Onweluzo and Nwabugwu (2009) reported for pigeon pea millet weaning food. The fat content of the formulations ranged from 5.60 g in FNBM to 10.07 g in FNBP. The values obtained except for FNBM were higher than the value 6.3 g recommended by Lutter and Dewey (2003) for fortified complementary food but lower than (8.40-11.07 g) reported by Onweluzo and Nwabugwu (2009) for pigeon pea and millet, cerelac and casein.

Table 2: Proximate, Vitamin and Mineral contents of the formulated diets.

Parameters	FNBN	FNBP	FNBM	FNBU
Proximate	19.48 ^b ±0.00	21.70 ^a ±0.01	13.80 ^d ±0.02	18.13 ^c ±0.02
Composition (%)	7.14 ^b ±0.02	10.07 ^a ±0.00	5.60 ^c ±0.01	7.12 ^b ±0.02
Crude Protein				
Fat	4.56 ^a ±0.00	4.58 ^a ±0.02	1.74 ^b ±0.01	4.59 ^a ±0.02
Ash				
Crude Fibre	0.34 ^b ±0.00	0.35 ^b ±0.01	0.32 ^c ±0.02	0.49 ^a ±0.01
Moisture	3.24 ^c ±0.01	3.70 ^c ±0.01	3.70 ^a ±0.03	3.45 ^b ±0.03
Carbohydrate	65.24 ^c ±0.03	59.60 ^d ±0.01	74.84 ^a ±0.01	66.22 ^b ±0.02
Energy kcal/g	403.14 ^c ±0.01	415.91 ^a ±0.01	404.00 ^b ±0.96	401.56 ^c ±0.01
Vitamin content of mg/100g				
Thiamin	0.082 ^b ±0.001	0.085 ^a ±0.002	0.054 ^d ±0.000	0.074 ^c ±0.002
Riboflavin	0.53 ^b ±0.002	0.060 ^a ±0.001	0.043 ^d ±0.0001	0.049 ^c ±0.001
Niacin	0.18 ^c ±0.02	0.28 ^a ±0.02	0.16 ^d ±0.01	0.21 ^b ±0.001
Vitamin A	214.3 ^c ±0.02	226.1 ^b ±0.00	97.8 ^d ±0.002	246.4 ^a ±0.002
Vitamin E	5.63 ^b ±0.02	5.94 ^a ±0.04	4.28 ^c ±0.02	5.63 ^b ±0.03
Vitamin C	8.62 ^b ±0.01	9.47 ^a ±0.02	7.37 ^d ±0.00	7.62 ^c ±0.02
Carotene (µg/g)	45.6 ^c ±0.02	87.4 ^a ±0.02	14.4 ^d ±0.02	46.2 ^b ±0.03
Mineral content mg/100g				
Calcium	396.47 ^c ±0.03	413.8 ^a ±0.02	294.48 ^d ±0.02	412.32 ^b ±0.02
Iron	8.08 ^b ±0.02	8.16 ^b ±0.02	6.77 ^c ±0.01	8.30 ^a ±0.01
Zinc	4.75 ^b ±0.02	4.74 ^b ±0.01	4.32 ^c ±0.02	4.85 ^a ±0.01
Iodine	56.31 ^c ±0.01	60.14 ^b ±0.01	216.78 ^d ±0.02	60.28 ^a ±0.02
Magnesium	329.41 ^c ±0.01	338.74 ^b ±0.02	128.76 ^d ±0.02	345.38 ^a ±0.02
Phosphorus	228.75 ^c ±0.02	234.8 ^b ±0.01	128.76 ^d ±0.02	236.61 ^a ±0.01
Sodium	156.85 ^c ±0.01	159.77 ^b ±0.02	58.31 ^d ±0.01	160.44 ^a ±0.02

Values are means of triplicate determination $\pm$ standard deviation (SD). Means with different superscripts on the same row is 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 unsprouted fonio and undehulled ricebean, carrot and crayfish.

There was little variation among the crude fibre content of the samples. The values were very low ranging from 0.32 % in the sample without fortificants (FNBM) and highest in the sample containing undehulled ricebean (FNBU) which can be attributed to the use of undehulled ricebean. The formulated diet had low moisture content which ranged from 3.24-3.70 %. These samples showed higher moisture value than (1.50%) reported by Onweluzo and Nwabugwu (2009) for weaning food formulated with pigeon pea and millet. The calorific values of the formulated diets ranged from 401.5 kcal/g for the untreated diet (FNBU) and 415.91 Kcal/g in the diet that contained milk (FNBP). These energy values were higher than the recommended value (400 kcal/g per 100g) fortified complementary food (Lutter and Dewey, 2003) but lower than (428.25 kcal/g) recorded by Onweluzo and Nwabugwu (2009) for sprouted pigeon pea and sprouted millet formulation.

The B vitamin (thiamin, riboflavin and niacin) contents of the formulated diets were very low ranging from 0.05 mg/100g to 0.3 mg/100g, 0.04 mg/100g to 0.07 mg/100g and 0.16 mg/100g to 0.32 mg/100g respectively. Vitamin A occurred at highest concentration among all the vitamins analyzed ranging from 97.8 mg/100g in FNBM to 246.4 mg/100g in FNBU. The high vitamin A in FNBU may be attributed to the non-dehulling of the ricebean since ricebean coats are rich in vitamin A (Ene-obong and Obizoba, 1996), crayfish and carrot which are rich sources of vitamin A. Vitamin C was the second predominant vitamin observed in the diets. Vitamin C was highest (9.47 mg/100g) in FNBP and lowest (7.37 mg/100g) in FNBM. There were slight variations in the value of vitamin C among the formulations due probably to the variation in the ingredients used in the formulation.

Carotene was predominant in the formulated diets with values that ranged from 41.4 µg/g to 87.4 µg/g. Despite the effect of heat, light and possible oxidation that might have occurred during processing, the level of carotene was high probably because of the inclusion of carrot and crayfish in the formulations. The presence of milk in sample FNBP might also have appreciably improved the carotene content of the sample.

The heat labile vitamins have been influenced by drying and milling. The B vitamins which are soluble in water and prone to leaching and thermal destruction might have been depleted during processing. Grosvenor and Smolin (2002) noted that thiamin is destroyed during cooking and storage because it is sensitive to heat, oxygen and low acid conditions while riboflavin is usually destroyed under alkaline conditions, light and excessive heat. Vitamin C is also sensitive to heat and light. Ene-Obong and Obizoba (1996) reported that vitamins in legumes are located in the seed coats so when the seed is dehulled, they are lost. Milling is also known to destroy the B vitamins and oxidize the fat-soluble vitamins except vitamin A. However, the level of these vitamins in complementary foods can be augmented by fortification with vitamin mix.

The observed high levels of minerals in the formulated diets may be attributed to the incorporation of crayfish in the diet since crayfish is a rich source of minerals. The minerals inherent in the seed coat of ricebean may have contributed to the level of minerals in the diet that contained unsprouted and undehulled ricebean (FNBU).

Calcium was the most predominate mineral in the diet. The range was 412.32 mg/100g to 413.8 mg/100g. These values were higher than the recommended level (400 mg/100g) for fortified complementary food (Lutter and Dewey, 2003). The calcium value observed in the sample were very much higher than that reported by Onweluzo and Nwabugwu (2009) for pigeon pea millet based weaning food (1.03 mg/100g to 6.63 mg/100g). The sample that contained untreated ricebean (FNBU) contained higher level of iron (8.30 mg/100g), Zinc (4.85 mg/100g) and iodine (60.28 mg/100g) than other formulated diets due probably to the contribution of these minerals from the hulls. Ene-Obong and Obizoba (1996) noted that the seed coat of ricebean and other legumes are rich in minerals. The level of iron and zinc observed in these samples were lower ($p < 0.05$) than the level (14 mg for iron and 8.3 mg for zinc per 100g) recommended for fortified complementary food (Lutter and Dewey, 2003) and differed significantly ($p < 0.05$) from the value (39.47 mg/100g to 46.30 mg/100g) for iron and 4.68 mg/100g to 7.66 mg/100g) for zinc reported by Onweluzo and Nwabugwu (2009) for pigeon pea millet based weaning food. The second predominant mineral in the

formulation was magnesium. It occurred in the range of 216.78 mg/100g in the unfortified diet (FNBM) to 345.38 mg/100g in the diet containing untreated ricebean (FNBU). However, all the formulations contain much higher level of magnesium than the level (80 mg to 120 mg) recommended per 100g of fortified complementary food (Lutter and Dewey, 2003). Significant differences ($p < 0.05$) were observed in the phosphorus contents of the formulated diets. The value ranged from 216.78 mg/100g to 345.38 mg/100g and higher than the recommended (150 mg to 200 mg/100g) for fortified complementary food (Lutter and Dewey, 2003).

5.0. Conclusion

This study has shown that the complementary food formulated with fonio and ricebean and fortified with carrot and crayfish had high amount of protein, energy and vitamin A. Therefore, can be used to ameliorate protein- energy malnutrition and vitamin A deficiency in infants and pre-school children. It was also observed that the formulated diets were low in B vitamins, E and C and minerals (iron and zinc) lower than the recommended values for fortified complementary foods. Therefore, it is recommended that complementary foods be fortified with vitamin and mineral (iron and zinc) premix. Generally, the formulated diets can favorably substitute the commercial complementary foods both in cost and nutrient dense.

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