Development and functional properties of complementary food produced from mixture of treated Fonio (*Digitaria exilis) and* sprouted Ricebean *(Vigna umbellata*) fortified with Carrot and Crayfish

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ABSTRACT

Sprouted (72h) ricebean, fonio, carrot and crayfish were used in the production of four complementary foods. Little information was available on the industrial potentials of the above foods. This study ascertains the functional properties of complementary foods produced with these foods. The formulated diets had low bulk density value (0.33g/ml-0.38g/ml), swelling index (1.16-1.94) and solubility (5.20%-6.24%). The gelatinization temperature of the diets ranged from 81.62^{o}C-85.50^{o}C while the particle size ranged from 80%-81%. The samples had good dispersibilities ranging from 70.24%-70.78%. Fonibean normal (FNBN) showed optimal water absorption capacity (WAC) (2.50glg), least gelation concentration (LGC) (14.0%) and viscosity (82.0cP) which compared with those of fonibean plus (FNBP) WAC (2.50glg), LGC (14.0%) and viscosity (84.74cP). The formulated diets had pH near neutrality (pH 6.12-6.25) and very low acidity values (0.68-0.76%). The values obtained for the functional properties of the formulated diets in this study suggest quality complementary food.

Keywords: *Complementary food; Functional properties; Fonio, Ricebean, Frisogold.*

INTRODUCTION

Nutrition in the early years of life is a major determinant of healthy growth and development during childhood and of good health in adulthood. Breast milk is the ideal food for infants during the first six months of life and can totally satisfy the infant's nutritional requirements. 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 food needs to be introduced to augment energy and nutrient intake. Yeung, (2000) defined complementary foods as transitional foods consumed between the time of exclusive breast milk or formula and the time of family foods. These foods are consumed for a relatively short period of four to six months to about twelve months of age. During this period, they constitute a large proportion of the baby's diet and contribute a significant amount of nutrients that are necessary for growth and development. Therefore, complementary foods must contain sufficient amounts of essential nutrients to complement breast milk. The World Health Organization (WHO) highlighted high viscosity as one of the characteristics of poor quality complementary foods that is a major course of malnutrition in children. In many parts of the world, staple foods are the basic raw material for complementary foods. In Nigeria, local staples such as cereals (maize, sorghum, millet, rice) and legumes (soy bean, pigeon pea, cowpea, African yam been) are used. Cereals are usually prepared into gruels and porridges suitable for children. According to Abiodun *et al.* (1999), to do this the food must be diluted with large quantity of water which results to more volume and low energy and nutrient density.

Complementary foods prepared traditionally with local staples such as maize, sorghum, millet, rice and tapioca among others bind so much water due to their starchy nature when being prepared to yield a gruel of fluid consistency suitable for the delicate mouth structures of infants. This limits the amount of nutrients derived from the gruel because the infant cannot consume large quantity at a sitting. On the other hand, if the nutrient content of the gruel is improved by increasing the solid content, the gruel may be too thick that the child can be chocked. The bulky and low energy/low nutrient density of native or unmodified cereal foods make them unsuitable for the feeding of infants.

The quality of cereal based complementary foods can be improved by complementation with legume, method of preparation such as malting, pressure cooking, cooking and fortification with micronutrients. Desikacher (1982) reported that the level of viscosity reduction of a complementary food depends on the extent of germination. Production of quality complementary foods with local staples in Nigeria has been minimal and successful production of quality complementary food with fonio, ricebean, carrot and crayfish will not only encourage improved cultivation of these crops but will also enhance the economic value of these crops. Therefore the aim of this work is to produce a low bulk/high nutrient dense complementary food with fonio and ricebean fortified with carrot and crayfish. The specific objective is to evaluate the functional properties of the formulated diets.

MATERIALS AND METHODS

Preparation of sample

One kilogram of fonio was cleaned, washed, soaked in hot water (100^{o}C) for 10min and allowed to boil for 15min and dried in on oven (Carbolite model 530 2RR, England) at 35^{o}C for 12h. Five hundred grams of ricebean was cleaned, washed, soaked overnight, sprouted for 72h, dehulled, boiled for 45min and dried in an oven at 35^{o}C for 10h. One kilogram of carrot was cleaned, washed, peeled, sliced (1mm thick), blanched in hot water (100^{o}C) for 10min and dried in an oven at 35^{o}C for 10h. Five hundred grams of crayfish was cleaned and dried in an oven at 35^{o}C for 10min.

Formulation of complementary food

Seventy grams of processed fonio, 30g of sprouted ricebean, 30g of dried carrot, 30g of cleaned crayfish, 5g of sucrose and 1g of salt were mixed, milled, sieved with muslin cloth, 5ml of vegetable oil added to the resultant flour and further dried in the oven at 35^{o}C for 10min. The formulation was designated fonibean normal (FNBN). A similar blend that contained 20g of powdered milk in addition designated fonibean plus (FNBP), a third blend that did not contain carrot and crayfish designated fonibean minus (FNBM) and a fourth that contained unsproutedricebean instead of sprouted ricebean designated fonibean untreated (FNBU) were formulated. A commercial rice based complementary food frisogold (FRSG) served as control.

Analyses

Bulk density and pH were determined using the methods of AOAC 2000. The water absorption capacity (WAC), swelling index (SI), gelation temperature (GT), least gelation concentration (LGC), viscosity, solubility and porridge acidity were determined using the methods described by James (1995). Dispersibiltiy and particle size were determined by the methods described by Kulkarni *et al.* (1991).

Statistical analysis of the results were done using SPSS version 17.0. Sample means were separated using Duncan's new multiple range test at 5% probability level.

RESULTS AND DISCUSSION

Functional properties of the formulated diets and the control are presented in Table 1. Bulk densities of the samples were low (0.33g/ml-0.39g/ml) with slight variations among the samples. The bulk density of the sample containing only fonio and sprouted ricebean (FNBM) differed significantly *($p<0.05$)* from that of the other samples but that of the sample containing sprouted (FNBN) and unsprouted (FNBU) ricebean did not differ significantly *($p>0.05$)*. Low bulk density food requires less water to form gruel hence consumption of more food and intake of more nutrients at a sitting. The water absorption capacities (WAC) of the samples were low ranging from 2.50g/g to 3.08g/g. Fonibean plus (FNBP) the diet containing milk and fonibean normal (FNBN) that containing sprouted ricebean had equal WAC (2.50g/g) values which did not differ from that of the commercial sample frisogold (FRSG)(2.40g/g). The WAC values of the samples were significantly higher *($p<0.05$)* than the range 1.20g/g-1.40g/g and 1.54g/g-1.83g/g reported by Kulkarni *et al.* (1991) for sorghum based weaning food and that reported by Onweluzo and Nwabugwu (2009) for pigeon pea millet based weaning foods respectively. Water absorption capacity (WAC) gives an indication of the amount of water the sample can absorb, retain and require when reconstituted to form gruel with suitable consistency when heat is applied. Low WAC is desirable to produce thin gruel that could be used for infants. All the formulated diets had good dispersibility values (70.24% - 70.78%) that did not differ significantly *($p>0.05$)* from that of the commercial sample (FRSG) (69.50%). Negligible variations occurred in the percent dispersibilities within the samples. The values were lower than the range of values (71% - 75%) reported by Kulkarni *et al.* (1991) for sorghum malt based weaning food. Dispersibility of food in water indicates reconstitutability, the higher the percent dispersibility, the better. Expectedly fonibean untreated (FNBU) which is the sample containing unsproutedricebean had the highest swelling index (SI) value of 1.94 among the formulated diets. The lowest SI (1.16) was observed in the unfortified (FNBM) diet. The SI of fonibean plus (FNBP) differed significantly *($p<0.05$)* with those of the other samples. Swelling index is an indication of quantity of water required for the food to form gel. Low swelling index is better for complementary food because less water is needed to form gruel of high nutrient density.

The solubility of the formulations was low ranging from 5.20% in the unfortified sample (FNBM) to 6.24% in the sample that contain milk (FNBP). The solubilities of samples (FNBP and FRSG) were comparable and significantly higher *($p<0.05$)* than those of the other formulations. The unfortified sample (FNBM) had the lowest solubility while the untreated sample (FNBU) and treated sample (FNBN) showed comparable solubilities. Solubility is the ability of a material to form a solution. Low solubility is required to ensure gruel of adequate consistency (Kulkarni et al., 1991). The gelatinization temperature (GT) of the formulated diets was high ranging from 81.62^{o}C – 85.50^{o}C. Sample FRSG had gelation temperature (GT) (83.16^{o}C) that differed significantly *($p<0.05$)* from that of the formulated diets. Samples FNBP and FNBN showed similar GT values of 82.38^{o}C which differed from those of other diets FNBU (85.50^{o}C) and FNBM (81.62^{o}C) and the commercial sample. Gelatinization temperature is the temperature at which gelatinization occurs. The observed GT of the diets suggests that the gruel can be formed by stirring in boiled water without necessarily subjecting the food to cooking. The particle size (80%-81%) of the formulated diets were higher than 78% reported by Kulkarni *et al.* (1991) for sorghum malt based weaning food. Particle size is an important feature of any granular mix that requires reconstitution with water. The smaller the particle size, the more surface area is made available for water absorption. A fine powder tends to form lump and takes more time and energy to disperse while large particle makes the dispersion gritty. Optimum particle size distribution is essential for the acceptability of complementary food. Samples FNBP, FNBN and FRSG had the same least gelation concentration (LGC) values (14.0%) that were higher than the LGC values of samples FNBU (12.0%) and FNBM (13.0%). The LGC values obtained for the formulated diets differ from those reported by Onweluzo and Nwabugwu (2009) for pigeon pea-millet based weaning food. The LGC is the concentration of the diet required for gel formulation. Diets that form gel at low concentrations are not ideal for weaning foods because they require a lot of dilution in an attempt to improve digestibility in relation to volume (Draper, 1994).

The viscosities of 5% (w/v) gruel made from the formulated diets were low ranging from 84.21cP in the unfortified sample (FNBM) to 85.77cP in the sample containing unsprouted ricebean (FNBU). There were slight variation among the viscosity values of the formulated diets and these values are higher *(p<0.05)* than that of the commercial sample (FRSG) (79.37cP). Fonibean plus (FNBP) (84.72cP) and fonibean normal (FNBN) (84.74cP) had comparable viscosity values. Decrease in viscosity is an indication of increase in nutrient density. Nkama *et al.* (2001) made similar observation. Ariahu *et al.* (1999) reported that low viscosity and high nutrient content are desirable characteristics of complementary food. Draper (1994) noted that one of the factors implicated in infant and young children malnutrition is low energy density. Low energy density is usually associated with complementary foods produced from unmodified starch staples (Nout *et al.*, 1988).

Table 1

Functional properties of samples

Parameter	FNBP	FNBU	FNBN	FNBM	FRSG
BD (g/ml)	$0.37^{a}\pm0.002$	$0.38^{a}\pm0.003$	$0.36^{b}\pm0.002$	$0.33^{c}\pm0.001$	$0.39^{d}\pm0.002$
WAC (g/g)	$2.50^{a}\pm0.00$	$3.08^{b}\pm0.01$	$2.50^{a}\pm0.01$	$2.80^{c}\pm0.01$	$2.40^{a}\pm0.02$
Dispersibility (%)	$70.78^{a}\pm0.02$	$70.56^{b}\pm0.01$	$70.75^{a}\pm0.01$	$70.24^{c}\pm0.02$	$69.50^{d}\pm0.01$
SI	$1.81^{a}\pm0.01$	$1.94^{b}\pm0.01$	$1.34^{c}\pm0.01$	$1.16^{d}\pm0.02$	$1.75^{e}\pm0.23$
Solubility (%)	$6.24^{a}\pm0.02$	$5.71^{b}\pm0.01$	$5.79^{b}\pm0.01$	$5.20^{c}\pm0.01$	$6.30^{a}\pm0.01$
GT (^{0}C)	$82.38^{a}\pm0.02$	$85.50^{b}\pm0.01$	$82.38^{a}\pm0.01$	$81.62^{c}\pm0.02$	$83.61^{d}\pm0.01$
PS (%)	$80.0^{a}\pm0.02$	$81.\ 0^{a}\pm0.01$	$80.0^{a}\pm0.01$	$80.0^{a}\pm0.02$	$80.0^{a}\pm0.01$
LGC (%)	$14.0^{a}\pm0.00$	$12.0^{b}\pm0.00$	$14.0^{a}\pm0.00$	$13.0^{c}\pm0.00$	$14.0^{a}\pm0.00$
Viscosity (cP)	$84.72^{a}\pm0.01$	$85.77^{b}\pm0.02$	$84.74^{a}\pm0.02$	$84.21^{c}\pm0.02$	$79.37^{d}\pm0.02$
pH	$6.12^{a}\pm0.02$	$6.20^{b}\pm0.02$	$6.18^{b}\pm0.02$	$6.25^{c}\pm0.02$	$6.32^{d}\pm0.02$
Acidity (%)	$0.\ 76^{a}\pm0.00$	$0.71^{b}\pm0.01$	$0.73^{b}\pm0.02$	$0.68^{c}\pm0.03$	$0.65^{d}\pm0.01$

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

BD =Bulky density, **WAC** = Water absorption capacity, **SI** =Swelling index, **GT**= Gelation temperature, **PS**= Particle size, **LGC**=Least gelation concentration. **FNBP** = Diet containing fonio, sprouted ricebean, crayfish, carrot and milk, **FNBU** = Diet containing fonio, unsprouted and undehulledricebean, crayfish and carrot, **FNBN** =Diet containing fonio, sprouted ricebean, crayfish and carrot, **FNBM** = Diet containing fonio and unsprouted ricebean only, **FRSG** = Commercial complementary food.

The pH values of the formulated diets were near neutrality (pH 7.0) with slight variations among the samples. The sample that contain milk (FNBP) had the lowest (pH 6.12) while the sample that contain only fonio and ricebean (FNBM) had the highest (pH 6.25) pH value and this 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). Samples containing sprouted (FNBN) and unsprouted (FNBU) ricebean had pH values that did not vary significantly. The pH values of the formulated diets were significantly lower ($p<0.05$) than that of the commercial sample (FRSG) (pH 6.32). The titratable acidity (TTA) values were very low showing slight variations among the samples. These values were higher than the TTA value of the commercial sample (FRSG) (0.65%). The TTA values (0.73%) of sample (FNBN) and (0.71%) of sample FNBU did not differ significantly ($p>0.05$). Sample FNBP had the highest (0.76%) while FNBM had the least (0.68%) TTA values. The near neutral pH and very low acidity value of the formulations suggest caution in the handling of the diets and feeding of the infants as these conditions may favor the growth of spoilage and pathogenic microorganisms.

CONCLUSION

It is evident from the study that a low bulk nutrient dense complementary food can be formulated by complementing unexploited cereal such as fonio and legume (ricebean). Such composite can serve as a potential source of much needed quality protein which can be used to check protein energy malnutrition in the rural communities in Nigeria. Treatments such as sprouting, dehulling and cooking modified the functional properties of the composite.

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