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Research Article

PROTEIN QUALITY AND SENSORY ATTRIBUTES OF FONIO (*DIGITARIA EXILIS*)/RICEBEAN (*VIGNA UMBELLATA*)-BASED COMPLEMENTARY FOOD INCORPORATED WITH CARROT AND CRAYFISH

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ABSTRACT

Objective: This work evaluated the protein quality and sensory attributes of four complementary foods produced from fonio and ricebean incorporated with carrot and crayfish.

Methods: The first sample fonibean normal (FNBN) was formulated by mixing 70 g fonio, 30 g sprouted ricebean, 30 g dried carrot, 30 g crayfish, 5 g sugar, and 1 g salt, milled, sieved with muslin cloth, and the resultant flour was mixed with 5 ml of vegetable oil. A similar blend fonibean plus (FNBP) contained an addition of 20 g powdered milk. A third blend fonibean minus (FNBM) contained fonio and sprouted ricebean only and no fortificants while the fourth blend fonibean untreated (FNBU) contained unsprouted ricebean instead of sprouted ricebean. The following methods were used to evaluate (a) protein – Kjeldahl method by Chang (2003) (b) Protein quality – bioassay as described by Onweluzo and Nwabugwu (2009) (c) Sensory evaluation – 9-point hedonic scale by Ihekoronye and Ngoddy (1985) (d) Statistical analysis – Statistical Package for Social Sciences version 17; Analysis of variance (ANOVA) was used to evaluate significant difference ($p<0.05$) while Duncan's new multiple range test was used to separate the means.

Results: The crude protein content of the formulated diets ranged from 13.80 to 21.70% which was higher ($p<0.05$) than (10-15%) the value recommended for complementary food. The protein efficiency ratio (PER) of all the formulated diets except the unfortified diet (FNBM) (1.49) was higher than (2.00) recommended for weaning food. The higher PER, BV, NPU, and digestibility values of samples FNBP, FNBU, and FNBN relative to FNBM suggest better quality sources. Though the ricebean used in sample FNBU was not sprouted, the sample showed a better quality protein than sample FNBM that contained sprouted ricebean. The fortified samples FNBN that contained sprouted ricebean and FNBU that contained unsprouted ricebean had comparable ($p>0.05$) sensory scores in appearance (7.90 and 7.87), taste (7.24 and 7.21), and flavor (7.86 and 7.82). Samples FNBP, FNBU, and FNBN had similar score (8.57) in consistency while samples FNBN and FNBP had significantly higher ($p<0.05$) score in overall acceptability than other samples.

Conclusion: The study shows that the formulated diets contained very high-quality protein that can be used to alleviate all forms of protein malnutrition, and the unfortified sample fonibean minus (FNBM) was least acceptable to the panelists.

Keywords: Complementary food, Fonio, Ricebean, Weanly rat, *Ad libitum*.

INTRODUCTION

Adequate nutrition is a cornerstone of child nutrition; therefore, foods rich in high-quality protein are essential for healthy growth and development throughout childhood even to adulthood. In the first 4 to 6 months of life, an infant's nutritional requirements can be totally satisfied by breast milk. However, after the first 6 months of life, infants cannot thrive only on the nutrients provided by breast milk, so high-quality protein complementary foods need to be introduced to augment protein, energy, and nutrient intake [1]. During this time, complementary foods make up a large proportion of the baby's diet and contribute a significant amount of the nutrients that are necessary for growth and development. Stunted growth or malnutrition or both can result if an infant does not receive adequate nutrients from its complementary foods. Approximately, one-third of children under 5 years of age in developing countries are stunted (low height for age). According to [2], protein is one of the more prevalent forms of nutrient deficiency among infants and preschoolchildren. Quality protein deficiency can cause growth stunting and kwashiorkor in children, especially in countries where complementary foods are based on tubers such as sweet potato or cassava. Quality protein is also needed in children for the formation of muscle tissues.

Complementary foods are prepared traditionally from local staple mainly cereals such as maize, sorghum, millet, and rice, among others. Proteins in most cereals are limiting in some essential amino acids such as lysine and tryptophan, making cereal protein low in biological value (BV). In addition, the digestibility of cereal protein is lower than that of animal protein partly due to inherent fiber and tannins that bind the proteins [3] besides the presence of other anti-nutritional factors such as trypsin inhibitor [4] among others. In Nigeria, efforts have been made to improve the protein quality of cereal-based infant foods by complementation of cereal protein with that of legume as in the case of soyogi [5]. This met some difficulties ranging from cost to unavailability, notwithstanding the enhanced protein quality. Meanwhile, there are many available and affordable indigenous unexploited cereals and legumes which if properly processed and complemented can be used to enhance the protein quality of complementary foods and thus improve infant nutrition, hence the choice of fonio and ricebean. The aim of this study was to formulate a high-quality protein complementary food from fonio and ricebean fortified with carrot and crayfish. The specific objective of this study was to evaluate the protein quality and sensory properties of the formulated diets.

MATERIALS AND METHODS

Material procurement

Fonio, ricebean, carrot, crayfish, sugar, salt, and vegetable oil were purchased from Ogbete main market, Enugu, Enugu State, Nigeria. Albino rats of 6 weeks old with the weight range of 42-46 g were purchased from the Department of Biological Sciences, Caritas University, Amorji Nike, Enugu, Enugu State, Nigeria. Palletized growers mash was purchased from Vital feed Industries Ltd., 9th Mile Corner, Enugu, Enugu State, Nigeria. Chemicals and reagents used were of analytical grade and purchased from credible scientific chemical dealers.

Preparation of raw materials

Five hundred grams of fonio was cleaned, washed, soaked in hot water (100°C) for 10 minutes, allowed to boil for 5 minutes, drained, and dried in an oven (Carbolite Model 530 2RR, England) at 35°C for 12 hr. Two hundred grams of ricebean was cleaned, washed, soaked in water at ambient temperature overnight, drained, sprouted for 72 hr, dehulled, boiled for 45 minutes, drained, and dried in an oven at 35°C for 10 hr. About 50 g of ricebean was cleaned, washed, boiled for 45 minutes, drained, and dried in an oven at 35°C for 10 hr. Five hundred grams of carrot was cleaned, washed, peeled, sliced (1 mm thick), blanched in hot water (100°C) for 10 minutes, and dried in an oven at 35°C for 10 hr. Two hundred grams of crayfish was cleaned, aspirated, and dried in the oven at 35°C for 1 minute.

Formulation of complementary foods

About 70 g of fonio, 30 g of ricebean, 30 g of carrot, 30 g of crayfish, 5 g of sugar, and 1 g of salt were mixed, milled, sieved, and 5 ml of vegetable oil was added. The formulation was designated fonibean normal (FNBN). A similar blend that contained an addition of 20 g powdered milk was designated fonibean plus (FNBP), a third blend that contained only fonio and sprouted ricebean with no fortificants was designated fonibean minus (FNBM), and a fourth that contained unsprouted ricebean instead of sprouted ricebean fonibean untreated (FNBU) was also formulated. A commercial rice-based complementary food frisogold (FRSG) served as control.

Determination of protein

The protein content of the formulated diets was determined by the Kjeldahl method described by [6].

Determination of protein quality using bioassay

The method described by Onweluzo and Nwabugwu [7] was used.

Determination of protein efficiency ratio (PER)

5 groups of 6 male weanly rats of albino strain with an average weight of 42-46 g were fed *ad libitum* with the test diets for 28 days, including the period of acclimatization. The average feed intake and body weight of the different groups were used to estimate the PER.

Determination of BV, net protein utilization (NPU), and digestibility

After the 28-day feeding experiment, a 7-day nitrogen balance study was conducted. Carmine red (0.2%) was used as a fecal marker at the beginning and end of the 7-day study. The feces of the individual rats per group were pooled together every day, dried at 85°C for 3 hr, weighed, ground into powder, and stored in a plastic bottle for fecal nitrogen (FN) determination. The urine was collected in sample bottles containing 0.1 N HCL to prevent loss of ammonia and stored in a refrigerator for urinary nitrogen (UN) determination. These were used to estimate BV, NPU, and digestibility.

Sensory evaluation

21 panelists made of nursing mothers were used. Attributes tested on a 9-point hedonic scale [8] included color, taste, flavor, consistency, mouth feel, and overall acceptability. Where 1 = dislike extremely and 9 = like extremely.

Statistical analysis

Data collected were analyzed using Statistical Package for Social Sciences version 17. Analysis of variance was used to evaluate significant differences ($p<0.05$). Duncan's new multiple range test was used to separate the means.

RESULTS AND DISCUSSIONS

Table 1 shows the result of the protein quality evaluation of the formulated diets. Rats fed unfortified diet (FNBM) had low ($p<0.05$) food intake (92.84 g) and weight gain (21.19 g) relative to the rats fed the other formulations fortified. According to [7], palatability among other factors influences food intake. Probably, FNBM was not palatable. Rats fed the diet that contained milk (FNBP) had the highest food intake (161.80 g) while rats fed diet containing unsprouted ricebean (FNBU) consumed less food (145.81 g) than those fed diet that contained sprouted ricebean. The weight gain of rats fed formulated diets were high FNBP (89.88g), FNBU(63.19g) and FNBN (70.45g) except for those fed the unfortified diet (FNBM) (21.19g). This implies that these diets promoted growth better than FNBM.

There were variations in the amounts of protein consumed by the different groups of rats. This is due to the differences in the protein contents of the samples. Rats fed the diet that contained milk (FNBP) consumed the highest amount of protein (35.11 g) while those fed unfortified diet consumed the least (14.22 g). Diets such as FNBU (2.39) and FNBN (2.41) had comparable PER values, indicating that they have comparable nutrient value.

The PER (2.56) of diet containing milk was higher ($p<0.05$) compared to the other formulated diets, suggesting superiority over the other diets. The PER values of the diets except the unfortified diet were significantly higher ($p<0.05$) than the 2.00 recommended for weaning food by [9]. The group of rats fed diet containing milk (FNBP) had higher nitrogen intake (1.23 g) and digested nitrogen (DN) (1.20 g) relative to the rats fed the other formulated diets. Rats fed unfortified diet (FNBM) had relatively high FN (0.12 g) loss. This indicates low nitrogen digestibility and utilization compared to those fed with fortified formulations which had low FN losses. Diet that contained milk (FNBP) had high DN (1.20 g) and low UN (1.10 g), BV (91.67%), NPU (89.43), and digestibility (97.56%). Diet FNBM had lower ($p<0.05$) retained nitrogen (0.13 g), BV (56.52%), NPU (37.14%), and digestibility (65.71%) than other formulated diets. The higher NPU for rats fed FNBP (89.43%), FNBU (83.12%), and FNBN (86.81%) suggests better protein sources than FNBM. The digestibility of the diets FNBP (97.56%), FNBU (97.41%), and FNBN (97.80%) did not differ significantly ($p>0.05$). The high digestibility of FNBM (65.71%) may be attributed to the sprouting of the ricebean because Salunkhe *et al*. [10] reported that sprouting decreases protein quantity but improves protein quality. The formulated diets have better protein quality than that reported by [7] for pigeon pea millet weaning foods.

The sensory scores of the formulated diets and control are presented in Table 2. All the samples including the control scored high in all the sensory attributes (appearance, taste, flavor, consistency, mouth feel, and overall acceptability) evaluated. Scores for appearance ranged from 6.62 to 8.29. Scores for the diet that contained unsprouted ricebean (FNBU) (7.87) and that contained sprouted ricebean (FNBN) (7.90) were comparable ($p>0.05$) and lower than that for the sample that contained milk (FNBP) (8.14). The commercial sample (FRSG) had the highest score (8.29) for color while the unfortified sample (FNBM) had the lowest (6.62). Sample FNBP (7.86) had comparable taste score with the control (FRSG) (7.81), the same as in the samples containing untreated ricebean (FNBU) (7.21) and that containing ricebean (FNBN) (7.24). Sample FNBM had the lowest score (6.00). Fonibean plus (FNBP) had higher score (8.43) for flavor relative to the other samples while the diet that was not fortified scored lowest (5.14). The flavor scores for samples FNBU (7.82) and FNBN (7.86) did not vary significantly ($p>0.05$), but the scores were lower than that of samples FNBP and FRSG (8.05). The consistency scores of fonibean plus (FNBP), fonibean untreated (FNBU), and fonibean normal (FNBN) were the same (8.57). Fonibean minus (FNBM) had the highest score (8.81). Differences were observed in the consistency scores obtained for fonibean minus and frisogold (FRSG). The control (FRSG) scored highest (8.24) in mouth feel while samples FNBP (8.00) and FNBN (7.90) were comparable.

Table 1: Protein quality of samples

Parameter	FNBP	FNBU	FNBN	FNBM	FRSG
FI (g)	161.80^{a}±0.01	145.81^{b}±0.02	150.09^{c}±0.02	92.84^{d}±0.04	170.54^{e}±0.03
BWG (g)	89.88^{a}±0.04	63.19^{b}±0.02	70.45^{c}±0.01	21.19^{d}±0.02	68.24^{e}±0.03
PC (g)	35.11^{a}±0.01	26.44^{b}±0.04	29.24^{c}±0.03	14.22^{d}±0.04	23.53^{e}±0.03
PER	2.56^{a}±0.03	2.39^{b}±0.03	2.41^{b}±0.02	1.49^{c}±0.01	2.90^{d}±0.03
NI (g)	1.23^{a}±0.02	0.77^{b}±0.03	0.91^{c}±0.04	0.35^{d}±0.01	0.52^{e}±0.01
FN (g)	0.03^{a}±0.04	0.02^{b}±0.03	0.02^{b}±0.04	0.12^{c}±0.03	0.03^{a}±0.03
DN (g)	1.20^{a}±0.04	0.75^{b}±0.03	0.89^{c}±0.01	0.23^{d}±0.03	0.49^{e}±0.04
UN (g)	0.10^{a}±0.03	0.11^{a}±0.04	0.10^{a}±0.03	0.10^{a}±0.02	0.10^{a}±0.02
RN (g)	1.10^{a}±0.02	0.64^{b}±0.01	0.79^{c}±0.03	0.13^{d}±0.04	0.39^{e}±0.02
BV (%)	91.67^{a}±0.20	85.33^{b}±0.40	88.76^{c}±0.35	56.52^{d}±0.10	79.59^{e}±0.10
NPU (%)	89.43^{a}±0.40	83.12^{b}±0.30	86.81^{c}±0.10	37.14^{d}±0.30	75.00^{e}±0.40
Digestibility (%)	97.56^{a}±0.06	97.41^{b}±0.06	97.80^{c}±0.06	65.71^{d}±0.01	94.23^{e}±0.06

Values are means of triplicate determination±standard deviation. Means with different superscripts on the same row are significantly different (p<0.05). FNBP: Diet containing fonio, sprouted ricebean, crayfish, carrot, and milk, FNBU: Diet containing fonio, unsprouted and undehulled ricebean, crayfish, and carrot, FNBN: Diet containing fonio, sprouted ricebean, crayfish, and carrot, FNBM: Diet containing fonio and unsprouted ricebean only, FRSG: Commercial complementary food, FI: Food intake, BWG: Body weight gain, PC: Protein consumed, PER: Protein efficiency ratio, NI: Nitrogen intake, FN: Fecal nitrogen, DN: Digested nitrogen, UN: Urinary nitrogen, RN: Retained nitrogen, BV: Biological value, NPU: Net protein utilization

Table 2: Sensory scores of samples

Parameter (%)	FNBP	FNBU	FNBN	FNBM	FRSG
Appearance	8.14^{a}±0.77	7.87^{b}±0.80	7.90^{b}±0.79	6.62^{c}±0.72	8.29^{d}±0.64
Taste	7.81^{a}±0.98	7.21^{b}±0.83	7.24^{b}±0.54	5.00^{c}±0.77	7.86^{a}±0.79
Flavor	8.43^{a}±0.68	7.82^{b}±0.93	7.86^{b}±0.57	5.14^{c}±0.79	8.05^{d}±0.67
Consistency	8.57^{a}±0.51	8.57^{a}±0.60	8.57^{a}±0.50	8.81^{b}±0.68	8.71^{c}±0.46
Mouth feel	8.00^{a}±0.71	6.48^{b}±0.51	7.90^{a}±0.77	7.48^{c}±0.51	8.24^{d}±0.84
Overall acceptability	8.52^{a}±0.51	7.00^{b}±0.77	8.33^{c}±0.58	5.62^{d}±0.67	8.67^{e}±0.48

Values are means of 21 responses±standard deviation. Means with different superscripts on the same row are significantly different (p<0.05). FNBP: Diet containing fonio, sprouted ricebean, crayfish, carrot, and milk, FNBU: Diet containing fonio, unsprouted and undehulled ricebean, crayfish, and carrot, FNBN: Diet containing fonio, sprouted ricebean, crayfish, and carrot, FNBM: Diet containing fonio and sprouted ricebean only, FRSG: Commercial complementary food

Sample FNBU scored lowest (6.48). The overall acceptability scores of the samples ranged from 6.62 for the unfortified diet (FNBM) to 8.67 for commercial sample (FRSG). Significant differences (p<0.05) existed in the overall acceptability scores of samples FNBP, FNBN, and FRSG. Sample FNBM had the least score (5.62) among the samples. Diet containing milk (FNBP) scored very high in all the attributes. This may be attributed to the milk used in the formulation. Diet that contained sprouted ricebean (FNBN) scored high in all the attributes and this may be due to the treatment (sprouting and dehulling) given to the ricebean and incorporation of crayfish and carrot in the formulation. The diet that contained untreated ricebean (FNBU) scored equally high except for the month feel and this may be as a result of the fortificants (crayfish and carrot) in the diet. The low scores for the sample that contained only fonio and sprouted ricebean (FNBM) in all the attributes except month feel and consistency may probably be due to non-inclusion of crayfish and carrot in the diet. Sprouting and dehulling may have accounted for these high scores.

CONCLUSION

The protein in the formulated diets was of very high quality; therefore, the diets may be used to alleviate malnutrition such as protein deficiency and stunted growth in infants and preschoolers. The study showed that all the formulated diets except the unfortified diet (FNBM) were acceptable to the panelists.

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