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ORIGINAL RESEARCH ARTICLE

CHEMICAL COMPOSITION OF MILLET-BASED INFANT FORMULA SUPPLEMENTED WITH TREATED BAMBARANUT FLOUR.

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ABSTRACT
Fermentation and sprouting have been shown to increase nutrient bioavailability and modify the functional properties of foods. Application of these methods in the preparation of infant foods and complementing cereals with legumes will address nutrient density and viscosity problems associated with infant foods. Infant foods were formulated from blends of treated bambaranut and pearl millet and chemical composition of the samples were studied. Millet and bambaranut were soaked separately in water and allowed to ferment for 48 hr at room temperature. While for sprouting, millet and bambaranut were soaked for 12 and 24 hr, respectively, at room temperature, and soaked seeds were separately sprouted for 48 hr. After fermentation and sprouting, the seeds were oven-dried and then milled into a flour of 0.6 mm size. The flours were formulated to six (A, B, C, D, E, and F) complementary diets. The results show that blending treated bambaranut with pearl millet significantly increased the protein, fibre, fat and ash content from 14.46, 0.68, 6.21 and 3.32% to 19.35, 1.21, 8.01 and 5.35% respectively; while, the moisture and carbohydrate contents were significantly reduced. In the same vein, blending treated bambaranut with pearl millet significantly increased all the amino acids composition of the blends. However, blending treated bambaranut with pearl millet increased the trypsin, hydrogen cyanide, oxalate and phytate contents; though, the values fall within the safe consumption limit. Hence, this study revealed that, blending treated bambaranut with pearl millet is beneficial in increasing the nutrient density of infant food.

1. Introduction

Infant formula or complementary foods are foods other than breast milk usually in liquid, semisolid or solid form introduced to infants to provide appropriate nutrients. In Nigeria and most especially West African countries, the common first weaning food is pap, locally called *akamu* in the south-east Nigeria, *ogi* in the south-west Nigeria or *koko* in northern Nigeria. It is made from cereals such as maize, millet or sorghum. These traditional weaning foods are starchy and characterized to be low in nutritive value (low protein and low energy density), high bulk density and high viscosity.

Traditional food processing methods such as sprouting and fermentation have been reported to increase bioavailability of nutrients, predigest macro molecules, reduce antinutrients and reduce gruel viscosity (James *et al.*, 2018). In essence, these processes make the foods simpler to digest and the nutrients easier to assimilate. Since heat is not required in the two processes, there is considerable retention of enzymes, vitamins and other nutrients that are usually destroyed by high temperature processing. Therefore, there is the need to augment the protein content with cheap and local protein source (bambaranut) and to assess the positive benefits of sprouting and fermentation on the chemical quality of the infant formula.

2. Materials and Methods

2.1 Sources of raw material

Bambara nut and pearl millet were purchased from Kure Ultra-Modern Market, Niger State, Nigeria.

2.2 Material preparation

2.2.1 Fermentation of pearl millet and bambaranut

Bambara nut and millet were fermented as described by James *et al*. (2018) with slight modification. The two raw materials were cleaned manually, washed in clean water after which they were soaked separately in cold water in a ratio of 1:3 weight by volume (w/v) and allowed to ferment for 48 hr at room temperature (28 ± 2°C). Fermented millet and bambara nut were thoroughly washed in clean water and oven-dried separately at 60°C for 12 and 24 hr, respectively, and then hammer milled into a fine flour of 0.6 mm size. The flours were packaged differently in coded high-density polythene bags for further analysis.

2.2.2 Preparation of sprouted pearl millet and bambaranut

Methods described by Okafor *et al*. (2014) and James *et al*. (2018) were used to sprout millet and bambara nut with slight modifications. Millet and bambara nut were sorted, washed, and soaked in clean water for 12 and 24 hr, respectively, at room temperature (28 ± 2°C) with change in soaking water at 4 hr interval to prevent fermentation. Soaked seeds were separately spread on jute bag and covered with the same and allowed to sprout for 48 hr with sprinkling of water at 3 hr intervals. After sprouting period, the seeds were evenly spread on oven trays and dried at 60°C for 12 and 20 hr, respectively, and then hammer milled into a flour of 0.6 mm size and packaged differently in high-density polyethylene for further analysis.

2.3 Product formulation

The samples for this study were formulated, thus 100% sprouted millet flour, 100% fermented millet flour, 95% sprouted millet flour and 5% sprouted bambara nut flour, 95% fermented millet flour and 5% fermented bambara nut flour, 95% sprouted millet flour and 5% fermented bambara nut flour, and 95% fermented millet flour and 5% sprouted bambara nut flour, representing samples A, B, C, D, E, and F, respectively.

Amino acid profile, antinutrients and proximate composition were determined using standard methods.

3. Results and Discussion

The results of this study show that samples A (100% spouted millet) and B (100% fermented millet) had significantly high moisture contents, 9.93 and 9.91%, respectively; while, different blends showed significantly low moisture content. Blending treated bambaranut flour with millet significantly increased the protein content from 14.46% to 19.35%. Sample F (95% fermented millet and 5% sprouted bambaranut flour) had significantly ($p<0.05$) high fibre (1.21%), fat (8.01%) and ash

(5.35%) contents; while, sample A (100% sprouted millet) had the lowest values: 0.68%, 6.21% and 3.32% respectively. This implies that blending treated millet and bambaranut flours at different ratios used in this study enhanced the fibre, fat and ash contents. Samples A (100% spouted millet) and B (100% fermented millet) had significantly high carbohydrate contents, 65.43 and 63.58% respectively. However, blending significantly reduced the carbohydrate content with sample F (53.29%) having the lowest value. Samples E (95% sprouted millet and 5% fermented bambara nut) and F (95% fermented millet and 5% sprouted bambara nut) had significantly ($p<0.05$) high histidine, isoleucine, leucine, lysine, methionine, phenyl alanine, threonine, tryptophan and valine. This implies, blending and treatment significantly increased the amino acid contents of samples. However, samples A and B showed significantly low values. In antinutrients, samples A (100% sprouted millet) and B (100% fermented millet) had significantly ($p<0.05$) low trypsin, hydrogen cyanide, oxalate and phytate contents; while, samples E and F showed significantly high values. This implies that addition of treated bambaranut flour to millet increased the antinutrients content of blended samples. In tannin content, samples A and B had significantly ($p<0.05$) high values 0.74 and 0.71% respectively; while blended samples showed significantly low values.

4. Conclusion

Sprouting, fermentation and blending ratios used in this study significantly increased the nutritional quality of the formula and these would improve digestibility and bioavailability of nutrients. Inclusion of treated bambaranut flour in the blend increased a number of antinutrients content, however, the values fall within the tolerable limits by humans.

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Table 1. Chemical composition of the formulated infant formula

Parameter (%)	A	B	C	D	E	F
Moisture	$9.93^{a} \pm 0.01$	$9.91^{a} \pm 0.01$	$9.86^{b} \pm 0.01$	$9.80^{c} \pm 0.00$	$9.79^{c} \pm 0.01$	$9.78^{c} \pm 0.01$
Protein	$14.46^{f} \pm 0.01$	$15.12^{e} \pm 0.00$	$16.44^{d} \pm 0.00$	$17.20^{c} \pm 0.00$	$18.42^{b} \pm 0.00$	$19.35^{a} \pm 0.01$
Fibre	$0.68^{f} \pm 0.01$	$0.75^{e} \pm 0.01$	$0.84^{d} \pm 0.01$	$0.94^{c} \pm 0.00$	$1.00^{b} \pm 0.00$	$1.21^{a} \pm 0.00$
Fat	$6.21^{f} \pm 0.00$	$7.11^{e} \pm 0.00$	$7.45^{d} \pm 0.00$	$7.81^{c} \pm 0.01$	$7.91^{b} \pm 0.01$	$8.01^{a} \pm 0.01$
Ash	$3.32^{f} \pm 0.06$	$3.51^{e} \pm 0.01$	$3.86^{d} \pm 0.00$	$4.22^{c} \pm 0.00$	$5.04^{b} \pm 0.01$	$5.35^{a} \pm 0.01$
Carbohydrate	$65.43^{a} \pm 0.05$	$63.58^{b} \pm 0.04$	$61.53^{c} \pm 0.03$	$59.35^{d} \pm 0.01$	$57.84^{e} \pm 0.03$	$53.29^{f} \pm 0.04$
Histidine	$1.12^{f} \pm 0.00$	$1.63^{e} \pm 0.00$	$1.85^{d} \pm 0.00$	$1.89^{c} \pm 0.00$	$2.04^{b} \pm 0.00$	$2.11^{a} \pm 0.00$
Isoleucine	$1.76^{f} \pm 0.00$	1.81e ± 0.01	$2.06^{d} \pm 0.01$	$2.51^{c} \pm 0.00$	$2.77^{b} \pm 0.00$	$2.84^{a} \pm 0.01$
Leucine	$5.11^{e} \pm 0.01$	5.34d ± 0.00	$5.52^{cd} \pm 0.00$	$5.62^{bc} \pm 0.00$	$5.84^{a} \pm 0.00$	$5.74^{ab} \pm 0.14$
Lysine	$2.72^{f} \pm 0.00$	$2.94^{e} \pm 0.00$	$3.23^{d} \pm 0.01$	$3.46^{c} \pm 0.01$	$3.82^{b} \pm 0.00$	$3.94^{a} \pm 0.00$
Methionine	$1.24^{f} \pm 0.00$	$1.56^{e} \pm 0.00$	$1.81^{d} \pm 0.01$	$1.94^{c} \pm 0.01$	$1.98^{b} \pm 0.00$	$2.42^{a} \pm 0.00$
Phenyl alanine	$2.45^{f} \pm 0.05$	$2.51^{e} \pm 0.00$	$2.78^{d} \pm 0.00$	$2.83^{c} \pm 0.00$	$2.94^{b} \pm 0.01$	$3.01^{a} \pm 0.00$
Threonine	$1.84^{f} \pm 0.00$	$1.92^{e} \pm 0.00$	$2.28^{d} \pm 0.01$	$2.47^{c} \pm 0.00$	$2.61^{b} \pm 0.00$	$2.84^{a} \pm 0.00$
Tryptophan	$4.71^{f} \pm 0.00$	$4.87^{e} \pm 0.00$	$5.05^{d} \pm 0.01$	$5.33^{c} \pm 0.01$	$5.63^{b} \pm 0.01$	$5.74^{a} \pm 0.01$
Valine	$1.72^{f} \pm 0.00$	$1.94^{e} \pm 0.01$	$2.27^{d} \pm 0.01$	$2.64^{c} \pm 0.00$	$2.75^{b} \pm 0.00$	$2.84^{a} \pm 0.00$
Trypsin	$0.28^{f} \pm 0.00$	$0.33^{e} \pm 0.01$	$0.39^{d} \pm 0.01$	$0.52^{c} \pm 0.01$	$0.62^{b} \pm 0.01$	$0.73^{a} \pm 0.00$
Tannins	$0.74^{a} \pm 0.01$	$0.71^{a} \pm 0.00$	$0.66^{b} \pm 0.00$	$0.54^{d} \pm 0.01$	$0.50^{e} \pm 0.00$	$0.59^{c} \pm 0.01$
Hydrogen cyanide	$0.29^{f} \pm 0.01$	$0.36^{e} \pm 0.01$	$0.43^{d} \pm 0.01$	$0.56^{c} \pm 0.00$	$0.62^{b} \pm 0.01$	$0.74^{a} \pm 0.01$
Oxalate	$0.14^{f} \pm 0.00$	$0.22^{e} \pm 0.00$	$0.30^{d} \pm 0.00$	$0.38^{c} \pm 0.00$	$0.47^{b} \pm 0.00$	$0.53^{a} \pm 0.01$
Phytate	$0.97^{f} \pm 0.01$	$1.22^{e} \pm 0.01$	$1.88^{d} \pm 0.00$	$2.11^{c} \pm 0.00$	$2.74^{b} \pm 0.01$	$3.04^{a} \pm 0.00$

Mean ± *SD* of triple determinations. Values followed by different subscript on a row are significantly different from each other ($p < .05$). A = 100% sprouted millet; B = 100% fermented millet; C = 95% sprouted millet and 5% sprouted bambara nut; D = 95% fermented millet and 5% fermented bambara nut; E = 95% sprouted millet and 5% fermented bambara nut; F = 95% fermented millet and 5% sprouted bambara nut.

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