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Evaluation of Nutritive Value of Yam Based Weaning Food Fortified With Soy and Vegetables Minerals Sources

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Abstract To make yam (*Dioscorea spp*) more useful as low-cost, nutritive weaning food, it has been developed a scheme for processing it into infant flours with a long shelf-life. An attempt was allow to highlight how manufacturing process and the incorporation of soybean (*Glycine max*), baobab pulp (*Andasonia digitata*), locust pulp or seeds (*Parkia biglobosa*) and *Cerathoteca sesamoides* leaves, modifies nutritive value of formulated infant foods prepared from fermented yam. Nutrient bioavailabilities of the formulations thus prepared were evaluated. In addition, antinutrient content in infant flours has been investigated. The results obtained show that, there is improvement in the nutrient quality of the formulated complementary foods containing malted millet, MCS and MNB. In general infant flours formulated retained an acceptable level on antinutrients content.

Keywords: *infant, food, nutrients, bioavailability*

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1. Introduction

Yam is widely used in most part of western Africa including Earstern Ivory Cost, Ghana, Togo, Benin and Nigeria [1]. To fat malnutrition in developing countries, formulation and development of nutritious weaning foods from local and readily available crops is received a lot of attention. Providing nutritious complementary foods, stimulating interest, in the use of household traditional process and the addition of legumes notably soybean in cereals, starchy root tubers [2].

Yam (Dioscorea spp) is an important root crop in most countries in the tropical regions of Africa. Furthermore, it is a readily energy-rich, available and quite affordable product with promising economic value. The utilization of yams as weaning food could be increased by developing suitable processing technology and securing desired characteristic.

Legume seeds are an important source of dietary protein, carbohydrates, minerals, vitamins, and antioxidants, with great potential for human and animal nutrition. But the nutritive utilization of legumes can be negatively affected by their content of antinutritional factors such as phytic acid, which interfere with the digestive utilization of protein and minerals. Perhaps, it is evident that the antinutrient concentration in legumes, leaves and pulp fruit can be eliminate or reduce to tolerable level through appropriate processing method and blending [3]. Therefore, locally available food commodities are been carried out by a number of researchers [4]. Despite the reported improvement in nutrient status of fermented cereal, root tubers, the nutrient met and functional food of infant end sick adults are still not met. Effectiveness of phytase in different dietary matrices, as important factors in the application of different processing technologies assayed to decrease phytate content and increase the bioavailability of protein and minerals. Nevertheless, information about the effect of phytase on the content of other nutrients and antinutritional factors is scarce.

In Côte d'Ivoire, pulp and leaft plant biodiversity, providing highly nutritional concentrated sources such as *Andasonia digitata*, *Parkia biblobosa* and *C. sesamoides* with innumerable functional properties can be found. However, great part of those sources in formulated weaning food is still unknown.

The aim of this study was to use simple bioprocessing method to improve nutritional value of yam-based infant flours. This research would provide an affordable and

nutritious weaning food in order to reduce the incidence of malnutrition.

2. Materials and Methods

2.1. Materials

- Material used in composite flours were yams (*Dioscorea alata* and *Dioscorea cayenensis)*, soybean (Glycine max), malted millet grains, dried baobab pulp (*Adansonia digitata*), processed seeds and dried Nere pulp (*Parkia biglobosa*), processed and powdered *Cerathoteca sesamoides* leaves (Table 1).
- Two types of industrial infant flours wellknowned and saled in Côte d'Ivoire, Cerelac (infant cereal milk, NESTLE®) and FARINOR® (infant cereal milk, PKL) was taken as references.

2.2. Materials Collection and Preparation

Sampling: Each material has been collected from local market were it is most common, in harvesting period.

Yams, *Dioscorea cayenensis* variety kponan were purchased in November 2011. *Dioscorea alata* variety Bete Bete were purchased in January 2012. Soybeans were purchase in January 2012 from Bouake CNRA Station (Côte d'Ivoire). Baobab pulp (*Adansonia digitata*), seeds and Nere pulp (*Parkia biglobosa*) were purchased in Mars 2012. *Cerathoteca sesamoides* leaves were collected at maturity in fields in October 2011.

Yams tubers, soybeans and *C. sesamoides* leaves were disinfected in diluted hypochlorite solution. The cleaned dry materials were then given different treatments. Figure Figure 1, Figure 2 and Figure 3 outline the processing scheme of each material.

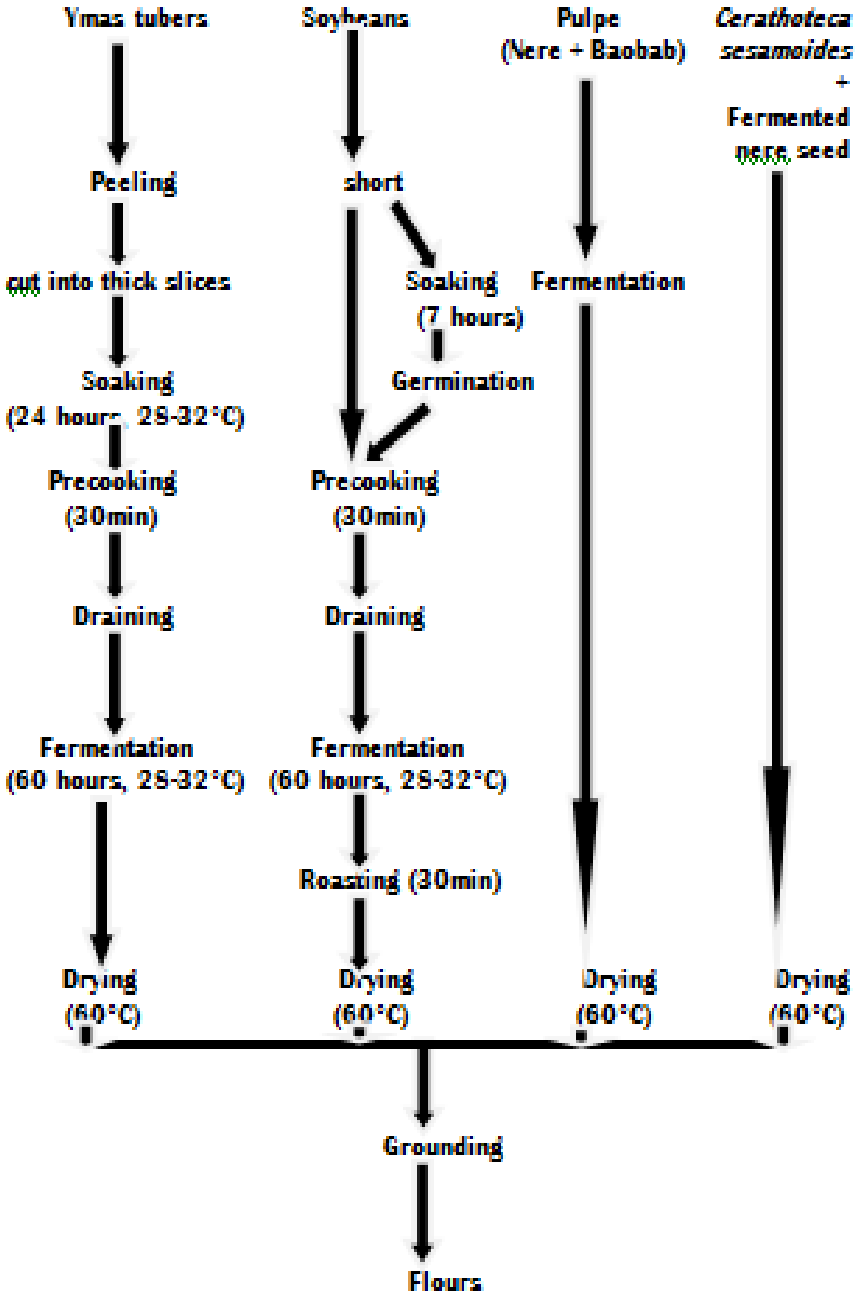

Figure 1. Diagram of preparation of flours

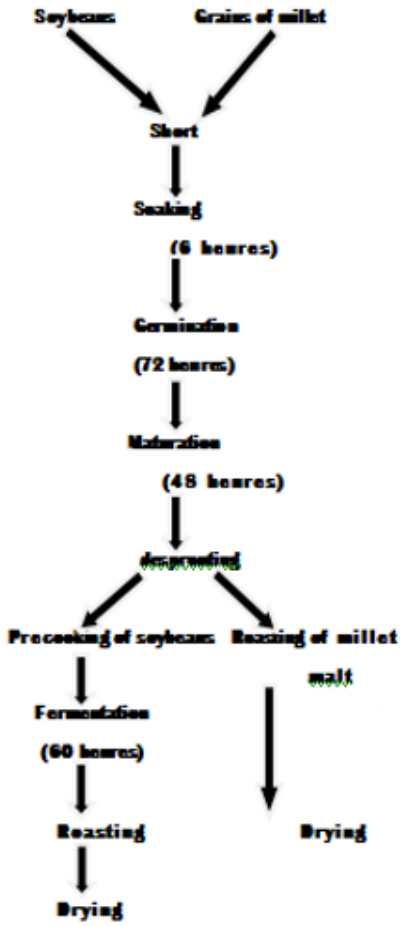

Figure 2. Diagram of preparation of sprouted soybean and millet malt

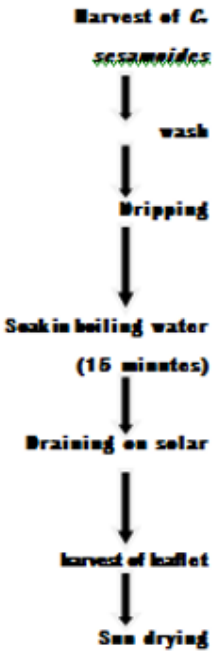

Figure 3. Diagram of preparation of *C. sesamoides* leaves

Preparation of fermented yam chips: Yam were sorted to remove defectives tubers, washed thoroughly and disinfected by soaking in diluted sodium hypochlorite solution [50mL (8°C hl)/ 30L water, v / v] for 20 minutes. Tubers were rinsed with tap water, dried and stored at 1 m above the ground for four weeks in a room whose temperature ranged from 26°C to 29°C and at relative humidity between 55% and 80% [5]. They are then peeled, cut into 1.5 cm thick slices and soaked in water (1:2, w / v) to 24 hours. After soaking the slices were cut into chips of 0.5 cm thick. These yam chips were precooked in a pressure stainless cooker for 30 minutes at 98°C. After purboiled, the cooking water was removed and yam slices were allowed to cool to 45°C, and then transferred into a large fermentation tank containing a polyethylene bag. The polyethylene bag was sealed tightly and tank was covered. The fermentation was carried out naturally for 60 hours at temperature of 30 ± 2°C. Fermented chips were dried to less than 65 °C for 8 h in a continuous dryer (Minergy ATIE PROCESS, 81666 PONT DE FRANCE-RNA). The thickness of the spreading layer on the trays of the drier was about 1 cm. The dried chips were packaged in sealed polyethylene bags and stored in a room less than 25°C. The same operations were performed for each variety of yams.

Preparation of non-germinated and fermented soybeans: 15kg hand-picked soybeans were cooked in a pressure cooker for 30 minutes in a pot of boiled water on a gas fire. Water was removed and the seeds were cooled to 45°C. Cooked seeds were transferred into a fermentation tank containing a polyethylene bag. The polyethylene bag was sealed tightly and tank was covered. The fermentation was carried out for 60 hours at a temperature between 30 ± 2°C. After fermentation, the beans are roasted at 95 °C for 30 minutes. Soybeans were then dried to less than 65 °C for 9 hours continuously in a dryer (Minergy ATIE PROCESS, 81666 PONT DE FRANCE-RNA). The thickness of the spreading layer on the trays of the drier was about 1 cm. The dried seeds were packaged in sealed polyethylene bags and stored in a room less than 25 °C.

Preparation of germinated and fermented soybeans: 15kg sorted soybeans were first disinfected with diluted sodium hypochlorite solution [(8 °Chl) 50mL / 30L (v / v)] for 15 min and thoroughly rinsed in tap water. They were then soaked during 7 hours in water (30L of water to 15 kg of seed). Soaked seeds are then drained and made sprouted in a perforated container, covered to prevent direct sunlight. Germination took place in a room at 30 ± 2 °C for 72 hours and was followed by drying for 48 hours at 40 ± 5 °C. The resulting malt is desprouted. Desprouted soybeans were then subjected to the same processing operations as in the case of non-germinated.

Preparation of malted millet: 6 kg of millet grains were sorted first disinfected with diluted sodium hypochlorite solution [(8 °Chl) 50mL / 30L water (v / v)] for 15 min and thoroughly rinsed with tap water. They were then soaked in water (15 L of water to 6kg of seeds) for 7 hours. The seeds are then drained and made sprouted in a perforated container and covered to prevent direct sunlight. Germination took place in a room at 30 ± 2 °C for 72 h and was followed by drying for 48 hours at 40 ± 5 °C. Malt thus obtained was desprouted, grilled, then subjected to the same operations (drying and packaging) in the case of non-germinated soybeans.

Treatments of vegetables *Cerathoteca sesamoides* leaves: The shoots of *Cerathoteca sesamoides* were collected in the field and disinfected with diluted sodium hypochlorite solution for 15 min and thoroughly rinsed with tap water. Shoots have been suspended from a ribbon

in the sun for 2 hours at 40°C ± 5°C. The shoots were then immersed in a boiling water for 15 minutes, drained and put in the sun. Leaflets were parts of shoots and then were dried in the sun for 48 hours at 40 ± 5 °C.

2.3. Formulated Infant Flours and Their Abbreviations

The yam-based formulas were prepared by mixing (by weight), yam chips (55, 60 or 70%) with sprouted or unsprouted soybean (30%), millet malt (10%), mixture of baobab and Nere flour (5%), or mixture of Nere seed and *Cerathoteca sesamoides* leaves powder(5%). After which, the mixture were milled using an electric grinder (Forplex model). to pass through a 167-mesh (0.25 mm) sieve, packaged in airtight plastic containers and stored in a room at less than 25°C. The different formulated flours were coded as follows:

BbSG: 70% fermented Bete Bete yam, and 30% sprouted soybeans ;

BbSNG: 70% fermented Bete Bete yam (70%), and 30% no sprouted soybeans;

BbSGM: 60% fermented Bete Bete yam (60%), 30% sprouted soybeans, and 10% millet malt ;

BbSNGM: 60% fermented Bete Bete yam, 30% no sprouted soybeans, and 10% millet malt ;

BbSGMCS: 55% fermented Bete Bete yam, 30% sprouted soybeans, 10% millet malt, and 5% *C. sesamoides*;

BbSNGMCS: 55% fermented Bete Bete yam, 30% no sprouted soybeans, 10% millet malt, and 5% *C. sesamoides*;

BbSGMNB: 55% fermented Bete Bete yam, 30% sprouted soybeans (30%), 10% millet malt, and 5% (Nere and baobab);

BbSNGMNB: 55% Bete Bete yam (55%), 30% no sprouted soybeans, 10% millet malt, and 5% (Nere and baobab);

KpSG: 70% fermented Kponan yam (70%), and 30% sprouted soybeans;

KpSNG: 70% fermented Kponan yam (70%) + no sprouted soybeans (30%);

KpSGM: 60% fermented Kponan yam (60%), 30% sprouted soybeans (30%), 10% millet malt;

KpSNGM: 60% fermented Kponan yam, 30% no sprouted soybeans (30%), and 10% millet malt;

KpSGMCS: 55% fermented Kponan yam, 30% sprouted soybeans, 10% millet malt, and 5% *C. sesamoides*;

KpSNGMCS: 55% fermented kponan yam, 30% no sprouted soybeans, 10% millet malt, 5% C. sesamoides;

KpSGMNB: 55% fermented Kponan yam, 30% sprouted soybeans, 10% millet malt, and 5% (Nere and baobab);

KpSNGMNB: 55% fermented kponan yam, 30% no sprouted soybeans, 10% millet malt, and 5% (Nere and baobab);

E17: Child Feeding Flour (wheat-soy): Reference 1

E18: Child Feeding Flour (cereal-milk): Reference 2

2.4. Chemical Analysis

Samples and standard solutions were prepared according approved methods AOAC [6].

The moisture content of the different flours was determined by drying to constant weight in an oven at 105°C.

Total nitrogen was determined according to Kjeldahl's method. Crude protein was calculated as N × 6.25. The lipid content was determined using hexan in a soxhlet ((SYSTEM HT2 1045 UNID Tecator, Sweden) extraction apparatus. The proximate composition of the formulated complementary food samples was determined as described by AOAC [6]. Total carbohydrate was determined by difference.

Total mineral content in flours was determined by ashing in a furnace at 550°C which consists in calcining 5g of dry flour in a muffle furnace oxidizing until a white residue. Calcium, iron, zinc and magnesium were determined in the ash solution in 10% HNO_3 by atomic absorption spectrophotometer [6]. Total phosphorus was determined as orthophosphate by the ascorbic acid method after acid digestion and neutralization using phenolphthalein indicator and combined reagent [7]. The absorbance was read at 880nm (Spectronic 21 D, Miltonroy, New York, USA) and KH_2PO_4 (Merck, Mumbal, India) served as a standard.

2.5. Determination of Gruels Energy

The energy of gruels was determined after calculation of the flours energy and expressed in kcal/100mL.

$$\mathbf{E_{(kcal/100g\ \ of\ slurry)}} = \left(\mathbf{E_{(kcal/100g\ of\ flour)}} + \mathbf{m_{sugar}} \times \mathbf{4}\right) \times \mathbf{100} / \left(\mathbf{100} + \mathbf{m_{water}} + \mathbf{m_{sugar}}\right)$$

100: flour weight

m_{sugar}: weight of sugar mixed in the gruels cooking with 100 g of flour

m_{water}: weight of water used for cooking 100 g of flour in gruel.

2.6. Determination of Available Carbohydrate

Enzymatic hydrolysis of infant flours was performed according Bergmeyer [8] with some modifications. 100 mg of defatted samples were boiled for 10 minutes in 10 mL of potassium phosphate buffer (PH7, 0.02 M). After cooling, 5 mL of solution prepared by diluting 2 mg of diastase (α-amylase, 1300 units / g, Hi-Media, Mumbai, India) in 12.5 mL of potassium phosphate buffer (pH 7 0, 02M) were added. The mixture was then incubated at 37 °C for 3 hours. The enzyme was then inactivated with 1 mL of NaOH (0.5 N). The mixture was centrifuged and the supernatant was diluted to 5 mL with distilled water. Sugar released by the digestion was assayed using a curve of calibration and the method of DNS [9]. The standard solution was glucose (1 mg / mL). The absorbance (DO) was readed at 540 nm against the blank. If q, the amount of sugar determined after reading on the curve of calibration, it used to calculate the percentage hydrolysis (Q):

$$Q = \frac{q \times 100 \times F}{m \times DM}$$

m: weight of the sample (g)
DM: dry matter F = dilution factor.

2.7. Determination of Digestible Proteins, "in Vitro" Using Pepsin and Pancreatin

Digestible crude protein was estimated "in vitro" used the method described by Marrion *and others* [10], with some modifications.

1 g of flour was mixed with 35 mL of pepsin (1.5 g / L) prepared in pH 2 phosphate buffer (KH2PO4, 0.1 M). The mixture was incubated at 37 °C in a shaker water bath for 2 hours and then centrifuged for 15 minutes at 4000trs/min.

The residue was washed with 10 mL of buffer (KH2PO4, pH 7) and centrifuged again for 15 minutes at 4000trs/min. The residue was delivered in 35 mL of pancreatin (1.5 g / L) prepared in KH2PO4 (0.1 M) at pH 8 and incubated in a shaker water bath at 37 °C for 1 hour. At the end of the incubation, the mixture was centrifuged for 30 minutes at 3000trs/min. The residue was washed with 10 mL of phosphate buffer (pH 7), and then centrifuged for 30 minutes at 3000trs/min. The residue of the later centrifugation was used for determining the undigested protein content by kjelhdal method [6]. The results were expressed as percentage of protein digested by the relation:

$$\text{Digested protein}\,(\%) = \frac{\text{Total protein} - \text{undigested protein}}{\text{Total protein}} \times 100.$$

2.8. Determination of Bioavailable Lysine Content

Obi method [11] was used for the assay. The flour is putted in presence of sodium carbonate, trinitobenzen sulfonic acid (TNBS), concentrated hydrochloric acid and then readed the absorbance at 346nm.

For that 10mg of flour were introduced into a tube, 1mL $NaHCO_3$ (4%, w / v), pH 8, 5 has been added. The mixture was placed in a shaker water bath at 40 °C for 10 minutes. 1 mL of TNBS in 1% (w / v) was added to the mixture, which again incubated at 40°C for 2 hours. 3 mL of concentrated HCl (12N) were incorporated into the content of the tube and was capped and left in an oven at 120 °C for 1 hour. After cooling to room temperature, 5 mL of distilled water was added to each tube and the mixture was filtered with Whatman filter paper No.1 to remove insoluble particles. The filtrate from each tube was washed twice with 3 × 10 mL of diethyl ether each time, which is evaporated in the hot water for 5 minutes. The optical density (DO) was read at 346 nm against the blank. The blank was prepared in the same manner as the samples except that the concentrated HCl is added before TNBS. Available lysine concentration was calculated using the specific absorption coefficient of TNBS-lysine ε= 1.46 × 10^4/mole/cm). The amount of lysine in % dry matter was given by the relation

$$QLys = \frac{DO\ PMLys \times m}{\varepsilon \times DM} \times 100$$

with PMLys = 146.25
m: weight of the sample analyzed
DM: dry matter of the sample.

2.9. Determination of Bioavailables Minerals

Mineral bioavailability was estimated by their digestibility in simulated physiological condition "in vitro" using a method proposed by Bermejo and others [12].

Preparation of the pepsin solution

Just before use, 0.4 g of pepsin were dissolved in 10 mL of HCl (0.1 M) and mixed by stirring with a rotary shaker at 60 rpm, then 10 mL of HCl (0.1 M) was added.

Preparation of pancreatin solution + bile extract

Just before use, 0.05 g of pancreatin and 0.3 g bile extract sheep were dissolved in 35 mL of $NaHCO_3$ (0.1 M).

Gastric digestion

In an Erlenmeyer flask dipped in a solution of HCl (1M), rinsed with distilled water, 2 g of flour were dissolved in 20 mL of distilled water and boiled for 10 minutes. The mixture was then cooled and incubated in a water bath with gentle stirring at 37 °C to 10 minutes. The pH was adjusted to 2 with a solution of 1M HCl before adding 10 ml of pepsin solution. The mixture was incubated again for 90 minutes with gentle stirring at 37°C. still, The pH of gastric digestate was increased to about 4.5 with 0.1 M NaHCO3, before the addition of 5 mL of pancreatin + extract bile. The pH is then adjusted to 7 with the same solution of 0.1 M $NaHCO_3$. The mixtures were incubated for 2 hours at 37°C with gentle stirring constantly. The mixtures were then placed on ice until cool, then transferred in full in tubes and centrifuged at 10 000g for 30 minutes at 4°C Bermejo *and others* [12]. The supernatant recovered in silica capsules and minerals released during digestion were measured.

Determination of bioavailables minerals

Digestate were initially evaporated on hotplate under vacuum host and then placed in an oven at 95° for complete evaporation. They followed the assay determination of total mineral (mineralization, fixation by nitric acid, dissolving in a solution of HCl and assay atomic absorption spectrophotometer).

The percentage of digestible minerals is the ratio of the amount of mineral in the digestate on the amount present in the sample multiplied by 100.

2.10. Anti-nutritional Evaluation

Estimation of phytates: The phytates was extracted by the method described by Nwosu [13]. 0,5g of the samples was dispersed in chloride acid solution (0,5N). The mixture was stirred (at 20trs / min) for 2hrs. The mixture was high speed centrifugation at3500trs/min at 20°C during 20 min. The phytate in the supernatant was

precipitated with excess of ferric chloride as ferric phytate and iron. The precipitate was converted to sodium phytate using 2ml of 2% NaOH before digesting with an acid mixture (1mL) containing equal portions of concentrate H_2SO_4 and 65% $HClO_4$. The phytic acid was determined by estimating the amount of phosphorus present in the precipitate. The phytic acid was estimated by multiplying the amount of phytate phosphorus by the factor 3.5514 based on the empirical formula $C_6P_6O_{24}H_{18}$.

Hydrogen cyanide determination: HCN was estimated by AOAC [14].

Two grams of the sample was weighed into a flask and 100mL of distilled water was added to it and allowed to hydrolyze for lhr. 10ml of 2.5% NaOH was measured and carefully poured into the sample holder. The soxhlet apparatus was set up and was distilled into the sample holder containing the 2.5% NaOH until about 70ml was collected. It was carefully transferred to a 100mL volumetric flask and the sample holder was rinsed with distilled water and poured into volumetric flask. It was made up to the mark. Twenty-five milliliters (25ml) of the distillate was pipetted into a conical flask, 2ml of 6M NH_4OH and 0.5ml of 10% Kl solution were added. It was titrated with 0.02M$AgN0_3$ to a first turbid color.

NB: lmL of 0.02 M $AgN0_3$ = 1.08mg cyanide.

Oxalate determination: Oxalate level was estimated by AOAC [6].

Five grams of the sample was weighed into a 100ml beaker, 20ml of 0.30N HCl was added and warmed to (40 - 50°C) using magnetic hot plate and stirred for one hour. It was extracted three times with 20ml of 0,30N Hcl and filtered into a 100ml volumetric flask. The combined extract was diluted to 100ml mark of the volumetric flask. Total oxalate was estimated by pipetting 5ml of the extract into a conical flask and made alkaline with 1.0ml of 5N ammonium hydroxide. A little indicator paper was placed in the conical flask to enable us know the alkaline regions. It was also made acid to phenolphthalein (2 or 3 drops of this indicator added, excess acid decolorizes solution) by dropwise addition of glacial acetic acid. 1.0ml of 5% $CaCl_2$ was then added and the mixture allowed standing for 3hrs after which it was then centrifuged at 3000rpm for 15min. The supernatants were discarded and the precipitates washed 3 times with hot water with thorough mixing and centrifuging each time. Two milliliters of 3N H_2SO_4 was added to each tube and the precipitate dissolved by warming in a water bath (70 - 80°C). The content of all the tubes was carefully poured into a clean conical flask and titrated with freshly prepared 0.05N KMnO4 at room temperature until the first pink color appeared throughout the solution. It was allowed to stand until the solution became colorless. The solution was then warned to 70 - 80°C and titrated until a permanent pink color that persisted for at least 30 seconds was attained.

$$\mathbf{Q} = \left(\mathbf{P_{ox}} \times \mathbf{N} \times \mathbf{V} \times \mathbf{10^3} \times \mathbf{DM}\right) / \mathbf{m}$$

P_{ox}: Oxalate molecular weight
N: 0.05N
V: volume of $KMnO_4$
DM: dry mater
M: weight of sample

2.11. Statistical Analyses

Results expressed were calculated from the average of 3 replicate data for each experimental analysis. Statistical analyses were performed using analysis of variance (ANOVA) and on the case of a significant difference between groups of each parameter, treatment means were differentiated using Tukey's multiple range tests. A 5% level of probability ($P < 0,5$) was chosen on advance, to sufficiently demonstrate a statistically significant difference. The software used was STATISTICA 8.0. Results were expressed as mean ± standard deviation.

3. Results

Table 1 showed result of proximate analyses of the yam/soy fortified with minerals sources formulated complementary foods. Protein densities ranged from 4.6 ± 0.03 to 6.44 ± 0.26 g/100kcal. Iron densities ranged from 1.53 ± 0.05 to 5.59 ± 0.18 mg/100 kcal. Zinc densities ranged from 0.85 ± 0.17 to 1.12 ± 0.16 mg/100 kcal. BbSGMCS had significantly ($p < 0.05$) lower fat densities (1,54±0,07g/100kcal) while comparable higher values of protein densities were recorded for BbSGMCS (6,44±0,26g/100kcal), KpSGMCS (6,29±0,19g/100kcal), BbSGMNB (5,89±0,13g/100kcal) and kpSGMNB (5,77±0,25g/100kcal). Pattern of variation of the essential micronutrients densities indicates that BbSGMCS, KpSGMCS, BbMCSMNB and KpSGMNB were higher compared to the other formulated complementary foods.

Table 1 showed that vitamin C densities ranged from 1.47±0.197 to 6.47±0.039g/100 kcal with the vitamin A ranging from 29.58±2.39 to 275.83±6.63g/100 kcal. Comparable higher values of vitamins C and A densities were recorded for formulated complementary foods contained MCS and MNB. Values for vitamin C and A were respective higher than the international reference values of 2,3 mg/100kcal and of 35 µgER/100kcal.

Levels of bioavailable lysine (0.195±0.003 to 0.254±0.006g/100kcal) in most formulated complementary foods were higher than the international reference values of 0.12. Percentage *in-vitro* protein digestibilities of the formulations (2.90±0.031 to 4.57±0.092g /100kcal) is comparable to that of the references used complementary foods (2.92±0,051 g/100kcal E17 and 3.23±0.008 g/100kcal E18) and were higher than the international reference values of 3.

Table 2 showed that phytates content ranged from 1.12±0.13 to 3.19±0.19 mg/100 g with oxalates content ranging to 2.35±0.91 to 4.82±0.59 mg/100gMS. Result showed that molar ratios of *Phy/Fe*, *Phy/Zn*, *Phy×Ca/Zn* and content ratios of *TAO/TCa*. were mostly lower than the limit values above which a low bioavailability of minerals is generally observed. And then, with regards to levels of percentages of bioavailables minerals observed (Table 2), they were in considerable amounts, whose may still be able to higher than 60%.

Table 1. Nutrients and micronutrients content of infant flours (per 100kcal)

Samples	Protéines (g)	Lipides (g)	Fer (mg)	Calcium (mg)	Phosphore (mg)	Zinc (mg)	Magnésium (mg)	Vitamins C (mg/100kcal)	Vitamins A (µgER/100kcal)	Bioavailable lysin (g/100kcal)	Digestible protéine (g/100kcal)
Bb SG	5,51±0,08	1,68±0,05	2,72±0,19	104,31±1,29	67,96±0,15	0,99±0,16	32,83±1,6	2,98±0,081	57,91±2,35	0,21±0,006	3,60±0,090
Bb SGM	5,69±0,11	1,61±0,03	3,94±0,32	96,75±4,01	77,27±7,23	0,91±0,13	33,69±1,61	2,56±0,080	40,83±3,38	0,215±0,006	4,09±0,068
Bb SGMCS	6,44±0,26	1,54±0,07	5,59±0,18	163,24±1,53	143,4±0,81	1,12±0,16	46,5±1,55	5,20±0,08	275,83±6,63	0,254±0,006	4,10±0,082
Bb SGMNB	5,89±0,13	1,55±0,08	3,96±0,18	132,74±3,96	131,2±0,65	1,05±0,16	36±0,69	6,47±0,039	178,75±4,29	0,237±0,004	4,26±0,046
Bb SNG	4,78±0,18	1,98±0,11	2,69±0,15	86,33±0,81	67,75±0,9	0,85±0,17	29,49±1,18	2,09±0,051	47,91±1,63	0,20±0,006	2,90±0,031
Bb SNGM	5±0,17	1,92±0,1	2,91±0,13	76,44±7,95	85,47±0,97	0,86±0,19	29,16±1,41	1,79±0,073	42,08±2,93	0,202±0,008	3,59±0,05
Bb SNGMCS	5,55±0,2	1,87±0,02	4,36±0,12	162,85±1,95	144,8±1,05	1,04±0,2	44,38±1,73	4,21±0,076	226,66±5,44	0,231±0,007	3,42±0,15
Bb SNGMNB	5,25±0,18	1,83±0,1	3,65±0,15	129,48±2,22	130,2±1,3	0,99±0,18	35,2±1,86	5,62±0,079	146,25±3,51	0,203±0,008	3,76±0,025
Kp SG	5,37±0,05	1,7±0,08	1,69±0,14	111,05±3,91	71,55±0,88	0,95±0,15	32,41±1,45	2,80±0,062	48,75±1,89	0,210±0,002	3,90±0,093
Kp SGM	5,59±0,05	1,63±0,03	2,76±0,14	103,21±4	98,99±1,45	0,95±0,14	33,4±1,52	2,43±0,071	32,91±3,19	0,213±0,004	4,43±0,027
Kp SGMCS	6,29±0,19	1,56±0,05	3,85±0,12	169,7±1,11	156,4±0,51	1,06±0,15	45,61±1,77	4,07±0,069	208,75±5,01	0,243±0,003	4,57±0,092
Kp SGMNB	5,77±0,25	1,4±0,03	2,89±0,19	140,52±2,93	153,2±1,05	1,03±0,17	31,23±1,32	5,50±0,086	140,41±3,37	0,232±0,001	4,17±0,048
Kp SNG	4,6±0,03	1,99±0,07	1,53±0,05	98,42±1,98	73,08±0,94	0,93±0,18	30,4±1,26	1,67±0,192	35,41±1,57	0,195±0,003	3,26±0,14
Kp SNGM	4,77±0,06	1,78±0,11	2,55±0,16	93,93±5,86	111,2±2,04	0,91±0,13	33,56±1,33	1,47±0,197	29,58±2,39	0,198±0,01	3,21±0,095
Kp SNGMCS	5,4±0,05	1,76±0,05	3,28±0,19	161,58±2,06	156±0,75	1,03±0,18	43,03±1,62	3,76±0,166	180,41±4,33	0,212±0,004	3,80±0,07
Kp SNGMNB	5,12±0,14	1,59±0,02	2,6±0,15	134,28±4,08	136,2±3,01	0,99±0,17	33,43±1,61	5,04±0,222	135,83±3,26	0,202±0,006	3,52±0,056
E17	4,88±0,05	1,99±0,04	4,18±0,16	157,01±2,29	125,4±0,47	1,64±0,08	17,77±1,07	12,07±0,063	89,58±2,15	0,201±0,006	2,92±0,051
E18	4,48±0,08	2,17±0,07	1,51±0,1	149,35±3,91	51,39±0,29	0,75±0,02	8,9±0,69	11,22±0,067	69,58±1,67	0,192±0,001	3,23±0,008
Recommandations	2,6-5,5*,**	2,7*,**	4*	125*	114*	0,8*	19*	2,3*,***	35*,***	> 0,12	> 3

Protein, fat and micronutrients densities (per100kcal) nécessary in complemnetary food for 6 to 23 monyhs old children according RDA (2008)*, Lutter et Dewey (2003) **. Values higher or in conformity for recommended values were indicated in red color
Sources: USDA (2005), USDA (2008)***, Values higher than recommandations (USDA, 2005 and 2008) were indicated in red colors.

Table 2. Oxalates and phytates content, index and percentages of bioavailables of minerals

Samples	Oxalates (mg/100gMS)	Phytates (mg/100gMS)	Phy/Fe	Phy/Zn	Phy×Ca/Zn	%Iron	%Zinc	%Phosphorus	%Calcium	%Magn
Bb SG	2,35±0,91	1,12±0,13	0,10±0,003	0,28±0,005	0,37±0,05	76,62±4,28	70,31±6,43	67,38±4,08	79,47±0,55	72,32±7
Bb SGM	2,74±0,17	2,01±0,13	0,12±0,007	0,58±0,002	0,82±0,09	84,69±6,64	74,48±9,81	67,55±6,96	66,83±1,64	73,1±7,
Bb SGMCS	2,93±0,03	1,59±0,27	0,09±0,006	0,46±0,001	0,72±0,04	85,91±3,38	61,99±5,54	72,95±5,63	71,9±3,57	72,61±7
Bb SGMNB	4,57±0,55	2,02±0,26	0,16±0,008	0,74±0,005	1,02±0,08	83,33±3,89	72,63±6,34	75,57±6,15	66,49±2,08	75,19±8
Bb SNG	2,56±0,92	2,08±0,19	0,14±0,009	0,45±0,001	0,63±0,04	74,69±2,3	66,54±10,29	65,99±1,87	69,69±3,76	69,03±8
Bb SNGM	2,94±0,98	3,06±0,12	0,17±0,007	0,67±0,006	0,98±0,05	79,6±2,03	69,27±9,26	64,28±7,04	73,99±5,09	67,47±9
Bb SNGMCS	3,18±0,09	2,34±0,28	0,12±0,008	0,48±0,005	0,80±0,01	91,44±1,66	69,48±9,24	73,61±1,89	69,47±1,68	74,35±7
Bb SNGMNB	4,82±0,59	2,53±0,31	0,16±0,005	0,63±0,007	0,88±0,01	81,49±2,25	67,44±8,08	70,44±1,31	69,79±2,17	75,25±6
Kp SG	3,17±0,17	1,51±0,16	0,18±0,008	0,39±0,003	0,50±0,07	61,51±3,28	64,44±7,1	67,54±4,48	74,47±4,27	72,36±7
Kp SGM	3,87±0,01	2,21±0,22	0,13±0,004	0,45±0,008	0,63±0,02	75,91±5,13	81,35±7,67	71,84±2,31	77,97±4,65	73,54±7
Kp SGMCS	4,13±0,39	1,40±0,23	0,14±0,006	0,52±0,004	0,83±0,08	83,52±8,67	68,68±4,77	75,55±4,31	73,02±5,54	75,42±6
Kp SGMNB	4,44±0,48	2,27±0,13	0,22±0,005	0,74±0,001	1,17±0,01	78,4±9,29	63,57±4,42	72,53±4,88	67,97±2,36	70,38±8
Kp SNG	3,24±0,83	1,76±0,24	0,18±0,009	0,36±0,005	0,49±0,06	64,53±2,97	73,96±10,81	66,77±1,59	74,45±2,67	70,21±8
Kp SNGM	3,97±0,35	3,04±0,46	0,18±0,003	0,60±0,001	0,84±0,01	70,61±8,5	66,66±6,73	79,47±10,81	69,96±2,13	73,93±7
Kp SNGMCS	4,44±0,46	2,23±0,06	0,17±0,002	0,54±0,005	0,88±0,05	76,58±4,77	71,85±8,69	76,68±2,37	77,58±5,39	76,24±6
Kp SNGMNB	5,07±0,70	3,19±0,19	0,26±0,009	0,80±0,002	1,30±0,01	70,05±7,05	61,39±6,75	71,46±6,52	69,56±0,18	73,4±7,
E17	1,92±0,76	2,77±0,16	0,14±0,004	0,43±0,001	0,65±0,05	65,25±1,66	68,54±6,09	65,63±13,66	68,65±0,68	64,18±1
E18	4,63±0,51	4,85±0,83	0,70±0,001	1,16±0,003	2,38±0,07	68,24±3,18	61,13±5,06	74,44±9,55	57,92±1,98	62,72±4

4. Discussion

Infant flours were produced from solid spontaneous formulation process of yams chips and soybean during 60 hours. The proximate composition, as well as antinutrients and bioavailable of mineral at different type of flour are presented in Table 1 and Table 2 respectively. Result shown that processing methods allowed increasing significantly protein and mineral content of formulated flours. Perhaps, lipid content has been decreased. The crude protein values obtained (Table 1) in the formulated complementary foods were higher than the 2,6 to 5,5 g/100kcal [15] recommended for infants up to one year The increase of the protein content of the fermented blend could be attributed to the breakdown of nutrients of the substrate, especially soybean, by the starter organisms. Soybean is known to be a protein rich seed. The decrease in the lipid content at the end of fermentation may have resulted from oxidation due to pre-fermentation treatment of nutrients, especially soybean. The microorganism could also oxidize the lipid to obtain energy for their metabolic activities. Lipid yields are considerable amount of energy for microorganism when oxidized. Similar result was obtained by Iluyemi and others [16,17]. However, this low of fat is desirable to enhance the storage stability and keeping qualities of the formulated blends.

The bioavailable lysine values and percentage *in-vitro* protein digestibility (Table 1) for all of the formulated complementary foods were higher than the international reference values for infants [18]. These values of formulated complementary foods were comparable to those of the references

There was improvement in concentrations of mineral elements in the formulated complementary foods (Table 1) contained MCS and MNB, compare to the yam/soy based complementary foods. And then, values obtained for all the mineral elements were higher than RDA for infant up to one year and may contribute to the overall daily intake of mineral elements. It has been found that, the concentration of minerals was proportional to the ash content in MCS and MNB. Especially, those complex flours that were used as supplementary feed could contribute to a large proportion of calcium, phosphorus, iron, zinc, vitamin A and vitamin C. These minerals were presented in considerable amounts, which is extremely important since they act as co-factors in various metabolic reactions in human organism. Amongst the macrominerals presented in Table I, calcium relevant in the prevention of bone problems, such as rachitism in children, since low calcium consumption is a potential problem. Magnesium is co-factor of more than 300 metabolic enzymes and participates in fatty acid and protein synthesis reactions [19]. Iron deficiency anemia has a high incidence in women and children in developing countries [20], which emphasizes the importance of the presence of this mineral in infants flours studied. Zinc is essential because it is a co-factor for more than 100 enzymes and participates in diverse metabolic processes such as cellular growth and multiplication, cicatrization, and macrophage and lymphocyte functioning [21]. The body depends on a regular zinc supply provided by improvement of zinc obtained in the formulated complementary foods may help decrease the prevalence of stunting with linear growth. The presence of these minerals in formulated infant flours enriches the nutritional value of this food even more. Considered the bioavailability of these minerals, 100 g of formulated flours can supply higher than 60 % of these minerals required. Iron, zinc and magnesium of flours contained MCS and MNB comply with the recommendation for these minerals, whereas comply fully with the requirements of the daily requirements, both for 6 to 24 months old of children. Several studies have reported that the high prevalence of protein energy malnutrition in many parts of developing countries is a result of low-dense energy and other vital nutrient intake [21,22].

These complex minerals and vitamin A or C, had high protein content with greater increase of amount of bioavailable lysin and digestible protein. Process used cause greater improve of “in vitro digestibility”. Ash and vitamins A or C seens to be important in the complex flours containing MCS or MNB.

Regarding vitamin A, the results shown in Table 1 indicate that formulated complementary foods contain high level. The fact that vitamin A exert many functions, for example, antioxidant activity makes this result of utmost importance for children life since this complementary food could be used for the prevention of various diseases, amongst them eyesight problems caused by vitamin A deficiency, diseases that result from oxidative stress, such as cancer, amongst others.

Ascorbic acid has various functions which are based mainly on its property as a reversible biological reducing agent. Thus, it is essential as a co-factor for various biochemical reactions and as a protective antioxidant that works in the aqueous phase, which can be regenerated in vivo when oxidized; it also affects a variety of factors associated to the risk of heart disease, including the integrity of vascular tissue, vascular tonus, lipid metabolism, and blood pressure [23]. It can also increase non-heme iron absorption and participate in the formation of collagen [24]. The results showed that the ascorbic acid contents in formulated infant flours containing MCS and MNB are close to the recommended and are much lower than those found in values found in commercial infant flours (E18 and E17).However, when considering the high content of this antioxidant substance in formulated flours is of great relevance to children health given its relationship with the prevention of diseases caused by oxidative stress, amongst others, as previously mentioned.

The results obtained (Table 2), show that the incorporation of germinated soybean and malted millet involves an increase rate of flow associated with a decrease of the dry matter and energy density of the porridges. This made it possible to obtain porridges which, with consistency equal to 120mm/30s have dry matter close to that of the porridges resulting from the traditional. This observation suggests that an annealing process occur during both unit operation as already indicated by the decrease of gruel cooling flow. The fell of gruel viscosity may be linked to a decrease in starch content due to hydrolysis has already been observed. And then pasting viscosity fell during tuber storage. The thinning effect could be explained by the viscosity reduction which is explained by the fact that germinated soybean and malted millet contain active amylolitic enzymes that could degrade the starch component in the gruels and thus make them more liquid. Staple foods such as cassava, yam and potato are high in starch hence absorbed a lot of water during cooking which make them bulky [25]. Infants need to consume large quantities to get enough energy and nutrients that is difficult because they have small stomach. This problem is solved if families feed children with weaning foods prepared from germinated cereal flour, fermented and enrich bulky foods. Malting reduces viscosity of the foods and hence a child can eat more at a time [26]. However germination has been reported [27] to reduce the concentration of antinutritional factors like phytates in malted grains hence improves its nutritional quality [28].

The anti-nutrients levels in infant flours produced are compared favorably with that of the references commercials infant flours. Consumption of high levels of oxalate causes corrosive gastroenteritis, shock convulsive symptoms, low plasma calcium and renal damage [29]. Also, oxalate like phytates limit the availability of calcium in the body (being calcium binders) by forming insoluble calcium oxalates salts, hence decreasing the utilization of the mineral by the bones and tissues [30]. And then, studies of some leguminous plants have shown that high levels of phytates in human nutrition are toxic and limit the bioavailability of calcium, magnesium, iron and phosphorus by the formation of insoluble compounds or salts with the minerals. These minerals are indispensable to the child as they play important roles in the long term effect of growth, bone and tissue development in infants [21]. There was no hydrogen cyanide observed in infant flours. However, the antinutrients levels of the samples are

within safe limit and therefore would not pose danger to infant. Heat treatment and malting affected all the nutritional stress factors and all decreased with increased period of heating. Processing operations were achieved in oxalates and phytates respectively, while complete elimination was achieved in hydrogen cyanide. These results were in agreement for other similar seed as reported by [30]. Several studies indicated that processing method such as soaking, germination, fermentation and roasting (dry heat treatment) destroyed all factors. Phytate has been hydrolysed by phytase which believed to be activated during the germination and fermentation processes. These hydrolyses contribute to increase strongly the amount of iron, zinc calcium and phosphore. What contributed to the increase of iron solubility (index of iron bioavailability) at the end of fermentation.

5. Conclusion

Bioprocess used cause considerable changes, affected antinutrients and proteins content. There is improvement in the nutrient quality of the formulated complementary foods comparable to that commonly used which can be improve on with the ultimate goal of contributing to the reduction of malnutrition in children. There is a great potential for utilizing formulated BbSGM as weaning food. In addition, after optimize their sweet; BbSGMCS and BbSGMNB could have greater potential for utilizing as weanning food with good source of protein and nutraceutical content. The results obtained from this study shown that antinutrients content of formulated flour could further reduced either by soaked, germination or fermentation treatments. Losses of these toxins during processing make their presence to be of little concern.

This study suggests that the development of efficient processing technique is warranted for better utilization of soybean in soy complex of Nere-baobab pulp, *C. sesamoides* leaves, as well as, to make use of their by-products is values added foods. *C, sesamoides* and Nere-baobab pulp complex on minerals and vitamins sources. It incorporation into weaning food could improved food qualities.

It can be concluded that in addition to preservation of there antioxidant properties conferred by its contents of ascorbic acid and vitamin A, the processing for manufacturing these complementary food was appropriate and had great preservation of bioactive compounds with functional activities due to the high concentrations of iron, zinc and carotenoids and for being a great source of vegetable protein. However, further studies are necessary to confirm the beneficial effects of those functional substances.

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