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Formulation of Weaning Food from Fonio (*Digitaria exilis Stapf*) and Soya Bean (*Glycine max*)

Nkiruka Charity Eboagu*, Collins Chibuzor Odidika, Kate Ekwy Ochiagha, Joy Nwando Nwokoye, Chiagozie Michael Ekwunife

Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka, Nigeria

Email address:

nc.eboagu@unizik.edu.ng (N. C. Eboagu)

*Corresponding author

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Abstract: Malnutrition is a major health problem for children in developing countries. This study examines the use of fonio and soya bean flours as locally and readily available raw materials for production and formulation of weaning foods. Weaning food was produced from fonio and soya bean flour in varying proportions. Four blends A, B, C and D were formulated respectively. Proximate, vitamin and mineral contents were determined using standard methods. The chemical compositions of the formulations were as follows, for samples A, B, C and D respectively. Moisture contents = 3.20%, 3.00%, 2.50% and 2.00%. Ash contents = 3.30%, 3.20%, 3.00% and 2.80%. Protein = 29.00%, 25.00%, 20.00% and 17.50%. Fibre contents = 3.50%, 3.30%, 3.00% and 2.70%. Fat contents = 11.00%, 10.00%, 10.00% and 8.00%. Carbohydrate contents = 50.00%, 55.50%, 61.50% and 67.00%. Energy contents (Kcal/100g) = 415.00, 412.00, 416.00 and 410.00 Kcal/100grespectively. The mineral content of the formulated weaning food were determined which confirmed the presence of calcium, magnesium, sodium, potassium, copper, iron and phosphorus. Vitamin A, B_1, B_2 and C were also determined. These values fall within the Food and Agriculture Organization (1966) recommended values of food for infants. The complementary diet prepared from fonio and soya bean flour was also compared with Cerelac and Nutrend a commercial weaning food. Sample C was compared favourably with those of the commercial weaning foods. It is also complied with infant food specification established by Food and Agricultural Organization (FAO)/World Health Organization (WHO) which had agreeable appearance, light yellow colour, good flavour and taste and readily dispersed in hot water. Sample C is recommended as the best formulated weaning foods which can therefore used as alternatives to the weaning foods in the Nigerian market as well as other countries in the world to improve nutritional status of children and also help to curb protein–energy malnutrition.

Keywords: Weaning Food, Fonio, Soya Bean, Flour, Formulation, Malnutrition

1. Introduction

Baby foods are those items that provide the nutrients needed by infants for their body nourishment. These nutrients are needed by their body to survive and grow [1]. The quality of nutrients presents in the volume of milk produced by healthy lactating mothers has been found to be adequate in meeting the baby's nutrient and energy requirement up to the age of two to three months [2]. Breast milk from well nourished mother is adequate to meet the nutritional needs of the infant for the first six months of life [3]. The World Health Organization (WHO) recommends exclusive breast feeding for the first six months of life with addition of weaning foods until the age of about two years [4]. As the child's needs for nutrient increases, other foods of high biological value must be provided to supplement the breast milk [5]. The feeding of infants with foods other than breast milk is termed weaning [6]. The necessity for weaning is evident as the infant grows because there will be an increase demand for various new activities like sitting, crawling, walking, teething and all other physical developments. Failure to introduce weaning food at required time will lead to malnutrition [7]. Malnourished infant and mother will be

prone to infections and overall poor developments. In Nigeria, the main weaning food available to the majority of the people is mainly pap (akamu) made from corn of either white or yellow varieties. Some other grains are millet, cowpeas and guinea corn (sorghum). All these grains do not meet the nutrient requirement of weaning babies as they are rich only in carbohydrate. The major sources of dietary vegetable protein in weaning food are cereal grain and legumes. Cereal is high in carbohydrate and fibre, low in fat void of essential proteins and vitamins that the body needs. For this reason, it is necessary to produce an instant fonio (*Digitaria exilis Stapf*) and soya beans (*Glycine max*) which would provide a better balanced nutritional value.

Weaning foods fortified with soya beans flour have been shown to be nutritionally similar to based formula currently in the Nigeria market today. Soya bean is a versatile and leguminous crop. It is very rich in protein and also one of the most concentrated and nutritious plant foods. Fonio is a cereal crop. The seed is richer in protein than other known cereal crops in West Africa. The grain has good nutritional quality and attractive flavour. Fonio are very good source of calories and other nutrients [8]. Legumes contribute significantly towards protein, mineral and B-complex vitamin needs for people in developing countries. Hence, fortification of fonio flour with inexpensive staples such as legumes helps in improving the nutritional quality of fonio product [9]. Fonio flour has been fortified with soya bean flour to improve the nutritional value of weaning food. Infants who were feed with cereal porridge and adult food as a weaning food were malnourished. Malnutrition is a major health problem for children in developing countries [5] and also contributes to infant mortality, poor physical and intellectual development of infants as well as lower resistance to diseases. Protein–energy malnutrition occurs when children are weaned from liquid to semi solid food. During this period, children need nutritionally balanced calorie–dense supplementary foods in addition to mothers' milk because of the increasing nutritional demands of the growing body [10]. Weaning food plays a vital role in the all round growth development and mental health of children. Introduction of weaning food too late or too early can lead to malnutrition [11]. Poor nutritional quality and inadequate quantity of weaning foods have negative impacts on the child. They affect growth, mental development and increase infant morbidity and mortality [12, 13]. As a result of these, there is need to formulate nutritious weaning food using fonio/acha and soya bean. In developing countries, 70% of weaning foods are supplied by cereals which are relatively poor source of protein. Formulations of nutritious weaning foods from locally and readily available raw materials have received a lot of attention in many developing countries [14]. Since most commercially available weaning foods are expensive and not affordable by low income mothers. The problem of malnutrition in infants can be solved by introducing nutritious weaning food by formulation of weaning food using fonio/acha *(Digitaria exilis Stapf*) and soya bean (*Glycine max).*

2. Materials and Methods

2.1. Sample Collection, Processing and Formulation

2.1.1. Samples Collection

Fonio/acha and soya beans were purchased from Eke Awka market in Anambra State, Nigeria. The major reasons for choice of these grains were the high nutritional value of soya bean, affordability to consumers and the yield and availability of fonio/acha.

2.1.2. Samples Preparation and Processing

Soya bean seeds were sorted and cleaned. After washing, the seeds were cooked for 30 minutes then drained and washed with water. The soya bean seeds were soaked in water for 24 hours with six hourly change of water. The tasta were removed and then washed. The dehulled seed were dried in the oven at 110°C for 1hour. Then dried milled and sieved with a 0.6mm sieve. Soya beans flour were obtained and stored in an air tight container.

Fonio were sorted and cleaned. After washing, it was boiled for 5 minutes and drained. The grains were steeped in water for 24 hours. Then drained and washed with water. The grains were dried in the oven at 110°C for 1hour. Then dry milled and sieved with a 0.6mm sieve. Fonio flour was obtained. All the samples were stored in an air tight container. All the chemicals used for the analysis were of analytical grade.

Flow Chart of Processing of Fonio and Soya bean flours were shown in Figures 1 and 2

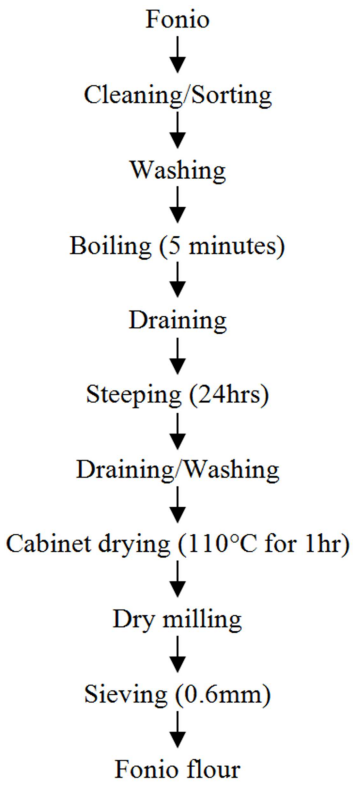

Figure 1. *Flow Chart of Processing of Fonio flour.*

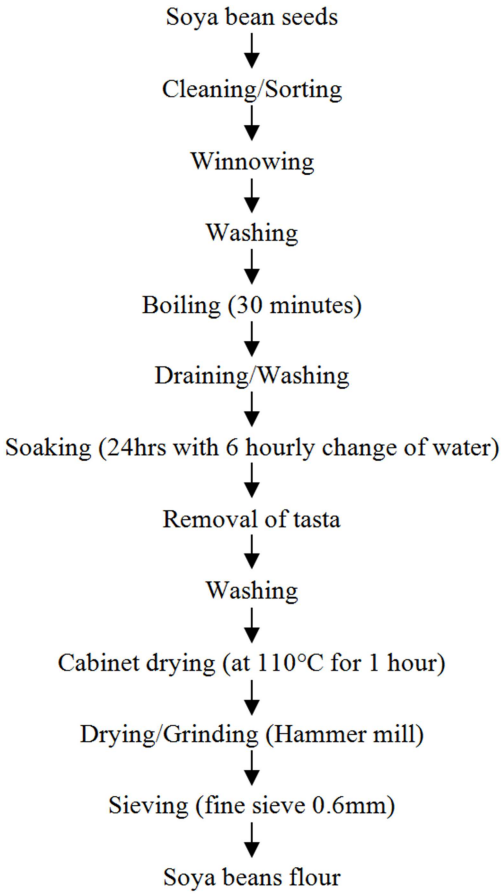

Figure 2. *Flow Chart of Processing of Soya beans flour.*

2.1.3. Formulation of Weaning Food

Four formulated composite A, B, C and D were prepared by mixing in varied proportion of sample powders. The compositions of the sample on dry weight are given in Table 1 below.

Table 1. *Percentage composition of the formulated weaning food.*

Composites	Cooked fonio	Cooked soya beans
A	50	50
B	60	40
C	70	30
D	80	20

2.2. Proximate Chemical Analysis

Proximate analysis was carried out on the cooked fonio flour and soya beans flour and also on each of the formulations. The moisture content, crude protein, crude fat, crude fibre and ash content were determined based on the official methods of analysis [15]. Crude protein was determined by micro kjeldahi method. Crude fat was determined by soxhlet extraction method. Carbohydrate content was estimated by difference [16]. The food energy level was determined by calculation using the Atwater factor [17, 18]. The mineral contents such as potassium, copper, iron, phosphorus, magnesium, calcium, sodium and zinc were determined by Atomic Absorption Spectrophotometer [19]. Vitamins such as vitamin A, B_1, B_2, and C were also determined.

3. Results and Discussion

The results of the proximate chemical analysis of the food samples are given in Table 2.

Table 2. *Proximate Chemical Composition of the Formulated Weaning Foods and Commercial Products.*

Samples	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Fat (%)	Carbohydrate (%)	Energy (Kcal/100g)
A	3.20	3.30	29.00	3.50	11.00	50.00	415.00
B	3.00	3.20	25.00	3.30	10.00	55.50	412.00
C	2.50	3.00	20.00	3.00	10.00	61.50	416.00
D	2.00	2.80	17.50	2.70	8.00	67.00	410.00
Nutrend	4.00	2.30	16.00	5.00	9.00	63.70	400.00
Cerelac	2.50	3.30	15.00	2.80	9.00	67.40	411.00

Where:
A = 50: 50 Cooked fonio + cooked soya beans.
B = 60: 40 Cooked fonio + cooked soya beans.
C = 70: 30 Cooked fonio + cooked soya beans.
D = 80: 20 Cooked fonio + cooked soya beans.

The results of the proximate chemical composition of the samples powder are shown in Table 3.

Table 3. *Proximate Chemical Composition of the Samples Powder.*

Samples	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Fat (%)	Carbohydrate (%)	Energy (Kcal/100g)
E	6.00	3.50	31.00	4.00	10.00	45.50	396.00
F	7.00	4.50	36.50	4.50	11.50	36.00	393.50

Where:
E = Cooked Fonio.
F = Cooked Soya beans.

The results of the mineral contents of the formulated weaning food are shown in Table 4.

Table 4. *Mineral Contents of the Formulated Weaning Food.*

Minerals Contents	A	B	C	D
Potassium (mg/100g)	26.10	24.60	20.30	14.30
Copper (mg/100g)	26.42	25.21	24.93	22.98
Iron (mg/100g)	4.91	4.73	3.72	3.70
Phosphorus (mg/100g)	58.60	54.94	47.44	37.50
Magnesium (mg/100g)	3.73	8.95	12.68	13.43
Calcium (mg/100g)	1.29	1.86	2.57	4.29
Sodium (mg/100g)	2.80	2.80	2.80	2.80
Zinc (mg/100g)	Nil	Nil	Nil	Nil

The results of the vitamin contents of the formulated weaning food are shown in Table 5.

Table 5. *VitaminContents of the Formulated Weaning Food.*

Samples	Vitamin A (mg/100g)	Vitamin B_1 (mg/100)	Vitamin B_2 (mg/100)	Vitamin C (mg/100)
A	376.44	8.85	8.84	156.80
B	732.10	8.60	7.30	175.20
C	1020.79	8.40	3.00	180.00
D	1221.71	8.20	2.60	191.20

From Table 2, Moisture content is one of the outstanding qualities and widely used parameter in the processing and testing of food. It was found that moisture contents range from 2.00%–3.20%. Sample A has the highest moisture content of 3.20% followed by sample B (3.00%). The moisture content of sample C is 2.50% which is the same with moisture content of the commercial product (Cerelac). Sample D has the least moisture content of 2.00%. Nelson [20] reported that moisture content is used as a quality factor for prepared cereals which should have 3–8% moisture content. The low moisture contents of the formulations requires for the convenient packaging and transport of the products [21]. Low moisture content could be an advantage to the keeping quality and shelf life of the products. Therefore, there is less microbial growth when moisture is less available.

The ash content gives an indication of mineral composition of the blends [22]. The ash contents of the formulations ranged from 2.80% – 3.30%. Sample A has the highest ash content of 3.30% while sample D has lowest ash content of 2.80%. Although A, B, C and D has low ash contents, they are acceptable by the Protein Advisory Group [23] standard which recommended that the ash content should not exceed 5.00%. The ash content indicates the presence of mineral matter in food. It is a non organic compound that constitutes the mineral content of food. It aids in the metabolism of other compounds such as protein, fat and carbohydrate [24].

Protein is one of the most important nutrients required in weaning foods [25]. FAO [26] recommended a minimum of 20.00% of protein. Sample A, B and C were within FAO recommended values while sample D was below FAO recommended value of 20.00%. Sample C has the protein content of 20.00% which is within the FAO [26] recommended value of weaning food. Sample D had a protein content of 17.50% which is still higher than the commercial product (Nutrend and Cerelac). Sample A has the highest protein content of 29.00%. The high protein contents of the formulation were contributed by the fonio and soya beans. According to FAO/WHO [27] a minimum protein content of 15.00% is required for maximum complementation of amino acids in foods, thus the formulations satisfy the protein demand of infants. Proteins provide calories and also the amino acids necessary for building and maintaining body tissues and regulating body processes. The deficiency of protein in infants leads to kwashiorkor [28]. The crude fibre contents ranged from 2.70–3.50%. It is known that fonio flour is good source of dietary fibre which are used in prevention and treatment of constipation, cardiovascular diseases and hypertension [29]. The health benefits of fonio/acha product are now widely recognized and considered to result from the presence of bioactive components including dietary fibre and phytochemicals [30].

The fat contents of the formulations ranged from 8.00%–11.00%. The fat content of sample D differed significantly from the other three blends. Sample D has the lowest fat content of 8.00% which is below the FAO recommended value of 10.00% [26]. The low fat content resulted to the low energy level of the blends. The storage life of the blend may increased due to the fat content because all fat containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity [1] and when exposed to hot air rancidity will not be encouraged. The low fat content of sample D of these formulation is however lower than that of Nutrend and Cerelac infant formula. Fat are very essential which deficiency in infants leads to growth retardation. A fat composition of 10.00% in formulations B and C correspond to the FAO recommended fat level for weaning foods [23] which is 10%. The fat content of a food sample can affect its shelf stability. This is because fat can undergo oxidative deterioration which leads to rancidification and spoilage. Hence a food sample with high fat content is more liable to spoilage than one with a lower fat content. Furthermore, high intake of fat especially saturated fatty acids has been shown to increase the level of cholesterol in the blood; however, this is not the case with unsaturated fats such as fat found in soya bean [31] and cereals [32, 33]. This implies that the products would supply the needed energy to

meet infant growth demands.

The carbohydrates also contribute to bulk of the energy of each of the formulation. From the result obtained, sample D has the highest carbohydrate value of 67.00%, followed by sample C with 61.50% which is similar to the values of commercial products (Nutrend and Cerelac). Then sample B has 55.50% and the least carbohydrate content is sample A which is 50.00%. The high carbohydrate contents of these weaning food blends makes then ideal for babies since they require energy for their rapid growth.

The energy content of these formulated weaning food blends ranged from 410.00 Kcal/100g–416.00Kcal/100g. Sample C has the highest energy content of 416.00 Kcal/100g. There was no significant difference in energy content of the blend. The energy content resulted from the high carbohydrate content. The energy contents of the formulated products showed that the products are rich in energy.

From Table 4, the mineral contents of the formulated weaning foods falls within FAO recommended values [26]. It can be observed that, potassium, magnesium, calcium, phosphorus, iron and sodium are the major elements available in the formulations while copper and zinc are the minor elements. Iron and potassium were highest in sample A (4.91 and 26.10mg/100g) and lowest in sample D (3.70 and 14.30 mg/100g) respectively. Iron is an important mineral needed to form haemoglobin, which is the pigment in red blood cells responsible for transporting oxygen in the blood while potassium helps to maintain cell membranes. Deficiency of iron in children causes anaemia. On the other hand, calcium and magnesium were lowest in sample A (1.29 and 3.73 mg/100g) and highest in sample D (4.29 and13.43 mg/100g) respectively. Calcium contents of the formulated weaning food are needed for development of the bones and teeth while magnesium is important for maintaining the nerve and muscle cells.

From Table 5, the formulated weaning food contained good amounts of vitamins which are necessary for metabolism and proper growth in children. Sample C blend can equally supply approximately the same proportion of nutrients, which shows that it is a standard weaning formulation for infants. Since its taste, texture, colour, flavour and nutrients confirmed to that of the commercial weaning food. Vitamin A helps in maintenance of the skin and vision. Deficiency of vitamin A in children causes night blindness and excessive skin dryness. Vitamin B_1 (thiamine) ranged from 8.20–8.85 mg/100g. It plays a role in the synthesis of nerve regulation. Deficiency of vitamin B_1in children causes beri-beri. Vitamin B_2 (riboflavin) serves as a co-enzyme. Vitamin C is important in the formation and maintenance of collagens, the protein that supports many body structures and plays a major role in the formations of bone and teeth. The deficiency of vitamin C in infants and children causes scurvy (bleeding gum).

4. Conclusion

This study showed that formulation of weaning food from fonio/acha and soya beans can be produced. Analysis carried out showed that the fortified fonio flour is rich in protein, fat and energy. The results of the study revealed that the production of a nutritious weaning food from local foods stuffs using a simple but adequate method that can easily be adopted by many families. When this product is compared with the commercial products, sample C was acceptable and adequate to meet the energy, protein and mineral requirements of the growing infants. This shows that the product fall within minimum and maximum level of nutrient requirements of the infants. A number of convenient commercial weaning foods are now available but they are very expensive. This study revealed that food products formulated from locally available food commodities can meet the macro nutritional needs of infants and children. Therefore, proper formulation and fortification of these local diets can provide nutritious foods that are suitable for weaning children and can be more cost effective. The results also showed that the formulated weaning food prepared from fonio and soya beans had protein content which conformed to the FAO/WHO recommended value. Sample C formulation is therefore recommended as a weaning food for infants and children. This product provides alternatives to the weaning foods in the Nigerian market as well as other countries in the world. The formulation of this weaning food from fonio and soyabeans will also help to minimize malnutrition.

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