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NUTRITIONAL EVALUATION OF WEANING FOOD PREPARED FROM FERMENTED SORGHUM, GERMINATED SOYBEAN AND DEFATTED SESAME SEED

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ABSTRACT

Any item besides breast milk that is given to the infants in any manner represents a weaning food. Experiments were conducted to formulate weaning food from germinated soybean, fermented sorghum flour and defatted sesame seeds. The dried samples were milled separately and formulated as follows: Sorghum-Soybean-Sesame seed consisting of 80% fermented sorghum flour, 10% germinated soybean flour, 10% defatted sesame seed flour, Sorghum-Soybean diet consisting of 80% fermented sorghum and 20% germinated soybean flour and Sorghum-Sesame diet consisting of 80% Sorghum flour and 20% defatted Sesame seed flour. The products were evaluated for proximate composition and used in animal feeding trials. The data obtained were compared with that of a commercial weaning food containing 16% protein, 9% fat, 5% ash and 61% carbohydrates. The protein, fat, ash and carbohydrates contents of the Sorghum-soybean-sesame diet were 24.60%, 12.69%, 4.65% and 47.70% respectively. There was no significant difference (P>0.05) when Sorghum-soybean diet (containing germinated grains) was compared to the control but significant difference (P<0.05) was found when Sorghum-sesame diet (ungerminated diet) was compared to the control. The bioassay parameters: Protein Efficiency Ratio (PER) 3.22 and Net Protein Ratio (NPR) 4.20 for soybean-sesame-ogi when compared with the PER 4.10 and 4.62 for commercial diet were favourable. The results from this study had shown that germination of grains and mixing of digestible plant protein offer a good potential in the formulation of weaning (complementary) food suitable to improve infants feeding.

Keywords: Breadfruit, Breadnut, Groundnut, Weaning, Proximate composition

INTRODUCTION

Breast milk is the perfect food for the infant during the first six months of life. It contains all the nutrients and immunological factors an infant requires to maintain optimal health and growth (UNICEF, 1999). Breastfeeding is a caring practice (Dewey & Brown, 2003) and it is also a unique form of infant care that has been shown to be very important for infant development (UNICEF, 2000). It has been discovered that in the first year of life, infants undergo periods of rapid growth when good nutrition is crucial (Davis, 2001). In fact, nutrition in the early years of life is a major determinant of healthy growth and development throughout childhood and of good health in adulthood (WHO, 2000). Infant generally show satisfactory growth during the first six months of life when they are almost exclusively breastfed (Pelto et al., 2003). Childhood malnutrition is very common in developing countries (FAO, 2004). This is because infants at this stage of development require a higher energy and proteins in their diet so as to meet increasing demand for metabolism. The amount of nutrients provided by complementary foods should be covered by the daily nutritional requirements beside the human milk (WHO, 2001).

Appropriate breastfeeding and complementary feeding practices are fundamental to infant's nutrition, health, and survival during the first two years of life. Infant feeding in the early years of life influences an individual's whole life. Therefore, the nutritional adequacy of complementary foods is essential for the prevention of infant morbidity and mortality, including malnutrition and overweight. The linear growth retardation acquired early on in infancy cannot be easily reversed after the second year of life. In this context, providing infants with optimal feeding should be the key objective of a global strategy to guarantee the nutrition safety of a population.

The period from birth to two years is the "critical window" for the promotion of optimal growth, health and development. Breast feeding alone will not meet the child nutritional requirement after six months (Elemo *et al,* 2011). Insufficient quantities and inadequate quality of complementary foods, poor child-feeding practices and high rates of infections have a detrimental impact on health and growth in these important years. Even with optimum breastfeeding children were stunted if they do not receive sufficient quantities of quality complementary foods after six months of age (FMOH, 2005). Among many approaches needed to improve child survival and growth in developing countries is the provision of safe and nutritious infant foods (Pelto *et al.,* 2003). In developing countries like Nigeria, one of the greatest problems affecting millions of people, particularly infants is lack of adequate protein in terms of quality and quantity. Evidence has shown that protein deficiency is a major nutritional problem among children and has hindered health, especially mental capability, school performance and productivity, thus affecting the country's economic growth (Ijarotimi and Famurewa, 2006). Weaning is a gradual process of introducing solid foods to an infant's diet alongside breast milk from the age of three to four months, at this stage, breast feeding alone cannot meet the infant nutritional requirements. Most often poverty and lack of nutritional knowledge are some of the major factors attributed to this low protein intake, resulting in the child not getting adequate nutritional requirement (Berkman and Kawach, 2000).

Traditional weaning foods in Nigeria and most parts of West Africa consist of single monocereal grains prepared from either fermented millet, maize or sorghum into gruels referred to as ''Akamu" or 'Ogi' which is of poor nutritional value (Gazhim *et al*., 2015). About 40% of the Nigerian population live below poverty line and cannot afford commercial weaning foods for their infants or good quality animal source of protein (Elemo *et al*., 2011). Thus, protein energy malnutrition can be said to be a major problem that frequently occurs during the important transitional phase of weaning in infants, thereby affecting the physical and mental growth of many infants in developing countries. WHO, (2001) estimate is that about 150 million children under the age of five in developing countries are mal-nourished and an additional 200 million have stunted growth. The problem of protein energy malnutrition can be prevented by introducing weaning foods of the correct protein quality and quantity at the right stage of the weaning period (FAO/WHO/UNU, 1985).There is therefore the need for strategic use of inexpensive high protein sources that complement the protein quality of these staple food crops in order to enhance their nutrition value (Nnam, 2002). Traditional weaning foods could be improved upon by combining locally available foods that complement each other in such a way that new pattern of protein quality created by this combination is similar to that recommended for infants (Okafor *et al.,* 2008). This research work aimed at processing and evaluating the formulated weaning food from germinated soybean flour, fermented sorghum flour and defatted sesame seeds flour.

MATERIALS AND METHODS

Procurement and processing of the Complementary Diets: Sorghum, Soybean and Sesame seed were purchased at the Ife central market while the commercial baby food was purchased from one supermarket in Ife. The vitamin and mineral mix used were obtained from Pfizer Nigeria PLC but mixed by the researcher (FAO, 1970). Thirty albino rats (Wister Strain) of both sexes were obtained from the Department of pharmacology and physiology, University of Ibadan, Nigeria.

Preparation of Diets: The experiment included the preparation of fermented sorghum flour, germinated soybean flour, defatted sesame seed flour and formulation of the experimental diets. Also analysis were based on determination of proximate analysis, with further test which were conducted using animal experimentation and the analyses of animal tissues for the estimation of protein qualities.

Preparation of fermented sorghum flour: The grains were cleaned and steeped for 48 hours to encourage fermentation. The fermented sorghum was then washed and dried after which it was dry milled and sieved to obtain fine sorghum flour, packaged in a polythene bag and stored in the refrigerator. The flow chart is as shown in scheme 1.

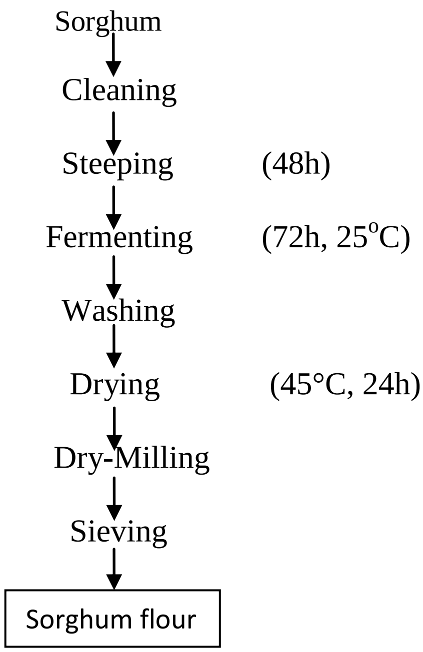
Preparation of germinated soybean flour: The soybean seeds were sorted, cleaned and steeped for 6 hours and germinated for 48 hours in the germinating chamber with watering three times daily. After germination, it was thoroughly washed and dried in the cabinet dryer at 45°C for 24 hours. The dried sprout soybean seeds were then cleaned by winnowing and then dry-milled into flour, sieved and packed. This was then stored in the refrigerator. The flow chart is as shown scheme 2.

Preparation of defatted sesame seed flour: The seeds were cleaned, floating seeds and unwanted materials were removed by floatation method. The seed were thoroughly washed, after which they were dried and roasted. They were later milled and defatted using soxhlet extractor. The resulting product was dried and packed. The flow chart is as shown in scheme 3.

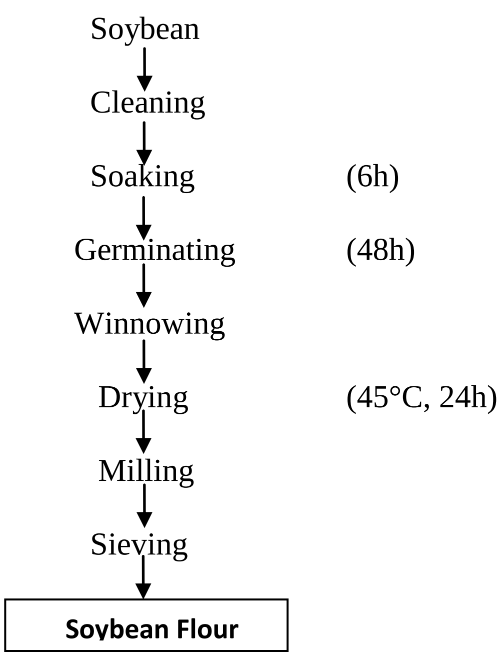
Mineral and vitamin mixtures

Mineral: The mineral mixture in gram per kilogram of the corn flour contained 5 .40g calcium, 4.30g phosphorus, 0.0lg iron, 1.60g sodium, 6.60g potassium, 0.035g Zinc. This was mixed for 10 minutes using Kenwood mixer (FAO, 1970).

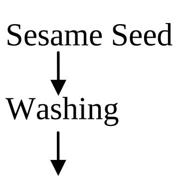
Vitamin Mixture: The vitamin mixture in milligrams per 50gram of corn flour contained 3.0mg vitamin A, 0.60mg vitamin D, 300mg vitamin E, 350mg vitamin C, 0.25mg folic acid, 8.0mg thiamine, 3.0mg riboflavin, 40mg niacin, 3.0mg vitamin B6, 0.075mg vitamin B12, 2.5mg biotin and 15.0mg pantothenate and starch to make up to 50g. This was thoroughly mixed for 10 minutes using kenwood mixer (FAO, 1970).

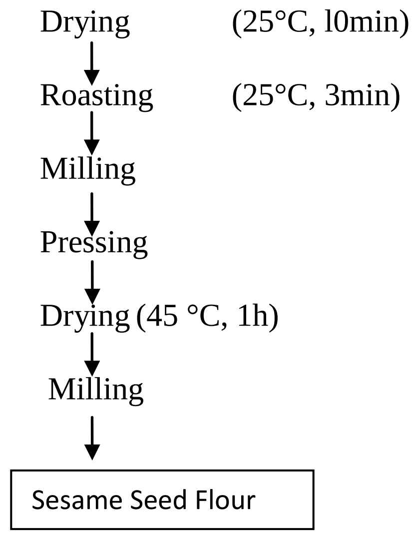


Scheme. 1: Flow chart for the preparation of sorghum flour.



Scheme 2: Flow chart for the preparation of germinated soybean flour.





Scheme 3: Flow chart for the preparation of sesame seed flour.

Formulation of the Dietary Sample

Basal Diet: The basal diet was formulated according to Adepeju and Abiodun (2011). The diet contained per kilogramme, 809g of Fermented Sorghum flour, 60g of sugar, 100g vegetable oil, l0g vitamin mix, 16g mineral mix, 5g cod liver oil (A basal diet does not contain protein). The individual ingredients were weighed into kenwood mixer for a period of 10 minutes after which it was packed in a plastic and stored in the refrigerator.

The Experimental and control diets: The basal diet was mixed with individual protein source as recommended to achieve an Isonitrogenous diet at 10% protein level. The protein content of the experimental diets was reduced to the same level and they were named the isocaloric diets.

Soybean-Ogi diet: The soybean—ogi, was formulated in the ratio 2:8. The soybean was 200g, sorghum flour or Ogi, 609g, l0g vitamin mix, 16g mineral mix, 60g sugar, 100g vegetable oil and 5g cod liver oil. The ingredients were then mixed in the kenwood mixer for 10 minutes, packed in a plastic container, labeled soybean-ogi, and stored in the refrigerator.

Sesame-Ogi – Diet: The ratio of sesame to ogi was 2:8. It contains 200g sesame seed flour, 609g sorghum f1our, 10g vitamin mix, 16g mineral mix, 60g sugar, l0g vegetable oil and 5g cod liver oil. This was also mixed in the kenwood mixer and tagged sesame— ogi. It was then packed in a plastic container and stored in the refrigerator.

Soybean-Sesame-Ogi Diet: This was formulated in the ratio 1:8. 100g soybean flour, l00g sesame seed flour, 609g of sorghum flour, 16g mineral mix, l0g vitamin mix, 60g sugar 100g vegetable oil and 5g cod liver oil. These are also mixed in the kenwood mixer, packed, labeled as soybean-sesame-ogi and stored in the refrigerator.

Commercial Diet: Commercial baby food, which is a cereal with vegetable based protein, was used in this work as a control for the formulated diets. The nutrient composition of the commercial baby food is shown in Table 1.

Table 1: Proximate analysis of the commercial baby food (Per 100g).

Protein	16.0
Ash	2.0
Crude fire	5.0
Fat	9.0
Moisture	4.0
Carbohydrate	64.0

Source: Nestle Nigeria Plc, 2014

Experimental Animals: In most biological assay experimental rats (Wister Strain) are used because their diets and metabolism are similar in many respect to those of man (Adepeju and Abiodun, 2011). Thirty weanling rats of both sexes of varying weights (27-50) g were obtained from the Department of Pharmacology and physiology, University of Ibadan. They were weighed and randomly distributed into six groups. The average weight per group was approximately the same. One group of five animals served as the control for the experimental group and was sacrificed. Tissue from the liver, kidney and plantaris muscle of the hind-leg were removed, weighed and frozen till nitrogen was determined.

The remaining animals were placed on the experimental diet fed *ad libitum* over a period of twenty eight days. During the period dietary intake per day and weight of the animals were recorded.

Proximate Analysis: Proximate analyses of commercial (control) and experimental diets were carried out using AOAC (2000) methods. The organs such as the muscle, liver and kidney were collected and examined. Net protein ratio (NPR) and Protein efficiency ratio (PER) were calculated

RESULTS

Table 2: The proximate composition of dietary samples in grams per 100g of diet (Mean ±SEM)

Dietary sample	Protein	Fat	Crude fibre	Moisture	Ash	Carbohydrate	Energy (kCal)
Diet A	19.33±0.02	9.64±0.02	3.40±0.03	7.20±0.02	4.32±0.05	56.11± 0.01	388.52±0.10
Diet B	17.50±0.20	10.85±0.02	3.21±0.04	7.46±0.03	4.10±0.02	56.88± 0.02	395.17±0.20
Diet C	24.60±0.10	12.69±0.02	3.26±0.02	7.10±0.02	4.65±0.04	47.70± 0.02	403.41±0.10
Commercial	16.00±0.10	9.00±0.20	5.00±0.02	4.00±0.04	5.00±0.02	61.00± 0.03	401.00±0.30

DIET A-Soybean-Ogi   Diet B-Sesame-Ogi   Diet C- Soybean-sesame-Ogi

Table 3. Weight of various tissues of the experimental animals.

Dietary sample	Liver	Kidney	Muscle
Diet A	2.74±0.02	0.62±0.02	0.90±0.02
Diet B	2.96±0.01	0.64±0.01	0.95±0.01
Diet C	4.08±0.03	0.85±0.05	1.59±0.02
Commercial	4.14±0.02	0.84±0.01	1.63±0.02
Basal	1.36±0.10	0.20±0.01	0.38±0.01
Control (zero-day animal.)	1.83±0.02	0.29±0.02	0.40±0.02

Table 4: Protein efficiency ratio (PER) and Net protein ratio (NPR) of dietary sample (Mean ± SEM)

DIETARY SAMPLE	PER	NPR
Diet A	3.06±0.01	3.82±0.02
Diet B	2.04±0.01	2.10±0.05
Diet C	3.22±0.02	4.20±0.02
Commercial	4.10±0.01	4.62±0.03

Diet A - Soybean-Ogi   Diet B - Sesame-Ogi   Diet C - Soybean-sesame-Ogi

Table 5: Total protein level (mg/N) in various tissues of experimental animals

Dietary sample	Liver	Kidney	Muscle
Diet A	82.04±0.10	50.19±0.10	46.22±0.20
Diet B	74.10±0.22	48.71±0.20	46.15±0.11
Diet C	94.20±0.05	64.24±0.10	60.06±0.25
Basal	50.46±0.04	30.22±0.40	28.14±0.10
Commercial	110.42±0.02	78.20±0.20	76.19±0.10
Control(zero day animal)	60.22±0.20	32.21±0.22	31.42±0.10

* The zero day animals (control) are the animal sacrificed on the first day of the experiment. The tissues collected from these animals served as the initial level for the other animal's tissues at the end of the experiment.

DISCUSSION

Proximate Composition of the Dietary Samples

Table 1 show the proximate composition of the dietary samples. From the table, the protein in all the diets compared well with the control diet. There protein contents meet the normal required standards set for infant diet (FAO/WHO, 1992).

The high fat content obtained in sesame-ogi may be due to the fact that sesame seed is an oilseed (despite the defatting). The fat content in sesame-ogi diet meets the normal required standards recommended for infant diet (FAO/WHO, 1992).

Both soybean and sesame seed increased the protein content of ogi by five and four times respectively since Ogi averagely contains 3.40g/l00g (Banigo and Miller,1982). The crude fibre content of the soybean-sesame-ogi, soybean-ogi and sesame-ogi, are 3.26%, 3.40% and 3.21% respectively. These values are low as compared with that of the control diet. A very low level of fibre content in weaning food has been recommended (Desikachar, 1980). The low fibre content will encourage high digestibility and absorption of the diets by the infants.

For moisture, ash and carbohydrate contents, the moisture content of all the diets were higher than that of the control diet. However these values still fall within the expected range for weaning diet which must not exceed 10%. The high value of moisture content may be due to the type of drying technique used for the production of the constituents' ogi flour, soybean and sesame flours in the diet preparation as well as packaging and storage conditions. The cabinet drier was used. The ash content of the diets were lower than that of the control diet but falls within the recommended value for weaning food which must not exceed 5%.

The carbohydrate content of the diets were obtained by difference. It indicated the caloric or energy values of the diets and were found to be 56.11 g, 56.88 g, 47.70 g, and 61.00 g and for soybean-sesame-ogi, sesame-ogi, soybean-ogi and commercial diet respectively.

Animal Feeding Experiment: During the 28-days experimental period the adaptation of the animals fed on each dietary sample and utilization of each diet were studied. Food and water were given to the animals *ad libitum.* The animals that depend on the basal diet for their survival were found to become leaner and weaker each passing day of the experiment. Changes were observed on their skin and in their consumption rate. Loss of weight was dramatic from average weight of 33.28 gm at day one to 21.40 gm at the twenty eight days, even an animal died in this group. This implies 'Ogi," has a protein of poor biological value and does not support growth in rats (Fashakin *et al*., 1991). On the other hand, the animals fed with other diets increased in weight especially in the commercial diet group followed by the soybean-sesame-ogi, then by the soybean-ogi and lastly by sesame-ogi as shown in figure 1

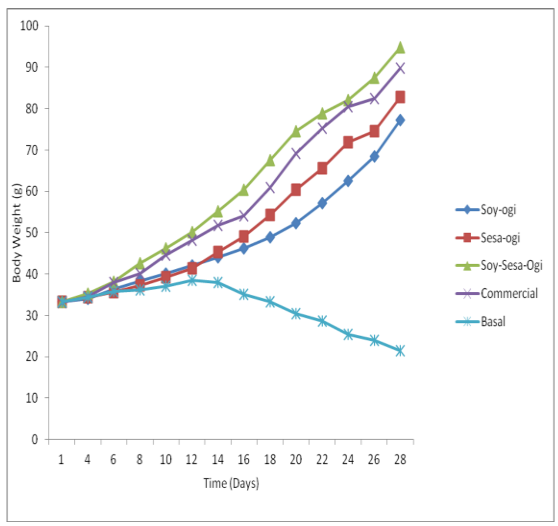


Figure 1: Effect of Diet on Body Weight of Animals

There was a great vitality exhibited by the commercial diet group throughout the experiment. The soybean-sesame-ogi group followed the control (Commercial) group closely in all respects in the latter days of the experiment. On comparing the rate of consumption of the diets, the rate at which soybean-sesame - ogi was consumed by the animal was high but a bit lower than that of the animal fed with the Commercial diet. When the animals were sacrificed, the tissues from liver, kidney and muscle were collected and examined. The tissues of animal.fed on basal diets were found to be very small and indeed much smaller than those of animals from other experimental groups. The livers were paled. There was large fat deposition in and around the adipose tissues of the animals fed commercial diet because of its composition.

Weight of the various tissues of the experimental animals: The efficacy of the mixture of vegetable protein over the use of individual protein was further investigated by the weight of various tissues as given in Table 3.The livers of animals in the soybean-sesame-ogi found to carry the highest weight when compared with that of the soybean-ogi diet and sesame-ogi diet groups. There was no significant difference (P>O.01) in weight of tissues of soybean-sesame-ogi group animal and Commercial diet group. The weight of kidney of sesame-ogi diet group was almost same as that of soybean-ogi group but higher than that of basal diet group.

Protein Efficiency Ratio (PER) and Net Protein Ratio (NPR) of Dietary The calculated PER values which is the Protein Efficiency Ratio calculated with the formula, weight gain per amount of protein consumed and the Net Protein Retention (NPR) are indicated on Table 4. The mean PER values are 4.10, 3.22, 3.06 and 2.04 for commercial, soybean-sesame-ogi,

soybean-ogi and sesame-ogi respectively. The most favourable values were apparent in groups treated with commercial (control) and soybean-sesame-ogi whereas PER and NPR were inferior in groups receiving individual protein sources. The soybean-sesame-ogi compared fairly well with commercial which further confirmed its efficacy. The values of PER obtained in these diets exceeded the recommended values which is 2.1 (FAO, 1970). This shows that all the diets were far above the recommended requirement. This further indicated that germination improves the nutritional quality of protein products when measured by PER (Fasakin *et al,* 1991) The NPR values followed the same pattern with commercial taking the lead, followed by the mixed diet and then soybean-ogi and finally by sesame-ogi groups. Soybean-Ogi diet compared well so far with soybean-sesame-ogi due to the effect of germination which tends to improve the nutritional quality of protein.

Total protein level (mg/N) in various tissues of experimental animals: The total protein level in the tissues is shown in Table 5. The animals in the Commercial group showed a clear lead over all other groups followed by the animal fed with the soybean-sesame-ogi group. This was due to the presence of protein mixture (soybean and sesame) in the formulation of soybean-sesame-ogi diet and also due to the effect of germination of the legume. The soybean-sesame-ogi supplied complementary amino acid to each other for example; the presence of methionine, lysine and tryptophan in the sesame seeds compensated the limiting factors of this amino acid in the soybean. Thus, the soybean-sesame-ogi was close to the concept of an amino acid profile characteristics of an ideal protein.

CONCLUSION

Based on the findings of the investigation it may be concluded that local resources have great potentials in the formulation and preparation of infant weaning foods. Since most Nigeria children are already accustomed to weaning preparation from sorghum, or other cereal gruels, the greatest task was to improve the protein contents of these weaning foods. This is achieved by the application of soybean, sesame and ogi mixture.

This work also shows that germination or sprouting played significant roles in the digestibility of the soybean-sesame-ogi. It was thus concluded that soybean-sesame-ogi diet was potentially viable in the formulation of an infant weaning diet. The implication of these finding is far reaching since all the components used in the formulation were obtained from local resources. This would indicate that the product would be cheaper and more accessible. When produced on a commercial scale, it will go a long way in ameliorating the usual symptoms of Protein — Energy - Malnutrition (PEM) commonly prevalent in the developing country such as Nigeria.

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