Nutritional Quality of Infant Formulated Diet from Plant-Based Milk.

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ABSTRACT

Traditional complementary foods are with limiting nutrient quality and can be fortified using protein rich crops like soy bean, coconut and almond seeds. This research thus aimed at investigating nutritional quality of infant formulated diet from locally underutilized almond seeds, soybeans and coconut. The milks were produced from locally accessible plant –based vegetable. The energy was supplied from cereals and tuber. Proximate composition and sensory evaluation of each product was determined in pediatric ward of women and children primary health care Bauchi, Bauchi State of Nigeria. Protein contents was significantly different (p< o.o5) varies from 18.34-12.64%. The weaning formula with soy milk has maximum protein contents while almond milk formula recorded lowest. The scores of aroma and mouth feel for diet (I) was significant (p < 0.05) lower than diets (II and III). The weaning foods composite plant- based milk can be a cost-effective and possible tool to overcome malnutrition among children in developing countries.

Keywords: Plant-based, milk, infant, formulation, diet.

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1. INTRODUCTION

World's population increase by over 9 billion and almost ten million people are determined to be protein or energy malnourished (Alexandratos and Bruinsma, 2012). By 2050, it would be needed two times more food production as compared to recent food production worldwide to meet the demand of the times. Nutritionists and other scientists follow similar observations that animal and plant sources will play a more important role in fulfilling the increased future food and energy requirements worldwide (Alexandratos and Bruinsma, 2012; Sass et al., 2020). Sufficient nutrition requirements through infancy and early childhood are necessary for the growth of a beach child's full human potential. It is fully noticed that the first 2 years of children's age is a "critical window" for the development of health, optimal growth, and behavioral improvement.

When a child attains 2 years of age, it is quite challenging to change the stunting that has happened earlier (Bernard et al., 2016). The instant results of inadequate nutrition throughout these developmental years include significant delays in motor and mental growth and significant morbidity and mortality. So, this early stage of nutritional deficiency is associated with impairments in mind (Bernard *et al.*, 2016; Martorell et al., 1994). Complementary feeding starts when mother milk individually no longer adequate to satisfy the nutritional demands of infants.

So, that's why the other liquids and foods are required, accompanied by mother milk. Complementary feeding commonly starts at 6 months up to 24 months of age (United Nations Children's Fund, 1998). More than one-third of child mortality occurs due to nutrition deficiency and from extended severity of disease (Addis et al., 2013). In Africa, the most common forms of malnutrition are protein-energy malnutrition (PEM), vitamin A, iodine, and Iron deficiencies as recommended by UNICEF, (2014) also responsible for about one-half of deaths among children under five years (World Health Organization, 2014).

Fruits and vegetables possibly beneficial origins of micronutrients and can be used for the formulation of complementary foods. The quality of protein can be enhanced by the incorporation of foods from both plant and animal source (Bernard *et al*., 2016; Roobab et al., 2020). Several types of weaning foods are marketed in market but due to high cost, only available for 30% of the infant community. Rural mothers, that's why to rely on accessible low-cost complementary foods to wean their children, these household foods may not provide the needed nutrients for the infant; hence the demand for substitute sources that will be increased which is affordable for everyone. Because of this nutritional issue, various approaches have been applied to form weaning food, by using the combination of locally accessible foods. This study aims to formulate complimentary instant food from locally accessible, underutilized components (coconut milk, almond milk, soy milk, carrot, banana, date fruit, beetroot, immature green beans and local white rice) which will provide the needed nutritional demand for infants and will be available and affordable to all mothers.

Coconut milk is rich nutrients. It mostly contains fat that are good for the body. Babies need essential fats for brain development, insulation and for benefits of their skin (Victor, E.E. 2014). It contains several vitamin and minerals like iron, magnesium, zinc, vitamin C and E. All these nutrients can help in maintaining baby's good health, development and boosting immunity (Elvira, V.*et al.,* 2012). Other protein supplements include soy milk and almond milk. They are great substitute for babies who have dairy allergies. The use of soy milk was first reported about 2000 years ago in China. Soy milk was the first plant-based milk which served the purpose of providing nutrients to a population where the milk supply was inadequate Singhal, Baker and Baker (2017). Soy beverage contains much lower carbohydrates and fats compared to CM. Therefore, it has a lesser energy value, while the protein supply is also lower. Regarding the lipidic profile, it contains low levels of saturates, while it represents a good source of trans fats, MUFA, and PUFA (ALA and LA).Regarding micronutrients, it contains isoflavones probably responsible for the beneficial effects of soy against cancer, cardiovascular disease, and osteoporosis; phytosterols widely recognized for their cholesterol-lowering properties .

Soy drink shows calcium and vitamin B-12 deficit; for this reason, those micronutrients are often supplemented. The claimed benefits of consuming soy milk include the absence of lactose and cholesterol, high nutritive value, higher protein quality compared to other beverages, and high digestibility Singhal, Baker and Baker (2017). However, these drinks should not be given to younger children (early years of life). In this regard, it is judged necessary to resort to a 3 or 7 days food diary to define the micronutrient intake according to age needs. Unfortunately, a well-known disadvantage of soy milk preparation is a characteristic beany flavor Sethi, Tyagi and Anurag (2016). Furthermore, soy beverage cannot be used in individuals allergic to soy proteins as it may result in possible flatulence. Almond milk, compared to bovine milk, has less protein content while the amount of carbohydrates and fats almost compares to those in CM. Regarding the lipidic profile, it presents fewer levels of saturates and higher levels of trans-fats, MUFA (oleic acid) and PUFA (ALA and LA). Regarding almond milk micronutrients, it has good levels of vitamin E, an important antioxidant, and manganese.

Almonds are also a rich source of other nutrients such as calcium, potassium, magnesium, iron, selenium, copper, and zinc Giovannini et al., (2014). This nutritional profile makes it unsuitable as the only food in a baby's diet. If given as a milk substitute, it would be essential for fortification by adding critical micronutrients like calcium and B12, based on the growing need. The stated benefits of almond milk are the cholesterol-lowering power and potential prebiotic features, which may determine the bifidobacteria growth Singhal, Baker and Baker, (2017). Generally, this drink is nutritionally better than other plant-based beverages, and it represents a good trans-fat and vitamin E source but has downsides too: the prevalence of nut allergies and high price limit the consumption Singhal, Baker and Baker, (2017). Despite its characteristics, it cannot be considered as a milk substitute but as a beverage to be given to children during snack time.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Material and Preparation of Weaned Products

All the ingredients need for the preparation of weaning foods was purchased from the food chemical store in Jos, Plateu State, Nigeria.

2.2 Preparation of Soy Milk

Soybean was prepared using the method described by Nyagaya, (2008). Soybeans were cleaned and soaked in100ml of water for 12hr at room temperature (25°C). After draining the soaking and rinsing with cold water, the beans were ground with 200ml of water of water using a warring laboratory electric blender (HGBTWTG4, USA) and squeezed with muslin cloth and boiled (100°C) for 10mins, package and cooled at temperature 4°C.

2.3 Preparation of Almond Milk

Almond seed was prepared using the method described by Preeti et al., (2018). Almond seeds were cleaned and soaked in 100ml of distilled water for 12h followed by draining and dehulling to reduce the level of oxalic. The dehulleds almonds were ground with water in a blender. The obtained slurry was strained through a two layer muslin cloth to obtain filtrate (almond milk). The almond milk was boiled (100°C) for 10mins, package and cooled at temperature 4°C.

2.4 Preparation of Coconut Milk

Coconut milk was prepared using the method described Victor, E E. and Aniekpeno, I.E (2016). The coconut was dehusked, cracked to separate the meat from the shell while the coconut water was poured into a container and stored for further use. The brown skin of the coconut meat was removed and the meat thoroughly washed and grated using manual grater. The grated coconut meat was mixed in a ratio of 1:1 with a solution containing 75% distilled water and 25% coconut water and allowed to stand in a water bath. The slurry was then pressed and filtered through cheese cloth to remove the solid residue and recover the milk. The milk was pasteurized at 90°C for 30 min and allowed to cool at temperature 4°C.

2.5 Preparation of the Weaning Food

The date fruits and local white rice were sorted to remove defective portion. They were soaked for 6hr. Carrot and green beans were cleaned and cut into small size. These entire ingredients were blended in food processing blender (Kenwood, USA) for 3-4min. The blended slurry was mixed with soy milk and boiled (100°C) for 3-4mins in sauce pan and transfer into serving bowl for further analysis (first formulation diet). The oat, date fruits and green beans were cleaned, cut and soaked with warm water (for 10mins). It was further autoclave at 121°C for 15mins. Then, the beetroot was cleaned, peeled and cut into small size.

The same procedure was followed for almond milk (second formulation diet). The yellow sweet potatoes, date fruits and green beans were cleaned and cut into small size. It was steamed in pressure cooker until after 2-3 whistling. The ripped banana was sliced and blended with steamed potato and green beans. The same procedure was followed for coconut milk (third formulation diets)

Rice, date, carrot and green beans
↓
Sorting
↓
Cleaning (cold water)
↓
Soaking (for 6hr)
↓
Blending
↓
Mixing (soy milk)
↓
Boiling (100 for 3-4mins)
↓
Serving

Oat, date, beet and beans
↓
Cleaning (cold water)
↓
Cutting
↓
Soaking
↓
Blending
↓
Mixing (almond milk)
↓
Boiling
↓
Serving

Potatoes, date, beans and banana.
↓
Cleaning
↓
Peeling and cutting
↓
Steaming (2-3 whistling)
↓
Slicing (approx. 2cm)
↓
Blending
↓
Mixing (coconut milk)
↓
Boiling

Table 1: Formulation chats for infant weaning food from 6-24 month old Formulation Table

Materials	Diet I	Diet II	Diet III
Soy milk	25ml	-	-
Almond milk	-	25ml	-
Coconut milk	-	-	25ml
White rice	50g	-	-
Oat	-	50g	-
Yellow sweet potatoes	-	-	50g
Immature green beans	10g	10g	10g
Date fruits	10g	10g	10g
Carrot	5g	-	-
Beet root	-	5g	-
Ripe banana	-	-	5g

2.6 Physicochemical Analysis of Formulated Diets

The formulated diet products were evaluated for proximate composition i.e. moisture content, crude protein, crude fat, crude fiber, and ash content according to the method described Association of Official Analytical Chemists (2006).

2.7 Sensory Quality Evaluation and Acceptability Test.

The quality of different weaned food products was ranked according to the 9-point Hedonic scale (Meilgaard et al., 2007; Shahzad et al., 2020). The sensory evaluation was carried out at pediatric ward in woman and children primary health center Bauchi metropolis, Bauchi State, Nigeria.

The children age group range from 6month -24month old were used to investigate the acceptability of three (3) different formulated diets (control) using two commercially baby foods milk based and vegetable based were used as controls. Briefing regarding the evaluation was given at the beginning of the session. Each panelist (mothers) was assigned a number for identification purposes and he/she was responsible to evaluate different samples. Samples were coded using a 3-digit random number and served successively. Panelists were asked to fill out a score sheet for each sample they evaluated in term of taste, mouth feel, aroma and overall acceptability. Each sample attribute was rated using a nine-point Hedonic Scale. The nine points on the Hedonic Scale were: dislike extremely = 1, dislike very much = 2, dislike moderately = 3, dislike slightly = 4, neither like nor dislike = 5, like slightly = 6, like moderately = 7, like very much = 8 and like extremely = 9. The average and mean values of scores for each of attributes was computed and analyzed statistically.

2.8 Statistical Analysis

The proximate composition and sensory analysis of the formulated diets samples were statistically evaluated using t-test.

3. RESULTS AND DISCUSSION

The proximate composition of all weaning products presented in Table 1. The results reveal that the moisture contents of all prepared weaning products were inside the normal range of moisture contents (5-10%) as described by FAO/WHO guidelines. Moisture contents were shown variation among all treatments from F_I- F_{III} due to the different percentages moisture content in each material used for the treatment. Moisture contents ranged from 9.5% to 7.2% which indicated that the prepared food can be preserved for a long time. The ash content of food products gives an idea about mineral content and in present research; it varied from 3.0% to 1.8%. The obtained results are comparable with the results published by Aderonke et al. (2014) for complementary diets prepared from soybean, maize, and pigeon pea. The results of the present study are in the recommended range, according to the Protein Advisory Group of the United Nations System (1972), the ash content of weaning foods should not exceed 5%.

The fat contents of the formulated foods significantly ($p < 0.05$) varies from 2.31% to 3.54%. The prescribed level of fat for formulated foods should not be higher than 10% (Protein Advisory Group of the United Nations System, 1972) because if it's higher than it can influence the stability of the weaning foods. A food sample with higher fat contents more porn to spoilage because fat can undergo oxidative decay, which directs to spoilage and rancidification.

The obtained results indicate that the protein content significantly ($p < 0.05$) varied from 18.34% to 12.62% for formulated weaning foods. The highest protein content was observed in F_I. According to WHO/FAO (Reddy et al., 1984), a minimum of 15% protein and a maximum of 25% is needed for the best complementation of amino acids in growth and foods (Sanni et al., 1999). So, this formulation, satisfy the necessary demand for protein for infants. Maximum dietary fiber content of 3.42% were found formulation diet (I) compared to all other formulation. This work is in line with the study of Oche et al. (2017) explained that crude fiber content in the formulated food of soybean and cereals (2.64%) is higher than the mean crude fiber in both proprietary formulae (1.74%) and complies with Protein Advisory Group (PAG) recommendation (<5%). This implies that the formulated food will better promote lactation, bacterial colonization, and maturation of the gastrointestinal tract, but may interfere with mineral absorption more by adsorption (Temesgen, 2013).

Table 1: Proximate composition of weaning products

Parameters	Formulation Diet I	Formulation Diet II	Formulation Diet III
Proteins content (%)	18.34±0.2	12.62 ± 0.4	14.10 ± 0.2
Moisture content (%)	7.20 ± 0.1	8.20 ±0.2	9.50 ± 0.1
Fat content (%)	2.04 ± 0.6	2.31± 0.4	3.54± 0.3
Dietary Fiber (%)	3.42 ± 0.2	2.80 ± 0.2	3.20 ± 0.3
Ash content (%)	3.01 ± 01	2.85± 0.3	1.80 ± 0.5

The sensory evaluation results for all the treatments are significantly ($p < 0.05$) varies and shown in Table 2. The obtained results confirm the average likeness of the formed weaning foods for mouth feel, appearance, color, taste, and aroma. The mean scores ranges of characteristics assessed were: taste (9.0. to 6.4), aroma (9.2 to 6.4), mouth feel (8.5 to 6.8), color (9.2-8.8), and appearance (8.4 to 8.0). The mean score for mouth feel and aroma in weaning formula mixed with soy milk were significantly difference ($p < 0.05$). This might be as a result of beany flavor. Similar findings were also been reported by Bernard et al. (2016) who reported that the taste values, flavor values, texture scores, and overall acceptability scores of all diets ranged between like slightly and like moderately.

Table 2: Sensory attribute of the weaning foods

Parameter	Formulated Diet I	Formulated Diet II	Formulated Diet III
Taste	6.40 ± 0.1	8.20 ± 0.1	8.90 ± 0.2
Aroma	6.40 ± 0.3	8.00 ± 0.2	9.20 ± 0.2
Mouth feel	6.80 ± 0.1	7.20 ± 0.1	8.50 ± 0.4
Color	9.20 ±0.2	9.00 ± 0.2	8.8 ± 0.1
Appearance	8.0 ± 0.2	8.4 ± 0.1	8.2 ± 0.2

4. CONCLUSIONS

The possibility of occurring PEM during this transitional phase when children are weaned from liquid to semi-solid or fully adult foods where the growing body of children needs nutritionally balanced and calorie-dense supplementary food such as weaning foods in addition to mother's milk. The proximate compositions of all the formula for the weaning products were varied significantly. The overall acceptability of formula (I) products by sensory panelists was significantly different in taste and aroma due to soy bean flavor. It is therefore recommended can be added to lessen the bean flavor of the soy milk. All these milks have several benefits but it can be substituted for breast milk.

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