

# Formulation, Nutritive Value Assessment and Effect on Weight Gain of Infant Formulae Prepared from Locally Available Materials

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**Abstract:** The widespread problem of infant malnutrition in developing countries has stirred efforts in research, development and extension by both local and international organizations. As a result, the formulation and development of nutritious weaning foods from local and readily available raw materials, which are cost effective has become imperative in many developing countries. Thus, the local and readily available raw materials were used to compound and develop nutritious new infant formulae. The materials used for this study include maize, millet, cowpea, pumpkin, fingerlings and fish bone. The materials were dried and blended to powder. The powders were weighed in the ratio of 4:4:4:3:1:1 respectively and were then mixed properly. Analysis of nutritive value was performed on the formulae and compared with NAN-2 (control) and results revealed that the formulae had reasonable amount of moisture, lipids, carbohydrate, protein and fibre. Although NAN-2 was superior in carbohydrate and protein, our infant formula was higher in mineral elements, vitamins, fibre and lipids. All the essentials vitamins and both macro and micro minerals were found in appreciable quantity capable of meeting the biochemical and physiological demand of the body while the anti-nutrients composition were significantly ( $p < 0.05$ ) below FAO and WHO safe limits. Finally, the compounded infant formulae was feed to a set of albino wistar rats, while some other set of rats was feed with NAN-2 for the period of twenty seven (27) days and body weight gains were measure at three days intervals. The results of body weight changes was spectacular as their body weight over shot or almost double that of those animals that were feed with NAN-2 at each point of measurement. The results suggest that the widespread problem of infant malnutrition in the developing world especially among the low income segment of the society can now be reduced, if not totally eradicated since nutritive and cost effective weaning formulae can be prepared locally from common readily available materials.

**Keywords:** Formulation, Nutritive-Value, Weight-Gain, Infant-Formulae, Local-Material

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## 1. Introduction

Throughout much of human evolution, it is likely that large amounts of plant foods were and are being consumed Jane, (2005). In addition to being rich in fiber and plant protein, the diets of our ancestors were also rich in phytochemicals. The widespread problem of infant malnutrition in the developing world has stirred efforts in research, development and extension by both local and international organizations. As a result, the formulation and development of nutritious weaning foods from local and readily available raw materials which are cost effective have received a lot of attention in many

developing countries. Malnutrition is a major health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants, as well as lowered resistance to disease and consequently stifles development. Protein-energy malnutrition generally occurs during the crucial transitional phase when children are weaned from liquid to semi-solid or fully adult foods. During this period, children need nutritionally balanced, calorie-dense supplementary foods in addition to mother's milk because of the increasing nutritional demands of the growing body (Cameroon and Hofvander, 1971; Berggren, 1982; Sajilata *et al*, 2002; Umata *et al*, 2003). Thus, weaning food plays a vital

role in the all round growth, development and mental health of children.

Generally, foods eaten in developing countries contain high levels of carbohydrate with very low or no proteins due to the high cost of protein rich foods and some traditional beliefs about feeding infants with protein foods. Apart from protein and energy, weaning diets of infants in developing countries require more calcium, vitamin A and D, iron and some important trace elements. These can be obtained by combining the local staples presently available in the country. Combination of commonly used cereals with inexpensive plant protein sources like legumes can be use. Cereals are deficient in lysine, but have sufficient sulphur containing amino acids which are limited in legumes (Tsai *et al*, 1975; Wang and Daun, 2006; Iqbal *et al*, 2006; Shewry, 2007) whereas legumes are rich in lysine. The effects of the supplementation are highly beneficial, since nutritive value of the product is also improved and nutritional status of the consumers are assured.

Hunger or other nutritional related problem most especially among the infant have remain and continue to threaten infant's health and existence. Problem of nutrition during weaning period are complex and sometime complicated by many environmental factors. For example, early childhood infection, poverty of parents and ignorance among the population are some of the factors that affect the type of local weaning food. The problem of the developing a compromised immune system among poorly nourish infant must be weighed against the essential goal of good nutritional health; that is to reduce morbidity and mortality among infants. Thus a balance must be reached that attempts to achieve both goals whilst not compromising either too much by doing so. However, the type of weaning formula employed for weaning depends on the resources within the locality under consideration. Thus, all these have contributed to the widespread problem of infant malnutrition in the developing world including Nigeria. The most successful attempts so far have been in the administration of combined formulated supplement and mixed which are even expensive and may not be affordable by poor parents living below poverty line in most developing countries. Hence, this studies is justify by the fact that it will improve on the quality of the traditional weaning foods which is important to supply more available proteins, vitamins, minerals and all round nutrients required for growth and general wellbeing of a weaned child since it aimed at combining local and readily available raw materials which are inexpensive to develop nutritious new infant formulae with long shelf life and overall consumer's acceptability but at the same time cost effective.

The scope of this study covers; the formulation of new infant formulae base on locally available materials like millet, cowpea, pumpkin (cucurbita pepo'l), maize, dry flesh and ashed bones of fingerlings (fish), determination of anti-nutrients content, nutrients composition of the formulae and comparing it to commercial available formulae (NAN-2), feeding of the formulation and commercially sold formulae (NAN-2) to animal rat model to determined their growth rate.

## 2. Materials and Methods

### 2.1. Materials

The materials used for this work include millet, maize, cowpea, pumpkin, fingerlings.

### 2.2. Source of Materials

Millet, maize, cowpea, pumpkin and fingerlings was obtained from Wurukum market Makurdi, Benue State Nigeria.

### 2.3. Preparation

#### 2.3.1. Preparation of Maize Flour

The maize was sorted for stones, rot and other physical defects. The grains without defects was cleaned and roasted under an open flame until golden brown. The roasted maize was allowed to cool, milled with a hammer mill and sieved to obtain the flour.

#### 2.3.2. Preparation of Millet Flour

The millet was screened for stones, rot and other defects, cleaned, dried and milled and sieved to obtain the flour.

#### 2.3.3. Preparation of Fish Bone Meal

Fingerlings was cleaned and dried to flakes to remove the moisture content. The flesh was removed and blended into powder and the bone was also milled to obtain the meal and the bone was further ash to obtain the calcium content.

### 2.4. Constitution of the Formulae

The formulae was constituted by mixing maize, millet, cowpea, pumpkin, fish and fish bone powder together in ratio 4:4:4:3:1:1 respectively and was mix properly using a mechanical mixer to obtained an homogenous mixture.

### 2.5. Determination of Proximate/Energy Composition

Percentage moisture crude protein, crude fat, crude fiber and ash content of the formulation were determined based on the official methods of analysis (AOAC, 2012). Percentage carbohydrate was determined by difference. The food caloric value was determined by calculation using the Atwater factor. (Southgate and Durnin, 1970).

#### 2.5.1. Moisture Contents

Moisture content was reported as the loss in known weights of the samples upon drying in a hot air circulating oven (Gallenkamp hot box) at 50°C for 24 hours.

#### 2.5.2. Ash Content and Organic Matter

The weight of the ash was determined after incineration of the sample in a muffle furnace at 550°C until ash was obtained. The percentage of material burnt off was regarded as the organic matter.

#### 2.5.3. Crude Fibre

Crude fibre was determined from the loss in weight on ignition of dried residue remaining after digestion of fat free

sample with 1.25% H<sub>2</sub>SO<sub>4</sub> solution and 1.25% NaOH solution under specified conditions (Joslyn, 1970).

#### 2.5.4. Crude Protein Content

The Crude protein was determined by the macro-kjeldahl method (AOAC 1991). It determines nitrogen content of protein by digestion, distillation and titration.

Protein with concentrated sulphuric acid in the presence of a catalyst was liberated as ammonia by addition of sodium hydroxide (NaOH) followed by distillation. The amount of ammonia liberated was trapped in boric acid and estimated by titration using standard hydrochloric acid to have a purple pink end point.

#### 2.5.5. Crude Fat

The lipid in the sample was determined by exhaustively extracting known weights of the samples with petroleum ether (bp 40-60°C) using soxhlet apparatus for 6 hours. The amount of lipid in the sample was obtained by subtracting its weights after extraction from that before extraction.

#### 2.5.6. Carbohydrate Content

The carbohydrate content was obtained by subtracting the sum of protein, fat, ash and fibre from the 100%.

#### 2.5.7. Caloric Value

The caloric value was obtained by multiplying the values of crude protein by 4g, lipids by 9g and carbohydrate by 4g and taking the sum of the products.

### 2.6. Determination of Vitamins

The vitamins in the samples were determined using the methods of association of vitamin chemists (AOVC 2013) vitamin A and B were determined using the spectrophotometer method described by Kirk and Sawyer, (1991) at 325nm. Vitamin B (Niacin, thiamin and Riboflavin) was determined using a flame photometer while vitamin C was estimated by the 2,4-dinitrophenol hydrazine methods as described in (AOAC 1966).

### 2.7. Determination of Minerals

The mineral composition in the fresh and dry samples was determined using the dry ash method James (1995). Calcium and Magnesium were determined by the versenate EDTA complexometric titrimetry. Sodium and Potassium were determined using a flame photometer. Phosphorus was obtained by the variable molybdate colorimetric method. Determination of heavy metals was done by the atomic absorption spectrophotometry (AAS) according to James (1995).

#### 2.7.1. Test for Tannins

This was done by the ferric chloride test described by Harbone (1973). Ferric Chloride and K<sub>3</sub>Fe (CN) 6 were used to develop the colour of tannin extracted from the sample and absorbance taken at wave length 710nm.

#### 2.7.2. Oxalate

The Method of Munro & Bassir (1969) a modified method of Dye (1956) was used. The oxalic acid was extracted from the sample and precipitated as calcium salt. The oxalate was then dissolved in sulphuric acid and concentrations of oxalate in the solution determined by titration with K<sub>2</sub>MnO<sub>4</sub> for a faint pink end point.

#### 2.7.3. Hydrocyanic Acid

This was done using the method of Balogoplan (1998) the alkaline picrate colorimeter method. The sample was dissolved in 200mls of distilled water and a picrate paper (yellow) was suspended over the mixture and incubated at room temperature for 18 hours. The picrate paper was diluted in 60mls of distilled water and the diluents were measured at 540nm.

#### 2.7.4. Phytate

The spectrophotometer method as described by (Onwuka, 2005) and Oberleas, 1978) was employed. The sample was mixed with 60mls of 0.2M HCl and shaken for 30 minutes before boiling in water bath for another 30 minutes and cooled in ice water for 15 minutes. 2mls of 2, 2-Bipyridine solution was added to the mixture and mixed thoroughly. Their respective absorbances were measured with a mixture of pyridine addition. Absorbance was measured at 500-520nm.

### 2.8. Assessment of the Effect of the Formulae on Body Weight

Our locally made formulae and the commercially available formulae (NAN-2) were fed to two different experimental groups using animal rat model. Their weight was measured using electronic weighing balance and recorded and compared at 3 days interval for 21 days and this was compared with animals that were placed on regular rat pellet to evaluate the growth rate.

### 2.9. Statistical Analysis

Data obtained was expressed as Mean  $\pm$  Standard Deviation and analyzed using the Analysis of Variance 'ANOVA; f-ratio' (Welkowitz, *et al.*, 2006) and Statistical Package for Social Scientists (SPSS version 18). Values at P<0.05 were regarded as significant in comparison with appropriate controls.

## 3. Results

### 3.1. Proximate Composition

The results of the moisture, ash, protein, lipids, fibre and carbohydrate content of NAN and our local formulation is presented in figure 1. The statistical analysis reveals that NAN had a higher protein and carbohydrate compared to our formulae. However, our formulation recorded a significant (p<0.05) high values for moisture, lipids and fibre while the ash content of both samples compares favourably well with each other.

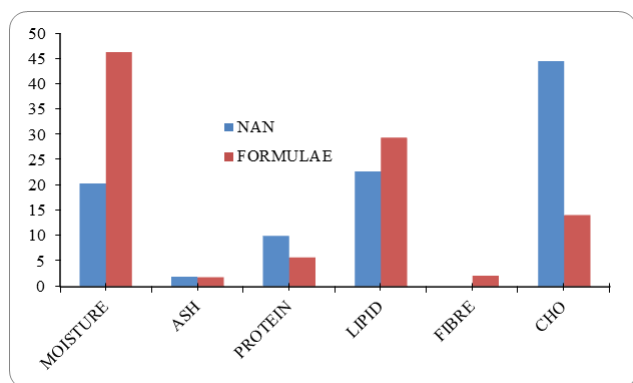


Figure 1. Proximate composition (NAN/LOCAL FORMULATION).

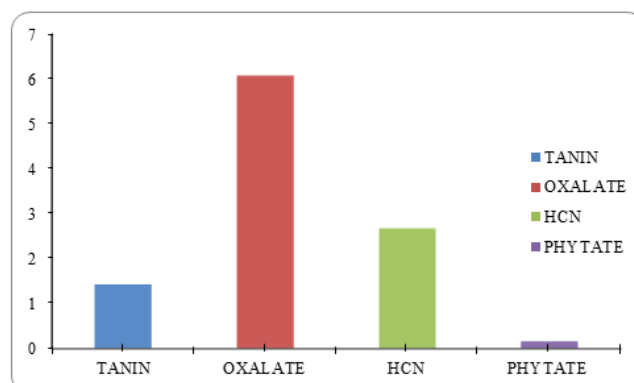


Figure 4. Anti-nutrient content of LMF.

### 3.2. Vitamin Contents of Nan and Local Formulation

The results of the vitamins content both NAN and our local formulation are presented in figure 2. Figure 2 shows that pro-vitamin A and ascorbic content of NAN was higher than that of our formulations while thiamine, riboflavin and folic acid were all higher in our formulation when compared with NAN. However, niacin, cyanocobalamin, pyroxal phosphate, cholecalferol, tocopherol levels of both weaning formulations compared favourably with each other.

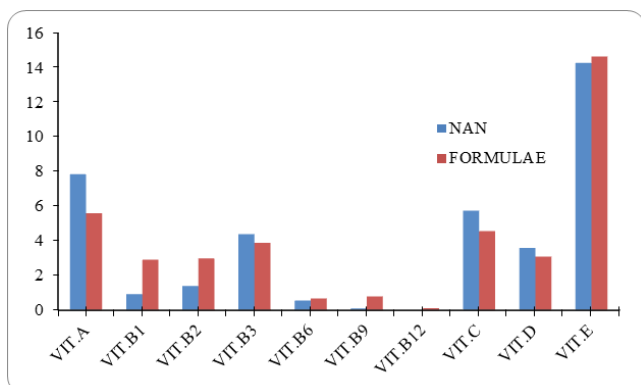


Figure 2. Vitamins composition (NAN/LOCAL FORMULATION).

### 3.3. Anti-Nutrient Composition of the Locally Made Formulae

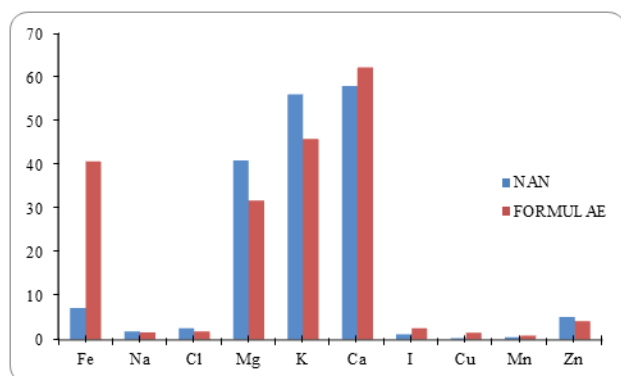


Figure 3. MINERAL COMPOSITION OF NAN/LOCAL FORMULATION.

The results of the Anti-nutrient present in our LMF are presented in figures and the results the presence of phytate, HCN, tannins and oxalate. The level of phytate was infinitesimal followed by HCN, tannins and oxalate in an increasing order.

### 3.4. Body Weight Changes

The body weight changes of wistar rats feed with rat pellet, commercially weaning formulae (NAN-2) and locally made formulae (LMF) is presented in figure 5-7.

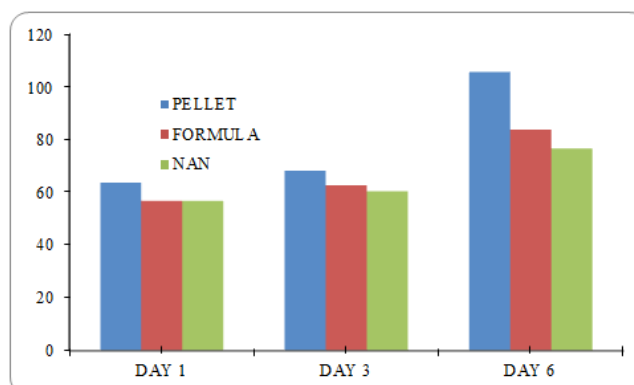


Figure 5. Body weight changes; Day 1-6.

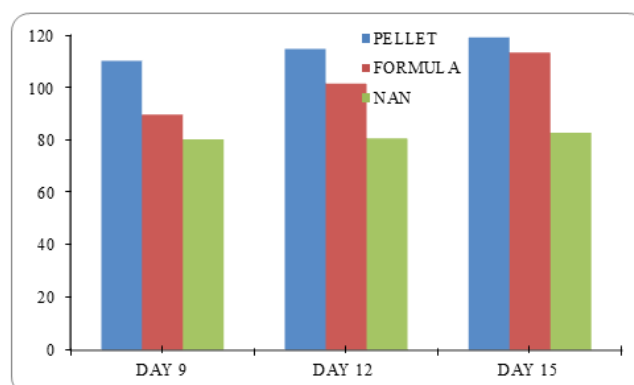


Figure 6. Body weight changes; Day 9-15.

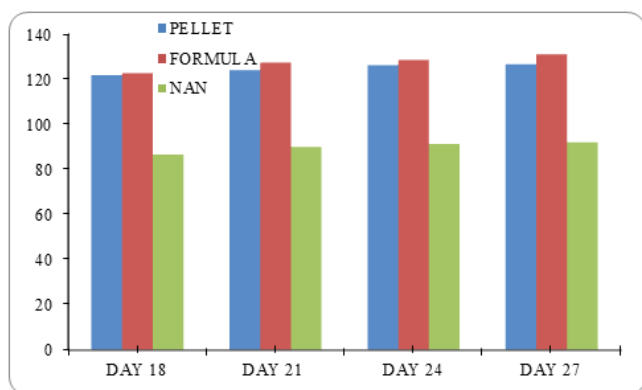


Figure 7. Body weight changes; Day 18-27.

At day one to three, the weight of all three groups compares well with each other. However, slight changes were noticed at day six where those feed with pellet showed high value followed those feed with LMF and then NAN.

On day fifteen, the weight of animals feed with LMF compares very well with those feed with rat pellet while the group that was feed recorded lower weight value at day fifteen.

More so, from day eighteen till day twenty seven, the weight of animals in groups feed with LMF overshoot that of other groups.

## 4. Discussion

Locally made weaning formulae was compose from cheap and readily locally available materials (millet, yellow maize, cowpea, pumpkin and fingerlings) in Benue State Nigeria and the nutrients and anti-nutrients compositions of the formulae was analyzed and values obtained were compared with that of commercially available weaning formulae (NAN).

The values of proximate composition reveal high moisture, fibre and lipid for LMF which was lower in NAN. The high moisture and fibre values seem to be healthy since it will prevent constipation. However, the protein and carbohydrate which was found to be higher in NAN than LMF indicated reason behind high caloric index for NAN. The slightly lower caloric value for LMF must have been due to high fibre value. This agrees with the findings of Potter and Hotchkiss (1997), Osse (1990), Shiela (1978), Bollard (1970), Tindall (1994) and Pamplona (2008) who worked on nutrient components of local food prepared from maize, cowpea, millet etc.

The results of vitamin and minerals content of LMF shows that it has high thiamine, riboflavin and folic acid value while other vitamins compares well with that of NAN. This is a strong indication that the energy domicile in the compose formulae can be properly utilized with the aid of thiamine being a co-enzyme for pyruvate decarboxylase. The vitamin A, C and E serve anti-oxidant role while the ascorbic acid also aid in building connective tissues and cholecalciferol is pivotal in the absorption of calcium.

According to Anderson (1966) fruits when fresh provides vitamin C which is essential for strong blood vessels and

healthy gums, but results from this study has shown that dry fruits also contain an appreciable amount of vitamins as in fresh fruits, which agrees with Pamplona (2008) who stated that fresh ripe fruits evidently provides the greatest level of vitamin, flavonoids and antioxidants but if not available, it is always better to eat fruits that has been preserved by some methods than not to eat it at all.

The minerals results also shows that LMF had a very iron level while the values of other minerals compares well the values in NAN-2. Higher content of macro minerals; magnesium, potassium phosphorus and micro minerals, iron and zinc in our formulation recorded in this study is similar with earlier works by El-Adaway (2004), USDA (2003). High content of potassium was recorded in the LMF and (Murkovic et.al. 2002) reported that cowpea, millet and some aquatic life contained considerable amount of phosphorus, potassium, magnesium, manganese and calcium. This might be as a result of the mineral content of the soil where the crop was grown as stated by FAO (1984).

Four different anti-nutrients of varying levels were found in the local formulation. There were tannins, oxalate, HCN and phytates with values ranging from 1.8ug/100g, 6.9ug/100, 3.2ug/100g to 0.3mg/100g respectively and these values were below FAO recommended tolerable levels. For example, 15mg/kg for tannins, the oxalate level is also within the tolerable limit for man 10 20 ppm/kg, 0.02mg/100g for hydrocyanide and phytic acid 0.74mg/100g (Brandbury, 1991; Onwuka, 2005).

Francis (2001) indicated that tannins can interfere with digestive processes by binding to feed proteins, vitamins, minerals and digestive enzymes. Dietary hydrolysable tannins was also reported to retard growth. The presence of high concentration levels of tannins therefore implies possibilities of poor protein digestibility caused by formation of protein tannin complexes which irreversibly bind digestive enzymes, thus inhibiting the activities of the enzymes making them unavailable for breaking down proteins with the resultant effect that proteins and other nutrients are liable to escape digestion. The presence of high concentration of tannins also indicate possibilities of poor palatability of feed due to bitter tastes hence reduction in feed intake (Akinmutimi, 2004). Patridge et al. (1982), Cherbut et al. (1998) and Akinmutimi et al. (2009) also reported that high tannin contents depresses cellulase activity by binding fibre, thus affecting bio degradability (digestibility). Hydrogen cyanides the hydrolysed toxic products of cyanogens suppress natural respiration and cause cardiac arrest (Davies, 1991). The presence of cyanide inhibits action of porphyrin enzymes (cytochrome oxidase in tissues and rapidly leads to suffocation).

Oxalate and calcium is known to interfere with calcium absorption by forming in-soluble salt with calcium, thus making it unavailable for use by the body while phytate binds iron out as iron phytate making it unavailable (Umar, 2006). More so, studies have shown that high vitamin C levels can liberate iron from phytate. However, alkaloid, saponins were not detected.

The results of body weight changes shows that wistar rats that were feed with LMF recorded a steady growth rate in terms of body weight changes throughout the twenty seven days period and the body weight at day twenty seven over shot feed with rat pellet and NAN-2. This shows that the nutrient domicile in our locally compose formulae can be essential for a growing infant that has been weaned from breast milk.

## 5. Conclusion

The major purpose of this study was to compose weaning formulae from local and readily available raw materials which are inexpensive to develop, nutritious new infant formulae with long shelf life and overall consumer acceptability but at the same time cost effective while comparing it with the commercially available weaning formulae (NAN-2). It explored the chemical evaluation and anti-nutrient contents of the two formulae. It was also the interest of this study to evaluate the mineral elements and vitamin contents of the formulars. Finally, the results obtained from this study have shown that the LMF have good levels of protein, lipids, fibre, carbohydrate and calories. While both macro and micro minerals were also present in abundant alongside water and fat soluble vitamins. All these contributed to excellent growth rate measure via weight changes recorded for animals feed with this formulation. More so, no changes on the physiochemical property of the formulae till date. Hence, this formulae (LMF) appears to be healthy and reliable to be used as weaning formulae for the local populaces who leaves below the poverty line and thus, cannot afford the commercially available weaning formulae.

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