Innovations

Nutritional Evaluation of Two Popular Indigenous Complementary Foods Commonly Used in Southern Nigeria

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Abstract: *Poor weaning practices in addition to inadequate nutritional content of weaning foods, have resulted in increased malnutrition and illness among infants in Nigeria. Also, the quality of nutrition received in infancy, is a major player in an individual's general growth, development and well-being. This study investigated the adequacy of two local weaning food formulations commonly used in southern Nigeria. The compositional composition, vitamin composition and mineral composition were determined. The result obtained from the study showed that blend 1 (F-Pap) contained higher amounts of vitamins B_{12}, B_3, E and B_2 relative to blend 2. However, blend 2 (tom-brown contained significantly higher amounts of all minerals analyzed compared to blend 1(F-Pap). Blend 2(tom-brown) also contained significantly higher amounts of moisture, lipid and protein than blend 1(F-Pap), while blend 1(F-Pap) contained significantly higher amounts of carbohydrate, ash and fiber than blend 2 (tom-brown).Blend 2(tom-brown) also contained significantly higher concentrations of vitamins B_1, A, B_6 and C compared to blend 1 (F-Pap). This study indicates that locally made weaning food from cereal- grains and crayfish may be rich in nutrients enough to meet the nutritional needs of infants.*

Key words: *weaning, nutrition, complementary feeding, formulations, indigenous, malnutrition, composition, infant.*

Introduction

Breast milk is the best food for infants, as it supports them with all the necessary nutrients for normal mental and physical growth. It provides polyunsaturated fatty acids, proteins, immunological and bioactive compounds, as well as essential minerals in a readily absorbable form (Ballar and Morrow, 2013). However, human milk alone is no longer sufficient to meet the nutritional needs of a growing baby after 6 months of age (Hampson et al., 2019). These babies thus require additional food sources to support their growing nutritional demands besides their mother's milk. This is known as weaning or complementary feeding and begins from the age of 6 months until about 24 months of age (WHO, 2023). Most times, the development of childhood malnutrition usually coincides with the introduction of complementary foods during weaning. The weaning period is a crucial time in an infant's life since it not only involves a great deal of rapid change for the child, but is also associated with the development of food preferences, eating behaviors and body weight in childhood, adolescence, as well as in adulthood (Abeshu et al., 2016).

In sub-Saharan Africa, one in seven children die before their fifth birthday (Walton and Allen, 2011). Nearly half of these under five deaths are attributable to underlying undernutrition which manifests as stunting, wasting, growth restrictions, and micronutrient deficiencies (Kramer and Allen, 2015). Protein-energy malnutrition is a common challenge in Nigeria, due to the decline in the breast-feeding tradition and early introduction of often under-nutritious and contaminated commercial milk products. This is usually as a result of very busy schedules of mothers who are engaged in white-collar jobs or other businesses in an attempt to increase their financial power. This gives rise to the assumption of motherly duties by nannies who are not able to breastfeed these babies and therefore feed them with complementary foods that are most times low in energy and nutrients, with a high prevalence of diarrhea and infections. An ideal food for the prevention and management of malnutrition should be of high nutritive value, acceptable to the children and their mothers, readily available and affordable, easy to prepare and well tolerated by the babies (Patel and Rouster, 2023).

Malnutrition during infancy can permanently change the body's structure, physiology, metabolism and function, sometimes leading to chronic ailments later in life (Patel and Rouster, 2023). Therefore, the formulation and development of a balanced complementary diet based on locally and readily available foodstuffs that can provide optimal nutrition to the young child has received a lot of attention in many developing countries, including Nigeria (Anigo et al, 2010).

Most African mothers prepare complementary foods such as plain pap made up of only one cereal. These foods are often known to have low nutritive value and are characterized by low protein, low energy density, and high bulk. Previous studies have suggested that proper combination, processing and blending of certain cereals and legumes have the potential to provide nutrients and serve as complementary food for infants (Abeshu et al., 2016). This work will educate the general public on the nutrient composition of two locally formulated infant foods in Cross River State Nigeria, and also guide them in making wise feeding choices for their weaning infants. Also, the breastfeeding mothers in the host community (Eteagbor, Calabar) and its environs, especially the illiterate ones will benefit tremendously, as they will be educated on adequate food combination choices for their weaning babies based on findings from this research. Whereas several studies have looked at the nutritional composition of most popular commercial infant weaning foods available in the markets, the truth remains that most mothers especially those in the rural areas are not able to afford these commercial baby products especially with the current rate of inflation in a country like Nigeria at this time. These mothers most times, totally rely on their locally produced cereal blends for their infants' nutrition without any concrete information or knowledge about the nutritional quality of these blends. This study was therefore designed to analyze the nutritional efficiency of these locally made infant foods and see how they can measure up to the regular commercial baby foods readily available in the global markets. The study will also identify gaps or deficiencies in the locally made blends, as well as suggest ways of improving these blends in order to enrich the nutritional intake of the weaning babies. Nutrition is critical in supporting healthy brain development early in life, with long-lasting, and often irreversible effects on an individual's cognitive development and life-long mental health (Cohen-Kadosh, 2021). Proper nutrition is crucial for normal brain and neurocognitive development. Failure to optimize neurodevelopment early in life can have profound long-term implications for both mental health and quality of life (Cohen-Kadosh, 2021).

The development of low-cost, high-protein food supplements for infants is a constant challenge for developing countries (Martin-Rodriguez et al 2022); in many poor homes, infants are given family diet early in life or continue to be breastfed, both resulting in sub-optimal nutrient intake.It is therefore important to ensure that complementary foods are able to meet the recommended nutrient intakes/recommended dietary allowances (RDAs) of infants and young children (IYC), as this will ensure proper growth, adequate cognitive development, and a strong immune system in IYC. The result from this research will be compared with the RDA for infants and young children especially with regards to protein content, and identify any lapses in the locally made blends that may need to be adjusted in order to obtain maximum nutrition for weaning babies. The Dietary intake values for infants and young children for various essential nutrients are shown in Tables:1,2 and 3.

The major raw materials usually available and used by most rural mothers in Cross River state to prepare their babies' weaning food include: pearl millet, soybeans, crayfish, groundnuts and maize. The maize could be yellow corn, white corn or guinea corn depending on availability and cost as the case may be. In EdimOtop and Eteagbor communities here in Calabar Municipal, most mothers prepare two major kinds of weaning food blends for their babies. The blends are usually made up of the five ingredients listed above, while the F-pap is made with three of the listed ingredients namely: maize, soy beans and crayfish.

Pearl millet (Pennisetum glaucum)

Interestingly, the protein in millet is preserved even when cooked, hence they are helpful for muscle growth and development. Its rich magnesium content makes it excellent for neuromuscular function. It also helps in normal contraction of muscles. It is required for the formation of bones and teeth. Its alkaline nature also contributes to its easy digestibility for infants and toddlers (Team,2012). Millet is one of the least allergenic foods available and affordable to most parents today and very easy to digest because of its rich fiber content which hydrates the colon and prevents constipation in children. It is high in vitamin B, protein, potassium, iron, calcium, magnesium and phosphorus, making it a nutritionally valuable food for babies with numerous health benefits (Anitha et al., 2021). Millets are extremely safe for infants when prepared correctly. Babies are usually introduced to millets at around 6 months of age (Rao et al., 2017). Its rich calcium content helps in the development of strong and healthy bones in the baby. Protein is important for muscle recovery and millets are a magnificent source of protein for babies. They are also a rich source of healthy carbohydrates called complex carbohydrates, which helps with weight management by keeping baby full for longer periods. Millet supports overall growth and development in babies due to its nutrient density (Kothapalli et al., 2024). It aids in bone development, boosts energy levels, supports digestion, and helps in maintaining healthy blood sugar levels, promoting overall well-being.In a nutritional study by Kothapalli*et al* (2024), millets were reported to promote immunity and health and subdue malnutrition in children and adolescents.

Soybeans (Glycine max)

Soya-beans are easily processed and can be combined with a variety of foods to increase nutritive value and make them ideal both as a staple and as a weaning food. Soy-milk as well as soya-beans have been found to be valuable in the management of malnutrition in infants. It has been observed to be as good as the more expensive commercial soy-milk product in the dietary management of acute diarrhea in children. The use of soya-beans among other formulations in the formulation of complimentary baby food is recommended for prevention and management of malnutrition in children (Abiodun, 1991).

Nigerian crayfish (*Procambarus clarkii*)

Crayfish have been reported to possess good nutritional value high in amino acids and proteins with easy digestibility (Ibironke et al., 2014). This makes it an important food for babies who require protein for body building and strong immunity, the easy digestibility is also a plus for babies' tender digestive system and for free bowel movement. Crayfish (*Procambarus clarkii*) is a common diet around the riverine community in South-South Nigeria, and is very rich in calcium, potassium, copper, zinc, iodine, proteins, vitamin D and A and about 1g of total fat without saturated fat and cholesterol (Nahid et al, 2009). This makes it very important for teeth muscles and bone development in children. Childhood fish consumption has also been associated with theprevention of allergic disorders. Fish and its products have been implicated in the treatment of 'attention deficit hyperactivity disorder' (ADHD) symptoms, depressive symptoms, treatment of allergic diseases, prevention or treatment of inflammatory bowel disease, cognitive development, including memory, processing speedand IQ in infants (Bernstein et al., 2019).

Groundnut/Peanut (Arachis hypogaea)

Peanuts are very rich in protein which is an important nutrient for muscle growth and overall development in children. It has been reported to be very crucial in brain development, and also reduces the risk of cognitive impairments or behavioral defects in children. As a significant part of the immune system, proteins in the form of antibodies help the body to fight diseases and infections. Protein also contributes to the mineral density of the bone, thus reducing the risk of fractures and improving bone health (Salina, 2021). The fat in peanuts and peanut butter provides healthy calories to malnourished infants and children at their time of need (Arya et al., 2016). Based on these observations, recently peanut protein has been incorporated into infant formula (Nimsate et al., 2010).

Yellow maize

The yellow maize is a very good candidate for infant nutrition as it contains all the essential nutrients needed to nourish a child. The energy densities of maize-peanut porridges were sufficient to cover energy required from complementary foods for infants aged 6 to 11 months receiving four meals of complementary foods per day(Ejigui et al., 2007). Maize-legume blends can efficiently improve the nutritional quality of traditional porridge for babies. It may be more beneficial in terms of duration of both diarrheal episodes and rehabilitation period and overall institutional cost if malnourished children's diets are supplemented with Tempe-yellow maize porridge (Kalari et al., 1996).

Materials and methods

Equipment

Electric blender (Sinreen manufacturers), muffle furnace (Carbolyte Scientific Laboratory Supplies), Oven (Memmertthermostatic oven), desiccator (Gilson Company, Inc.), UV visible spectrophotometer (VarianCary 50 Scan), electronic thermostat water bath (Stuart RE300B, Infitek Company), Sensitive balance (G J Industrial Suppliers), kjeldahl flask (Bionics Scientific), centrifuge machine (Infitek Company).

Reagents/Chemicals

All reagents and chemicals used were of analytical grade, they include: Sodium hydroxide, concentrated sulphuric acid, anhydrous sodium sulphate (BDH laboratory), Copper sulphate, acetic acid, calcium chloride, concentrated hydrochloric acid, Ferric Chloride solution (Labtech chemicals), amongst others.

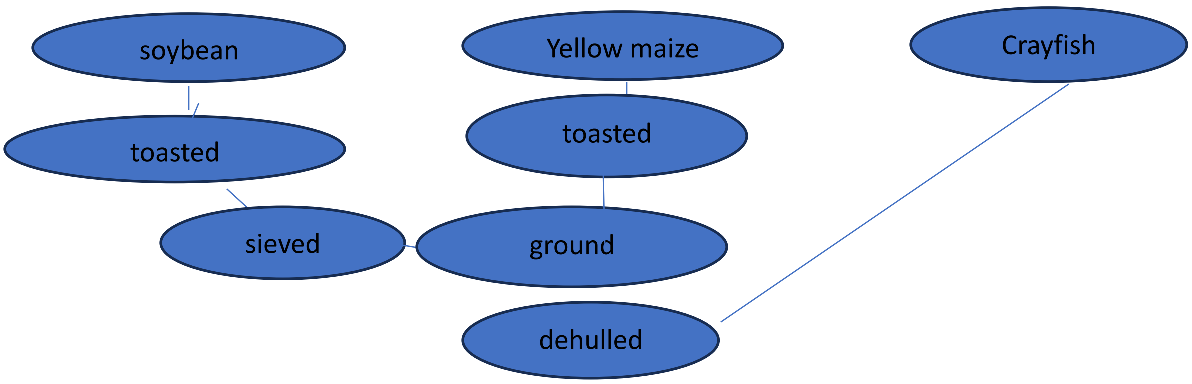
Methods

Collection of samples, and preparation of formulars

Corn, millet, soy bean, groundnut and crayfish used for this study were obtained from Watt Market in Calabar South LGA of Cross River State Nigeria. The cereal grains were sorted to remove stones. Millet, yellow corn and soybean were manually washed to further remove tiny sand particles/dust and dried at room temperature. Soybean, millet, groundnut and yellow corn were each toasted separately to a golden-brown appearance and 100g of each sample was weighed out, together with 40g of crayfish. The soybean was slightly crushed with a mortar and pestle to dehull, the shaft was sifted out in a sieve while the groundnut was peeled and shaft blown off. This was done to replicate the exact processing method usually employed by mothers in Cross River State Nigeria for the preparation of their babies' complementary diets. The weighed samples were mixed together and ground into a powdered form using a manual blender, they were thereafter, stored in an air tight plastic container. The powders were analysed for proximate, vitamins, minerals and anti-nutrient composition.

Detail of ingredients and the quantities used in the preparation of both blends can be found in Table 1.

Figure 1: Flowchart for blend 1:



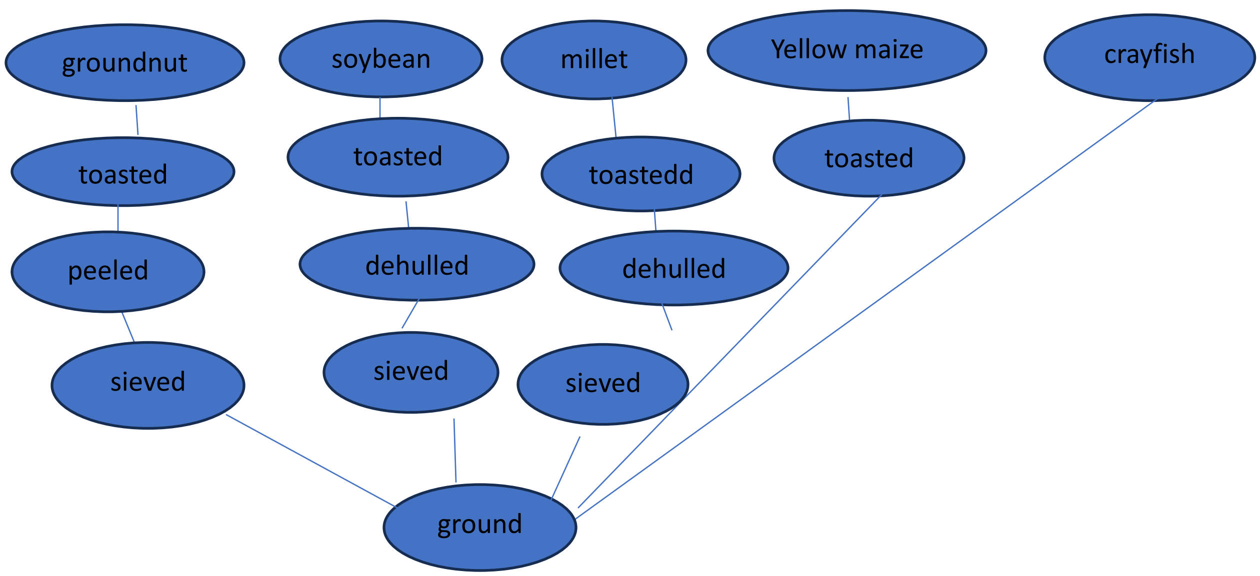


Figure 2: Flowchart for blend 2:

Determination of nutrient composition

Proximate composition of samples was determined using standard methods of Association of Official Analytical Chemists (AOAC, 2012). The Carbohydrate content was calculated as the difference between 100 and the summation of other proximate parameters as Nitrogen Free Extract (NFE) percentage as shown below.

NFE = 100 - (Moisture + Protein + Fat + Ash + Fibre).

Vitamin A, B_2, B_3, B_6, B_{12}, C and E contents were determined by the AOAC Method (AOAC,2012), and minerals including: magnesium, sodium, iron, zinc, potassium and phosphorus were determined by the AOAC method (AOAC, 2017). Qualitative and quantitative determination of saponin and phytate was done by the method of Trease and Evans (Trease and Evans, 2002), while oxalate andtannin were determined by the methods of Dye (1956) and Burns (1963), respectively.

Results and discussion

The proximate, vitamin, mineral and anti-nutrient composition results are presented in Tables: 5, 6,7 and 8, respectively.

The result ofthe nutritional analysis on F-pap and tom-brown mix (Tables 5,6, 7 and 8) showed that tom-brown mix contained significantly higher concentrations of moisture, lipid and protein relative to the F-pap mix, while the F-pap mix contained significantly higher concentrations of carbohydrate, ash and fiber relative to the tom-brown mix. The moisture content of foods or their processed products indicates their freshness and shelf life. High moisture content subject food items to increased microbial spoilage, deterioration and short life (Adepoju and Onasanya, 2008). The tom-brown mix would require a more delicate storage system for preservation in order to prevent quick spoilage due to its relatively high moisture content, especially since it appears more infant-friendly due to its high protein and fat content relative to the pap mix. Proteins are of significant importance in the body especially for babies, since it helps their rapid growth, and development of essential body tissues and organs. It also helps them to build immunity against infections and other diseases that they may encounter. Carbohydrates also provide energy for the child and help to promote proper growth in babies. The result of the lipid composition, shows that 100g of each blend contain16g and 21g of lipid for blends 1 and 2 respectively, while the DRI for 6-12 months is 30g/day. This means that a 200g portion of both blends will adequately meet and even exceed the DRI for lipids. During complementary feeding babies are usually fed between 2 to 4 times daily in addition to breastmilk. Thus, a child who takes any of these blends at least twice a day (for a 100g portion) will adequately meet the DRI for lipid. Both blends (a hundred-gram portion) also adequately meet the daily requirements for protein in a weaning baby as seen from the result. Infants require a lot of fat to keep them warm and protect them from vitamin deficiency especially of the fat-soluble vitamins. Also, many essential fatty acids required for effective brain development are contained in fat. Fat also helps to maintain healthy skin and hair, as well as protect against infections (Olusanya, 2008). The F-pap and tom brown formula contain good amounts of protein, which makes them suitable for infant feeding. Both blends adequately met the DRI for infants 6-12 months as shown in Table 2. A 100g portion of both blends may not meet the DRI for carbohydrate of 95g per day. However, consumption of 100g portion, 3 times in a day for blend 1, could adequately meet the DRI for carbohydrate, blend 2 does not meet the DRI for carbohydrate and may need to be complemented with other rich energy foods. A weaning baby is usually given water and not expected to get all their water from food. Access to water on demand should adequately meet the DRI of 0.8 liter per day for weaning babies. The tom brown mixture contains an appreciable amount of fat and is therefore suitable to maintain the warmth that an infant requires to keep healthy and warm. Table 6 reveals that both blends met and actually exceeded the DRI for all vitamins tested except vitamin A (Table 4), which is usually supplemented in babies up till 18 months of age.

Vitamins and minerals help in the growth and total development of a healthy child. The best way to ensure adequate amounts of vitamins and minerals in a child's diet is by providing them with a wide variety of foods from the five classes of food each day (O'Conor, 2022). Vitamins and minerals are essential for the proper functioning of many enzymes, in the form of cofactors and coenzymes that promote maintenance, formation, and homeostasis of body tissues, and to perform metabolic activities, such as cell signaling, motility, proliferation, differentiation and apoptosis.

Vitamin B_1, a water- soluble vitamin is needed by infants to help their body release energy from carbohydrates during carbohydrate metabolism and plays vital role in the normal functioning of the nervous system. Vitamin A deficiency has been reported to be widespread in children from developing countries and is associated with blindness and increased mortality and morbidity arising from infectious diseases. Some risk factors associated with vitamin deficiency in infancy usually last well into early childhood and even adulthood depending on severity (Leaf, 2007). Vitamin A promotes strong immune system, vision and healthy skin and hair.

The B group of vitamins generally help the body to turn food into energy. Vitamin B_1, keeps baby's nervous system healthy and reasonably active, B_2 keeps baby's skin, eyes and nervous system healthy, it also protects cells from oxidative damage. VitaminB_3keeps skin and nervous system healthy, B_6 helps store energy from food and in the formation of haemoglobin, it also keeps the brain and immune system healthy.

VitaminB_{12} helps in the formation of healthy red blood cells and nerve cells, as well as in the production of DNA and functioning of the nervous system (O'Conor, 2022).

Vitamin C plays a major role in wound healing, enhancing the absorption of iron, formation of collagen; a protein that gives structure to bones, cartilage, muscle, blood vessel and other tissues. It also promotes the formation of healthy connective tissues and is therefore very important in infants and young children to prevent anaemia and for strong bones, muscles and cartilage.

Vitamin E, a fat- soluble vitamin protects vitamin A and essential fatty acids in the body as well as prevents the breakdown of tissues. Essential fatty acids are very crucial for proper brain and cognitive development in children of weaning age. Vitamin E also helps to maintain healthy skin and eyes, and to build strong immune system, as well as protect cells from damage.

Both blends were considerably rich in vitamins. Table 7 shows that all the mineral components in tom-brown mix were significantly higher compared to those in F-pap mix. F-Pap (blend 1) contained low mineral concentrations relative to tom-brown. Weaning babies who are fed F-Pap (blend 1) may require mineral supplements to make up for the deficiency in minerals in F—Pap. This also implies that one or both ingredients (millet and groundnut) present in tom-brown (blend 2), but absent in F-Pap (blend 1) are likely responsible for the high mineral content observed in tom-brown. This is particularly surprising, given the fact that F-Pap had more ash content than tom-brown, as observed from the results. This means that the tom-brown mixture may be preferable in terms of essential minerals for optimal development of infants.

While blend 1 did not meet the DRI for any of the minerals in mg/l (Table 3), blend 2 (tom-brown) adequately met the DRI for zinc and more than half of the DRI for iron. This means that with the blends there may be need to supplement baby's diet with rich sources of minerals like magnesium, potassium and sodium for optimum development of the baby. Minerals are very essential for proper growth and development of infants. Potassium helps to keep a healthy heart and together with sodium works to maintain an optimal level of homeostasis in the body system (O'Conor, 2022). Magnesium helps to generate adenosine triphosphate (ATP), and eliminate ammonia in the brain. It also reduces oxidative stress related to the physiopathology of attention deficit hyperactivity disorder (ADHD) in infants. Its deficiency can lead to hypoparathyroidism, severe reduction in cognitive capacity and processing, and in particular reduced attention, together with increased aggression, fatigue, and lack of concentration. This is because magnesium is associated with the parathyroid gland and bone remodeling (Elbaz et al., 2017). Other symptoms of deficiency include: hypocalcemia, and impaired bone growth in children, which can be more severe under two years of age, during the fastest growth and development phase and when complimentary foods are usually introduced.

Zinc is important for the formation of new cells and enzymes, and is also very important in wound healing. Zinc deficiency is considered a public health problem since nutritional scarcity in the first years of life involves multiple etiologies. Deficiency is related to the decline of zinc concentrations in maternal milk, after the first 6 months of breastfeeding, or the low ingestion of zinc in complementary food. Zinc deficiency can have deleterious effects on the immune system, favoring pathologies related to the skin, lungs, and gastrointestinal tract that can persist until adult life (Rodriguez-Carmona et al., 2020). Iron is essential for making healthy red blood cells and for brain development in weaning babies. Iron deficiency, which is a common problem in children can cause anaemia resulting in a significant reduction in the number of T cells produced, and reducing innate and adaptative immunity, while exposing the organism to pathogens (Ward et al., 2011). The incidence of iron deficiency in babies is 73%, and its evolution to anemia is very high(Zhukovskaya et al., 2019). If anemia occurs in the first year of life, studies demonstrate that delayed speech is possible, since iron is essential for myelinization, and transmission in the central nervous system (Zhukovskaya et al., 2019). Iron deficiency can lead to delayed development, reduced school performance, behavioral disorders, ADHD and risk of cerebrovascular accident (CVA) in healthy young children. There is evidence that iron-deficient and obese children can develop neurodegenerative diseases due to elevation of hepcidin, a protein regulator of iron, that is required for the adequate functioning of neurons, and is necessary for insulin and its receptor signal in the brain system (Zhukovskaya et al., 2019).

Table 8 shows that the phytochemical composition of tom-brown mix was significantly higher compared to that of F-Pap. Phytochemicals are chemical compounds produced by plants which help in the overall maintenance of the health of an organism but are not essential nutrients. This is because in excess some phytochemicals can decrease the nutrient intake of the body. The tom brown mix contain slight concentration of these compounds namely: oxalate, phytate, saponin and tannins. Tannins are water soluble compounds which precipitate proteins from aqueous solution. They bind to proteins making them bio- unavailable. Oxalates function as chelating agents and may chelate many toxic metals such as mercury and lead. Oxalate crystals can be razor sharp and may cause damage to various tissues due to their physical structure. However, mineral and vitamin contents of the blends were significantly high and may be capable of chelating and neutralizing some of the adverse effects of these antinutrients (Table 6 and 7). Phytochemicals can also be beneficial to organisms. For instance, saponins reduce iron induced oxidative injury, reverses stimulation and tumor formation due to its mineral chelating potential. As a naturally occurring antioxidant, dietary phytates have been claimed to prevent kidney stone formation, protect against diabetes mellitus, caries, atherosclerosis and coronary heart disease, as well as fight the progression of a wide range of cancers (Abdulwaliyu et al., 2019).

Furthermore, in comparing the result values with the DRIs for IYC, it can be observed that if children are fed adequate amounts (about 300 - 500mls per day depending on their age) especially the tom brown mix, they will be meeting their recommended intakes of most essential nutrients. It is also advised that IYC are fed these in addition to fruits and vegetables in order to prevent micronutrient deficiencies.

Conclusion and recommendations

Optimum nutrition and good feeding of infants and young children are among the most important determinants of their health, growth and development. Proper selection and combination of local household foodstuff can be used to formulate multi-mixes that can be used as home-based complementary foods. The blends formulated in this study can be used by rural and urban mothers to feed their infant and children during the complementary feeding period. It ensures availability and affordability as well as help in alleviating some economic and time related constraint faced in child feeding practices. Also, the cost of these blends is more pocket friendly especially for mothers who do not earn much and may not be able to afford the very expensive commercial products on the shelves of big supermarkets, these blends are readily acceptable, affordable and very convenient for most mothers as it is prepared at their convenience. They are also responsible for the level of hygiene observed in preparing these meals.

This study was an exploratory effort on complementary foods which made use of stable foodstuffs from cereal grains, legumes and crayfish to formulate composite blends that can be nutritious, readily available and affordable to both rural and poor urban mothers. Further investigations are needed to determine the sensory evaluation of the blends. The composites formulated in this study can be recommended as adequate complementary foods for babies especially those above 6 months (after being exclusively breastfed), as both contained reasonable amounts of nutrients needed for infant growth and development but more preferably the tom-brown mix. Note that these blends are usually mixed with hot water to form a thick pap before it is fed to babies. The results obtained are purely for the powdered form of the ingredients processed as shown in the flowchart. The analysis does not take into account any changes in nutrient content that may arise from processing with hot water into pap before consumption by the baby. However, it is a useful indicator of the nutrient composition of each blend. Further studies on the hot water processed blends may be necessary.

Table 1: Ingredients.

Raw materials	**Blend 1(percentage of total weight)**	**Blend 2 (percentage of total weight)**
Soybeans	100g (42%)	100g (23%)
Millet	———	100g (23%)
Yellow maize	100g (42%)	100g (23%)
Groundnut	▭	100g (23%)
Crayfish	40g (16%)	40g (8%)
Total	240g	440g

Table 2: Dietary Reference Intakes (DRIs)

(Food and Nutrition Board, Institute of Medicine, National Academies)

Life Stage Group	**Total Water[a] (L/d)**	**Carbohydrate (g/d)**	**Total Fiber (g/d)**	**Fat (g/d)**	**Linoleic Acid (g/d)**	**α-Linolenic Acid (g/d)**	**Protein[b] (g/d)**
Infants							
0–6 mo	0.7*	60*	ND	31*	4.4*	0.5*	9.1*
6–12 mo	0.8*	95*	ND	30*	4.6*	0.5*	**11.0**
Children							
1–3 y	1.3*	**130**	19*	ND[c]	7*	0.7*	**13**

Table 3: DRIs for some elements

Life-Stage	**Calcium (mg/d)**	**Iodine (μg/d)**	**Iron (mg/d)**	**Magnesium (mg/d)**	**Phosphorus (mg/d)**	**Selenium (μg/d)**	**Zinc (mg/d)**	**Potassium (mg/d)**	**Sodium (mg/d)**
0–6 mo	200*[a]	110*	0.27*	30*	100*	15*	2*	400*	110*
7–12 mo	260*[a]	130*	11	75*	275*	20*	3	860*	370*
1–3 y	700	90	7	80	460	20	3	2,000*	800*

Table 4: DRIs for some vitamins

Life Stage	Vit A (μg/d)[a]	Vit C (mg/d)	Vit D (μg/d)[b,c]	Vit E (mg/d)[d]	Thiamin (mg/d)	Riboflavin (mg/d)	Niacin (mg/d)[e]	Vit B_6 (mg/d)	Folate (μg/d)[f]	Vit B_{12} (μg/d)
Infants										
0–6 mo	400*	40*	10*	4*	0.2*	0.3*	2*	0.1*	65*	0.4*
6–12 mo	500*	50*	10*	5*	0.3*	0.4*	4*	0.3*	80*	0.5*
Children										
1–3 y	**300**	**15**	**15**	**6**	**0.5**	**0.5**	**6**	**0.5**	**150**	**0.9**

Table 5: Proximate composition of samples

Samples	**Moisture (%)**	**Ash (%)**	**Lipid (%)**	**Fibre (%)**	**Protein (%)**	**Carbohydrate (%)**
F-Pap	14.80± 0.17	10.85±0.62 [a]	15.56 ± 0.39	10.26±0.46 [a]	17.17 ± 0.08	31.26 ± 0.24[a]
Tom-brown DR1 for 6-12 months	33.69±0.67 [a] 0.8 l/d	6.51 ±0.25 NI	21.06 ± 0.02[a] 30 g/d	8.45 ± 0.24 NI	18.44 ± 0.24[a] 11 g/d	12.25 ± 0.42 95 g/d

Values are expressed as Mean ± SEM, n=3. Using Unpaired T-test with Welsh correction.

a= significantly higher value.

DR1: Dietary Reference Intakes

NI: Not indicated

g/d = gram per day

l/d = liter per day

Note that the amounts in percentage depicts the concentration of each nutrient in 100g of sample.

Table 6: Vitamin composition of samples

Samples	A (μg/100ml)	B_1 (μg/100ml)	B_2 (μg/100ml)	B_3 (μg/100ml)	B_6 (μg/100ml)	B_{12} (μg/100ml)	C (μg/100ml)	E (μg/100ml)
F-Pap	1.95 ± 0.03	3.78 ± 0.02	1.08± 0.01[a]	1.47± 0.01[a]	6.49 ± 0.02	1.91 ± 0.02[a]	4.39 ± 0.05	1.15 ± 0.03[a]
Tom-brown	16.30±0.03[a]	23.14±0.04[a]	0.78 ± 0.03	1.17 ± 0.03	12.09±0.05[a]	0.67 ± 0.01	7.31 ± 0.07[a]	0.28 ± 0.03
DR1 for 6-12 months	500μg/d	0.0003 μg/d	0.0004 μg/d	0.004 μg/d	0.0003 μg/d	0.5 μg/d	0.05 μg/d	0.005 μg/d

Values are expressed as Mean ± SEM, n=3. Using Unpaired T-test with Welsh correction.
a= significantly higher values
μg/d =microgram per day

Table 7: Mineral composition of samples

Samples	Magnesium (mg/l)	Sodium (mg/l)	Iron (mg/l)	Zinc (mg/l)	Potassium (mg/l)	Phosphorus (mg/l)
F-Pap	0.203 ± 0.004	1.077 ± 0.038	0.067 ± 0.006	0.417 ± 0.009	1.199±0.019	0.826 ± 0.015
Tom-brown	3.725 ± 0.054[a]	27.80 ± 0.51[a]	6.255± 0.030[a]	3.222 ± 0.070[a]	23.67± 0.29[a]	8.637± 0.134[a]
DR1 for 7-12 months	75mg/d	370mg/d	11mg/d	3mg/d	860mg/d	275mg/d

Values are expressed as Mean ± SEM, n=3. Using Unpaired T-test with Welsh correction.
a= significantly higher value
mg/l= milligram per liter
mg/d = milligram per day

Table 8: Anti-nutrient/Phytochemical composition of samples

Samples	Tannin (mg/g)	Saponin (mg/g)	Oxalate (mg/g)	Phytate (mg/g)
F-Pap	0.001 ± 0.005	0.004± 0.001	0.015 ± 0.001	0.009 ± 0.001
Tom-brown	1.32 ± 0.02[a]	0.66 ± 0.01[a]	0.86 ± 0.03[a]	1.16 ± 0.03[a]

Values are expressed as Mean ± SEM, n=3. Using Unpaired T-test with Welsh correction.

a= significantly higher value

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Declaration of conflicting interest: The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding statement: No external funding was received for this research

Ethical approval and Informed consent: Not applicable

Data availability statement: Not applicable

References

1. *Abdulwaliyu, I., Arekemase, S.O., Adudu, J.A., Batari M.L., Egbule, M.N and Okoduwa S.I.R (2019). Investigation of the medicinal significance of phytic acid as an indispensable anti-nutrient in diseases. Clin. Nutr. Exp 2019; 28: 42-61.*
2. *Abeshu, M.A., Lelisa, A and Geleta, B (2016). Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries - Lessons from Ethiopia. Frontiers in nutrition; 3: 41.*
3. *Abiodun, P.O (1991). Use of soya-beans for the dietary prevention and management of malnutrition in Nigeria. Acta Paediatr Scand Suppl. 374:175-82.*
4. *Adepoju, O.T and Onasanya, L.O (2008). Nutrient composition and antinutritional factors of Dialiumguineenese wild fruit pulp. Ife journal of science 2008; 10 (1): 33-37.*
5. *Anigo, K.M., Ameh, DA., Ibrahim, S and Danbauchi, S.S (2010). Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. African Journal of Food Science. 4(3): 65-72.*
6. *Anitha, S., Kane-Potaka, J., Botha, R., Givens, D.I., Sulaiman, N.L.B., Upadhyay, S., Vetriventhan, M., Tsusaka, T.W., Parasannanavar, D.J., Longvah, T., Rajendran, A., Subramaniam, K and Bhandari, R.K (2021). Millets Can Have a Major Impact on Improving Iron Status, Hemoglobin Level, and in Reducing Iron Deficiency Anemia–A Systematic Review and Meta-Analysis. Front Nutr. 8:725529.*
7. *Arya, S.S., Salve, A.R, and Chauhan, S (2016). Peanuts as functional food: a review. J Food Sci Technol.53(1):31-41.*
8. *Association of Official Analytical Chemists (AOAC) (2012). Official methods of analysis. (19th ed.) 2012;Washington DC.*
9. *Association of Official Analytical Chemists (AOAC) (2017). Official methods of Analysis. Washington DC.www.eoma.aoac.orgAccessed October 2023.*
10. *Ballard, O and Morrow, A.L (2013). Human milk composition: nutrients and bioactive factors. Pediatric Clin. 60 (1):49 – 74.*
11. *Bernstein, A.S., Oken, E and de Ferranti, S (2019). Council on Environmental Health; Committee on Nutrition. Fish, Shellfish, and Children's Health: An Assessment of Benefits, Risks, and Sustainability. Erratum in: Pediatrics. 144(4): e20190999.*
12. *Burns, R.E (1963).Methods of Tannin analysis for forage crop evaluation. Georgia Exp. Sta. Tech. Bull. N 1963; S 32.*

13. *Cohen, Kadosh K., Muhardi, L., Parikh, P., Basso, M., Jan Mohamed, H.J., Prawitasari, T., Samuel, F., Ma, G and Geurts, J.M (2021). Nutritional Support of Neurodevelopment and Cognitive Function in Infants and Young Children-An Update and Novel Insights. Nutrients.13(1), 199.*
14. *Dye, W.B (1956). Chemical studies on Halogeton glomeratus. Weeds Journal of Horticultural sciences. 4(1): 55-60.*
15. *Ejigui, J., Savoie, L., Marin, J., and Desrosiers, T (2002). Improvement of the nutritional quality of a traditional complimentary porridge made of fermented yellow maize (Zea mays): effect of maize-legume combinations and traditional processing methods. Food and Nutr Bull.28(1):23-34.*
16. *Elbaz, F., Zahra, S and H, Hanafy (2017). Magnesium, zinc and copper estimation in children with attention deficit hyperactivity disorder (ADHD) Egypt J. Med. Hum. Gen.18:153–163.*
17. *Hampson, G., Roberts, S.E, Lucas, A and Parkin, D (2019) An economic analysis of human milk supplementation for very low birth weight babies in the USA. BMC Pediatr.19(1):337.*
18. *Ibironke, S.I.,Fashakin, J.B and Ige, M.M (2014). Nutritional quality of animal polypeptide (Crayfish) formulated into complementary foods. American Journal of Food and Nutrition. 2:39-42.*
19. *Kalavi, F.N., Muroki. N.M., Omwega, A.M and Mwadime, R.K (1996) Effect of tempe-yellow maize porridge and milk-yellow maize porridge on growth rate, diarrhoea and duration of rehabilitation of malnourished children. East Afr Med J. 73(7):427-31.*
20. *Kothapalli, S., Ramalingam, S and Nair, S.S (2024). Millets as Nutri-cereals and its health benefits: an overview. International Journal of Community Medicine and Public Health. 11(3), 1384–1389.*
21. *Kramer, C.V and Allen, S (2015). Malnutrition in developing countries. Paediatr. Child Health; 25:422–427.*
22. *Leaf, A.A RCPCH (2007). Standing Committee on Nutrition. Vitamins for babies and young children. Arch Dis Child.92(2):160-4.*
23. *Martín-Rodríguez, A., Bustamante-Sánchez, Á., Martínez-Guardado, I., Navarro-Jiménez, E., Plata-SanJuan, E., Tornero-Aguilera, J.F and Clemente-Suárez, V.J (2022). Infancy Dietary Patterns, Development, and Health: An Extensive Narrative Review. Children (Basel, Switzerland). 9(7), 1072.*
24. *Nahid, F., Zaglol, I and Fayza, E (2009). Study on Chemical Quality and Nutrition Value of Fresh Water Cray Fish (Procambarus Clarkii). Journal of the Arabian Aquaculture Society. 4 (1):1 18.*

25. *Nimsate, K., Mohamed, A andJianmei, Y (2010). Development of a fortified peanut-based infant formula of severely malnourished children Int J Food Sci Technol.45(10):1965–1972.*
26. *O'Connor, A (2022). Children, vitamins and minerals. 2022. www.whattoexpect.comvitamins-and-babies.aspx. Accessed online 29th May 2024.*
27. *Olusanya, J.O (2008). Proteins, In: Essential of food and nutrition. Apex Books Limited, Lagos. Pp. 13- 21.*
28. *Patel, J.K and Rouster, A.S (2023). Infant Nutrition Requirements and Options. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing.2023; www.ncbi.n lm.nih.gov . Accessed November 2023.*
29. *Rao, B.D., Bhaskarachary, K., Christina, G.D.A., Devi, GS and Tonapi, V.A (2017). Nutritional and Health Benefits of Millets; ICAR – Indian Institute of Millets Research (IIMR) Rajendranagar, 2017; Hyderabad, pp 112.*
30. *Rodríguez-Carmona, Y., Denova-Gutiérrez, E., Sánchez-Uribe, E., Muñoz-Aguirre, P., Flores, M and Salmerón, J (2020). Zinc Supplementation and Fortification in Mexican Children. Food Nutr. Bull. 41:89–101.*
31. *Salinas, J (2024). 5 Benefits of Peanuts for Children.; www.pnuff.com ; Accessed online 23rd May 2024.*
32. *Team, F (2017). Benefits of Millets for Child's Growth. www.fitterfly.com.*
33. *Trease, G.E and Evans, W.C(2002). Pharmacognosy. (15th Ed). London: Saunders Publishers; pp:42-44.*
34. *Walton, E and Allen, S (2011). Malnutrition in developing countries. Paediatr. Child Health; 21:418–424.*
35. *Ward, R.J., Crichton, R.R., Taylor, D.L., Della, C.L., Srai, S.K and Dexter,D.T (2011). Iron and the immune system. J. Neural Transm.118:315–328.*
36. *World Health Organisation. Appropriate complementary feeding. E-Library of evidence for nutrition actions (ELENA). Retrieved from: www.who.int.*
37. *Zhukovskaya, E., Karelin, A and Rumyantsev, A (2019). Neurocognitive Dysfunctions in Iron Deficiency Patients. In: Rodrigo L., editor. Iron Deficiency Anemia. Intech-Open; London, UK. pp. 83–113*