International Journal of Agriculture and Nutrition
www.agriculturejournal.net
Online ISSN: 2664-6072; Print ISSN: 2664-6064
Received: 01-08-2019; Accepted: 02-09-2019; Published: 09-09-2019
Volume 1; Issue 4; 2019; Page No. 01-08

Protein enrichment efforts of complementary foods-an update

Ameh C Ochanya[1], Ochelle O Paul[2], Ukeyima T Moses[3]
[1-3] Department of Food Science and Technology, College of Food Technology and Human Ecology, Federal University of Agriculture, Makurdi, Nigeria

Abstract
An update on protein enrichment efforts of complementary foods was reviewed. Complementary foods are foods used during the transition from consuming solely human milk or infant formulas to the introduction of mixed diets. Recent advances on Protein enrichment efforts of complementary foods include fortification of whole grains with legumes, fruits, tubers, crops, bioactive compounds and vegetables that are rich in micro and macro nutrients, commercial technologies such as malting, popping, fermentation and using of modern food-processing technologies such as roller drying and extrusion cooking and other unusual animal products such as insects, periwinkle, termites, cockroaches. To guarantee the nutritional wellbeing of children, a holistic approach with a focus on the first 1000 days of life is required and consistency of complementary foods should change from semisolid to solid foods to meet the nutritional needs of children. The introduction of nutritionally adequate and safe complementary (solid) foods at 6 months together with continued breastfeeding up to 2 years of age or beyond will address adequate complementary feeding practices including feeding frequency, quality and quantity of diet and food safety in addition to breastfeeding.

Keywords: malnutrition, protein, complementary foods, breastfeeding, fortification

1. Introduction
Protein Energy Malnutrition is a form of malnutrition that is defined as a range of pathological conditions arising from coincident lack of dietary protein and/or energy (calories) in varying proportions. The condition has mild, moderate and severe degrees (WHO, 2009) [29]. Protein energy malnutrition is responsible, directly or indirectly, for over half of all childhood deaths. Protein deficiency has become a dietary problem facing the world especially the underdeveloped and developing countries (Enweremadu *et al.,* 2008) [27]. Infants and young children are at increased risk of malnutrition from six (6) months of age onwards, when breast milk alone is no longer sufficient to meet all nutritional requirements then complementary feeding needs to be started (Dendegh *et al.,* 2019) [27]. Complementary foods are often of lesser nutritional quality than breast milk. They are often given in insufficient amounts and, if given too early or too frequently, they displace breast milk

Fortification of food refers to the addition of essential micronutrients to food particularly to correct specific nutritional deficiencies such as addition of vitamins and iron to breakfast foods (cereals and beverages). Examples include; fortification of sugar with vitamin A, fortification of table salt with iodine (Mbaeyi and Onweluzo, 2010) [47]. Several studies have shown the enrichment of cereals with different food substances such as okra seed meal (Aminigo and Akingbala, 2004) [10], bambara groundnut (Mbata, Ikenebomeh and Alaneme, 2009) [48], cowpea (Ashaye *et al.,* 2000 and Oyarekua, 2009) [15] soybean (Adeleke and Oyewole, 2010) [3], scarlet runner bean (Aremu *et al.,* 2011) [13], groundnut flour (Ajanaku, 2012) [6], crayfish Ajanaku *et al.* (2013) [6] among others. One cheap method of enhancing the nutritive value of cereals is by adding protein sources to it. In most developed societies, nutrient fortified cereals are the first complementary foods introduced to the infant, followed by fruits, vegetable and meat produce. The use of high nutrient dense food stuffs such as cereal, legumes, vegetables and animal food products to prepare complementary foods for infants and children has been suggested (Shiriki *et al.,* 2015) [62].

Complementary foods are food other than breast milk or infant formula such as solid, liquid and semi-solid food materials which are introduced to infants to provide nourishment (Anigo *et al.,* 2010) [11]. It is a meal given to infant prior to withdrawal of breast milk. It begins when parent gradually introduce semi-solid food, other than breast milk to their babies' diet. This is specifically done because young children have high nutritional requirement and in part because they are growing fast (Aldermal *et al.,* 2004 and Akinola, *et al.,* 2014) [8].

Proteins are large molecules composed of one or more chains of amino acids in a specific order determined by the based sequence of nucleotides in the DNA coding for protein. Proteins are required for the structure, function and regulation of the body's cells, tissues and organs (Clark 2003 and WHO, 2009) [20, 29]. Demand for the relatively cheap sources of protein that can be incorporated to value added food products is increasing worldwide, and numerous researches are still going on various sources of plant proteins that may help in improving the nutritional value of food products at low cost (Gurpreet *et al.,* 2006) [38]. Proteins sources should complement the protein in cereal grains since the chemical and nutritional characteristic of protein make them natural complements to cereal based diets (Akinola, *et al.,* 2014) [8]. Complementary feeding helps in filling in gap; this is because as a baby grows and becomes more active, an age is reached when breast milk alone is not sufficient to meet the child's nutritional needs. Therefore, complementary foods are

introduced to fill the gap between total nutritional needs and the amount provided by breast milk and breast feeding for two years or longer helps the child to develop and grow strong and healthy. Protein energy malnutrition in infants and children can be prevented by feeding them with enough nutritious and safe complementary foods which can be achieved by any of the followings; dietary diversification, supplementation or fortification of locally available foods to enhance micronutrient intake of infants and younger children during complementary feeding period. The objective of this review was to provide an update on protein enrichment efforts in complementary foods.

2. Literature Review

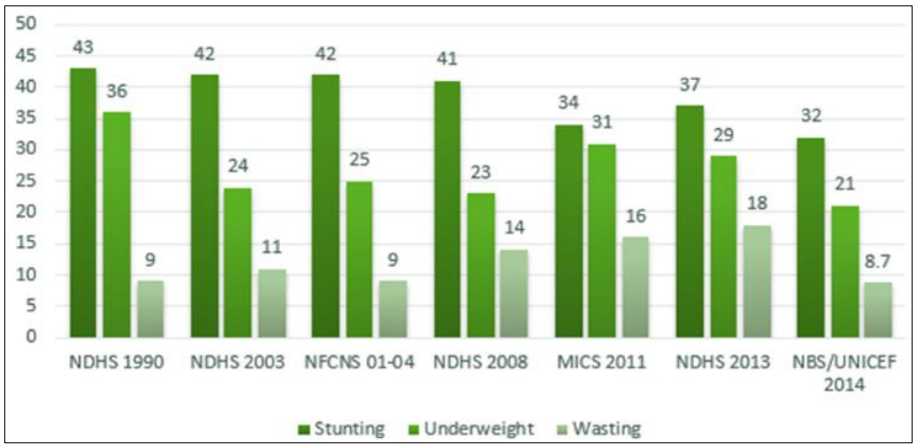
The increase in infant malnutrition in Africa during the weaning period has been attributed to inappropriate complementary feeding practices which is responsible for half of the child mortality cases (2.9 million out of 5.9 million) (UNICEF, 2016) [70]. West Africa region reported that 31.4 % of children under five were stunted, while 8.5 % were wasted. Stunting is a huge burden for nations, which will result in future citizens that will neither be as healthy nor as productive as they should be. Optimal nutrition in the first two years of life is crucial to laying the foundation of good nutrition and health for human wellbeing. According to the World Health Organization (WHO), it is recommended to practice exclusive breastfeeding (EBF) during the first six months of an infant's life, followed by timely introduction of complementary foods while continuing breastfeeding until two years of age to ensure optimal development during childhood (WHO, 2009) [29]. Early or late introduction of complementary foods, inappropriate feeding frequency, inadequate nutrient density and food contamination characterize the suboptimal feeding practices which make children more vulnerable to irreversible effects of malnutrition, making them more susceptible to infectious diseases particularly during the first 1,000 days of life. Growth faltering in particular is often widespread as soon as complementary foods are introduced because of the low nutrient density of most traditional complementary diets. In addition to breastfeeding, optimal complementary feeding should be the key objective of a global strategy to ensure the nutrition security of infants and young children aged 6 to 23 months. Until now, over the last 10 years, considerable global and national efforts have been devoted to breastfeeding promotion, but unfortunately, the same does not apply to complementary feeding PAHO/WHO (2003) [31] and WHO (2009) [29]. Premature and late introductions of complementary foods appear to be important concerns since they are widely observed inadequate infant feeding practices in many West African countries. According to the recent UNICEF report State of the World's Children, less than 60% of children 6 to 8 months old were introduced to solid, semi-solid or soft foods in Burkina Faso, Mauritania, Gambia, Liberia and Guinea. Benin, Ghana and Guinea-Bissau were countries where the timely introduction of complementary foods was better, with proportions of children 6 to 8 months old having been introduced complementary foods estimated beyond 70%. A study on Nigerian children found that 53.8% had premature initiation of complementary foods while 5.1% had delayed initiation of complementary food (Ogunlesi *et al.,* 2014) [55]. Other studies, in Mali and Senegal, revealed early introduction of complementary foods as a poor infant feeding practice (Gupta *et al.,* 2014) [35]. The prevalence of protein malnutrition remains high with poor child feeding practices. It appears that suboptimal complementary feeding practices remain one of the major causes of child malnutrition and mortality in West Africa (Idris *et al.,* 2013) [40]. Concerning the time of initiation of complementary feeding, complementary foods introduced too early or too late is the main impediment to exclusive breastfeeding (EBF) (Ogunlesi *et al.,* 2014) [55]. The inappropriate age of introduction of complementary foods remains a challenge that significantly hampers optimal child growth and development. Early introduction of complementary foods (before six months old) could reduce the consumption of breast milk and increase the risk of iron and zinc deficiencies and infectious diseases such as diarrhea, pneumonia, measles, malaria, respiratory illness (Gyampih *et al.,* 2014), which further contributes to impaired growth and health disorders. In an attempt to resolve stomach pains and to prevent diseases, water and herbal tea should be the first liquids introduced in the first three months of life (Gupta *et al.,* 2007 and Sawadogo *et al.,* 2010) [35]. Poor knowledge, misconceptions of the mothers and traditional beliefs are factors that contribute to inappropriate complementary feeding practices (Egyir *et al.,* 2007) [26]. The greater the frequency of prenatal clinic visits, the more often mothers will respect the timely introduction of complementary foods through appropriate counselling from health workers. Hence, health facility access will be essential for enhancing good infant feeding practices.

2.1 Prevalence of Protein Energy Malnutrition in Nigeria

The prevalence of protein energy malnutrition is on a rapid rise in Nigeria and it poses a major health challenge as it is the leading cause of morbidity and mortality. The 1990 DHS conducted by the Federal Office of Statistics estimated the prevalence of wasting at 9 percent, underweight at 36 percent, and stunting at 43 percent among preschool children. There was a decrease in prevalence of stunting in the 2003 NDHS with 11 percent of children wasted, 24 percent underweight, and 42 percent of children stunted (NDHS, 2003) [51]. 2008 prevalence survey showed; underweight had decreased to 23 percent and stunting had dropped to 41 percent but wasting increased to 14 percent (NDHS, 2008) [51]. Similar trends were reported by the 2001–2003 NFCNS showing wasting to be 9 percent, 25 percent underweight, and 42 percent stunting, with significant variations across rural and urban areas (Maziya Dixon *et al.*, 2004) [46]. The (NDHS, 2003) [51] showed that rural children (43 percent stunted) were disadvantaged compared to urban children (29 percent stunted). There was a decrease in prevalence of protein energy malnutrition reports of the Multiple Indicator Cluster Survey (MICS, 2011) in Nigeria with 34 percent of children under five stunted, 31 percent underweight, and 16 percent wasted, while about 15 percent of children had low birth (at less than 2,500 grams at birth). Prevalence of stunting decreased to 37 percent, with a higher concentration among rural children (43 percent) than urban (26 percent). However, the proportion of children underweight (29 percent) and wasting (18 percent) increased (NDHS 2013) [51]. Similarly, the 2014 National Nutrition and Health Survey Report by the National Bureau of Statistics and UNICEF showed that children's nutritional status modestly improved since 2013, according to the 2013 NDHS report, with 32 percent of children under five stunted, 21 percent underweight, and 9 percent wasted. The national nutrition and

health survey (2018) reported that protein energy malnutrition has been on the increased 5-9.9% over the years since 2014. The prevalence of Underweight among children aged 0-59 months was 19.9 percent, just at the margin of the 20 percent threshold for serious situation that it has been since 2014, higher than the global estimate of 15 percent but consistent with the rates in the West and Central Africa region (22%). The prevalence of stunting was 32.0 percent and has remained the largest burden of protein energy malnutrition with stagnated rates of above 30 percent since 2014, and with many states in the north west and north east recording prevalence above 40 percent- the WHO critical levels. Stunting indicates a long term nutritional problem in the country and at similar levels to that of Sub-Saharan region (37 percent) with serious and irreversible consequences.

Overweight prevalence at 1.2 has however remained below the 7 percent threshold in the Country. Overall, only 64 percent of children in Nigeria are growing healthily without being stunted or wasted. Improving nutrition in the first 1000 days in infants and children is critical to improving the nutrition status of the entire population of Nigeria. The protein energy malnutrition prevalence trend status of children under five from 1990 to 2014 is presented in Figure 1.



Keys: NDHS Nigeria Demographic and Health Survey; NFCNS = Nigeria Food Consumption and Nutrition Survey; MICS = Multiple Indicator Cluster Survey. Source: NDHS 2013; NBS/UNICEF 2014 [51, 70].

***Source*:** NDHS, NBS/UNICEF, 2014 [51, 70].

Fig 1: Trends in Protein Energy Malnutrition Status of Children under five in Nigeria, 1990-2014.

2.2 Nutritionally Improved Complementary Foods in Diverse Cultures

Guptill *et al.* (2004) [36] and Guptill (2009) [37] investigated ways complementary foods could be improved upon in developing Countries as shown in Table 1. Most of the foods developed were grain-based porridges to which protein, energy and micronutrient-rich ingredients were added. Household and Recipe Programme Trials to Improve Complementary Food intakes of infants 6 –12 months of age in Developing Countries is showed in able 1 and examples of first Foods Introduced to Infants in Different Cultures is showed in Table 2.

Table 1: Household and Recipe Programme Trials to Improve Complementary Food intakes of Infants 6–12 months of age in Developing Countries

Countries	Enriched weaning foods	Nutrient profile	Time period	Acceptance
Peru	Sanquito: wheat flour, toasted pea flour, brown sugar, oil, carrots, water	237 kcal/100 g, recommended to feed 1 cup/d, providing 550 kcal, 11.9 g protein, and 206 µg RE	Small groups of women in 10 rural highland communities	88% (on 1st try, accepted 4 mouthfuls); compared with pudding, children consumed 6 times more kcal/kg/12-h day
Nigeria	Eko ilera, a fortified ogi, containing maize or sorghum ogi paste, cowpea flour, red palm oil, sugar, water, sorghum malt flour	85 kcal/100 g (+50 kcal/100 g from traditional eko); designed for 12% increase in net energy intake/d		Good acceptance, but no estimates available
Cameroon	Bouillie enrichie, the traditional pap enriched with milk, egg, or peanut butter			Good acceptance, but no estimates available
The Gambia	Millet pap ogi, enriched with peanut paste; alternative additional ingredients were bean flour, butter, milk, and dried fish		31 women visited 4 times at home over 2 weeks period	68% liked the peanuts, an additional 13% added alternative ingredients
Tanzania	Maize peanut gruel ugi with germinated sorghum flour (“power flour”) or kimea		40 children aged 5–60 mothers in 3-months trial	28% prepared gruel with kimea regularly; 85% used gruel about 25% of the time

Ghana	Traditional cereal porridge, thickened and enriched with legumes, fish powder, or oil; frequency of feeding also increased		About 50–70 mothers over 4–7 days	79% willing to thicken; 82% willing to enrich; 82% willing to increase feeding frequency
Swaziland	Maize porridge liphalishi with germinated sorghum malt, enriched with relish, oil, or peanut butter		28 families over 1 week	86% were able to enrich; 90% added the malted grains
Niger	Millet flour-based porridge with sugar and peanut solids (kulikuli), sour skimmed milk, or a fried bean, millet, or wheat cake	83 kcal/100 g enriched with cakes; 51 kcal/ 100 g enriched with peanut solids or milk	116 mothers of mostly ill children 4–24 mother old in a 1-wk trial	73% used food at least once a week; 11% used it for 3 or more days; 4% never tried it; 26% modified the recipe slightly; 91% would continue to give the food to their children
Senegal	Porridge enriched with peanut butter, milk, butter, or oil		31 mothers	77% tried food; 68% would continue; milk and butter were preferred; butter for infants 6–11 months old.
Indonesia	Nasi tim bayi, rice enriched with fish, vegetables, and oil		22 mothers	86% made it as milk; 55% continued to make it with slight changes; 45% were willing to add fat source to the recipe

***Source*:** Guptill *et al.* (2004) [36] and Guptill (2009) [37]

Table 2: First Foods Introduced to Infants in Different Countries

Region	Country	First food	Age at first food	Feeding methods
Africa	Nigeria (Yoruba people)	*Eko*, a liquid pap from sorghum or maize	6 months	The pap is held in the mother's cupped hand and poured into the baby's mouth. The mother may force-feed the baby if the baby resists swallowing it.
Africa	Tanzania (Wagogo people)	*Uji*, a thin millet gruel	3 to 4 months	Uji is drunk from a cup or gourd.
Africa	Mali	Porridge or gruel made of millet or rice, perhaps with fish or potatoes	7 months for girls and 10 months for boys	Children feed themselves, with their right hands, from a bowl.
Africa	Zimbabwe	*Bota*, a pap made from ground corn meal	3 months or earlier	The mother or caregiver feeds the baby with a cup or spoon.
South America	Brazil	Cornstarch and other grains	4 months	Powdered milk was often given to newborns before 3 months of age. After 6 months, most babies ate beans and rice or whatever the family ate. Adult foods were broken into small bits and fed from the mother's hand.
South America	Guatemala	Cornmeal or eggs, and fruit juice	4 to 6 months	Mothers normally chose suitable food from among what the family was eating. Cornmeal gruel was often given in a bottle.
South America	Peru	Wheat and potato soup	6 to 8 months	Children were normally allowed to feed themselves, unless they were ill. Urban children were given solid foods sooner than rural children.
Asia	Bhutan	Porridge of rice flour or maize, cooked with butter	2 months	Babies are fed from their mother's hands.
South America	Dominican Republic	Orange juice, lime juice, beans	3 months	Powdered milk is often given to newborns before 1 month of age. Milk and juice are usually given in a bottle. Fruits and vegetables are usually introduced before meat and beans, and grains were usually last.
Asia	Bangladesh	Dry finger foods, rice or rice-like foods	4 months	The food is held in the caregiver's hands. Babies were given very small amounts of solid food multiple times each day.
Asia	Nepal	Grains	6 months	Mothers pre-chewed grains that they were cooking for the rest of the family, mixed them with water or butter, and used their fingers to put the food in their baby's' mouth. Babies in Hindu families were fed rice at the age of 3 weeks in the celebration of Annaprashana (in Nepal Pasni), but did not regularly eat food until later. Many start with rice porridge (jaulo) and powdered cereals porridge (lito).
Oceania	Papua New Guinea	mashed papaya, sweet potato, pumpkin, and banana	6 to 12 months	Water, vegetable broth and peeled sugar cane were given to young infants as an extra source of fluids. Liquids were given in a bowl, cup, or bamboo straw. Taro and meat were withheld until the baby was about a year old. Traditionally, babies were not given solid foods until they could walk.
Oceania	Solomon Islands	Pre-chewed taro with water or sweet potato cooked in coconut milk	0 to 9 months	Many mothers began feeding their babies solid foods within 1 to 2 months after birth; they thoroughly chew the food and feed it mouth-to-mouth for the first few months. This was also a common practice for feeding a hungry baby if the mother was temporarily unavailable. Sukuru mothers usually began feeding solid foods between 6 and 9 months. Some fed babies mouth-to-mouth; others pre-chewed, boiled, or mashed the food and gave it to the baby in a spoon or the baby's hand.

North America	USA	Infant cereal, and later pureed fruits or vegetables	2 to 6 months	Cereal mixed with infant formula and given in a bottle, or fed to the baby with a spoon. Poor women began feeding solid foods much earlier than wealthier women.

***Source*:** (Pelto *et al.,* 2003) [60].

2.3. Recent Advances on protein enrichment efforts in Complementary Foods

Several efforts which have been made to enrich the protein contents of cereal based complementary foods includes such as fortification of whole grains with legumes, supplementation of fruits and Vegetables, fortification of Infants formulas with Bioactive Compounds, By commercial technologies: E.g malting, popping, fermentation and using of modern food-processing technologies such as roller drying and extrusion cooking and through Bio-fortification: This is done by supplementing Infant foods with varied types of crops that are rich in vitamins and minerals. This helps in providing a balanced complementary food items containing cereals, tubers, food of plant, fat and vegetable origin. Fortification of Infants formulas with food that are rich in micro and macro nutrients guarantees sufficient nutrients: This enhances good eating habits and prevents the development of anorexia caused by monotonous foods (WHO, 2009 and FOA, 2011) [29] and other Unusual Animal Protein Sources Addition of insects, periwinkle termites, cockroaches to cereals based products (Obatulo, 2010 and Inyang and Effiong, 2016) [43].

2.3.1 Protein and its Sources

Proteins are large molecules composed of one or more chains of amino acids in a specific order determined by the based sequence of nucleotides in the DNA coding for protein. Proteins are required for the structure, function and regulation of the body's cells, tissues and organs (Clark 2003) [20]. They have similar basic structure but differ in their side chains. This difference in side chains give the proteins their specificity and functionality. These amino acids are classified as essential (those that cannot be synthesis by body but rather taken as supplement from diet), and nonessential (that can be synthesis by the body). Demand for the relatively cheap sources of protein that can be incorporated to value –added food products is increasing worldwide, and numerous researches are still going on various sources of plant proteins that may help in improving the nutritional value of food products at low cost (Gurpreet *et al.,* 2006) [38]. Proteins are available in different varieties of dietary sources including animals, plants origin and from highly marketed spot supplement industry. Typically, all dietary animal proteins (e.g. eggs, milk, meat, fish and poultry) are considered complete protein because they containall essential amino acids. Proteins from vegetable sources (such as legumes, nuts and soy) are incomplete proteins since they are lacking one or two essential amino acids. Examples of protein sources includes;

2.3.1 Protein Isolates

Most refined form of protein products containing the greatest concentration of protein (90%) but unlike flour and concentrates which contains no dietary fiber. They are very digestible and easily incorporated into different food products. Protein isolates have been developed from a variety of legumes among which are soy bean, peanut, canola, cashew nut, almonds, sesame, pinto and navy beans (Umar and Sawinder, 2014) [69].

2.3.2 Protein Concentrate

Protein concentrates has less protein compared to Isolates. Many concentrates are 70% protein, which means on a dry basis, 70% of the total weight is protein. The most common concentrates are soy and fish protein concentrate (FPC). Concentration of proteins from different sources is primarily aimed at providing a satisfactory solution for protein malnutrition/undernutrition and effective utilization of the underutilized protein sources (Singh *et al*, 2008 and Sipos 2013 and Abhishek j, 2017) [45, 66, 1].

2.3.3 Flour

Protein flour is made by grinding legumes into a fine powder. It comes in three forms: whole or full-fat (contains natural oils); defatted (oils removed) with 50% protein content and with either high water solubility or low water solubility; and lecithinated lecithin added (Singh *et al.,* 2008; Shurtleff and Aoyagi, 2013 and Sipos, 2013) [45, 66, 63].

2.4 Nutritional Significance of Cereal Legume Formulation.

Legumes are low priced sources of protein rich foods that have been important in alleviating protein malnutrition and in the tropics; they are the most important food crops after cereals (Ashaye *et al.,* 2000) [15]. Leguminous seeds include soybean, cowpea, groundnut, pigeon pea (red gram), mucuna (velvet beans), jack bean, oil bean and chicken pea etc. The legume and grain families are by far the world's most important sources of food; grain supply starch, whereas legumes which include bean, peas and alfalfa supply protein, starch and fats. Legumes are rich sources of protein, energy, vitamins, dietary fiber, mineral and oil, especially the oil-seeds (Arawade and Borokini, 2010) [12]. Cereals are deficient in lysine and tryptophan, but rich in methionine, leucine and cysteine, whereas legumes are deficient in sulfur containing amino acids such as methionine andcysteine, and rich in lysine (Sodipo and Fashakin, 2011) [67]. Legume products are ideal sources of some of the essential amino acids used to complement cereal proteins (Oluwole *et al.,* 2017) [58].

The utilization of cereals and legumes by the human race offers them an essential place in global nutrition which plays a vital part in the conventional food practice of many provinces all over the world. Cereals and legumes reside a significant position in human nutrition particularly in the dietary pattern of low economic population from budding countries are said to be the best combination for delivering good nutrients. National Health and Medical Research Council state that cereals including barley, maize, wheat, rice, oats, sorghum, rye and millet and the foods prepared out of the cereals supply more than 56 percent of the energy and 50 percent of the protein to the human population (National Health and Medical Research Council, 2003).

Foods prepared out of whole cereals contain increased concentration of phytochemicals along with other vitamins and minerals. In addition to this, a smaller percentage of population used cereals like sorghum and other millets and their food products have received the attention in new food formulations as they are proved to be the good and comparable sources of proteins and other functional components (Duodu *et al.,* 2003) [24]. They

also hold considerable levels of an extensive range of phenolic compounds (Dykes and Rooney, 2006) [25]. Like cereals, legumes which are considered as poor man's meat are also excellent sources of dietary complex carbohydrates (starch and dietary fiber), protein, minerals and B vitamins (Tharanathan and Mahadevamma, 2003) [68]. The legumes that are generally consumed by the people including red gram, green gram, black gram, green peas proved to contain good nutritional profile ensuring health benefits. They contain low fat, high protein, dietary fiber and good amount of micronutrients and phytochemicals. After few mechanical processes like steel cutting, rolling or flour making, most of the cereals can be eaten as whole, refined or as breakfast foods which may add required nutritional profile like high fiber, low fat and retention of some micronutrients.

Legumes which have some anti-nutritional factors like phytates, tannins and cyanogenic agents need specific processing techniques to make them suitable for consumption. Though the cereals and legumes are unique in their individual nutrient composition, health benefits and other functional properties, cereals are poor source of the essential amino acid lysine which is abundant in pulses. On the other hand, methionine is complemented by cereal protein which is less in legume (Iqbal *et al.*, 2006) [44]. Hence, the overall protein quality, nutritional value and health promotion further more increases when cereals and legumes are combined together as composite mix, weaning food mix, supplementary food mix and other ready to cook flour mix. New composite mix and weaning or supplementary food mix are being introduced by emerging food industries and also by the health professionals and nutritionists in order to combat with the deep rooted food insecurity, malnutrition and certain diseases in infants, children and adults. These food mix prepared by combining cereals and legumes are economical which contain locally available ingredients to improve the overall food and nutritional quality. Ahmed *et al.* (2008) [5] formulated six mix using flours of soybean and wheat at different ratios. Soybean was treated with heat for 5, 10 and 15 min before milling into powder and blended with wheat flour at the proportion of 95:5 and 90:10. Further 3g of milk powder and 5g sugar were added to all the mix and analyzed for nutritional composition. The processed mix contains 12.52 - 13.63 g of protein, 4.58 - 4.88 g of fat, 1.47 - 1.57 g of ash and 72.69 - 73.72 g of carbohydrates. Two types of mix were made up of finger millet, lima bean and peanut at the proportion of 65:25:15 were formulated and analyzed. The result revealed that the mix possessed higher content of fat (6.8 g), protein (12.80 g), ash (1.10 g), iron (2.5 mg), phosphorous (283 mg) and calcium 260 mg for every 100 g of finger millet when compared to rice based mix (12.20 g, 5.9 g, 0.9 g, 0.5 mg, 205 mg and 63 mg/100g respectively).

Ijarotimi *et al.* (2006) [42] developed and analyzed the nutritional quality of multi mix consisted of sorghum and pigeon pea at different combinations of 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. With the increment in ratio of pigeon pea an increased content was noted in crude protein and crude fibre with a decrease in carbohydrate content. Mix possessed 12.7 - 21.9 g protein, 2.3 - 2.6 g fat, 1.4 - 2.2 g crude fiber, 5.8 - 6.5 g ash and 58.3 - 71.8 g carbohydrates. Apart from this, incorporation of cereals and legumes along with leafy vegetables, nuts and oil seeds have remarkable effect on the nutritional and functional properties of composite mix. This composite mix also ensures high organoleptic and sensorial qualities suitable for all individuals targeting low cost food mix formulations with high nutritional significance

3. Conclusion and Recommendation

3.1 Conclusion

Several efforts have been made to enrich the protein contents of cereal based complementary foods such as fortification of whole grains with legumes, fruits, tubers, crops, bioactive compounds and vegetables that are rich in micro and macro nutrients, commercial technologies such as malting, popping, fermentation and using of modern food-processing technologies such as roller drying and extrusion cooking. Other unusual animal products such as insects, periwinkle, termites, cockroaches have also been supplemented with cereal based complementary foods. To guarantee the nutritional wellbeing of children, a holistic approach with a focus on the first 1000 days of life is required and consistency of complementary foods should change from semisolid to solid foods to meet the nutritional needs of children.

3.2 Recommendation

The introduction of nutritionally adequate and safe complementary (solid) foods at 6 months together with continued breastfeeding up to 2 years of age or beyond will address inadequate complementary feeding practices. Complementary foods should be varied to include adequate quantities of meat, poultry, fish or eggs, as well as vitamin A-rich fruits and vegetables every day. Where this is not possible, the use of fortified complementary foods, vitamin and mineral supplements may be necessary to address a particular dietary gap.

References

1. Abhishek RI. Process of making protein Isolate and concentrate. Luseev Pub Company. Bangalore, India, 2017.
2. Adedeji OE, Oyinloye OD, Ocheme OB. Effects of germination time on the functional properties of maize flour and the degree of gelatinization of its cookies. African Journal of Food Science. 2014; 8:42-47.
3. Adeleke AO, Oyewole OB. Production of Ogi from germinated sorghum supplemented with soybeans. African Journal of Biotechnology. 2010; 9(42):7114-7121.
4. Adeoti A, Osundahunsi OF. Nutritional characteristics of maize based complementary food enriched with fermented and germinated moringa oleifera seed flour. International Journal o, 2017.
5. Ahmed M, Uddin MB, Aktar S, Eun J. Effect of processing treatments on quality of cereal based soybean fortified instant weaning food, 2008.
6. Ajanaku CO, Oluwole O. Dieary fortification of sorghum-ogi using crayfish (Paranephrops plkanifrons) as supplement in infancy. Food Science and Quality Management. 2013; 15:11-10. ISSN 2224-6088.
7. Ajanaku KO, Ajanaku CO, Edobor O, Nwinyi OC. Nutritive value of sorghum-Ogi fortified with groundnut seeds. American Journal of Food Technology. 2012; 7(2):82-88.
8. Akinola OO, Opreh OP, Hammed IA. Formulation of local ingredients based complementary food in south west Nigeria. Journal of Nursing and health, 2014, 57-61. ISSN: 2320-1959.

9. Alderman H, Hoddinott J. "Hunger and malnutrition" (International Food Policy Research Institute Washington, D.C (2004 draft); L. Haddad, H. Alderman, S. ppleton L. song and y.yohannes, 2004.
10. Aminigo ER, Akingbala JO. Nutritive composition of Ogi fortified with okra seed meal. Journal of Applied Science and Environment Management. 2004; 8(2):23-28.
11. Anigo KM, Ameh DA, Ibrahim SS, Danbauchi SS. Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. African Journal of Food Science. 2010; 4(3):65-72. ISSN: 1996-0794.
12. Arawande JO, Borokini FB. Comparative study on chemical composition and functional properties of three Nigerian legumes (Jack beans, pigeon pea and cowpea). Journal of Engineering Trends in Engineering Applied Sciences. 2010; 1:89-95.
13. Aremu MO, Olaofe O, Audu S, Ijalana DM. Biochemical evaluation of fermented white maize (Zea mays L.) blended with scarlent runner bean. The Open Nutraceuticals Journal. 2011; 46:163-171.
14. Arntfield SD, Ismond MAH, Murray ED. The fate of anti-nutritional factors during the preparation of faba bean protein isolate using micellization technique. Canadian Inst. Food Sci. Technol. Journal. 1985; 18:137-143.
15. Ashaye OA, Fasoyiro SB, Kehinde RO. Effect of processing on the chemical and sensory quality of ogi fortified with full fat cowpea flour. Journal of Agricultural Research. 2000; 1:115-123.
16. BMZ. 10-Punkte Programm des BMZ zur ländlichen Entwicklung und Ernährungssicherung, 2012.
17. BMZ-GIZ. International Agricultural Research. List of BMZ funded projects, 2011.
18. Bukusuba J, Isabiry F, Nampala P. Enhancing Nutritional Density and Quality of Banana-Soy Based Complementary Diet through Substitution with Sesame. African Journal of Food, Agriculture, Nutrition, and Development. 2008; 8(1):104-117.
19. CGIAR. Agriculture for improved nutrition and health. Executive Summary. Research Programme: Proposal submitted by IFPRI, 2011.
20. Clark DR. Improving in vitro protein digestibility and determining protein nutritional quality by modelling dissertation. Athens Georgia Uni. US, 2003.
21. Copenhagen Consensus Center: Summary – Results, 2008.
22. Dendegh TA, Ukeyima MT, Dendegh RA. Proximate composition functional and sensory properties of pearl. Asian food science Journal. 2019; 8(3):1-11. ISSN: 2581-7752.
23. DFID. The neglected crisis of undernutrition. DFID's strategy. Evidence for action, 2009.
24. Duodu KG, Taylor JRN, Belton PS, Hamaker BR. Factors affecting sorghum protein digestibility. Journal of Cereal Science. 2003; 38(2):117-s131.
25. Dykes L, Roonas LW. Sorghum and millets phenols and antioxidants. Journal of Cereal Science. 2006; 44:236-251.
26. Egyir BK, Ramsay SA, Bilderback B, Safaii S. Complementary Feeding Practices of Mothers and Their Perceived Impacts on Young Children: Findings from KEEA District of Ghana. Maternal and Child Health Journal, 2016. 20:188694.
27. Enweremadu CC, Waheed MA, Adeala A. The energy potential of brewers spent grains for breweries in Nigeria. J Eng. Appl Sci. 2008; 3:175-177.
28. FAO. Dietary Protein Quality Evaluation in Human Nutrition. FAO Food and Nutrition Paper 92: Report of an FAO Expert Consultation, Auckland, New Zealand, 2011.
29. FAO/WHO. Carbohydrate in Human Nutrition: Report of a Joint FAO/WHO Expert Consultation, 14-18 April 1997, Rome. FAO Food and Nutrition, 1998. Paper No. 66. Rome.
30. FAO/WHO. Report of the Third Session of the Codex Ad Hoc Intergovernmental Task Force on Foods Derived from Biotechnology. Yokohama, Japan, 2002.
31. FAO/WHO/UNU. Energy and Protein Requirements. Report of a joint FAO/WHO/UNU Expert Consultation. WHO Technical Report Series No. 724. WHO, Geneva, 2002, 207pp.
32. Food and Agriculture Organization of the United Nations (FAO): Voluntary Guidelines to support the progressive realization of the right to adequate food in the context of national food security, 2005.
33. Food and Agriculture Organization. The State of Food Insecurity in the World: How Does International Price Volatility Affect Domestic Eco nomies and Food Insecurity? Rome: Publishing Policy and Support Branch: FAO. Available from, 2011.
34. Grantham Mc Gregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B. Developmental potential in the first 5 years for children in developing countries, 2011.
35. Gupta N, Gehri M, Stettler N. Early Introduction of Water and Complementary Feeding and Nutritional Status of Children in Northern Senegal. Public Health Nutrition. 2007; 10:1299-304.
36. Guptill KS. Evaluation of An Infant Weaning Food Intervention In Kwara State, Nigeria. Doctoral dissertation, Department of International Health, Johns Hopkins University, Baltimore, Md, USA, 2009.
37. Guptill KS, Esrey SA, Oni GA, Brown KH. Evaluation of a Face-to-Face Weaning Food Intervention in Kwara State, Nigeria: Knowledge, Trial and Adoption of a Home prepared Weaning Food. Soc Sci Med, 2014, 665-72. 28.
38. Gurpreet K, Chandi GK, Sogi DS. Functional Properties of Rice Bran Protein Concentrate. J Food Engr. 2006; 79:592-597.
39. Gyampoh S, Otoo GE, Aryeety RN. Child feeding knowledge and practices among women participating in growth monitoring and promotion in Accra, Ghana. BMC Pregnancy and Childbirth, 2014, 14.
40. Idris S, Popoola-Zakariyya B, Sambo M, Sufyan M, Abubakar A. Nutritional Status and Pattern of Infant Feeding Practices among Children under Five in a Rural Community of Northwestern Nigeria. International Quarterly of Community Health Education. 2013; 33:83-94.
41. IFIC-International Food Information Council Foundation. Background on Functional Foods: Food Insight content 161 functional foods background, 2009.
42. Ijarotimi Steve O, Ayobami AO. Nutritional Composition, Sensory and Biological Evaluation of a Potential Weaning Diet from Low cost materials (Sorghum bicolourand

Cajanuscajan). Journal of Food Science and Technology. 2006; 4(3):178184. 42.
43. Inyang UE, Effiong EW. Chemical composition, functional and sensory properties of Maize Ogi fortified with periwinkle Meat Flour. International journal of Nutrition and Food Sciences. 2016; 5(3):195-200.
44. Iqbal A, Khalil IA, Ateeq N, Khan MS. Nutritional Quality of Important Food legumes. Food Chemistry. 2006; 97:3313-3543.
45. Kaur KD, Jha A, Sabikhi L, Singh AK. Significance of Coarse Cereals In Health And Nutrition: A Review. Journal of Food Science and Technology, 2011, 1-13.
46. Maziya-Dixon B, Dixon AGO, Adebowale AA. Targeting different end use of cassava genotypic variation for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB Symposium. Whitesands Hotel, Mombasa, Kenya, 2004.
47. Mbaeyi IE, Onweluzo JC. Effect of sprouting and pre-gelatinization on the physicochemical properties of sorghum-pigeon pea composite blend used for the production of breakfast cereal. Journal of Tropical Agriculture, Food, Environment and Extension. 2010; 9(1):8-17.
48. Mbata TI, Ikenebomeh MJ, Alaneme JC. Studies on The Microbiological, Nutrient Composition and Antinutritional Contents Of Fermented Maize Flour Fortified With Bambara Groundnut (Vigna Subterranean L.). African Journal of Food Science. 2009; 3(6):165-171.
49. National Health and Medical Research Council. Dietary Guidelines for Australian Adults. Endorsed 10 April 2003. Common-wealth of Australia: Canberra, 2003.
50. National Research Council Manual. Guide for the Care and Use of Laboratory Animals (8thed.). Washington, D.C: The National Academies Press, 2011.
51. NDHS. Nigeria Demographic and Health Survey. Columbia, Maryland: FOS and IRD. NDHS. Nigeria Demographic and Health Survey. Calverton, Maryland: National Population Commission and ORC Macro, 2003.
52. NDHS. Nigeria Demographic and Health Survey, 2008.
53. NNHS. A report on Nutritional and Health survey, 2018.
54. Obatolu VA. Nutrient and Sensory Qualities of Extruded Malted or Unmalted Millet/Soybean Mixture. Food Chem. 2010; 76:129-133.
55. Ogunlesi TA, Ayeni VA, Adekanmbi AF, Fetuga BM. Determinants of Timely Initiation Of Complementarsy Feeding Among Children Aged 6-24 Months in Sagamu, Nigeria. Journal of clinical practice. 2014; 17:785-90.
56. Okoye JI, Ezigbo VO, Animalu II. Development and Quality Evaluation of Weaning Food Fortified with African Yam Flour. Continental Journal of Agricultural Science. 2010; 4:1-6.
57. Oluseyi AK, Oluwafunmilalo A, Oluwasegun ST, Abimbola AA, Oluwatoyin AC, Olubusola. Dietary fortification of sorghum using cray fish (paranephrops planifrons) as supplements in infancy. Food sci. Quality Mangt. 2013; 15:1-9.
58. Oluwole O, Ididapo O, Odediran O, Kosoko S, Owolabi S, Adeyoju A. *et al*. Evaluation of Quality characteristics of soy fortified wheat-cassava composite Bread. International Journal of Food Science and Biotechnology. 2017; 2(2):38-42.
59. Omemu AM, Faniran OW. Assessment of The Antimicrobial Activity of Lactic Acid Bacteria Isolated from Two Fermented Maize Products-Ogi and Kunu Zaki. Malaysian Journal of Microbiology. 2011; 7(3):124-128.
60. Pelto G, Levith H, Thiaru L. Improving feeding practices. Food and Nutrition Bullein. 2003; 24(1):45-67.
61. Sharma S, Singh R, Rana S. Bioactive peptide. A review, International Journal of Bioautomotion. 2011; 15:223-250.
62. Shiriki D, Igyor MA, Gernah DI. Nutritional Evaluation of Complementary Food Formulations from Maize, Soybean and Peanut Fortified with Moringa Oleifera Leaf Powder. Food and Nutrition Sciences. 2015; 6:496-500.
63. Shurtleff W, Aoyagi A. History of Roasted Whole Soy Flour (Kinako), Soy Coffee. Lafayette, California: Soyinfo Center, 2012; 709:1420.
64. Shurtleff W, Aoyagi A. History of Soy Flour, Grits and Flakes. Lafayette, California: Soyinfo Center. 2013; 2053(6):616.
65. Singh P, Kumar R, Sabapathy, SN, Bawa AS. Functional and Edible Uses of SoyProtein Products. Comprehensive Reviews in Food Science and Food Safety. 2008; 7:14-28.
66. Sipos ES. Edible Uses of Soybean Protein Archived, 2013.
67. Sodipo MA, Fashakin JBV. Physicochemical Properties of a Complementary Diet Prepared from Germinated Maize, Cowpea and Pigeon Pea. Journal of food, agricultural environment. 2011; 9(3-4):23-25.
68. Tharanathan RN, Mahadevamma S. Grain Legumes a Boon to Human Nutrition. Trends in Food Science and Technology. 2003; 14(12):507-518.
69. Umar G, Sawinder K. Protein Isolate, Production, Functional Properties and Application. International Journal of current Research. 2014; 6(3):35.
70. WHO, UNICEF. WHO Child growth standards and the identification of severe acute malnutrition in infants and children, A Joint Statement, 2009.
71. WHO. Infant And Young Child Feeding. Model Chapter for Textbooks for Medical Students dand Allied Health Professionals. WHO, Geneva, 2009.