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Traditional Complementary Foods: A Critical Review

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ABSTRACT

Traditional complementary foods are popular minimally processed baby food used to introduce old infants and young children to adult foods. Cereal grains are it main ingredient, when cooked, because of its starch content, get gelatinized and swollen thereby making the diet viscous and bulky, so that it gives the stomach of old infants and young children enormous work to do. Traditional complementary foods consumed by old infants in many parts of the third world are deficient in essential macronutrients and micronutrients leading to malnutrition, which is one of the serious problems in developing countries. Protein energy malnutrition (PEM) generally occurs during this growing stage when children are weaned from breastmilk to semi-solid and later to family foods. The purpose of this study is to review literature findings on complementary foods. It's also aims to draw the attention of stakeholders and decision makers on the need to assess the nutrients quality and health risks associated with the consumption of low quality complementary foods and, consequently, the necessary measures and steps to reduce intake of low quality complementary foods by old infants and young children.

INTRODUCTION

Complementary foods are formulated food mixtures meant to be fed along with breast milk for infants from 6 months until completely weaned off breast milk (FAO/WHO, 2002), while weaning is the process of gradual withdrawal of breast-milk which is no longer sufficient to meet the nutritional requirements of infants and introduction of other foods and liquids known as complementary foods, to complement the breast milk and then to replace it with family diets (Dewey & Brown, 2003; Onabanjo *et al*., 2008; Anigo *et al*., 2009; Igyor *et al*. 2010). Thus, in a weaning process there is always the need to introduce soft, easily swallowed foods to supplement the infant's feeding early in life. The weaning process may be gradual, lasting for months until the infant is finally introduced to the family diet. In Nigeria, traditional complementary foods are usually introduced to the young children between 3 and 6 months depending on the locality and types of cereal grain and root crop available (Onofiok & Nnanyelugo, 2007). The usual first complementary food is called pap, "akamu", "ogi", or "koko" and is made by fermentation of maize, millet, or guinea corn (Ikujendola & Fashakin, 2005; Onabanjo, 2007). After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child; such foods include yam, rice, gari, and cocoyam, which may be eaten with sauce or soup (Onofiok & Nnanyelugo, 2007; Ikegwu, 2010).

Research has shown that fermentation of cereal grains to produce *ogi* (complementary food) not only removes part of its kernel such as seed coat and germ, but also involves washing, sieving and decanting, all of which induce changes in the chemical composition and nutritive value of the final fermented complementary food (Akinrele, 1970; Banigo *et al*., 1974; Akingbala *et al*., 1981; Adeyemi, 1983; Brown *et al*., 1998; Onofiok & Nnanyelugo, 2007; Ezeocha & Onwuka, 2010). Cereal based traditional complementary foods commonly fed to infants are inadequate to meet daily nutrients, energy and micronutrient requirements, where such complementary foods form the main source of nutrient to an infant, it may lead to the problems of under-nutrition and micronutrient malnutrition in infants and young children (Anju, 2002; WHO, 2002; Amina & Agle, 2004; Igyor *et al*., 2010). Malnutrition in childhood could predispose a child to chronic diseases including high blood pressure, diabetes, and stroke later in life (WHO, 2003; Anigo *et al*., 2009). The major cause of childhood micronutrient deficiencies is attributed to a variety of factors such as intake and chemical forms of minerals, food processing practices, and presence of other dietary factors that may enhance or inhibit mineral bio-availability, health, and physiological status of the individual (Gibson, 2000; Igyor *et al*., 2010).

Moreover, traditional complementary foods tend to be given in form of a gruel which has gelatinized, become bulky during cooking, and increased in viscosity, whereas the digestive system of a young child that will eat it is such that only gruel of light fluid consistency can be swallowed without choking (Sanni *et al.,* 1999; Amina & Agle, 2004; Igyor *et al*., 2010). Cereal based diets are generally low in protein quality as a result of been limited in some essential amino acids particularly lysine and tryptophan, which is necessary for the growth and development of old infants and young children (Ikujendola & Fashakin, 2005; Onofiok & Nnanyelugo, 2007; Muhimbula *et al*. 2011). Many researchers, food technologists, food scientists, nutritionists, etc, have worked extensively on how to improve the nutrient value of existing complementary foods by trying to combine cereals, legumes, and other staples in such a way that will maximize the efficiency of their proteins for weaning babies. For instance, Fashakin *et al*., (1986) developed a complementary food using corn gruel and melon seed (ogi and melon protein) and reported that the mix was superior to corn *ogi* and could be used as complementary food for old infants and young children.

Abbey and Nkanga (1988) evaluated a blend of cowpea flour, maize flour, sucrose and palm oil, and found out that the best mixture had a protein efficiency ratio of 1.69, net protein utilization of 62.2%, true digestibility of 78.5% and biological value of 76.5%. They reported that it could be used as alternative complementary food for old infants and young children, and there was no significant difference between the animals fed with the standard diet and those fed with the cowpea-supplemented diets. It was concluded in the study that the diet which comprised of 19.72% germinated cowpea and 59.15% maize could serve as a source of quality protein for feeding young children. Idowu *et al*. (1993) formulated complementary food from pre-gelatinized maize-potato mixture fortified with soybean and groundnut, and reported that it could be used as supplementary food for infants, while Olusanya (1998) formulated 30 different diets based on the principles of multi-mixes, but evaluated the protein quality of seven of them. He obtained protein efficiency ratio ranging from 1.7 to 2.7, net protein ratio of 1.6 to 4.8 and true digestibility values ranging from 81.3 to 87.7%, and recommended that the formulation is good for feeding babies.

Omueti *et al*. (2000) also evaluated a blend of freshly blanched soybean and grains of harvested green field maize (soy-corn) mixed in different ratios. This product called soy-corn "milk" according to the researchers can be used for combating malnutrition in developing countries. Ikujendola & Fashakin (2005) developed a complementary food from maize and cowpea (cowpea-ogi) and reported that the complementary food could be used to feed infants with addition of milk, and food supplement, while Walker & Pavitt (2007) carried out experiment on the energy density of third world weaning foods and reported that most traditional complementary foods energy density meet recommended daily allowance for old infants and young children, but low in protein quality. Other relevant contributors include Martin *et al*. (2010) who formulated a soybean based complementary food and reported that it could be used to complement a baby's food, while Anigo *et al*. (2010) observed that no single protein from a particular legume grain could be adequate to promote growth or enhance nitrogen retention compared to a milk-based diet. It could therefore be concluded that the search for local foodstuffs in the formulation of nutritionally adequate complementary food has long been in existence and is still in progress. A mixture of maize, millet, and soybean therefore could provide adequate nutrient intake for a child if well processed. Millet, one of the raw materials used in this study, has been reported to be richer in protein, vitamin B-complex, and ash content (Ca, P, Mg, Fe) than most cereal grains (Ihekoronye & Ngoddy, 1985). Soybean on the other hand, would provide the complementary food with minerals, vitamin B-complex, fat and protein; especially lysine and tryptophan which are deficient in cereal grains and thus possess great potential in overcoming protein-energy malnutrition in infants and young children (Dhingra & Jood, 2001).

Moreover, pro-vitamin A (carotenoid) found in yellow maize and finger millet would make a formulated complementary food from maize, millet, and soybean a health complement to infants and young children diets. Processing methods such as fermentation, germination, roasting, boiling, grilling, steaming, etc, have also been shown to have significant effect on the nutrient density, bulkiness, and viscosity of most traditional complementary foods (Ikujenlola & Fashakin 2005; Anigo *et al*., 2010). Fermentation is a common way of preserving food, improving digestibility and increasing appetizing flavours (Dewey & Brown, 2003; Igyor *et al*., 2010). During fermentation, proteins are broken down to amino acids; starches are converted into simple sugars, while riboflavin and niacin content increase, vitamins such as B_{12} are synthesized and the amount of available iron is increased because some anti-nutrients such as phytate which chelate minerals are removed (Onofiok & Nnanyelugo, 2007; Ezeocha & Onwuka, 2010). *Ogi,* a fermented product of maize is a common complementary food in Nigeria used for weaning infants and young children (Akinrele, 1970; Brown *et al*., 1998). Traditional processing of *ogi* has been reported to have a number of slight processing variations (fermentation method) which could have effect on the composition and quality of the final product (Banigo *et al*., 1974; Akingbala *et al*., 1981; Adeyemi, 1983; Brown *et al*., 1998; Onofiok & Nnanyelugo, 2007; Ezeocha & Onwuka, 2010). For instance, Ikujendola and Fashakin (2005) reported that protein, minerals and some vitamins especially the water soluble ones are lost during fermentation of maize and subsequent processing into ogi, while its riboflavin content seemed to depend on the type of microorganisms involved in the fermentation.

Germination on the other hand could improve nutritive value, and increase digestibility, appetizing flavours are also developed and palatability is improved. Sprouting also has been reported to reduce anti-nutrients in legumes such as phytate and flatulent factors (Babajide, 1998). Muhimbula *et al*. (2011) also reported that germination as a processing method increases starch and protein digestibility, bio-availability of vitamins and minerals, and causes a decrease in antinutrient factors of such food products. In soybean, sprouting has been shown to reduce anti-nutritive factors such as trypsin inhibitors and hemagglutinins (Oshaug & Haddad, 2002; Aminu *et al*., 2010). When flour of germinated grain is used, the concentration of the gruel can be increased 3 – 5 times while maintaining the same viscosity as that of gruel of ungerminated flour (Dewey & Brown, 2003). Apart from fermentation and germination methods, roasting have also been found to improve colour, flavour, and overall acceptability of some food products. Roasting method could reduce moisture content in order to improve storage stability, and also develop desirable colour and flavour. Roasting also reduces anti-nutritional factors (protease inhibitor and lectins, phytic acids, oxalic acids, and tannin) of composite flours (Keku, 2006). Onuorah & Akinjide (2004) reported that during roasting some chemical changes take place such as pyrolysis of proteins to amino acids, destruction of the reducing sugar and browning of food products and these if not controlled, some of the most valuable nutrients needed by the baby could be lost. A complementary food developed from fermentation, germination, and roasting singly or combined therefore would be expected to provide adequate nutrient for a child and have long shelf life. Most of the previous researchers on complementary foods did not report storage stability and shelf life of their complementary foods, while many are also silent on the safety and toxicity (aflatoxin) of the products. Therefore, the goal of this review is to look into the complementary food in totality

Complementary Foods

Complemenatary foods in Nigeria are often given to babies as gruels. Research have shown that traditional complementary foods do not contain more than 10 – 12% dry matter, the rest is water due to the fact that the gruel gets gelatinized during cooking and increase in viscosity (Simango, 1997). During feeding, the gruel is usually diluted with water to make it digestible for the young child and at the same time avoid choking (Juke *et al*., 2002; Rapley, 2006). After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child; such foods include yam, rice, gari, and cocoyam, which may be eaten with sauce or soup (Onofiok & Nnanyelugo, 2007; Ikegwu, 2010). People from low-income groups seldom feed their infants with meat, eggs, or fish, because of socio-economic factors, taboos, and ignorance (Nnanyelugo, 1985; Onofiok & Nnanyelugo, 1992). Cherian (1981) and Onabanjo (2007) reported that people from high-income groups used these foods more often and tended to add variety to their weaning foods.

Legumes are rarely used for weaning and are introduced much later (after six months of age) because of the problems of indigestibility, flatulence, and diarrhea associated with their use (Uwaegbute & Nnanyelugo, 1987; Solomon, 2005). However, Uwaegbute & Nnanyelugo (1987) noted that 67% of their study population satisfactorily used cowpea products for weaning. Armar-Klemesu & Wheeler (1987) reported that in Ghana, the main complementary food for infants up to six months of age was a traditional fermented maize porridge (koko) and from six months onwards, the infants were given the family diet with complementary breastfeeding. Most traditionally used processing methods have resulted in the loss of other nutrients apart from protein. Makinde & Lachance (1976) reported a 98% loss of the original tryptophan in maize during the processing of *ogi*. In Anambra State, Nigeria, Agu (1976) observed that pap contained only 0.5% protein and less than 1% fat, as compared to 9% protein and 4% fat in the original corn. Indeed, Akinrele and Edwards (1971) reported that the protein content of pap *ogi* was too low, even to support the growth of rats, Ketiku and Ayoku (1984) noted that corn gruel can only provide some energy, but not other nutrients needed for growth of the baby. Onofiok and Nnanyelugo (2007) similarly noted that the traditional millet gruel used for weaning Senegalese children was not energy dense and was insufficient to cover all the nutrient needs of the infant (Table 1).

Table 1: Traditional complementary foods fed by West African mothers

Country	Food	Major nutrient composition	Introduction month	Description
Nigeria	Ogi, pap, akamu, koko	Carbohydrate	3 – 6	Fermented cereal from maize, sorghum, or guinea corn.
Ghana	Koko, Kenkey	Carbohydrate	3 – 6	Fermented corn porridge.
Sierra-Leone	Ogi, couscous ogi	Carbohydrate	4 – 6	Cereal gruel from fermented maize, or sorghum.
Benin	Ogi	Carbohydrate	3 – 6	Cereal gruel from fermented maize, sorghum, or millet.
Senegal	Ogi	Carbohydrate	3 – 6	Cereal gruel from fermented maize or millet

Source: Onofiok and Nnanyelugo, 2007.

Agyepong and Vallen (1991) reported that in 1987 Ghanaian National Survey, 58% of the Ghanaian children were below 80% weight-for-weight age, 8% suffered from severe malnutrition, 40% were wasted, and 52% were stunted. Amar-Klemesu and Wheeler (1991) observed that 30% of the infants who were fed cereal porridge and adult foods as complementary foods were malnourished as a result of inadequate complementation with breast milk. Jonsyn (1985) reported that ogi prepared from maize or sorghum (couscous ogi), a popular complementary food in Sierra Leone was found to be inadequate in meeting the nutrient needs of the baby (Table 1). According to Onabanjo (2007), Demographic and Health Survey (DHS) of children aged 6 to 36 months in Ondo State, Nigeria, showed 28% prevalence for underweight, 32% for stunting, and 7% for wasting. It is therefore clear that during the period of weaning, children in West Africa are very vulnerable to malnutrition, and one of the major factors that causes stunting or what makes some children appear stunted can be traced to inadequate food intake. Children in West Africa are therefore at high risk of infection during weaning.

Malnutrition increases susceptibility to infectious diseases and affects child mortality from diseases such as diarrhea, whooping cough, acute respiratory infection and reduces the capacity of the host to resist the consequences of such infection, thereby making death inevitable for some. However, available statistics from Nigeria shows that infant mortality is responsible for almost 50% of all the deaths of children up to 14 years of age, and under-five mortality accounts for 93% of these deaths, 70% of which are attributed to preventable diseases (Onabanjo, 2007). According to Cameron and Hofvander (1983), the simplest recipe for complementary food called multi-mix is one which has a basic mix of cereal or starchy root/tuber mixed with legume. Appropriate use of low cost, affordable formulated complementary foods with emphasis on vegetable source of protein has been recommended for the developing countries (Dewey & Brown, 2002; Lutter & Dewey, 2007). Being a complement to breast milk, such diets should provide enough energy and nutrients that are needed to meet increasing physiological requirements of the young children and at the same time support growth and development.

Raw materials commonly used for tradition complementary foods

The International Programme of Complementary Food Mixtures is aimed at developing products whose ingredients are produced locally (FAO/WHO, 1991). In selecting the raw materials, attention should be paid to availability, maturity and processing method employed as this will affect the acceptability of the final product. Also, it is necessary to realize that the complementary food must be acceptable to the mother before she will agree to feed her baby with the product. The raw materials commonly used are cereal grains and legume.

Cereal grains

Cereal grains which belong to the family *graminaeae* are the most widely cultivated and consumed crops on a global basis. It is also a staple food of the people in the tropics where it provides about 75% of their total caloric intake and 67% of their total protein intake (WHO, 1998; Rapley, 2006). In Nigeria, especially in the Northern part of the country, cereals are the major sources of energy and protein in the diets of the people. The major cereals cultivated are sorghum, millet, maize and rice; together these four crops occupied an estimate of over 16 million hectares of farmland (Okoh, 1998). The structure of all cereal grains is basically similar, differing from one cereal to another in detail only. The composition of mature cereal grains consist mainly of carbohydrates, proteins, lipids, mineral salts, water and vitamins which are present in small quantities (Okoh, 1998). Several reports on the major chemical composition of cultivated cereals in Nigeria have been given as proximate composition (Adeyeye & Ajewole, 1992; Ngwu, 2005). Compared with root and tuber crops, cereals offer a better source of protein in the diet of Nigerians whose intake of protein from animal sources is low. However, the nutritional quality of most cereal protein is poor because they contain less of the essential amino acids, particularly lysine, needed for growth and maintenance (Juke *et al*., 2002; Okoh *et al*., 1985).

The major protein of cereals responsible for the poor biological value of the grain is prolamine. Protein quality is inversely related to its prolamine content, that is the lower the prolamine content the higher the protein quality, although there may be several other interacting factors (Onabanjo *et al*., 2008). The protein values of major cereals grown in Nigeria according to Okoh (1998) are quite different, ranging from 6.96 to 13.69 g. Millet and wheat have slightly higher protein contents of 13.69 and 11.63 g/100g than maize, sorghum, and rice with 10.03; 9.28, and 7.07 g/100g, respectively. Acha, a lesser known cereal in Nigeria has remarkably lower protein content of 6.96%. Apart from rice with mineral salts content of 0.56%, the rest of the cereals have mineral salts ranging from 1.16 – 2.44%. The crude fat content in acha of 2.10% is similar to those of sorghum, rice and wheat with 2.27, 2.25, and 2.33%, respectively, but lower than the values of maize and millet 2.54% and 5.39%, respectively (Okoh, 1998). Okoh *et al*., (1985) reported that cereal protein is of low nutritional quality because they contain less of essential amino acids especially lysine needed for growth and maintenance.

Cereals, therefore needs to be fortified with a high protein rich food such as soya beans, groundnuts, cowpeas, bambara beans, etc. (Okoh, 1998). According to Ihekoronye and Ngoddy (1985), most cereals have high carbohydrate content ranging from 68 to 83% in oats and maize, respectively; while their protein content is between 6.96 in acha to 13.69% in corn. The writers reported that except for the two amino acids (lysine and tryptophan), most cereals contain the essential amino acids required by man as well as vitamins and minerals. Adeyeye and Ajewole (1992) reported the chemical composition of cereal grains cultivated in Oyo State, Nigeria and showed that rice has the least amount of crude protein compared with cultivated sorghum, millet and maize. The report by Nwasike *et al*., (1987) on the proximate, mineral and amino acid composition of early and late maturing Nigerian millets showed that the total seed protein was higher in the late maturing millets and ranged from 14.09 to 17.14%, while the protein in the early maturing millets ranged from 12.30 to 13.69%. Compared with Nigerian sorghum varieties, millets have higher protein content and were found to be superior in their most limiting amino acid content (Okoh, 1998).

Significance of morphology and structure in cereal grain processing

The work of several authors have clearly shown that, without a full understanding of the grain morphology and structure, the studies on technological and product quality characteristics will not be complete in cereal grains (Srinivas *et al*., 1991). The main constituent of cereal grains, which make them important in food preparations are their starch and protein contents. The behaviour of cereal grain starch, like any other starch such as corn starch is to thicken and form a gel. Kordylas (1990) reported that this ability makes starch in cereal grains a very important ingredient in food preparation where thickening and gel formation are desirable. Hence, the determining factors of grain morphology and structure are inherent in the parent plants. Texture of grains is another factor that largely affects the end product quality of maize and other cereal grains. This determines the product acceptability by the consumer (Adeyemi, 1983; Onuorah & Akinjide, 2004; Ikegwu, 2010). The endosperm texture (vitreousness) is commonly associated with hardness and dry-milling behaviour of cereal grains and a good breeding indicator of grain quality (Mestres *et al*., 1995). Carcea and Acquistucci (1997) reported that the starch granules of maize show deep indentations on their surfaces. Softness and stickiness of sorghum tuwo were correlated significantly with particle size index of the flour which is determined by the texture of the kernel (Akingbala & Rooney, 1990; Sanni *et al*., 2004). The existence and function of features such as pores which are often found randomly distributed over the surface of the cereal starch granules of the members of sub-family panicoideae (Fannon *et al*., 1992; Adebowale *et al*., 2005), also contributed to the texture of the cereal flours.

Starch granules absorb water, and finally the suspension thickens to form a paste, with an accompanying change in appearance of the heated suspension. Starch granules are primarily composed of amylose and amylopectin (Takeda *et al*., 1987; Wankhede *et al*., 1989; Adebowale *et al*., 2005). Takeda *et al*., (1987) reported that amylose is essentially a linear polymer consisting of 1 – 4 linked D-glycopyranosyl units, but some amylose molecules can be slightly branched with D-(1 – 6) linkages. Amylopectin is a highly branched polymer of -D-glycopyranosyl unit, primarily linked by 1 – 4 bonds, with branches resulting from (1 – 6) linkages.

Matz (1984) recommended a 5 – 20% amylose level in starch to give acceptable texture with adequate crispness. Amylopectin contribute to swelling, whereas amylose and lipids inhibit swelling (Tester & Morrison, 1990). The transition from a suspension of starch granules to a paste, when heat is applied is accompanied by a large increase in viscosity. Jideani and Akingbala (1993) reported that the starch granules of acha grains gelatinized between 76 and 78^{0}C, compared to that of sorghum 68 - 75^{0}C and a bit higher than that of maize 70.1^{0}C. According to Oyewole and Akingbala (1993), acha has a higher gelatinization temperature than other common cereal in Nigeria. The presence of naturally occurring non-carbohydrate such as lipid is also an important factor in starch gelatinization (Mora-Escobedo *et al*., 1991; Sanni *et al*., 2001). Swinkles (1985) showed that the formation of amylose-lipid complexes could restrict swelling and solubility of the starch, hence affect its rheological properties, while June *et al*., (1991) reported that the increase in paste viscosity when a hot paste is cooled is governed by the retrogradation tendency of the starch and this is largely determined by the affinity of hydroxyl groups in one molecule for another which occurs mainly between the amylose molecules.

Legumes

Legumes are important sources of proteins in many of the lesser developed countries and tropical areas. Legumes belong to the family *Leguminosae,* which is probably the second most important source of food and fodder, next only to the family *Graminaeae,* the cereal grains. The legume is, however a very important crop in terms of production systems since grains and fodder can be obtained with minimal investment in terms of nitrogenous fertilizers (Solomon, 2005; Ezeocha & Onwuka, 2010). Basically, legumes are divided into three categories as food legumes, oilseeds, and forage legumes. The major types of food grain legumes and pulses are groundnuts, cowpeas, bambara nuts, broad beans, pigeon peas, beans, jack beans and soya beans (Ikujenlola & Fashakin, 2005). Dry grains of legumes are used as sources of vegetable oil, while the defatted meals are used as sources of protein. Grain legumes (pulses) can be boiled and eaten as such or made into flour and used for various dishes. Legumes are good sources of dietary protein. They are rich in lysine and tryptophan but low in the sulphur-containing amino acids, methionine and cysteine (Anigo *et al*., 2009). Legumes are cheaper than animal products (meat, fish, poultry, egg) and are consumed worldwide as major source of protein, especially in the developing countries where consumption of animal protein may be limited as a result of economic, social, cultural, or religious factors. Elegbede (1998) and Anigo *et al*., (2010) reported that legumes are good sources of protein and energy; the protein content ranges generally from 20 to 40% for most grain while its carbohydrate content ranges from 23% in groundnut to 66% in bambara groundnut, pigeon pea, and lima bean.

Legumes, except the oilseeds are low in fat content, ranging from 1 to 5%. However, oilseeds have a range of lipid content from about 18% in soybean to as high as 43% in groundnut (Osagie, 1998; Dewey & Brown, 2003). All legume grains contain substantial amounts of minerals and vitamins, especially those of the B group. Cowpea, soybeans, and bambara groundnuts are good sources of calcium and iron with their contents being higher than those of meat, fish or eggs. These legumes also contain more thiamin, riboflavin and niacin than whole milk and cereals, with the levels of these vitamins being comparable to those available from fish, beef and egg (Elegbede, 1998; Ikujenlola & Fashakin, 2005). The quality of a protein is usually evaluated by comparing its amino acid profile to that of the FAO/WHO/UNU (1985) standard amino acid pattern or by observing the growth performance and nitrogen balance of animals fed on a diet containing legumes as the only protein source. Thus, by combining the protein from legumes and cereals, dietary proteins of high nutritive value similar to protein from meat, fish and egg are obtained due to mutual complementation (Solomon, 2005; Martin *et al*., 2010). However, one of the militating factors against the use of legume without proper and adequate treatment/processing is its antinutritional factors.

Antinutritional factors

According to Bajpai *et al*., (2005), the nutritional value of soybean meal is much lower than expected, in spite of its protein content and amino acid profile of the proteins. This is largely attributed to the presence of antinutritional factors, such as protease inhibitors, lectins, phytate and tannins. Protease inhibitors are the most important antinutritional factor. Soybean seed also contains trypsin inhibitor, hemagglutinins, phytic acid, goitrogens and urease enzyme that may limit the nutritional value of this legume. The presence of antinutritional factors such as trypsin and chymotrypsin inhibitors in soybean lowers the digestibility of the soybean protein (Storebakken *et al*., 2000; Olguin *et al*., 2003). Other antinutritional factors like tannins, phytate, anthocyanins, and hemagglutinins impart bitter or unacceptable taste to soybean, prevent protein digestibility and decrease the absorption of divalent metal ions in the intestine (Phillips & McWatters, 1991). These antinutrients form insoluble complexes with such divalent ions as Fe++, Zn++ and thus make them unavailable for absorption. Hemagglutinins are toxic protein found in soya beans. It agglutinates red blood cells, but does not affect the nutritional quality of soybean protein. The cyanogenic glycoside content of soybean represents another important factor against their widespread use, especially in areas where cassava consumption is high (Ologhobo *et al*., 1984; Olguin *et al*., 2003).

The high level of HCN can be reduced by different processing methods like autoclaving, cooking, soaking, fermentation and germination. The hard-to-cook phenomenon experienced with soybean and other legumes especially after long storage periods is another major constraint to the utilization of legumes. As the storage period of soybean increases, there is a tendency for the grains to develop hard-to-cook phenomenon (Phillips & McWatter, 1991). Also, the unacceptable, beany flavour and odour associated with soybean products is caused by the enzyme lipoxygenase. The beany flavour that makes soymilk and other soybean products unacceptable can be removed by inhibiting the activity of this enzyme. However, the effects of different processing techniques such as soaking, cooking, fermentation, germination, roasting, and autoclaving on the chemical composition of soybean have been examined (Alector & Ojo, 1989; Amina and Agle, 2004; Ikegwu, 2010), with particular reference to their inherent antinutritional components, and have been shown to cause some nutrient losses, but resulted in significant reductions of the antinutritional contents of processed foods.

Nutritional quality of complementary food

A good and quality complementary food should be nutritionally balanced, acceptable in terms of taste, appeal, colour, flavour, and storage stability (Bressani & Elias, 1983; Onuorah & Akinjide, 2004), and should be convenient and easy to prepare, involving few utensils and requiring short cooking and feeding times (Ikegwu, 2010). Nutrient recommendation for healthy infants must take into consideration several factors such as differential growth rates of infants, which is partly influenced by nutrition and partly by environment (Dewey & Brown, 2003). The amount of selected protein sources that could provide the additional amino acid needs from complementary foods show that the requirements for the sulfur containing amino acids (methionine and cysteine) could be met, for example, by providing 0.18 – 0.48 g of bovine milk protein or soy protein per kilogram body weight per day or 0.65 and 0.79 g of cereal protein per kilogram body weight per day could provide the needed amount of lysine (Lutter & Dewey, 2007). The nutrient requirement for healthy children according to Cameron and Hofvander (1983) is based on the average weight of 9 kg for a child of 9 months old; the energy requirement in food should be 900 kcal/day. Uauy & Castillo (2003) noted that the composition of dietary fat might be an important determinant of growth, infant development and long-term health. The fat content of infant and toddler complementary food diets is often low because of the dependence on cereal sources (Lutter & Rivera, 2003).

Uauy and Castillo (2003) recommend that between 6 months and 36 months, fat intake should be gradually reduced from between 40 and 60% to 30 and 35% of energy, while Dewey and Brown (2002) provide calculations for the percentage of lipid required from complementary foods when either 30 or 45% of energy is from lipid and the level of human milk intake is low, medium or high. These calculations show that for infants' aged 6 - 11 months, the percentage of energy from lipid that should be provided in complementary foods ranges from 0 to 24% (for 30% energy as lipid) or from 0 to 43% (for 45% energy as lipid). For children aged 12-23 months, the percentage of energy from lipid that should be provided in complementary foods ranges from 0 to 28% (30% energy as lipid) or from 34 to 44% (45% energy as lipid). The percentage of energy as lipid in complementary foods needed to ensure a minimum total intake of 30% energy as lipid for an infant who receives a low amount of human milk is 19, 24 and 28% at ages 6 - 8, 9 - 11 and 12 - 23 months, respectively. The total diet should provide infants with at least 3 - 5% of total energy from linolenic acid, to meet essential fatty acid requirements (Uauy & Castillo, 2003), however, hydrogenated fish oils should be avoided (WHO, 2002).

The requirements for maintenance of body protein equilibrium as well as the optimum pattern of individual essential amino acids change little between 6 months and 24 months (Reeds & Garlick, 2003). The calculations of the dietary requirement for whole protein suggest that a minimum protein-energy ratio of 6% in complementary foods is desirable. A methodological approach for determining the ideal proportion of macronutrients in a complementary food has not previously been proposed. Codex Alimentarius Guidelines for Formulated Supplementary Foods for Older Infants and Young Children (FAO/WHO, 1991) proposed an energy density of at least 400 kcal/100g of dry food, an amino acid score of not less than 70% of that of casein, and a fat content between 20 and 40% of energy, corresponding to 10 – 25 g of fats or oils per 100 g of dry food, with the level of linoleic acid not less than 300 mg/100 g or 1.4 g/100 g of dry product. Some recent abstracts showed an association between milk consumption and growth (Hoppe *et al*., 2003; Ruel, 2003) suggesting that milk may have a special role in child growth. The biological basis for this effect is not known, but calcium is associated with changes in body composition in favor of higher fat-free mass.

One hypothesis for this phenomenon is that branched-chain amino acids, which are abundant in dairy foods, promote growth of lean body mass. These amino acids enhance the recycling of glucose and favor muscle protein synthesis (Layman, 2003). This suggests that milk should be included in a fortified complementary food as a calcium and fat source, but information on the optimal quantity to include is not yet available. Data are also not available to guide a recommendation for the optimal mix of legumes and cereals or the appropriate ratio of simple to complex carbohydrates. However, it seems prudent to restrict sugar content to less than 10% of energy.

Energy requirement

Energy needs vary according to age and weight for full term infants in the first year of life. The total energy requirements of health, breastfed infants are approximately 615 kcal/day at 6 - 8 months, 686 kcal / day at 9 – 1 1 months, and 894 kcal/day at 12 - 23 months of age (Dewey & Brown, 2002; Lutter & Dewey, 2007). Energy needs from complementary foods are estimated by subtracting average breast milk energy intake from total energy requirements at each age. Among breastfed children in developing countries, average breastmilk energy intake is 413, 379 and 346 kcal/day at 6 - 8, 9 - 11 and 12 - 23 months, respectively (WHO/UNICEF, 1988). The equivalent values for industrialized countries (breastfed children only) are 486, 375 and 313 kcal/day, respectively. The amount of food to be offered should be based on the principles of responsive feeding, while assuring that energy density and meal frequency are adequate to meet the child's needs. The sample diets shown in the document complementary feeding: family foods for breastfed children (WHO, 2000), which have a composite energy density ranging from 1.07 to 1.46 kcal/day, the approximate quantity of complementary foods that would meet the energy needs described above is 137 - 187 g/day at 6 - 8 months, 206 - 281 g/day at 9 - 11 months, and 378 - 515 g/day at 12 - 23 months.

Protein requirement

Mature human milk protein content has widely been reported to meet the protein requirements of healthy infants for the first year of life provided breast milk intake continue un-interrupted and with slight reduction in volume over the year (Dewey & Brown, 2002; WHO, 2003). The protein quantity may be lower in breast milk produced by malnourished mothers but breast milk protein content normally falls slowly during the first four months of lactation in well-nourished mothers and falls slightly more after six months of lactation (WHO, 2002; Dewey & Brown, 2003; Onofiok & Nnanyelugo, 2007). About two third of the protein requirement of infants is used for growth in the first month and this gradually decreases to about 10% by the first year of the baby's life (WHO, 2003; Anigo *et al.,* 2009). Protein requirements are related to quality measured in terms of biological value (BV), protein efficiency ratio (PER), net protein utilization (NPU), and amino acid score.

Lipid requirement

Fat is important in the diets of infants and young children because it provides essential fatty acids, facilitates absorption of fat-soluble vitamins, and enhances dietary energy density, and sensory qualities (Onabanjo *et al*., 2008). Human milk provides a fat-energy ratio (FER) of 50%. Most of the human milk fat is provided as saturated and monounsaturated fatty acids and a relatively high cholesterol intake of 100 – 150 mg/day (WHO, 1998; Dewey & Brown, 2003). The oleic acid or linoleic acid content will depend on the oil source. The use of vegetable oils in the infant diet is based on availability, nutritional properties and relative costs. The need to include linoleic acid, linolenic, and arachidonic acids (essential fatty acids) has been recognized for over 40 years (WHO, 1998). More recently the need to provide linolenic acid as a source of essential fatty acid (EFA) found in retinal and nervous system development has been recognized (WHO, 2002). The (n-6) polyunsaturated fatty acids (PUFA) are abundant in commonly used vegetable oils whereas (n-3) PUFA are relatively low except in soy, canola and linseed oils (Dewey & Brown, 2003).

The human milk contains EFA, especially the long chain PUFA, and breast milk is generally a more abundant source of EFA than most complementary foods (Onabanjo, 2007; Onabanjo *et al*., 2008). Research has shown that total fat intake usually decreases with age as the contribution of breast milk to total dietary energy declines. Although there is debate about the optimal amount of fat in the diets of infants and young children, the range of 30 - 45% of total energy has been suggested (Bieri *et al*., 1999; Dewey & Brown, 2002) as a reasonable compromise between the risks of too little intake and excessive intake although the evidence on this point is limited (Dewey & Brown, 2002; Fermandez *et al*., 2002). The percentage of energy from fat in complementary foods that would be needed to achieve a level of 30 - 45% of energy from fat in the total diet depends on the level of breast milk intake and the fat content of the breast milk (Dewey & Brown, 2002). Adeyeye and Ajewole (1992) reported on the fatty acid profile of cereals grown in Nigeria which shows that palmitic, oleic and linoleic acids ($C_{16:0}$, $C_{18:1}$, $C_{18:2}$, respectively) were the three abundant fatty acids in the four cereals (sorghum, millet, maize, and rice) studied. All cereals showed high levels of unsaturated fatty acid ranging from 75% in millet to 86.4% in sorghum, and linoleic acid ($C_{18:3}$) was not detectable in maize, the other three cereals had reasonable quantities between 2.2 – 7.1%. These effects could exacerbate micronutrient malnutrition in vulnerable populations unless other measures (such as fortification) are taken to ensure adequate micronutrient intake.

Micronutrient requirement

Breast milk can only make a substantial contribution to the total nutrient intake of children between 6 and 24 months of age, particularly for protein and many of the vitamins. However, breast milk is relatively low in several minerals such as iron and zinc, even after accounting for bioavailability. At 9 - 11 months of age, for example, the proportion of the Recommended Nutrient Intake that needs to be supplied by complementary foods is 97 % for iron , 86 % for zinc, 81% for phosphorus, 76% for magnesium, 73% for sodium and 72% for calcium (Dewey, 2001). Vitamin A programme have also been demonstrated to reduce mortality rates of under-five years old children in both Africa and Asia (Davidson, 2002; Figueroa & Rodriguez-Garcia, 2002). The advice to provide pro-vitamin A-rich fruits and vegetables daily is based on the clear health benefits associated with preventing vitamin A deficiency, and the likelihood that consumption of such foods will also help meet the needs for many of the other vitamins (Martin *et al*., 2010). Micronutrient deficiencies, particularly deficiencies of iodine, iron and vitamin A are major problems for school age children in low-income countries, Nigeria inclusive. It has been revealed that such deficiencies will not only negatively impact on growth and increase susceptibility to infection, but also impair the mental development and learning abilities of school children (Figueroa & Rodridguez-Garcia, 2002; Oganah, 2005).

Iodine deficiency is associated with an average 13.5 point reduction in intelligent quotient. Its deficiency in school children lead to reduced cognitive function while deficiency during fetal life could have profound and irreversible effects on the child's mental capacity and hence reduction in school performance (Oganah, 2005). It is preferable to develop population-specific dietary guidelines for complementary foods based on the composition of locally available foods. However, it is clear from previous analyses (Dewey & Brown, 2002; Lutter & Dewey, 2007; Igah, 2008) that; plant-based complementary foods by themselves are insufficient to meet the needs for certain micronutrients. Therefore, it is advisable to include meat, poultry, fish or eggs in complementary food diets as often as possible. In an environment with poor sanitation, promotion of liquid milk products is risky because they are easily contaminated, especially when fed by bottle. Fresh, unheated cow's milk consumed prior to 12 months of age is also associated with fecal blood loss and lower iron status (Griffin & Abrams, 2001; WHO, 2003).

Protein-energy-malnutrition (PEM)

PEM and diarrhea are major factors responsible for the high under-five mortality in tropical countries, estimated at more than 15 million per year. The infant (less than one year) mortality rate in tropical developing countries is 15 times higher than in the industrialized regions (Nout, 1995; Ezeocha & Onwuka, 2010). Majority of the world children are hungry and living in poverty as a result of inadequate total food intake, or imbalanced food intake (Whitney *et al*. 2002; UNICEF, 2009). Children become malnourished and suffer growth retardation and may lead to death among children when such hunger is chronic (Sizer & Whitney, 2002; WHO, 2003). According to Salami and Ojo (2004), fifteen children die of malnutrition every 30 seconds but 125 children are born during the same 30 seconds, and every day the earth gains another 360,000 new residents to feed. Among the clinical symptoms of PEM are marasmus, marasmus-kwashiorkor, kwashiorkor, and dwarfism. The major cases of PEM are mild and moderate cases (nearly 80%), while the incidence of severe cases is 1 – 2% in pre-school age children and the problem exists in all the states of Nigeria (Onuorah & Akinjide, 2004).

Various Technological Approaches on Complementary Foods

Processing method has been shown to have significant effect on the viscosity, dietary bulkiness, and nutrient density of most traditional complementary foods. The major food constituent in cereal-based complementary foods is the starch component. It is also considered to be the major water-binding component in these foods and to a large extent determine the dietary bulk properties (Svanberg, 1987). Processing could be in form of dry-milling, wet-milling, germination, fermentation, roasting, boiling, autoclaving, extrusion, enzyme treatment, etc. Several investigations have been carried out on the effects of simple processing techniques on the antinutritional factors in plant foods (Antai & Obong, 1992; Solomon, 2005; Igyor *et al*., 2010). Osagie (1998) reported that traditional methods of processing cowpeas in Nigeria into "ewa", "gbegiri", "akara", and "moin-moin", compensate for any losses in nutrients of cowpeas associated with isolated treatments such as soaking, dehulling, and cooking. These processed products ensure a significant reduction in the antinutritional factors and maximum retention of nutrients. The effect of fermentation on phytate levels in maize, millet, rice, cowpea, and soya beans shows substantial reduction ranging from 80% to 90% in rice, and from 52 – 65% in maize, sorghum, soybean and cowpea (Osagie, 1998). Lowering of phytate was most rapid within the first 48h of fermentation. Hence, it may be inferred that the local food processing methods (boiling, fermentation, germination, roasting, and steaming) used in Nigeria minimize the concerns posed by metal chelation and protein-binding action brought about by the phytate naturally present in food materials of plant origin (Ikujenlola and Fashakin, 2005).

Milling

Dry milling is a process whereby the whole grain, after sorting and winnowing, is milled into flour and used in flour/powder forms, retaining almost all the nutrients present in the whole grain, it is nutritionally superior to dehulled cereal products. Traditionally, maize, sorghum, millet and rice are dehulled first by pounding, followed by winnowing. The crushed grain is then ground on large grinding stones to produce dry flour. The products, therefore derived from dry milling of maize are maize meal, maize flour and maize grits (Akingbala & Rooney, 1990). Other products are oil and by-products for animal feeds. Also the same source reported that particle size distribution when sample were suspended in water produce a bimodal particle size which cause differing chemical and physical properties. Adeyemi (1983) reported that dry milling of sorghum affects its texture as compared to wet milling of sorghum for ogi manufacture. According to Akingbala & Rooney (1990), flour fractions of the smaller particle size produce softer tuwo in acid, alkalis, or neutral medium than fractions of larger particles.

Svanberg (1987) reported that there are significant differences in bulk densities of dry milled cereal flour compared to germinated cereal flour. Akingbala & Rooney (1990) reported that dry milling procedure significantly affected flour properties, quality parameters and the amount of water required for agglomeration, while the effect of wet milling has been reported by many authors (Akingbala *et al*., 1981; Matilda, *et al*., 1993; Correia, *et al*., 2005). However, most wet-milling processing that have been studied extensively are fermentation of maize/millet/sorghum/guinea corn/acha to obtain a product known as *Ogi*.

Fermentation

Fermentation increases protein content and enhance protein quality of the cereal-based food by improving its digestibility and palatability. It also provides a better essential amino acid profile and makes its starch more available. Moreover, it also decreases the tannin content, increases the vitamin content, and appetizing flavours are developed (Cameron & Hofvander 1993; Correia *et al*., 2005). During fermentation, proteins are broken down to amino acids, starches are converted into simple sugars, riboflavin and niacin contents increase (Ameny & Hegsted, 2006; Correia *et al*., 2005). In addition, vitamin B is synthesized and some amount of available iron is increased because some anti-nutrients such as phytate which chelate vitamins and minerals are removed (Osagie, 1998). Fermentation is identified as an economical processing method that could be used at home to improve the nutritional quality of plant foods (Obizoba & Atti, 1991; Obizoba & Egbuna, 1992). The advantages of fermentation processing include overcoming the disadvantage of long cooking time, production of an easily digested product and reduction of some toxic components such as phytic acids, cyanide compound, and increase in the shelf life (Huffman *et al*., 2000).

The process of fermentation is particularly useful for hard seeds and could be of a short duration, overnight only or prolonged for months or even years as in the case of soy sauce (Obizoba, 1998). In Nigeria, fermented foods play a major role in the diet of the people; these include ogi from corn and gari from cassava, pito beer from millet/sorghum and different kinds of condiments. Fermented food legumes in Nigeria include the African oil bean which is widely eaten in Southern Nigeria, especially in the eastern states. It is popularly known as *Ugba* and could be eaten alone or mixed with other food ingredients. Melon and fluted pumpkin are fermented to produce different types of *ogiri* (food spices). Also, soya beans and baobab are other fermented products, replacing the locust bean seeds in the preparation of flavourings (Weingartner *et al*., 1987). Boralker and Reddy (1985) reported that fermentation of soybean for varying periods of 8, 12 and 16 h caused significant increases *in-vitro* digestibility of it protein, while Ene-Obong (1993) observed increases in iron, magnesium, phosphorus, protein, calcium, and zinc when African yam bean was fermented for 12 h and 24 h when compared with the control and other food processing methods. Riet *et al*., (1987) observed that fermentation of soybean into *tempeh* produced favourable nutritional changes. It reduced thiamin, phytate, starch and oligosaccharides levels. It increased protein and iron, and decreased total fibre and increased loss of soluble carbohydrate and potassium.

Germination

The process of malting is essentially physiological in nature and is the result of the action of enzymes. Malting consists of the controlled germination and subsequently drying of the seed. It is known to be the most effective method of reducing viscosity of gruels and improvement in nutrient composition of the malted grains (Desikachar, 1980; Ngwu, 2005). Germination improves nutritive value of legume in terms of vitamin C, riboflavin, digestibility and appetizing flavours are developed. Nnam (2000) reported that protein content of acha expressed on a percentage dry matter increased with increased days of malting because of dry matter loss. This is because a considerable proportion of the insoluble protein is transformed into soluble components. According to Obatolu *et al*. (2000) malting process increases riboflavin, niacin and iron content and malted flour thicken gruels less than plain flours. The changes in the starch composition which occur during germination represent the result of localized action of alpha-amylase and to some extent beta-amylases (Lasekan, 1996; Obatolu *et al*., 2000). Dextrin and free sugars are liberated and there is an increased amount of damaged starch granules. Ikujenlola & Fashakin (2005) and Igyor *et al*. (2010) reported that germination improve functions and nutritive value of substrates. Amino acid composition of malted sorghum showed a general increase in lysine, aspartic acid, glycine, and valine with increase in days of malting while glutamic acid, proline, phenylalanine and cystine decreased (Igyor *et al*., 2010).

Roasting

Roasting is always carried out to effect the following changes in food products; to further reduce the moisture content, improve the flavour and aroma, and to further reduce the anti-nutritional factors such as protease inhibitor, trypsin inhibitor, and lectins. Roasting brings about some chemical changes such as pyrolysis of proteins, destruction of the reducing sugar and browning of food products, enhanced flavour, and overall acceptability of such food products (Ihekoronye & Ngoddy, 1985; Onuorah & Akinjide, 2004). Keku (2006) reported that nutritive value and antinutritional factors of roasted maize reduces as a result of roasting. Also, Solomon (2005) and Ikegwu (2010) reported that vitamins and mineral contents of roasted and cooked maize decreased compared to the raw maize.

The gruels prepared from germinated and roasted flours have significantly lower viscosity than the gruels prepared from germinated flours at the same concentration (Okoh, 1998; Solomon, 2005). Roasting operation involve continuous stirring to ensure equal distribution of heat in order to achieve an acceptable end-products (Nout & Ngoddy, 1995). The high temperature of 140 to 160^{o}C for 2 – 5 min reduces the level of protease inhibitor and lectins in soya beans and has diminishing effects on porridge viscosity (Osagie, 1998).

Multiple processing methods on traditional complementary foods

There is paucity of information concerning the use of multiple processing methods in the production of food products especially complementary foods. Multiple processing methods could provide alternative for improving the nutritional quality of food products. According to Obizoba (1998), any procedure that would increase nutrient content, quality, availability, shelf life, flavour, aroma, palatability and reduce bulkiness in legumes, cereals, roots and tubers would be of great value in Nigeria. Combining processing methods would not only produce food products adequate in nutritive value, but would be well accepted and tolerated by the targeted groups. Combination of two or more processing methods would not only increase food security and diversification, but could also alleviate the problem of protein-energy-malnutrition and its accompanying results, especially infant morbidity and mortality.

Based on the available reports of singly processed (boiling, fermentation, germination, steaming, etc) food products especially complementary foods, combining two or more of these processing methods could have greater advantage in improving biological quality, micronutrient, microbial quality and safety of such food products. Available reports show that multiple processing methods are much embraced in tea (*Camellia sinensis*) production technology especially in black tea manufacture. Fementation led to loss of green colour, acquiring a coppery-red shade, due to strong oxidation reactions and development of pleasants aroma of fermented tea (Ihekoronye & Ngoddy, 1985). The fermented tea is treated with hot air or steam to inactivate enzyme (i.e. fermentation-steaming method), and then dried to a moisture content of 3%. This procedure shows that subjecting an already fermented, germinated, boiled, and/or steam products to roasting would not only enhance and improve its aroma, nutrients on dry matter basis, storage stability and shelf life, but would also reduce microbial load, toxicity (aflatoxin), and antinutritional factors of such food products, especially complementary foods.

Nutrition education

Ignorance and food taboos in West Africa could have resulted to traditional complementary foods of poor nutritional quality. Improving the nutritional value of complementary foods by itself will not eliminate the problems (Salami & Ojo, 2004). According to Juke *et al.* (2002), training and nutrition education of the mothers is necessary to change feeding practices and provide correct information. Health workers and nutritionists can educate rural mothers about the importance of adequate weaning foods and practices, infant health, host defense systems, home-scale drying, processing, and so on (WHO/UNICEF, 1988). The importance of varying the baby's diet and practicing good hygiene when handling and storing of baby's food can be included as well (Sizer & Whitney, 2002; UNICEF, 2009). The teaching and training of rural mothers could have a long-term impact on weaning practices and nutritional status of West African children. In the Philippines, a weaning education programme led to a reduction in the prevalence of malnutrition from 64% to 42%, and also in Nigeria the Africare Child Survival Programme yielded similar results (Nnanyelugo *et al.,* 1990).

The development of books of recipes for complementary foods of high nutrient density using locally available foods is useful and where recipe books are available, they should be properly distributed to mothers. Nigerian Ministry of Health (1986) produced a booklet called "Nigerian Weaning Diets" that contains more than 40 recipes for weaning foods, while WHO/UNICEF (1988) produced similar booklets for health and community workers.

CONCLUSION

Traditionally produced complementary food have been in existence from time immemorial, however, results from literature have shown that it is grossly inadequate to meet daily nutrients, energy and micro-nutrients requirements of third world old infants and young children. The food is bulky and moisture dense than nutrients required by the old infants and young children, hence malnutrition is prevalent in these countries than developed countries. Previous results had shown that fortified cereal grains with legume increase its protein quality in term of lysine and tryptophan which is limiting factor in cereal grains, and enhance growth and development of old infants and young children. It's therefore, imperative for adequate processing methods, quality control, regulatory policy and implementation of complementary foods fortified with legume because of its antinutritional factors in order to safeguard the health of its consumers.

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