NUTRITIONAL COMPOSITION OF COMMONLY USED AND ESHA FORMULATED COMPLEMENTARY FOODS FROM AVAILABLE FOODSTUFFS IN KADUNA NORTH LGA

BY

AISHA KABIR MOHAMMED

DEPARTMENT OF BIOCHEMISTRY,

AHMADU BELLO UNIVERSITY,

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Aisha Kabir <u>MOHAMMED</u>,

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DECLARATION

I declare that the work in this dissertation entitled **"Nutritional Composition of Commonly Used and Esha Formulated Complementary Foods from Available Foodstuffs**has been carried out by me in the Department of Biochemistry, Faculty of Life Sciences. The information derived from the literature has been duly acknowledged in the text and a list of reference provided. No part of this dissertation has previously been presented for another degree or diploma at this or another institution.

MOHAMMED, AISHA KABIR

Name of Student	**Date**	**Signature**

CERTIFICATION

This thesis entitled "**NUTRITIONAL COMPOSITION OF COMMONLY USED AND ESHA FORMULATED COMPLEMENTARY FOODS FROM AVAILABLE FOODSTUFFSIN KADUNA STATE** by Aisha Kabir MOHAMMEDmeets the regulations governing the award of degree of Masters of Science in Nutrition of the Ahmadu Bello University and is approved for its contribution to knowledge in literary presentation.

O.A. OWOLABI

Chairman, Supervisory Committee	**Signature**	**Date**

Prof D.B. James

Member, Supervisory Committee	**Signature**	**Date**

Prof. M.N. Shuaibu

Head of Department	**Signature**	**Date**

Prof. S.Z. Abubakar

Dean, School of Postgraduate Studies	**Signature**	**Date**

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ABSTRACT

Complementary foods (CF) are needed to fill the gap between total nutritional needs of the child and the amounts provided by the breast milk from six months of age. This study assessed the nutrient composition of commonly used complementary foods (CCCF) in Kaduna North local government area of Kaduna state and then formulates a composite blends of complementary foods (CBCF) using Elizabeth Stuart Hands and Associate (ESHA) nutrient analyser software. Nutrients composition of the CCCF, ESHA formulated complementary food (EFCF) and Commercial Complementary Foods (CMCF) were analysed using standard methods. The results revealed that about 67% of respondents introduced water from birth and complementary foods were introduced by majority of the caregivers (52%) between 3- 6 months. Commonly used complementary foods are sorghum pap (67%), sorghum-soybean-groundnut blend (14%), commercial formulas (12%), millet pap (5%) and maize pap (2%). The proximate composition (g/100g dry weight basis) shows that moisture content (10.63±0.11) of sorghum pap (SP) was significantly higher ($P<0.05$) than that of sorghum-groundnut-soyabeans pap (SGSP), millet pap (MiP) and maize pap (MaP). Crude protein (19.09± 0.38) and crude fibre (6.89±0.12) were significantly higher ($P<0.05$) in SGSP than in other complementary foods. Essential amino acids (leucine, histidine, and methionine) and all non-essential amino acids except cysteine and alanine were higher in SGSP complementary food. The nutrient composition of the developed CF as revealed by ESHA nutrient analyser is 432.29kcal of energy, carbohydrates (47.54), fat (22.53), protein(18.76), moisture (8.37) and ash (2.83). The EFCF had significant ($P<0.05$) higher calories, crude protein, fat, crude fibre, iron and vitamins (A, B1) when compared with CMCF and CCCF. Essential amino acids (leucine, phenylalanine, and histidine) and all non-essential amino acids except alanine and cysteine were higher in

EFCF. Oleic acid and bicycle (5,3,0) decapentaene were of higher proportion found as the essential and non-essential fatty acids. The results suggest that with proper selection of local ingredients, it is possible to formulate complementary foods of high nutrients composition than the commonly consumed complementary foods.

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LIST OF ACRONYMS

SGSP	Sorghum-Groundnut-Soya beans Pap
MiP	Millet Pap
MaP	Maize Pap
Sp	Sorghum Pap
ESHA	Elizabeth Stuart Hands and Associate nutrient analyser software
CCCF	Commonly Used Complementary Food
EFCF	Esha Formulated Complementary Food
CMCF	Commercial Complementary Food

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CHAPTER ONE

1.0 Introduction

In Nigeria, under-nutrition remains a public health problem. According to the 2013 National Demographic and Health Survey, in Nigeria, 37 percent of children under age 5 are stunted, 18 percent are wasted, and 29 percent are underweight (NDHS, 2013). The development of children's full human potential depends on adequate nutrition during infancy and early childhood. Exclusive breastfeeding is adequate for the first six months of life but timely introduction of nutritionally-adequate, safe, age-appropriate complementary feeding at sixth month of age is recommended for better health and development of infants (WHO, 2003). The World Health Organization recommends that breastfeeding should continue with appropriate complementary feeding from 6 months to 2 years and beyond (Zere and McIntyre. 2003). According to the Nigeria Demographic and Health Survey (2008) only 30 percent of infants aged 6-23 months and living are fed in accordance with the recommendation for infant and young children feeding practices (NDHS, 2008). Problems associated with complementary feeding in particular include poorly timed introduction of complementary foods (too early or too late), bottle-feeding, infrequent feeding, unsupervised feeding, poor feeding methods, poor hygiene, and child care practices (Shordt and Cairncross, 2004)

Malnutrition is responsible for more than 41% of the deaths that occur annually in children from 6 to 24 months of age in developing countries which total approximately 2.3 million. Moreover, one third of deaths among children less than five years of age are attributable to nutrition and well above two thirds of these deaths, often associated with inappropriate feeding practices, occur during the first year of life (Sandoval- Priego *et al.*, 2003). Inadequate feeding of girls affects nutrient stores, leading to poor obstetrics outcome when they are having children later in life. Other consequences include growth failure and stunting, delayed sexual development, reduced muscle mass and strength, impaired intellectual development, weakened immune system, poor cognitive performance and learning achievement and increased lifetime risk of osteoporosis (WHO, 2003).

Every year, more than 200 million children under five years old fail to reach their full cognitive and social potential. Most of these children live in South Asia and sub-Saharan Africa (Sandoval- Priego *et al.,* 2003). Among preventive measures that would reduce the excess mortality for children under the age of five years, exclusive breast feeding and good quality complementary feeding have been listed as first and third, respectively, with a calculated 600,000 deaths per year preventable by good complementary feeding (i.e. 6% of deaths) (Jones *et al.*, 2003). Growth faltering occurs mainly in the first two years of life because of high nutritional needs for growth and development between 6-24 months (IOM, 2006). In fact, the percentage of children who are underweight almost doubles from 14% among children less than 6 months of age to 26% among children age 12-17 because complementary foods are introduced to children in the latter group, thus increasing exposure to infections and susceptibility to illness (NDHS, 2008).

In Nigeria, and indeed most developing countries, the underlying problems have been identified to include poverty, inadequate nutrient intake particularly during pregnancy, period of rapid growth and complementary feeding in infants, ignorance about nutrient values of foodstuff and parasitic infections (NPAN, 2002). Result of the 2001- 2003 Food Consumption and Nutrition Survey showed a steep increase in the incidence of child wasting between 6 and 12 months, which is the period of complementary feeding for most children (IITA, 2004).

A common feature of plant foods is their high content of water, fibre, low energy and micronutrient densities (Solomon, 2000). This characteristic becomes particularly worrisome during the complementary feeding period in infants and children. Hence, traditional complementary foods from plant staples often fail to meet the nutritional needs of the infants, due to stiff consistency and high volume which combine to offer a low-cost filling meal that often lacks adequate nutrients (Fernandez *et al*, 2002). They are therefore known to poorly support growth and development**.**

Complementary feeding practices must be improved. Too often, complementary foods are introduced too soon or too late. The frequency and amounts of food that is offered may be less than required for normal child growth, or their consistency or energy density may by inappropriate in relation to the child's needs. Conversely, too much of a poor complementary food could displace the more nutritive breast milk in the child's diet. Other factors, such as the pattern of feeding (e.g., whether to breastfeed and follow it with complementary foods, or vice versa) may effect breast milk intake. In addition, the nutrient content of these foods may be inadequate or the absorption could be impaired by other components in these foods. Storage safety is important as well(NNN, 2000; NACMD, 2003).

Also very importantly, responsive feeding, maternal encouragement to eat and other psychosocial aspects of care during feeding likely to be important for ensuring adequate food and nutrient intake of the child. The complete understanding of what must be done to improve complementary feeding is somewhat limited due to the complexity of the behaviour. The necessary behaviours and foods change rapidly with the child's age and breast milk intake. Based on these recommendations, a joint FAO/WHO (1998) consultative forum in 1998, established the scientific basis for the development and evaluation of Food- Based Dietary Guidelines (FBDG) for various regions of the world.

Sequel to this, the Federal Ministry of Health (FMOH) in Nigeria published the Food-Based Dietary Guidelines (FMOH, 1999). The guidelines recommended some sustainable food-based approaches that encourage dietary diversification through the production and consumption by all population groups, of both macro- and micro-nutrient-rich foods, including traditional foods found in different parts of the country. The report recommended the use of staple starchy roots, tubers and cereals in combination with legumes, vegetables, fruits and if possible animal sourced foods in preparing complementary foods for infants and children. Based on these recommendations, different variables affecting micronutrient intake and ways to combat deficiency have been considered in several nutrition fora (NNN, 2000; NACMD, 2003). Besides, the reports by many researchers on the nutritive potentials of cereals, legumes, vegetables and fruits in the formulation of complementary foods have been promising (Badamosi et al, 1995; Owolabi *et al.,* 1996; FAO, 1997; Okoh, 1998; Ladeji et al, 2000;). It is imperative that blends of such foodstuffs found in various communities be formulated and biochemical studies be carried out on their composites for possible use as complementary foods. This study, which is part of an exploratory effort on the improvement of the nutritional quality of traditional complementary foods, was designed to use staple foodstuffs indigenous to Kaduna State to formulate composite blends that can be nutritious, readily available and affordable to both rural and poor urban mothers. Findings from the study would offer answers to the questions (a) whether such local blends can meet the various dietary recommendations for infants and children and (b) whether they can substitute the more expensive proprietary formulas sold in the markets.

1.1 Statement of Research Problem

In Nigeria, thirty-seven (37%) percent of children under the age five years are stunted, eighteen (18%) percent are wasted, and twenty nine (29%) percent are underweight. Infants and under-5 mortality rates in the past five years are 69 and 128 deaths per 1,000 live births, respectively. At these mortality levels, one in every 15 Nigerian children die before reaching age one year and one in every eight do not survive to their fifth birthday (NDHS, 2013).

Most families depend on locally formulated diets to feed infant and young children. The locally formulated foods (pap and porridges) are low in protein and high in anti-nutritional factors that reduce the bioavailability of some micronutrients. Poor processing and cooking methods also contribute substantially to loss of micronutrients, leading to micronutrient deficiency disorders in infants fed these foods (Saskia and Martin, 2009).

Complementary feeding practices must be improved. Too, often are introduced too soon or too late. The frequency and amounts of food that is offered may be less than required for normal child growth.

1.2 Justification

Complementary foods are needed to fill the gap between the total nutritional needs of the child and the amounts provided by breast milk. There is an alarming high rate of malnutrition in North Western region of Nigeria with Kaduna State second to Kebbi State (NDHS, 2013). Complementary foods are not introduced in a timely fashion for all children. Overall, only 10 percent of children ages 6-23 months are fed appropriately based on recommended infant and young child feeding (IYCF) practices (NDHS, 2013).

The period from conception to age 2 is especially important for optimal physical, mental, and cognitive growth, health, and development. However, this period is often marked by protein-energy and micronutrient deficiencies that interfere with optimal growth hence the need for safe, nutritious and affordable complementary foods (NDHS, 2013).

Proprietary formulas are usually considered nutritious, acceptable and safe to the infant but their high cost has put them beyond the reach of most families, especially those in the low income "bracket."

1.4 Aim and Objectives of the Study

1.4.1 Aim

The aim of the study is to survey commonly used complementary foods and use the available ingredients to formulate composite blends of ready to use complementary foods and assess the nutrient density.

1.4.2 Specific Objectives

i. To identify the commonly used complementary foods in Kaduna North LGA, Kaduna State.

ii. To assess the nutrient composition (macro and micronutrients) of the commonly used complementary foods.

iii. To develop complementary food (CF) blend from locally available foodstuffs using Elizabeth Stuart Hands and Associates (ESHA) Food Processor and Nutrient Analyser software.

iv. To determine the nutrient composition (macronutrients, vitamins and minerals) of the developed CF and compare with that of the commonly consumed CF and a popular commercial formula.

CHAPTERTWO

2.0 LITERATURE REVIEW

2.1 Infancy, Exclusive Breast Feeding and Complementary Feeding Period

Infancy is a period of rapid physical, physiological, immunological and mental growth and development when nutritional requirements are at their highest (Guthrie, 1989). Brain and tooth developments, for which macro and micro nutrients are crucial requirements, occur in the first one to five years of life (Guthrie, 1989; Uphoff, 1993). Deficiency of these and other nutrients can therefore have disastrous consequences, some of which can be long lasting or even lead to death.

WHO/UNICEF (1997) reported that millions of children are physically and mentally disabled due to Protein energy malnutrition (PEM) and micronutrient deficiencies. These shortfalls have been attributed to shortened period of exclusive breastfeeding, low dietary intake and poor bioavailability of nutrients in complementary foods (Lutter and Rivera, 2003).

Breastfeeding benefits for new-borns and infants are well-documented (WHO, 2002). Breastfeeding provides infants with superior nutritional content that is capable of improving infant immunity and possible reduction in future health care spending (UNICEF, 2006). At the Innocenti Declaration in 1990, the WHO/UNICEF called for policies that would cultivate a breastfeeding culture that encourages women to breastfeed their children exclusively for the first 6 months of life and then up to 2 years of age and beyond (WHO, 1991). However, an estimate by the WHO showed that worldwide only 35% of children between birth and their 5th month are breastfed exclusively (WHO, 2010). According to the Nigerian Demographic and Health Survey (NDHS), in 2008 17% of children were exclusively breastfed for less than 4 months, while 13% were exclusively breastfed for less than 6 months. The median exclusive breastfeeding period in Southwest Nigeria by months in the year 2003 and 2008 were 7 months and 6 months respectively. Within the same period, early initiation of breastfeeding among women in the region was 12.7% in 2003, and 35.5% in the year 2009(NPC, 2009). All these figures are far below the 90% level recommended by the WHO (Jones *et al.,* 2003). Child mortality remains high in low and middle-income countries (Gabriel, 2008). Nigeria has the highest under-five rural mortality rate of 242.7 per 1,000 among selected sub-Saharan Africa countries (Anyamele, 2009)

Improving the diets of infants has been recommended as one of the solutions to tackle childhood malnutrition in developing countries (Autumn *et al.,* 2018). The inadequacy of infant nutrition and its negative influence on attainment of full potential in life is now fully established [WHO, 2003;Adu- Afaruwah *et al.,* 2008; Beard, 2008] Grantham-McGregor *et al.,* (2007) suggested that poor nutrition during infancy is likely to lead to poor academic achievement, low incomes in adulthood and inadequate care for the children of subsequent generations. The cycle has contributed to the inter-generational poverty bedevilling low-income countries like South Asia and sub-Saharan Africa. (Walker *et al.,* 2007).

Nutritious dietary intake during this critical period therefore becomes very vital and priority must be accorded to its improvement. WHO (1991) have recommended that, after 6 months, nutritious, safe and appropriate foods (also known as complementary foods) be gradually introduced and continued up to 2 years of age, thereafter the normal family diet be introduced (Yeung, 1998).

The use of complementary foods does not only prime the infant's system to an adult diet, but also serves as a source of additional nutrients required for optimal growth and development (Fernandez *et al.,* 2002). Proper complementary practices coupled with lengthened breastfeeding period of at least two years can eliminate or reduce the high incidence of infant mortality and morbidity experienced in developing countries (Walker, 1990). It is believed that gradual introduction of complementary foods after six (6) months of age to the infant diet would have no adverse or shock effect on the digestive system of the child (Okungbowa, 1986).

2.2 Complementary Foods

Scientific study has proved that breast milk is the perfect food for the infant during the first six months of life. It contains all the nutrients and immunological factors an infant requires to maintain optimal health and growth (UNICEF, 1999). However, at the age of six months and above when the child is undergoing rapid growth, physiological maturation and development, breast milk is no longer sufficient to meet the nutritional needs of the infant. Nutritious complementary foods are therefore introduced – also known as complementary foods – which typically cover the period from six to twenty four months of age in most developing countries (WHO/OMS, 2000). Poor nutrition during this critical period of life may increase the risk of growth faltering and micronutrient deficiencies, and may have adverse effects on health and mental development. Hence, improved complementary foods at this period of life are essential for the child normal growth and cognitive development (WHO/OMS, 2000).

In Nigeria, the introduction of complementary food usually starts between age 4 and 6 years; and usually involves the use of a semi-liquid porridge prepared locally by the mother from staple cereals or tubers (Bentley *et al*., 1991; Nout,1993; Guptill *et al*., 1993). Complementary feeding period is the time when malnutrition starts in many infants, contributing significantly to the high prevalence of malnutrition in children less than 5 years of age worldwide (Daelmans and Saadeh, 2003).

The complementary food is often associated with low energy density and other essential nutrients; and in many parts of developing countries it is usually given too early or late in insufficient amounts to meet the nutritional needs of infant (Onyango, 2003; Muhimbula *et al.*, 2011). Scientific research has reported that timely introduction of appropriate complementary foods promotes good nutritional status and growth in infants and young children (Michaelsen *et al*., 2012; Domellof *et al*., 2002); and that too early (<6 months) or too late (>6 months) introduction of complementary foods increases infant morbidity (Bhandari *et al*., 2002; Kalanda *et al*., 2006) and mortality (Edmond *et al*., 2006) in many parts of developing countries due to diarrhea And malnutrition (Onyango, 2003; Hussein, 2005; NBS and ORC Macro, 2005).

The nutritional adequacy of complementary foods is essential for the prevention of infant morbidity and mortality. In most developed societies, pre-made nutrient-fortified cereals are the first complementary foods introduced to the child, followed by fruits, vegetable and meat and fish products. In most developing countries the nutrient fortified cereals are often too expensive and out of the reach of most families. Complementary feeding should be timely, meaning that all infants should start receiving foods in addition to breast milk from 6 months and beyond. It should be adequate; Foods should be prepared and given in a safe manner. And they should be given in a way that is appropriate, meaning that foods are of appropriate consistency for the age of the child and applying responsive feeding following the principles of psycho-social care (WHO, 2002).

The adequacy of complementary feeding should not only depend on the availability of a variety of foods in the household, but also on the feeding practices of caregivers. Responsive feeding practices should be used in feeding young infants.Young infants requires active care and stimulation, where the caregiver is aware of the child clues for hunger and also encourages the child to eat (WHO, 2002). WHO recommends that infants start receiving complementary foods at 6 months of age in addition to breast milk, it should be given 2-3 times a day between 6-8 months, 3-4 times daily between 9-11 months and 12-24 months with additional nutritious snacks offered 1-2 times per day (WHO, 2002).

The use of home-based complementary foods that can be readily prepared, easily available and affordable, is one feeding option that has been recommended (WHO, 1981; Fashakin and Ogunsola, 1982; Temple *et al.*, 1996; FMOH, 1999; Nnam, 2002) to stem the dire effects of malnutrition in infants and young children. A number of research efforts aimed at improving the nutrient quality of existing local complementary foods, and the formulation of new ones have being quite promising.

The composition of local complementary foods varies from place to place and from country to country. In West Africa generally, the common family diets and staple foods on which infants are weaned include cereals, starchy tubers, legumes and vegetables. Some of the diets are single, while some are mixed diets. In Ghana for instance, the main traditional *complementary* food is Koko (fermented maize porridge) (Armer-Klemesu and Wheeler, 1991), while Ogi prepared from maize or sorghum is used in Sierra Leone (Jonsyu, 1985). In Nigeria, a fermented maize or millet (akamu) and fermented garri (foo-foo) are commonly used in the Northern and Southern parts respectively.

2.3 Nutritional values of complementary foods in Nigeria

A good and quality complementary food should be nutritionally balanced, acceptable in terms of taste, appeal, colour, flavour, and storage stability (Bressani and Elias, 1983; Onuorah and 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 and 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 and 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 and 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 and 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 and 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 and 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 favour 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 favour 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.

2.4 Nutritional Problems of Traditional Complementary Foods

A common feature of plant foods is their high water and fibre contents, low energy and micronutrient densities (Solomon, 2000). This characteristic becomes particularly alarming during the complementary feeding period in infants and children. Hence, traditional complementary foods from plant staples often fail to meet the nutritional needs of the infants (Fernandez *et al.,* 2002). They therefore poorly support growth and development. For instance, Naismith (1973) and Fashakin and Ogunsola, (1982) have associated the aetiology of protein energy malnutrition in children to the frequent use of maize pap and millet gruel during the complementary periods.

It is possible to achieve an adequate nutrient intake by increasing the daily intake of such low nutrient-dense foods, but the volume of the food to be consumed may be too large for the child to consume in order to cover the nutrient needs. Poor combination and formulation has contributed to the poor performance of traditionally formulated complementary foods. A number of researches in Nigeria (Fashakin and Ogunsola, 1982; Marcos et al, 1983; Oyeleke *et al.,* 1985; Abbey and Nkanga, 1988; Abbey and Mark-Balm, 1988; Omoruyi *et al.,* 1994; Badamosi, *et al.,* 1995), has shown that a combination of cereals and legumes or tubers with vegetables and animal sourced food rather than the single diets, better supported growth and development.

Poor processing methods and hygiene have also been identified as other factors responsible for low nutrient density in locally formulated complementary foods. Processes such as parboiling, milling and fermentation, are intended to achieve specific purposes but however affect the nutrient content of the foods negatively. Okoye (1992) reported a 90% loss of free folic acid content of cereals and certain vegetables, 50% of yam thiamine and ascorbic acid and up to 20% of milk vitamin E content during boiling.

The presence of anti-nutritional factors in plant-based complementary foods has been shown to negatively influence the bioavailability of nutrients. The best documented being oxalate which forms oxalate precipitates with dietary calcium, while phytate forms insoluble phytates with Ca, Fe, Zn and possibly other metals. For example, the relatively poor availability of the high Fe content of cereals is mainly due to their correspondingly high phytate levels (Okoye, 1992).

Inappropriate feeding practices are repeatedly a greater determinant of inadequate intakes than the availability of foods in the households. WHO has developed a protocol for adapting feeding recommendations that enables programme managers to identify local feeding practices and common problems associated with feeding and the availability of adequate complementary foods. The protocol builds upon available information and proposes household trials to test improved feeding recommendations. WHO recommends that the protocol should be used to design interventions for improved complementary feeding, and should also be included as part of adaptation process of the Integrated Management of Childhood Illness strategy (WHO, 1992).

Research has shown that caregivers require skilled support to adequately feed their infants (Karen *et al*., 2000). Guidelines for appropriate feeding are included as part of the Infant and Young Child Feeding counselling course, the Complementary feeding counselling course, the Integrated Management of Childhood Illness guidelines and training course for first-level health workers. WHO has developed the guide "Complementary feeding: Family Foods for breastfed children" that gives more detailed guidance for health workers on how to support complementary feeding practices (WHO, 1992).

2.5 Review studies done in the area of complementary foods in Nigeria and Africa

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 and 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. 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 and 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 and 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 and 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 and Nnanyelugo, 2007; Ezeocha and 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 and 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 and 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 and Fashakin, 2005; Onofiok and 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 and 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 and 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 and 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 and Jood, 2001).

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 and 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 and 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 and 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

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 and Brown, 2002; Lutter and 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.

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 and 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 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.

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 and Fashakin, 2005). 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, and 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.

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 and Fashakin, 2005). However, one of the militating factors against the use of legume without proper and adequate treatment/processing is its antinutritional factors.

2.6 Formulation of Local Complementary Foods of High Nutritive Values

Several strategies may be used to improve the nutritive value of complementary foods in West Africa which include combining locally available foods that complement each other in such a way that the new pattern of amino acids created by this combination is similar to that recommended for infants (Uwaegbute *et al.*, 1989). Cereals are deficient in lysine but have enough sulphur-containing amino acids that are reduced in legumes. Therefore, the combination of cereals and legumes has been found to produce amino acid patterns that adequately promote growth (Uwaegbute *et al.*, 1989).

Many researchers have worked extensively on cereal-legume combinations in Nigeria. For example, Fashakin and Ogunsoola (1982) formulated nut-*ogi* (a mixture of corn gruel and groundnut), Akinrele and Edwards (1971) formulated soya-*ogi* (corn gruel plus soya bean), and the Collaborative Research Support Programme (CRSP) Cowpea Linkage Project at the University of Nigeria, Nsukka, formulated *cerebabe* (corn plus cowpea). Other useful combinations include *ogi* and melon protein (corn gruel plus melon seed) and cowpea-*ogi* (Fashakin *et al.*, 1986). Some of these combinations have been adopted by the food-processing industries and are available in the Nigerian markets.

However, Fashakin *et al.*, observed that no protein from the above sources was adequate enough to promote growth and also enhance nitrogen retention as well as a milk-based diet. To this end, a mixture of cowpea, melon, soya bean, and ogi was found to be superior to any single protein source in protein efficiency ratio, net protein retention, biological value, and net protein utilization (Fashakin *et al.*, 1986)

Fermentation was found to enhance the nutritive value of foods by increasing thiamine, nicotinic acid, riboflavin, and protein content as a result of microbial activity. It also reduces the high bulk of traditional complementary foods in West Africa. Microbial activities hydrolyse starch granules during cereal fermentation resulting in reduced viscosity of the porridge (Odunfa and Adeyeye, 1985).

In addition to fermentation, germination can also improve the nutritional value of traditional complementary foods by reducing the water-binding capacity of cereal flour and also converts insoluble proteins to soluble components and increases the levels of lysine as well as of vitamins B and C (Brandtzaeg *et al.*, 1981).

Dry milling can improve the nutritional value of complementary foods by conservation. The addition of sugar and oil increases the energy content of cereal gruel. Ignorance and food taboos in West Africa often result in complementary foods of poor nutritional quality. Improving the nutritional value of the complementary foods by itself will not eliminate the problems. Training and nutrition education of the mothers is necessary to change feeding practices and provide correct information. Nutrition education can easily be incorporated into primary health care programmes. The importance of varying the baby's diet and practising good hygiene when handling and storing the baby's food can be included as well (Odunfa and Adeyeye, 1985).

A number of convenient commercial complementary foods are available, but they are often very expensive and out of the reach of the target populations. A different approach maybe developed to offer rural and poor urban women the opportunity to feed their infants properly, perhaps through appropriate household- or village-scale technology.

2.7 HIV and Infant Feeding

Infant and young child feeding in the context of HIV poses significant challenges due to the risk of viral transmission via breastfeeding. Before the 2010 guidelines on HIV and infant feeding, avoidance or early interruption of breastfeeding seemed logical and appropriate. However, the impact for the health and survival of the infant or child were serious, with studies showing higher mortality rates due to diarrhoea, malnutrition and other diseases in non-breastfed children. The 2010 recommendations are based on the evidence of positive outcomes for HIV-free survival through provision of antiretrovirals to breastfed HIV-exposed infants. Thus the focus is now firmly on ensuring HIV-free survival, not only on preventing transmission. The 2010 UN guidelines provide a much clearer pathway towards this goal.

It is a well-known fact that breast feeding significantly improves child survival by protecting against diarrhoea, pneumonia and other potentially deadly infections. It enhances the quality of life of the infant through its nutritional, psychosocial and other benefits. As a result, lack of it presents substantial disadvantages and risks to both children and mothers such as increased child mortality and morbidity (UNAIDS/WHO/UNICEF, 1997; UNICEF, 2004).

The finding that HIV is transmitted through breastmilk presents a serious predicament particularly for mothers in poorer communities. This poses a greater problem to policy makers and health workers striving to strike out some sort of compromise between either breastfeeding or not breastfeeding of children (Latham and Preble, 2000). For such poor women, the choice not to breastfeed is much more risky because of inadequate access to resources necessary to obtain sufficient breast milk substitutes, as well as equipment and potable water to prepare it safely. The new guidelines on HIV and infant feeding outlined by UNAIDS/WHO/ UNICEF (2010) calls for urgent action to educate, counsel and support HIV-positive women in making decision on how to nourish their infants safely and appropriately. The guidelines emphasize that, in order for a mother to take such a decision, she should among other things, have access to information about other feeding options and the advantages and disadvantages associated with them. This differs from the previous recommendations in which health workers were expected to individually counsel all HIV-infected mothers about the various infant feeding options, and it was then for the mothers to decide between them. Where ARVs are available, mothers known to be HIV-positive are now recommended to breastfeed until 12 months of age. The recommendation that replacement feeding should not be used unless it is acceptable, feasible, affordable, sustainable and safe (AFASS) remains.

2.8 Nutritive Needs of Infants

According to WHO, 2003, adequate nutrition during infancy is essential for lifelong health and wellbeing. Infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods, while continuing to breastfeed for up to two years or more. Good nutrition is essential for the growth and development that occurs during an infant's first year of life. When developing infants are fed the appropriate types and amounts of foods, their health is promoted. Positive and supportive feeding attitudes and techniques demonstrated by the caregiver help infants develop healthy attitudes toward foods, themselves, and others. Throughout the first year, many physiological changes occur that allow infants to consume foods of varying composition and texture. As an infant's mouth, tongue, and digestive tract mature, the infant shifts from being able to only suckle, swallow, and take in liquid foods, such as breast milk or infant formula, to being able to chew and receive a wide variety of complementary foods. Okoye (1992) further stated that the unique nature of infant nutrition resides in factors such as the immaturity of the digestive system and related biochemical machineries. Hence the need for a special starting diet to compensate for inadequacies of any insufficient maternal endowments and the continuously changing nutrient requirements of a growing child.

Breast-milk satisfies the nutrient and energy requirements of the infant for the first 6 months of life.

As the child grows, the nutrient composition of milk increasingly becomes inadequate to meet the infants' requirements. The nutrients most affected are micronutrients such as iron, zinc, vitamins A and C. Therefore, to be able to meet the changing requirements of the infant, there is the need to complement the breastmilk with a nutritious diet, which could be a proprietary formula, cereal or locally prepared complementary food at home, while breastfeeding continues for at least two years (Okoye, 1992).

2.81 Energy needs

For a new-born infant exclusively breast-fed, breast-milk provides all the needed calories for the first 6 months. An intake of 95–145 Kcal/Kg (150 ml) has been considered adequate. By 6 months, energy needs increases for a very placid infant by 32Kcal, and a fretful infant by 60 Kcal (Guthrie, 1989). An excessive intake of calories, leading to a rapid gain in weight, is as undesirable in infants as in adults which support the concept that maximal growth is not synonymous with optimal growth.

Most traditional complementary foods are usually bulky i.e. food of high viscosity but low energy density, and have been found to provide low energy for the growing child (Akinyele and Omotola, 1986). The factors limiting energy intake of an infant weaned on such low energy foods are the volume the child can consume at a time and the frequency of feeding (Walker, 1990). Low energy density complementary foods caused by high bulk gruels have long been implicated in protein-energy-malnutrition (Guthrie, 1989; Okoye, 1992; Devlin, 1997). Protein energy malnutrition (PEM) refers to all disease conditions attributable to inadequate dietary protein and energy intake, comprising mainly of kwashiorkor and marasmus (Gurney *et al.*, 1985; Okoye, 1992). Children with mild or moderate PEM adapt to their inadequate diet by growing slowly and often become lethargic. They are usually susceptible to infections such as diarrhoea and may further develop other micronutrient deficiency disorders (Gurney et al, 1985).

2.8.2 Protein

Protein intake, both quantity and quality, during the first two years of life has important effects on growth, neurodevelopment, and long-term health. Although there is limited evidence that healthy infants in affluent countries do not receive enough protein to cover physiologic needs, there is emerging evidence that a high protein intake during the first two years of life may actually have long-term negative effects on health (Michaelsen *et al*., 2012). During the first year of life, the dietary reference Intake (DRI) for daily protein intake ranges between 9 and 13 grams per day. Breast milk or formula was the primary source of protein in the first six months of life and then can be supplemented with high-quality food sources of protein such as fish, yogurt, pureed meat, and eggs. Carbohydrates are the primary source of fuel for infants and, if sufficient amounts are not provided, growth may be stunted because protein was used to meet the energy needs. When introducing solid foods, focus on foods with complex carbohydrates such as mashed or pureed vegetables, fruit, and whole grain cereal. By five to six month, the protein needs drop slightly to 2g/kg. Protein with high biological value of at least 70 to 85%, e.g. eggs, milk, meat, with almost half of amino acids being essential amino acids, have been recommended to be used for infants (Picciano, 1987).

According to the 2007 WHO/FAO/UNU recommendations for protein intake, the safe level is the mean estimate for physiologic need for protein intake plus 2 SDs. The mean safe level gradually decreases from 1.77 $g \cdot kg^{-1} \cdot d^{-1}$ at age one month to 0.97 $g \cdot kg^{-1} \cdot d^{-1}$ by age two years. Infants' amino acid requirements are proportionately higher than those of adults. In addition, histidine is essential for infants at a level surpassed in both breastfeeding and bottle-feeding.

Some of the complementary food formulations, which have been advocated for developing countries, have high levels of protein. Ijarotimi and Olopade (2009) have however reported poor protein quality of some traditional complementary foods. It was concluded that the amino acid patterns of the mixes were not sufficiently complementary, and suggested other protein sources (of animal source) be added to raise the quality.

2.8.3 Fats and fatty acids

Fats supply infants with energy for their brain, liver and heart. The current recommendation for infants younger than one year is to consume a minimum of 30 grams of fat per day. This amount is easily provided in the milk produced by a healthy mother and consumed by a regularly breastfeeding infant (IOM, 2005).

The quality and type of fat consumed during infancy is also important. The DRI recommendations suggested daily intake of at least 4.5 grams of the omega-6 essential fatty acid linoleic acid. The amount can often be provided in human milk without special careful attention to the diet on the part of a nursing mother. However, the DRI recommendation of one-half gram intake of linolenic acid—an omega-3 fatty acid—may not be easily met by a nursing mom without more careful attention to her personal meal plan (FAO, 2010).

Omega-3 fatty acid (docosahexaeonic acid) plays a critical role in neurological development and visual acuity. Evidence from several studies suggests that changes in brain concentrations of omega- 3- fatty acids are associated with changes in cognitive and behavioral performance in infants and toddlers. Studies on maternal docosahexanoic acid (DHA) intake provided evidence that mothers who consume more fish have higher breast milk concentrations of DHA than those who do not. In 2008, a team of 19 international experts developed recommendations based on research on infant development and fatty acids and concluded that DHA should be added to infant formula. As a result of that, most infant formulas are now fortified with DHA (Agostoni *et al.,* 2008). The guidelines also recommended that pregnant and lactating women should include adequate DHA in their personal diets to support the brain and eye development of their babies. More recent studies have been inconclusive with respect to the efficiency of DHA-fortified infant formula and the effect on cognitive development (Agostoni *et al.,* 2008). While more research is needed, the weight of the evidence still suggests that omega-3 fatty acid play a critical role in early infant development. With that in mind, it makes sense for nursing mothers to include at least one source of omega-3 fats in their diet every day, in a serving size that provides closer to 1-2 grams of omega-3 fatty acid. Mothers who are unable to or choose not to breastfeed should select an infant formula that contains omega-3 essential fatty acids.

2.8.4 Micronutrients

Micronutrients – also known as vitamins and minerals – are essential components of a high-quality diet and have a profound impact on health. While they are only required in tiny quantities, micronutrients are the essential building blocks of healthy brains, bones and bodies (Stevens *et al*., 2015).

Consuming a diverse range of nutrient-dense foods alongside breastfeeding is the ideal way for young children to get essential micronutrients in their diets. But in many parts of the world, children's diets contain insufficient micronutrients and deficiencies are widespread (Stevens *et al.,* 2015).

Micronutrient deficiencies are often referred to as 'hidden hunger' because they develop gradually over time, their devastating impact not seen until irreversible damage has been done. While a child may go to sleep each night with a full belly, micronutrient deficiencies mean that his or her body is still hungry for good nutrition (Stevens *et al.,* 2015).

Millions of children suffer from stunted growth, cognitive delays, weakened immunity and disease as a result of micronutrient deficiencies. For pregnant women, the lack of essential vitamins and minerals can be catastrophic, increasing the risk of low birth weight, birth defects, stillbirth, and even death (Stevens *et al.,* 2015).

The common practice of milling and polishing of grains, parboiling of vegetables and legumes used during the processing and preparation of infant foods have been found to reduce the levels of micronutrients (La Roche, 1990), and could cause micronutrient deficiency and other nutritional deficiency disorders in infants and children (Lorri, 1996). Depending on the nutrient and severity of deficiency, the consequences of micronutrient malnutrition in infants and children may include growth retardation, anorexia, and susceptibility to infections, behavioural changes and learning disability. The high mortality and morbidity rate among infants and children has led to the view that the modern world should not tolerate the persistence of these deficiencies. UNICEF (2000) has put the global mortality rate of children due to "hidden hunger" at 114 per 1000 (11.4%) live births.UNICEF supports the following strategies to prevent and treat micronutrient deficiencies in women and children:

- **Dietary diversification** strategies help families access a range of nutrient-rich foods. They involve educating caregivers on appropriate infant and young child feeding practices and improving the use of locally available foods.
- **Supplementation** programmes provide specific micronutrients that are not available as part of the regular diet. Supplementation is especially important at times when the body has particularly high micronutrient needs – for example during pregnancy – that are difficult to meet with diet alone. One example is iron and folic acid supplements for pregnant women, which can reduce the risk of low birth weight, maternal anaemia and iron deficiency.
- **Mass fortification** is the process of adding micronutrients to foods or condiments that are consumed regularly by the population, such as flour, sugar, salt and cooking oils. Fortification programmes are extremely effective in preventing micronutrient deficiencies at minimal cost – often only a few cents per person per year. Universal salt iodization and flour fortification programmes (to add iron) have provided successful mass fortification in many countries.
- **Home fortification** programmes provide caregivers with micronutrient powders to sprinkle on the foods they prepare for children at home. This can significantly improve the dietary quality of complementary food for children from 6 months to the age of 2 or older. Home fortification empowers caregivers and provides them with the tools to improve the family diet without requiring a major change to their dietary practices.

These strategies, together with the prevention and treatment of infectious diseases and deworming, can minimize micronutrient depletion and reduce micronutrient deficiencies among vulnerable groups (Kennedy *et al*., 2003).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Experimental food samples

The foodstuffs used were–maize (*Zea mays*), acha grains (*Digitaria exilis*), millet *(Pennisatum typhoides)*, Sorghum *(Sorghum bicolar)*, soya beans (*Glycine max*), groundnut (A*rachis hypogea*), crayfish (*Macrobrachium sp*). The foodstuffs and the commercial formula were purchased from Kaduna central market.

3.1.2 Chemical and reagents

All chemicals and reagents are bought from a reputable company and are of good analytical grade. Reagents used include:

- Petroleum ether
- Pentadecanoic acid
- Potassium hydroxide
- Chloroform
- Bromocresol green among others.

3.1.3 ESHA Food Processor Nutrient Analyser Software

ESHA meaning Elizabeth Stuart Hands and associate nutrients analyser software is nutrition Analysis software combines an extensive and meticulously researched food and ingredient database with an uncluttered, easy-to-use interface for accurate and comprehensive nutrition analysis. For more than 30 years, Nutritionists, Dietitians, Restaurants, and Educational Facilities have used the Food Processor Analysis tool to analyze menus, diets, foods, recipes, and even fitness needs of their clients. The software was purchased from their website (see invoice attached in the appendix). The complementary food was developed using Esha Food processor software. This allowed for the use of a wide range of foodstuff available to mothers that could be used to prepare diets inexpensively, and nutritious enough to meet the nutritional requirement of infants and children. Analysis of the formulated diet was carried out alongside a commonly used proprietary infant cereal (Nestle Cerelac) as control and the most commonly consumed complementary food from the locality. This was to identify if the diet closely mimic the control, hence hold promise.

3.1.4 Survey to Determine Available Complementary Foods

A cross-sectional descriptive study was conducted among mothers of children 6-12 months of age in Kaduna north LGA to determine the available complementary foods using a semi structured interviewer's questionnaire. All the communities in the LGA were listed and the interview locations were selected from those communities.

3.1.5 Study Areas

Kaduna North is one of the 23 local Government Areas in Kaduna State, Nigeria with its coordinates at $10^0$20'N$7^0$45'E. It has an area of 72km^2 and a population of 357,694 at the 2006 census.

3.1.6 Sample size

The minimum sample size was calculated using prevalence of inappropriate infant and young child feeding practices in Kaduna of 10% (children aged 6- 23 months) based on the data from NDHS 2013. The sample size was determined using the formula:

$n = t^2 \times p\,(1-p) / M^2$ and adjusted for sampling defect $N = (n \times D)$ where $D = 1.5$ and non-response at 5% of the sample size was also considered in the sample size calculation.

3.1.7 Sampling Procedure

A multistage sampling technique was used to select wards, communities and households. The numbers of households required per community were selected using probability proportional to size approach.

3.1.8 Study Approval

Study approval was obtained from the local government before the commencement of the survey study

3.2 Methods

3.2.1 Development of Complementary Food CF)

A CF was designed and developed with the aid of ESHA (Elizabeth Stuart Hands and Associates) Food Processor and Nutrient Analyser software. Several trial formulations were proposed and evaluated by the ESHA software. The CF was prepared in batches within a period of 6 days; this was done in order to meet the National Food and Drug Administration and Control (NAFDAC) requirements for food analysis. All the portions processed for the 6 days received the same treatment. The different portions were combined and mixed to obtain homogeneous flour. The CF were stored in sealed containers for analysis.

3.2.2 Proximate Analysis

Recommended methods of the Association of Official Analytical Chemists (AOAC 2000) were employed in the analysis of moisture, fat, dietary fibre, and ash contents.

Moisture content:

An Isotemp vacuum oven was used to determine moisture content. Three grams of sample was weighed into a pre-dried aluminium weighing dish and covered with a lid. This was then place in the oven for 14 h with the temperature and pressure kept at 105°C and 25 mmHg, respectively.

The sample was transferred to a desiccator and then weighed. The residue was recorded as total solids and stored in a desiccator for fat analysis while percentage moisture was calculated from loss in weight by the following formula:

$$\%\text{Moisture} = \text{Loss in wt} \times 100/\text{wt of sample}$$

Each sample were analysed in triplicate.

Fat:

Fat was determined by petroleum ether extraction. Predried and labelled oil extraction beakers were weighed. Two grams of moisture free sample were weighed into numbered, labelled oil extraction thimble and glass wool placed at the top of the thimble to keep the sample in place during the extraction process. The thimbles containing the sample were placed in glass sleeves and the sleeves placed into the pre-labelled extraction unit. The oil extraction beakers were filled with 50 mL of petroleum ether and attached to the unit. The cold water was turned on followed by the power switches.

The unit was allowed to reflux overnight. With the switches turned off, the glass sleeves were replaced by solvent reclaiming tubes and the system allowed to run for a few minutes until the level of liquid in the oil extraction beakers reached 10 mm. Oil content was calculated by the following formula:

$$\%\text{Total oil} = \text{wt of extracted oil} \times 100/\text{wt of dry sample}$$

Each sample was analysed in triplicate.

Crude Protein:

Nitrogen content was determined using Nitrogen which is a nondispersive, infrared, microcomputer-based instrument. Sample (0.2 g) was weighed into the sample boat and the weight registered on the attached computer. The key designated as “analyse” was selected and the sample pushed into the combustion chamber. The furnace and the oxygen gas caused the sample to combust releasing nitrogen gas and an oxide of nitrogen. The nitrogen content was recorded and the protein content calculated using a conversion factor of 6.25 for cow pea and banana while 5.46 was used for peanut. Three replicates of each sample were analysed.

Carbohydrate:

This was calculated by difference (i.e., 100 minus sum of percentages of moisture, ash, lipid, and protein).

3.2.3 Calorie Determination

The Atwater conversion factor methodwas employed in calorie determination. This uses the general factors of 4, 4, and 9 calories per gram of protein, total carbohydrate, and total fat, respectively, to calculate the calorie content of food.

3.2.4 Fatty Acids Determination

Fatty acids were determined by gas-liquid chromatography with flame ionization detection (GLC-FID)/capillary column based on the method used by Oliveira *et al.*, (2000). The sample together with pentadecanoic acid, was treated with 2,2-dimethoxypropane and hydrochloric acid. 2, 2-dimethoxypropane serves as water scavenger, deproteinizing agent and as a methylating agent. Under assay conditions, only free fatty acids were converted to their methyl esters.

3.2.5 Vitamin Assay

Vitamin A:

Vitamin A concentration in the samples were determined using the method of Carr and Price (1926). The method was based on measuring the blue colour obtained when saturated antimony trichloride was added to a solution containing vitamin A in chloroform at 620nm. Dry materials containing fat or oil are first of all extracted with fat solvent before saponifying with alcoholic alkali. Vitamin A was present and assayed in the unsaponifiable fraction.

Extraction:

Five grams of the powdered samples were each weighed into extraction thimbles and extracted with petroleum ether (60 – 80^{o}C) on a soxlet extractor as earlier described. The petroleum ether was evaporated and the oil residues saponified with 10ml of alcoholic KOH under reflux for 45 minutes at 58^{o}C. The alcoholic hydrolysate was then diluted with 50ml of distilled water and the vitamin A extracted with 20ml of diethyl ether. The process was repeated twice, and the combined organic extracts washed free from alkali with more water, and then dried over anhydrous sodium sulphate overnight under reduced light. Solvent was allowed to evaporate on a water bath at 40^{o}C. The resultant residue was re-dissolved in chloroform and made up to 25ml with more chloroform.

Assay:

One milliliter each of the chloroform solution was then pippetted into l cm-glass cuvette. Saturated antimony trichloride solution (3mls) was added to each sample extract and absorbance read immediately at 620nm against chloroform blank.

Triplicate analysis was carried out on each sample.

Calculation:

The vitamin A content of each sample in microgram was read off from a calibration curve prepared from different concentrations of oily vitamin A palmitate. All samples were beshielded from light during the analytical procedures.

Vitamin B1 (Thiamine) Determination:

Measurement of vitamin B1 (thiamine) was done using the method of Stroebecker and Henning (1965). In this method, B1 is readily decomposed in neutral or alkaline solution, and extracted in acid medium. It is best extracted in 0.001 – 0.02M HCl. B1 is stable in acid medium even on prolonged heating.

Extraction:

Five grams of each powdered sample were weighed and ground in a porcelain mortar with 5ml 0.02M HCl. The mixture was rinsed quantitatively into a 100ml volumetric flask and more 0.02M HCl poured to the 70ml mark. The mixture was warm for 1 hour at $50^{o}C$ with occasional shaking on water bath. At the end of the heating, the content of each flask was then allowed to cool to room temperature before making up to 100ml with distilled water. It was then vigorously shaken several times and allowed to stand for 15 minutes each time. Suspensions are then filtered through No. 1 Whatman filter paper.

Spectrophotometric Measurement:

Five milliliter of each sample extract waspipetted into labelled test tubes, and 5ml of oxidation solution (potassium ferricyanide: NaOH mixture 1:9v/v) added. Each mixture was shaken and then allowed to stand for 1 minute. Three drops of hydrogen peroxide solution was added to each test tube and shaken again. Absorbance of each reparation were determined at 369nm against a blank prepared in the same manner, But 5ml of water added instead of the sample extract. Triplicate determinations were carried out on each sample extract.

Calculation:

The thiamine content in mg per 100g samples was obtained as follows:

Mg Vit. B1 = Abs.x100*x110x1000

Where 100* is the volume to which extract was made up to and 110 is a conversion factor.

Vitamin B2 (Riboflavin) Determination**:**

This assay was based on the method of Stroebecker and Henning (1965). Vitamin B2 occurs in natural products almost entirely in combined form as riboflavin- 5- phosphoric acid ester (flavine mononucleotide), and linked to protein as a constituent of “yellow enzymes”. Extraction with hot dilute acid (steam bath or water) splits vitamin B2 - protein complex. Protein was precipitated with excess acetone or methanol, while riboflavin stays in solution without being absorbed by the precipitated protein and other impurity. Dry samples such as cereal products and feeding stuffs, werefirst of all powdered and then defatted by extraction with ether or light petroleum.

Extraction:

Powdered moisture free samples were defatted using light petroleum ether (40 – 60^{o}C) for 8 hours. One gram each of the defatted samples were weighed into a 50ml conical flask and shaken with 120ml of 0.1N HCl on a water bath set at 70oC for 90 minutes. Fifteen (15) milliliters of acetone was then added and shaken for 5 minutes. Mixtures were filtered through No.1 Whatman filter paper. Excess acetone in the filtrate was evaporated on water bath until odour-free. Each extract was diluted to 10ml with distilled water, 1ml of glacial acetic acid added, and then shaken.

Assay:

Standard solutions of riboflavin were prepared by accurately weighing out 50, 100, 200, 400 and 600mg riboflavin and dissolved in 10ml distilled water to give concentration of 5, 10, 20, 40, 60mg/ml respectively. To 10ml of both sample extracts and standard solutions of riboflavin, 0.5ml of 4% $KMnO_4$ solution was added and allowed to stand for exactly two minutes. To this was then added 0.5ml of 3% H_2O_2 solution and shaken vigorously to expel excess oxygen. Solutions that were turbid or had precipitates of MnO, were centrifuged before absorbance of the resultant yellow colour solutions was measured at 444nm. Triplicate determinations werecarried out on each extract.

Calculation:

Absorbance obtained for the different concentrations of standard riboflavin were used to plot a calibration curve while the vitamin B2 concentration of each sample extract were read from the linear curve.

Vitamin B6 (Pyridoxine) Determination**:**

Vitamin B6 was determined by the modified method of Stroebecker and Henning (1965). The method was based on the principle that pyridoxine molecule possesses a phenolic hydroxyl group that gives a brown colour on interaction with ferric chloride, whose intensity was proportional to the concentration of the phenolic hydroxyl in the pyridoxine.

Extraction Procedure:

Exactly 1g of each powdered samples were weighed separately into a 100ml conical flask and extracted with 10ml 0.1M HCl with vigorous shaking for 10 minutes. Samples were filtered through No. 1 Whatman filter paper. Filtrates were then made up to 10ml with distilled water. Five milliliters of the slightly acidic filtrates were each treated with 1ml ferric chloride solution that had been diluted 1 in 50 with distilled water. The optical density of the resultant brown colour was then measured in a 1cm cell cuvette against a blank solution consisting of 1ml dilute ferric chloride solution at 450nm. Triplicate determinations were carried out on each sample.

Calculation:

The absorbencies obtained from the various sample extracts were converted into pyridoxine concentration by means of a calibration curve generated.

Vitamin C (ascorbic acid) Determination:

This was achieved by the method of Roe and Kuether (1943). Ascorbic acid is oxidized to dehydroascorbic acid, which was coupled with 2, 4 – DNPH. The oxazone so formed reacts with conc. H_2SO_4 to yield a red coloured complex, which absorbs at 520nm.

Extraction and Assay:

Five gram of each powdered diet sample were weighed into labelled porcelain dishes and grounded with 25ml of 0.5% oxalic acid for 10 minutes, mixed thoroughly and allowed to settle. Supernatants were then decanted and 0.5ml pipetted into clean dry test tubes, followed by the addition of 1.5ml of 4% TCA. Into two separate test tubes, 2.0ml standard vitamin C solution (0.5mg/100ml) was pipetted into two separate test tubes followed by 2.0ml 2, 4 – DNPH, mixed and incubated at 50oC for 1 hour. All tubes were then transferred to an ice bath for 5 minutes. With tubes still in ice, 2.5ml of 85% H_2SO_4 was added to each tube drop wise with constant mixing. Tubes containing mixtures were removed from the ice bath and allowed to stabilize to room temperature for about 30 minutes. Absorbance was read at 520nm using the blank solution to zero the spectrophotometer. Triplicate determinations were carried out on each sample extract.

Calculation:

Milligram of vitamin C in 100g of samples was calculated using the formula:

Mg Vit. C = Absorbance of sample extract x conc. of standard x 25 x 100

Absorbance of standard 0.5 x 5

Where 25 is the volume of extract for each sample

0.5 is the volume of extract taken for assay

5 is the weight of samples taken

100 is to convert to 100g sample.

3.2.6 Determination of amino acid profile

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Defatting Sample:

The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 4g of the sample was put in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 2006).

Nitrogen Determination:

A small amount (200mg) of ground sample was weighed, wrapped in whatman filter paper (No.1) and put in the Kjeldahl digestion flask. Concentrated sulphuric acid (10ml) was added. Catalyst mixture (0.5g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ratio of 10:5:1 was added into the flask to facilitate digestion. Four pieces of anti-bumping granules were added.

The flask was then put in Kjeldahl digestion apparatus for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100ml in standard volumetric flask. Aliquot (10m1) of the diluted solution with 10ml of 45% sodium hydroxide was put into the Markham distillation apparatus and distilled into 10ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70ml of distillate was collected.

The distillate was then titrated with standardize 0.01 N hydrochloric acid to grey coloured end point.

$$\text{Percentage Nitrogen} = \frac{(a-b) \times 0.01 \times 14 \times V \times 100}{W \times C}$$

Where:

a. = Titre value of the digested sample

b. = Titre value of blank sample

v. = Volume after dilution (100ml)

W. = Weight of dried sample (mg)

C. = Aliquot of the sample used (10ml)

14. = Nitrogen constant in mg.

Hydrolysis of the sample:

A known weight of the defatted sample was weighed into glass ampoule. 7ml of 6NHCL was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g. methionine and cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven pre-set at $105^0C \pm 5^0C$ for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. It should be noted that tryptophan is destroyed by 6N HCL during hydrolysis.

The filtrate was then evaporated to dryness in hot air oven. The residue was dissolved with 5ml to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

Loading of the hydrolysate into TSM analyser:

The amount loaded was 60 microliter. This was dispended into the cartridge of the analyser. The TSM analyser is designed to separate and analyse free acidic, neutral and basic amino acids of the hydrolysate.

Method of Calculating Amino Acid Values from the Chromatogram Peaks:

An integrator attached to the Analyser calculates the peak area proportional to the concentration of each of the amino acids.

Determination of tryptophan:

Tryptophan is a difficult amino acid to determine in proteins and peptides because it chemically decomposes during acid hydrolysis. It should be noted that tryptophan is destroyed by 6N HCL during hydrolysis.

Antioxidants such as thioglycolic acid or dodecanethiol have been used to 6 N hydrochloric acid (HCl) to preserve tryptophan. Alkaline hydrolysis has also been studied and was shown to produce higher tryptophan recovery than acid hydrolysis. The addition of phenol has also been reported. Alkaline hydrolysis was improved by using sodium hydroxide (Na0H) instead of barium hydroxide to prevent problems with both precipitation and adsorption of tryptophan.

The tryptophan in the known sample was hydrolysed with 4.2 M Sodium hydroxide (Robel, 1984). The known sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyser.

3.2.7 Mineral Determination

All Atomic Absorption Spectrophotometric measurements were carried out with a spectrophotometer which is equipped with a data processing unit and a strip chart automatic recorder. The technique was used for the determination of Cu, Mg, Zn, Ca and Fe which were the cations of interest.

3.3 Statistical Analysis

Data obtained were presented using descriptive statistics. The differences in the commonly consumed CF, formulated CF and a popular commercial proprietary formula were analyzed using Analysis of variance (ANOVA) procedures SPSS/20.0 software and further subjected to Duncan posthoc test where there was a significant difference. The results were expressed as mean ± standard deviation (SD), except where otherwise stated. P value less than 0.05 was taken as significant ($p < 0.05$)

CHAPTER FOUR

4.0 RESULTS

4.1 Socioeconomic CharacteristicsofCaregivers of 6- 23 Months Old Children in Kaduna North LGA

Table 4.1 presents the socioeconomic characteristics of the survey subjects. It was observed that 98.62% of the caregivers were females. Only 95 (43.77%) out of the 217 caregivers attended school out of which 10 (4.61%) of them attended post-secondary schools.The major income earners of the households are the husbands (84.79%), 119 (54.84%) of the subjects are engaged in petty trading while 65 (29.95%) are farmers and 33 (15.21%) are working in the civil service/ private sector.

4.2 Infant and Young Child Feeding Practices of Respondents Caregivers of 6-23 Months Old Children in Kaduna North LGA

The infant and young child feeding practices of the respondents is shown in Table 4.2. It was observed that all the survey caregivers' breast fed their infants and 47% initiated breast feeding immediately after delivery, 42.86% and 10.14% initiated at 24 hours and >24 hours respectively.

Most of the caregivers introduced water at birth with 66.36% giving their babies water at birth, 66.82% used Sorghum pap as the major complementary food at 6 months of age while 5.07%, 1.84%, 14.29% and 11.98% used Millet papa, Maize pap, Sorghum Soya beans G/nut blend and Commercial formula respectively.

Table 4.1: Socioeconomic Characteristics of the Survey Caregivers of 6- 23 Months Old Children in Kaduna North LGA

Variables	Frequency (n= 217)	Percentage
Sex of Respondents		
Female	214	98.62
Male	3	1.38
School Attendence	95	43.77
Highest Educational Attainment		
Primary	47	49.47
Secondary	38	40.00
Post-Secondary	10	10.53
Employment Status		
Fully Employed	33	15.02
Part time Employment	24	11.06
Housewives	160	73.73
Household Income Earners		
Husband only	184	84.79
Husband and Wife	33	15.21
Occupation		
Petty trading/ Business	99	45.62
Farming	60	27.65
Civil Service/ Private Sector	29	13.36
Artisan/ Skilled workers	29	13.36
Average household monthly income		
Below 5000 naira	68	31.34
Above 5000 naira	149	68.67

Table 4.2: Infant and Young Child Feeding Practices of Respondents in Kaduna North LGA of Kaduna State

IYCF practices	Frequency(n=217)	Percentage
Breasfeed		
Yes	217	100.00
Initiation of Breastfeeding		
Immediately	102	47.00
Within 24 Hours	93	42.86
≥24 Hours	22	10.14
Foods and water given to child less than 6 months		
Water	189	87.10
Infant formula	20	9.22
Age of Introduction of water		
From birth	144	66.36
Between 3 and 6 months	8	3.69
From 6 months	65	29.95
Major Complementary Foods at 6months and above		
Sorghum pap(Kunun jar dawa)	145	66.82
Millet Pap (Kunun gero)	11	5.07
Maize Pap (Kunun masara)	4	1.84
Sorghum, soya beans, g/nut blend	31	14.29
Commercial formula	26	11.98
Processing Methods of Complementary Foods		
Steep in water, Wet milling	118	61.78
Steep in water, Dry milling	73	38.22

4.3 Proximate Compositionof Commonly Used Complementary FoodsCaregivers of 6- 23 Months Old Children in Kaduna North LGA

Results of the proximate nutrients composition of the commonly used Complementary food in Kaduna North LGA is presented in Table 4.3. It was observed that values of moisture (10.63±0.11) content of Sorghum Pap (S.P) was significantly higher (P<0.05) than that of Sorhum groundnut Soyabeans Pap (SGSP), Millet Pap (MiP), Maize Pap (MaP). Crude protein (19.09± 0.38) and Crude fibre (6.89±0.12) were significantly higher (P<0.05) in SGSP than in SP, MiP and MaP. SP was significantly lower in Carbohydrate than the rest of the groups. The MaP had the highest calorie content of 394.36±1.27 at P<0.05 when compared to SP, SGSP, MiP. There was no significant difference in the Ash content of SGSP and MaP.

4.4 The Amino Acid CompositionofThe Commonly Used Complementary FoodCaregivers of 6- 23 Months Old Children in Kaduna North LGA

The Amino acid composition of the commonly used complementary food in Kaduna North LGA is shown in table 4.4. SGSP was significantly higher in essential amino acids (Leucine (6.65), Histidine and Methionine (1.60)). S.P is significantly higher in essential Amino acids (Isoleucine, Threonine and valine) while MiP is significantly higher in essential amino acid (Lysine, Phenylalanine, Tryptophan). MaP was significantly lower in all the essential and non-essential amino acids. SGSP was significantly higher in all the non-essential amino acids with the exception of Cysteine and Alanine that is higher in SP.

4.5 Nutrients Compositionofthe Developed ESHA FormulatedComplementary Food

Figure 4.1 shows the nutrient composition of the developed Complementary food using the ESHA software. It was observed to have 432.29kcal. Carbohydrates (47.54g) and

Fat (22.53g) recorded the highest value in the ESHA developed recipe while Water, Ash and Protein were 8.37g, 2.83g and 18.76g respectively. The ESHA developed Complementary Food was developed from THE SGSP from the survey of the commonly used household complementary foods. The ingredients used in the development of the new ESHA formulated Complementary Foods include Sorghum, Soyabeans, Groundnut and Crayfish.

Table 4.3: Proximate Composition of Commonly Used Complementary Foods in Kaduna North LGA of Kaduna State

Proximate composition (%)	S.P	SGSP	MiP	MaP
Moisture	10.63 ± 0.11^{b}	8.06 ± 1.62^{a}	6.37 ± 0.76^{a}	7.20 ± 0.00^{a}
Crude Protein	13.63 ± 0.18^{c}	19.09 ± 0.38^{d}	8.47 ± 0.03^{b}	5.82 ± 0.15^{a}
Fat	3.10 ± 0.33^{a}	5.51 ± 0.40^{b}	2.93 ± 0.10^{a}	5.02 ± 0.28^{b}
Crude Fibre	2.93 ± 0.09^{a}	6.89 ± 0.13^{b}	2.97 ± 0.04^{a}	2.95 ± 0.01^{a}
Ash	2.11 ± 0.16^{b}	2.09 ± 0.12^{b}	0.63 ± 0.01^{a}	0.48 ± 0.03^{a}
CHO	70.53 ± 0.11^{b}	65.23 ± 0.71^{a}	81.61 ± 0.91^{c}	81.49 ± 0.45^{c}
Calories (kcal)	364.54 ± 2.71^{a}	393.45 ± 1.21^{c}	386.65 ± 2.55^{b}	394.36 ± 1.27^{c}

Values with different superscript in a row are significantly different at $P<0.05$.

S.P= Sorghum pap

SGSP= Sorghum, g/nut and soya beans pap

Mip= Millet pap

MaP= Maize pap

The Atwater conversion factor was used for calorie determination (i.e. 4kcal/g of CHO, 4kcal/g of Protein and 9kcal/g of Fat) (Atwater and Benedict, 1902)

Table 4.4: Amino Acid Composition of Commonly Used Complementary Food in Kaduna North LGA of Kaduna State

Amino Acid (g/100g protein)	S.P	SGSP	MiP	MaP
Essential Amino acids				
Leucine	2.13	6.65	4.64	3.10
Lysine	1.87	2.12	2.21	2.10
Isoleucine	5.03	3.04	3.11	2.51
Phenylalanine	2.60	3.63	3.96	2.29
Tryptophan	1.06	0.87	3.40	3.10
Threonine	3.25	2.72	1.55	1.23
Histidine	2.22	2.23	1.88	1.40
Valine	3.80	2.83	3.16	1.28
Methionine	0.85	1.60	1.39	0.83
Non Essential Amino acids				
Proline	0.99	2.64	1.27	1.08
Arginine	4.25	5.33	3.10	3.04
Tyrosine	1.88	3.09	2.23	1.43
Cystine	2.02	0.84	1.05	1.01
Alanine	4.32	3.68	1.40	1.25
Glutamic acid	8.24	14.53	6.25	4.14
Glycine	1.35	2.87	1.37	2.37
Serine	3.03	3.16	1.20	1.10
Aspartic acid	4.19	8.40	3.99	2.41

S.P= Sorghum pap

SGSP= Sorghum, g/nut and soya beans pap

Mip= Millet pap

MaP= Maize pap

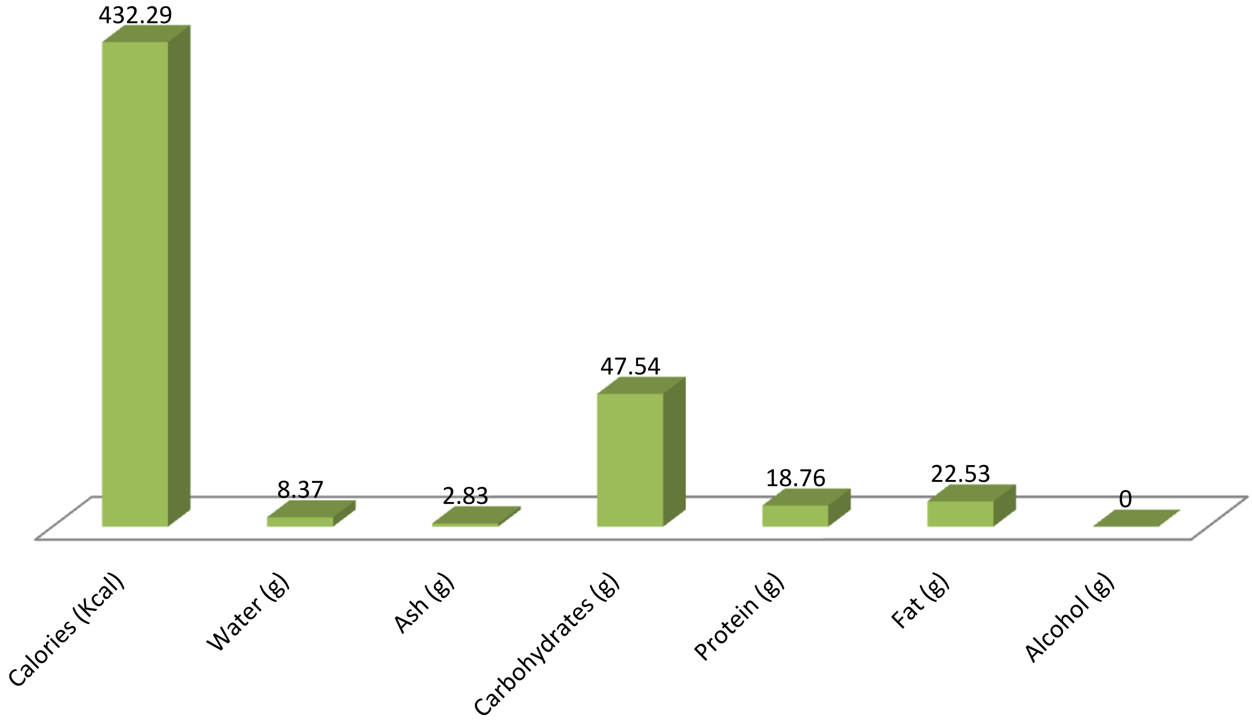

Figure 4.1: Nutrients composition (Per 100g) of the ESHA Formulated Complementary Food

4.6 Proximate Compositionofthe Commonly Consumed Complementary Food (CF), ESHA Developed CF, Commonly Used Commercial Formula

Proximate Composition the Commonly Used CF; ESHA formulated CF and Commonly used Commercial CF in Kaduna North LGA is shown in Table 4.5 The proximate composition shows significant higher values ($P<0.05$) of crude protein, crude fibre, fat and calories and lower Carbohydrate(CHO) in Esha Formulated Complementay Food(EFCF). It was observed that the value of the moisture contents of Commonly Consumed Complementary Food(CCCF) (10.63±0.11) was significantly higher than EFCF and CMCF®. The Ash content of Commonly Used Commercial Formula(CMCF) was significantly higher than EFCF and CCCF.

4.7 Mineral Composition of the Commonly Consumed Complementary Food (CF), ESHA Developed CF, Commonly Used Commercial Foods

The mineral elements composition of CCCF, EFCF and CMCF are presented in table 4.6. CCCF was significantly lower ($P<0.05$) in all the minerals but significantly higher in Cu. It was observed that Fe was significantly higher ($P<0.05$) in EFCF than in CMCF and CCCF. Mg, Zn and Ca were significantly higher ($P<0.05$) in CMCF than in EFCF and CCCF.

4.8 Vitamins Contents of Commonly Used, ESHA Formulated and Commercial Complementary Foods in Kaduna North LGA of Kaduna State

Table 4.7 presents the Vitamin contents of the 3 complementary foods (CCCF, EFCF and CMCF). All the vitamins were significantly higher ($P<0.05$) in all the formulated complementary foods (CCCF and EFCF) when compared to the CMCF. It was observed that Vitamin A (1.445±0.007) and Vitamin B2 (1.330±0.141) were significantly higher

(P<0.05) in EFCF while Vitamin B1 (0.713±0.004) and Vitamin B6 (13.275±0.212) were significantly higher in CCCF when compared to EFCF and CMCF.

4.9 Amino Acid Composition of Composition of the Most Commonly Consumed, ESHA Formulated and Commercial Foods.

Table 4.8 presents the Amino acid composition of CCCF, EFCF and CMCF.

EFCF was observed to have significantly higher (P<0.05) concentrations of essential amino acids (Leucine (7.62), Phenylalanine (4.08), Histidine (2.30) and Threonine (3.11)) while significantly higher (P<0.05) in all non-essential amino acid except for cysteine and alanine which was significantly higher in CCCF. CMCF was significantly higher in Lysine and Methionine when compared to the formulated CF (CCCF and EFCF). It was also significantly higher in non-essential amino acid (Cysteine, alanine and serine). Valine (3.0) and isoleucine (5.03) was significantly higher (P<0.05) in CCCF when compared to EFCF and CMCF.

4.10 Fatty Acid Profile of Commonly Used Complementary Food And ESHA Formulated Complementary Food in Kaduna North LGA

The proposed fatty acid composition of the CCCF, EFCF and CMCF is shown in Table 4.9. Oleic acid was present in all the three groups of the CFs with CMCF (58.95%) having the highest proportion. EFCF and CMCF shows the presence of Bicyclo (5,3,0) decapentaene with the proportion of 8.99% and 0.67% respectively. I-Octanol was present in both CCCF and CMCF with CCCF (11.20%) having the highest proportion.

Table 4.5: Proximate Composition of Commonly Used, ESHA formulated and Commercial Complementary Foods in Kaduna North LGA of Kaduna State

Proximate Composition (%)	CCCF	EFCF	CMCF®
Moisture	10.63 ± 0.11^{c}	5.14 ± 0.64^{b}	2.56 ± 0.14^{a}
Crude Protein	13.63 ± 0.18^{a}	25.25 ± 0.74^{b}	15.95 ± 1.24^{a}
Fat	3.10 ± 0.33^{a}	9.96 ± 0.134^{b}	3.17 ± 0.17^{a}
Crude Fibre	2.93 ± 0.09^{a}	8.42 ± 0.22^{c}	6.27 ± 0.44^{b}
Ash	2.11 ± 0.16^{a}	2.95 ± 0.85^{b}	6.42 ± 0.15^{c}
CHO	70.53 ± 0.11^{b}	56.67 ± 0.11^{a}	71.90 ± 0.78^{b}
Calories (kcal)	364.54 ± 2.71^{a}	417.32 ± 1.27^{c}	379.93 ± 2.01^{b}

Values with different superscript in a row are significantly different at $P<0.05$.

CCCF= Commonly used Complementary Food (locally formulated in household)

EFCF= ESHA Formulated Complementary Food

CMCF= Commercial Complemetary Food

The Atwater conversion factor was used for calorie determination (i.e. 4kcal/g of CHO, 4kcal/g of Protein and 9kcal/g of Fat) (Atwater and Benedict, 1902)

Table 4.6: Mineral Composition of the Most Commonly Consumed, ESHA Formulated and Commercial Complementary Foods in Kaduna North LGA.

Mineral Elements (mg/l)	CCCF	EFCF	CMCF ®
Fe	0.547±0.000[a]	0.984±0.000[c]	0.682±0.000[b]
Mg	0.993±0.000[b]	0.921±0.214[a]	1.150±0.000[c]
Zn	0.0484±0.000[a]	0.057±0.000[b]	0.107±0.000[c]
Ca	0.431600±0.000[a]	1.308±0.000[b]	3.25±0.000[c]
Cu	0.006±0.000[b]	0.006±0.000[b]	0.002±0.000[a]

Values with different superscript in a row are significantly different at $P<0.05$.

CCCF= Commonly Used Complementary Food (Locally formulated in household)

EFCF= ESHA Formulated Complementary Food

CMCF= Commercial Complementary Food

Table 4.7: Vitamins Contents of Commonly Used, ESHA Formulated and Commercial Complementary Foods in Kaduna North LGA of Kaduna State

Vitamin (mg/l)	CCCF	EFCF	CMCF ®
Vitamin A	7.947±0.004[b]	10.515±0.007[c]	1.445±0.007[a]
Vitamin B1	14.954±0.008[c]	9.916±0.006[b]	0.713±0.004[a]
Vitamin B2	8.660±0.006[b]	9.110±0.141[c]	1.330±0.141[a]
Vitamin B6	24.284±0.000[c]	17.796±0.006[b]	13.275±0.212[a]
Vitamin C	0.3200±0.01414[b]	0.320±0.000[b]	0.140±0.000[a]

Values with different superscript in a row are significantly different at $P<0.05$.

CCCF= Commonly Used Complementary Food

EFCF= ESHA Formulated Complementary Food

CMCF Commercial Complementary Food

Table 4.8: Amino Acid Composition of the Most Commonly Consumed, ESHA Formulated and Commercial Foods in Kaduna North LGA.

Amino Acid (g/100g protein)	CCCF	EFCF	CMCF ®
Essential Amino acids			
Leucine	2.13	7.62	7.44
Lysine	1.87	2.25	3.29
Isoleucine	5.03	3.21	3.47
Phenylalanine	2.60	4.08	3.90
Tryptophan	1.06	0.95	1.13
Threonine	3.25	3.11	2.99
Histidine	2.22	2.30	2.26
Valine	3.80	3.01	3.56
Methionine	0.85	1.81	2.19
Non Essential Amino acids			
Proline	0.99	2.94	2.84
Arginine	4.25	6.36	4.64
Tyrosine	1.88	3.27	3.09
Cystine	2.02	1.33	0.84
Alanine	4.32	4.09	3.60
Glutamic acid	8.24	16.20	11.20
Glycine	1.35	3.28	3.08
Serine	3.03	3.67	2.70
Aspartic acid	4.19	9.49	7.07

CCCF= Commonly Used Complementary Food

EFCF= ESHA Formulated Complementary Food

CMCF= Commercial Complementary Food

Table 4.9: Fatty Acid Profile of Commonly Used Complementary Food And ESHA Formulated Complementary Food in Kaduna North LGA

	Proportion (%)	SI	Fatty Acid
CCCF	1.49	89	Tridecanoic Acid
	1.08	89	Hexadecanoic Acid
	14.23	92	6-Octadecanoic Acid
	2.13	88	Oleic Acid
	63.78	92	Oleic Acid
	11.20	86	1-Octanol
	0.63	79	9-Tetradecenal
	2.36	85	13-Oxabicyclo(10,1,0) tridecane
	1.73	79	Fernesol isomer
	1.36	81	Tridecanoic Acid
EFCF	8.99	90	Bicyclo(5,3,0) decapentaene
	7.83	94	Pentadecanoic Acid
	7.37	94	n-Hexadecanoic Acid
	9.85	95	9,12- Octadecadienoic Acid
	14.34	89	11-Octadecanoic Acid
	2.45	92	Docosanoic Acid
	35.26	92	Oleic Acid
	7.07	87	Octadecanoic Acid
	0.66	83	Hexanoic Acid
	1.92	81	1,2-15,16- Diepoxyhexadecane
	2.57	86	Cis-9-Hexadecenal
	1.69	89	Squalene
CMCF	0.67	71	Bicyclo(5,3,0) decapentaene
	16.34	88	n-Hexadecanoic Acid
	3.26	85	13,16-Octadecadienoic Acid
	58.95	90	Oleic Acid
	2.70	74	1-Octanol
	2.94	75	1-Docosanol
	8.68	82	12-Methyl-E,E-2,13-Octadecadien
	6.46	85	9-Octadecenal

EFCF= Esha formulated complementary food

CMCF= Commercial Complemetary Food

CCCF= Commonly used complementary food

CHAPTER FIVE

5.0 DISCUSSIONS

The majority of the Households in the survey areas are involved in petty trading and farming and distribution of the average monthly income indicated that, close to a half of the households had incomes that are below the minimum Government wage of N18, 000. Low income adversely affects food and nutrition security in Households, though increasing the risks of malnutrition among the vulnerable groups. Only 95 out of the 217 survey subjects attended school. Low education level has indirect effects on understanding of food and nutrition as well as improvement of socio-economic conditions (Walraven *et al.*, 1997).All the survey respondents' breast fed their children. Majority of the respondents introduced water from birth to their infants. Giving water to young babies put at them at the risk of diarrhoea and malnutrition. Breast milk is more than 80% water, especially the first milk that comes with each feed. The use of locally available food stuffs to formulate complementary foods agrees with the guidelines and criteria set out by the Federal ministry of health Nigeria (FMOH, 1999), calling for the use of available foodstuff in various communities in the country to prepare complementary food for infants so as to ensure availability and affordability.

The use of locally available foodstuff to formulate the diet (blends) agrees with the guideline and criteria set out by the federal Ministry of Health in Nigeria (FMOH, 1999), calling for the use of available foodstuff in various communities in the country to prepare food for infants and children, so as to ensure availability and affordability.

Such guideline are particularly important in a developing country like Nigeria, where gross malnutrition has largely been attributed to inadequate intake of food materials due to inability of parents or families to afford the proper diets (especially animal-source foods), and disease states that could prevent adequate utilization of the food materials as well as loss of appetite associated with these diseases (NNN, 2000). In some cases, ignorance about the essential food materials that could provide a balance diet has resulted in poor dieting. Carbohydrate, Fat, proteins and vitamins are particularly important both in quality and quantity when formulating complementary foods for infants, where requirement must be met for rapid growth, development and maintenance of good health.

The law moisture content observed in the EFCF and CMCF were comparable to the control values, is a valuable attribute. Values of 2.56-5.14% reported in the current study fall within the 5% moisture content recommended for dry foods reported separately by Atinmo, (1986) and Badamosi and Ibrahim, (1995). Law moisture content would tend to increase the shelf life of the diets, more so that the diets may be prepared in quantities that would require storage. Hence, the lower the moisture content, the better the keeping quality. It is therefore recommended that small quantities of the diets be prepared at a time especially during humid seasons. Proper and hygienic cooking is also recommended to avoid diarrhea and other infections as observed by AHRTAG (1993). Moisture contents of the common complementary foods from the survey tend to be higher than the commercial CF because it was carried out as consumed and not based on dry matter content.

Crude protein content in all the complementary foods fall within the protein Advisory council recommendation of 11.9-23.3% for infants diet with the exception of MiP, MaP and EFCF. Although, the EFCF does not meet the guidelines, the improved protein content of the EFCF could be attributed to the inclusion of crayfish which is a good source of protein recommended by other researchers (Badamosi and Ibrahim, 1995; Temple *et al.*, 1996; Ladeji *et al.*, 2000), in the formulation of infants' foods.Other researchers such asTemple et al, 1996; Ladeji et al, 2000; Nnam, 2002) have also suggested the inclusion of milk and egg in infant diets to improve the protein quality. This is based on the fact that proteins of plant origin have low biological value. Protein is particularly important both in quantity and quality for the rapid growth and development of infants.

The high crude protein content observed in EFCF could be due to the inclusion of soya beans and groundnut which are oil dense legumes. Fats contribute to the energy value of foods as provide essential fatty acids for optimal neurological, immunological and functional developments in children (Guthrie, 1989).

Carbohydrate contents of MiP and MaP were found to be higher than the remaining complementary foods. The cereal based legumes complementary foods were found to contain Carbohydrate in the range of 56.67%- 65.23 %. According to Gibrey (1995), when formulating complementary foods for infants, the ratio of carbohydrate to fat and proteins must be taken into consideration. This is because, high protein and low carbohydrate complementary food would mean the amino acids of the protein was diverted to glucose synthesis and the body is deprived of protein meant for body building with resultant wasting and stunting. It is however believed that since breast feeding is expected to continue, frequent feeding with local diets would provide sufficient carbohydrate. Values obtained in this study seem to suggest that carbohydratewassufficient to meet requirements. Although there is no fixed RDA for carbohydrate intake, FAO/WHO (1998) has recommended an intake of about 50g per day as being sufficient to meet energy need. In this regard it would seem that only the control diet could meet this recommendation, while all the local diets fall short based on the estimated intake of

65g of weaning food by an infant per day (Fernandez, et al, 2002). It is however believed that since breastfeeding is expected to continue, frequent feeding with local diets would provide sufficient carbohydrate. The high growth rate observed in rats fed the modified diets seems to suggest that protein was spared for normal metabolic processes, hence energy needs were met by the diets.

The crude fat of the ESHA formulated complementary food was significantly higher than the rest of the complementary foods. Fats contribute substantially to the energy value of foods as well as provide essential fatty acids for optimal neurological, immunological and functional developments in children (Guthrie, 1989). Furthermore, lipid matrix in fat-based foods is inhospitable to bacteria (food spoilage) hence the spread of food-borne infection is avoided. This is particularly important in countries where household electricity and facilities for refrigeration are a luxury for most people. A product or food with a long shelf life at ambient tropical temperature is a valuable innovation.

Dietary fibre consists primarily of the indigestible carbohydrate of cell walls in plants. Crude fibre values were found to be higher in EFCF, SGSF and CMCF. The observed high value could be due to inclusion of whole grains and legumes with little or no refinement. The calculated amount of fibre in 65g of the formulated diets (2.33-5.40g) shows that there could be no risk of high intake by infants. FAO/WHO (1998) has recommended 10-15g/day. It is however, important to note that high fibre content or excessive intake may reduce the availability of nutrients such as Ca, Zn especially in food that marginal in these elements. High fibre content is also known to increase viscosity of food. This is particularly worth considering in infant feeding because highly viscous foods would reduce intake.

Energy values in the EFCF agreed with some literature reported values for locally formulated complementary food (Fashakin and Ogunsola, 1982); Temple *et al.,* 1996; Ladeji *et al.,* 2000; Islam *et al.,* 2004). However, none of the estimated daily intake values (364.54-417.32 Kcal) of the formulated diets met the RDA (650 Kcal) set for infants. Low calories as a result of inadequate intake of energy–giving nutrients notably carbohydrates and fats, will deprive the body of needed basal metabolic processes and strength for physical activities. It is believed that frequent consumption of the diets along with breast-milk, would satisfy the daily energy requirements of infants.

The EFCF was observed to have higher values of Fe than the CCCF and CMCF which could be attributed to the fact that soya beans are a good source of iron. The iron in soya beans is non heme iron; it isn't absorbed quite as well as iron from animal source. The CCCF had lower concentrations of Fe, Zn, Ca and Cu with the exception of Mg. EFCF had the highest value of vitamin A. The appreciable amounts of the global focal micronutrients found in EFCF partly informed the selection of the complementary food for further re-evaluation. Vitamins and minerals are very vital for growth and development in infants and children. Fruits and vegetables are therefore recommended to be included in infants' diets to increase micronutrients intake. Due to the importance of these minerals in the skeletal development and growth of infants, (Nduka, 1999; Affi, 2000), it would be necessary to increase intake through fortification and or supplementation. Since complementary foods are intended to complement breast milk, it is believed that continuing breastfeeding along with the consumption of these local formulations, would go a long way in meeting most of the requirement for infants. This practice is highly recommended by WHO/UNICEF (1997) and FMOH (1999).

One of the known procedures for assessing the biological value of protein is the determination of the amino acid profile. All the amino acids present in the CMCF are also present in the EFCF and CCCF. EFCF showed higher values of Leucine, Phenylalanine, Histidine, Proline, Arginine, tyrosine, Glutamic acid, glycine, Serine and Aspartate.Essential amino acids are critical for the maintenance of nitrogen balance as well as other body- building functions. The detection of histidine in the diets was also an added advantage because histidine is considered as essential amino acid in children since it cannot be synthesized in their bodies due to under developed mechanism for that.

All the complementary foods contain both essential and non-essential fatty acids. Essential fatty acids are in important in the formation of healthy cell membranes, proper development and functioning of the brain and nervous system. Soya beans in EFCF and SGSF are a good source of omega 3 fatty acids.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the findings of this study, it was concluded that with proper selection and combination, it is possible to use local food stuffs to formulate nutrient dense complementary foods that can be used as home based complementary diet. The EFCF formulated in this study is strongly recommended for used particularly by the low income bracket to feed their infants and children during complementary feeding period. This will ensure availability and affordability.

6.2 Recommendation

- Fortification and or supplementation of the ESHA formulated Complementary food with nutrients that are marginal should be explored.
- Effects of cooking on the nutrients and shelf- life studies of the ESHA formulated complementary food should be undertaken.
- Studies should be expanded to other local government areas in the state and neighbouring states to establish nutrient dense food stuffs which can be use to formulate complementary foods.
- Comprehensive food composition tables and recommended nutrient intakes for all population groups in Nigeria should be established to facilitate meaningful nutrition studies and dietary recommendations.

6.3 Contribution to Knowledge

- The infant and young child feeding practices of exclusively breast feeding in Kaduna North LGA of Kaduna state was 30% and the major complementary foods given are sorghum pap (67%), sorghum soya beans and groundnut (14%) and commercial formula at 12%.

- The nutrient composition of the common complementary foods are protein (5.8-19.1%), lipids (2.9- 5.5%) and carbohydrates (65.2- 81.6%).

- Using a highly sensitive nutrient analyser software (ESHA), the nutrient composition of complementary foods from locally available foodstuff was established at 25.3% protein, 9.7% lipids, 56.7% carbohydrates and 8.4% fibre.

REFERENCES

Abbey, B. W and Nkanga, U.B. (1988). Production of high quality complementary products from maize. *NutriReport International Journal*, 37(5):951-957.

Abbey, B.W. and Mark – Balm, T. (1988). Complementary foods prepared from composite ungerminated and germinated cowpea. *Nutri Report International journal*, 38 (3): 519-528.

Adeyemi, I. A. (1983). Dry-milling of sorghum for "ogi" manufacture. *Journal of Cereal Science*; 1, 221 – 227.

Adeyeye, A. and Ajewole, K. (1992). Chemical composition and fatty acid profiles of cereals in Nigeria. *Food Chemistry*; 44, 41 – 44.

Administrative Committee on Coordination/Subcommittee on Nutrition.(2010).*Sixth Report on the World Nutrition Situation*, Geneva.

Adu-Afaruwuah S, Lartey A, Brow KH, Zlotkin S, Briard A, Dewey KG (2007). Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: effects on growth and motor development. *Am. J. Cln Nutri*; 86 (2): 412-420.

Agu, V. C. (1976). *Feeding and Weaning practices in Enugu, urban and rural*. University of Nigeria, Nsukka, B. Sc. Thesis, (Unpublished).

Affi, A.T. (2000). *Preventive Nutrition: A practical handbook.* Malthouse Press.

AHRTAG. (1993). Dialogue on diarrhoea. *The International newsletter on the control of diarrhoea*, p. Issue no. 53.

Akingbala JO, Rooney DW and Faubon, JM. (1981). Physical, Chemical and Sensory Ealuation of Ogi from sorhum of differing kernel characteristics. *Journal of Food Sci*ence; 46:1523 -1526.

Akingbala, J.O. and Rooney, D.W. (1990). Effect of flour particle texture and size on the consistency of sorghum 'tuwo'. *Nigerian Food Journal*; 8, 48 – 55.

Akinrele, I. A. (1970). Fermentation studies on maize during the preparation of a traditional African starch-cake food. *Journal of Science Food Agriculture*; 21, 619 – 625

Akinrele, I. A. and Edwards, C. C. A. (1971). An assessment of the nutritional value of maize-soy mixture "Soy-ogi" as a weaning food in Nigeria. *British Journal of Nutrition*; 26, 172 – 185.and some inherent antinutritional constituents. *Die Nahrung*; 33, 1009 – 1016.

Akinyele, I.O and Omotola B.D. (1986). Energy and Protein intake of infants and children from the low income group of Ibadan. *Nutrition Research*; 6: 129-137

Amina, F. T. and Agle, A. N. (2004). Infant and Child Survival in Nigeria. *In proceeding of the 34th Annual Conference and Scientific meeting of the Nutrition Society of Nigeria*, Umudike, Abia State.

Aminu, R. F., Umeh, E. U. and Singh, C. (2010). Enteric bacteria associated with 'balangwu' (ready-to-eat meat product) sold in Anyigba, Kogi State. *Nigerian Food Journal*; 28(2), 171 – 176.

Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS. (2009). Infant feeding practices and nutritional status of children in North Western Nigeria. *Asian J. Clin. Nutr.*, 1(1): 12.

Anigo, K. M., Ameh, D. A., Ibrahim, S. and Danbauchi, S. S. (2010). Nutrient composition of complementary food gruels formulated from malted cereals, soybean and groundnut for use in North-western Nigeria. *African Journal of Food Science*; 4(3), 65 – 72

Anju, S. S (2002). Physicochemical properties and nutritional traits of millet-based weaning foods suitable for infants of the Kumaon hills. *Northern India*; 1440 – 1446.

Anyamele OD (2009). Urban and rural differences across countries in child mortality in Sub-Saharan Africa. *J Health Care Poor Underserved*, 20: 90-98.

AOAC (1990). *Official Methods of Analysis (15th ed).* Washington D.C. Association of Official Analytical Chemist.

AOAC (2000). *Official Methods of Analysis.* Washington D.C. Association of Official Analytical Chemist.

AOAC (2006). *Official Method of Analysis.* Washington; D. C.: W. Horwitz Editor Eighteen Edition, , AOAC.

Armar- Klemesu, M.A. and Wheeler E.F. (1991). Complementary practices and their outcome, A critical look with Reference to Ghana. *Bulletin of Noguchi Memorial Institute for medicinal Research*, (pp. 4: 3-2).

Atinmo, T. A (1986). The cultural significance of food and the nutritional values of Nigerian foods with respect to trace element nutriture.*A seminar paper on Nigerian food culture*,University of Ibadan.

Autumn L. DeLorme, Erika R. Gavenus, Charles R. Salmen, Gor Ouma Benard, Brian Mattah, Elizabeth Bukusi and Kathryn J. Fiorella (2018). Nourishing networks: A social-ecological analysis of a network intervention for improving household nutrition in Western Kenya, *Social Science and Medicine*; 197 :(95), (2018).

Babajide, J. M. (1998). Formulation and Biological Evaluation of Weaning foods from Cassava (Monihot esculenta) and Soybean (Glycine Max*).* University of Abeokuta, Nigeria, M.Sc. Dissertation, (Unpublished).

Badamosi E., and Ibrahim L. A (1995). Nutritional Evaluation of a locally formulated complementary food, JUTH-PAP. *West Afri. J. Biol. Sci* , 3:85-93.

Banigo E.I, De-Man J. M, and Duitschaever C. L. (1974). Utilization of high-lysine corn for the manufacture of ogi using a new, improved processing system. *Cereal Chemistry*; 51, 559 – 572.

Beard JL . (2008). Why iron deficiency is important in infant development. . *J. Nutr,* 138(12):2534.

Benitez, L. V (1989). Amino Acid and fatty acid profiles in aquaculture nutrition studies,. *Proceedings of theThird Asian Fish Nutrition Network Meeting.Asian fish. Society Special Publication* (pp. p.23- 35.). Manilla, Phillipines: S.S. DeSilva (ed.) Fish Nutrition Research in Asia.

Bentley M.E., Dickin K.L., Mebrahtu S., Kayode B., Oni G.A.,Verzosa C.C., Brown K.H., Idowu J.R (1991). Development of a nutritionallyadequate and culturally appropriate weaning foodin Kwara State, Nigeria: an interdisciplinary approach. *Soc. Sci. Med.*;33: 1103–1112.

Bhandari N., Bahl R., Taneja S., Strand T., Molbak K., Ulvik R.J., Sommerfelt H., Bhan M.K (2002). Substantial reduction in severe diarrheamorbidity by daily zinc supplementation in young North Indian Children. *Pediatrics J*; 109(6): e86, doi: 10.1542/peds.109.6.e86

Brandtzaeg P, Scott H, Solheim BG, Thorsby E. (1981). Relation between HLA-DR like antigens and secretory component in Jejunal epithelium of patients with coeliac disease on dermatitis herpertiformis. *Clinical experimental immunology*; 44(2): 233

Bressani, R. and Elias, L. G. (1983). Guideline for the development of processed and packaged weaning food. *Food Nutrition Bulletin*; 5(3), 57 – 64.

Brown, K. H., Dewey, K. G. and Allen, L. H. (1998). *Complementary feeding of young children in developing countries:* A review of current scientific knowledge. World Health Organization, Geneva. Available at: http://www.who.int/child adolescenthealth/Newpublicatons/NUTRITON/WHO/NUT98.1.PDF.ACCESSED Sept ember 10, 2002.

Calloway, D. (1995). Human Nutrition: Food and micronutrient Relationships Working paper on Agricultural Strategies for micronutrients.Washington DC: *International food policy. Res. Inst;* Pp. 23

Cameron, N. and Hofvander, J. (1983). *Manual on Feeding Infants and Children.* 3rd Ed. London. Oxford Medical Publication.

Campen, V.R.D (1996). Role of food and meal composition in determining bioavailabilities of micronutrients.*In: Food-Based Approaches to preventing micronutrient Malnutrition workshop*. Salt Lake city, USA.

Carr, F.H. and Price, E.A. (1926). Photometric assay of Vitamin A. *Biochem. J.*, 20:497.

Courage ML, McCloy UR, Herzberg GR (1998). Visual acuity development and fatty acid composition of erythrocytes in full-term infants fed breast milk, commercial formula, or evaporated milk. *J Dev Behav Pediatr*; 19:9–17.

Daelmans B., Saadeh R. (2003). Global initiatives to improve complementary feeding.*In: SCN Newsletter: Meeting the challenge to improve complementary feeding. United Nations System Standing Committee on Nutrition (ed. A.D. Moreira).* Lavenhem Press, UK.

Delvin, M. (1997). *Textbook of Biochemistry with Clinical Correlations,4th ed.* Pp. 540-548. New York/ Chichester/Toronto: Wiley- Liss Inc.

Dewey KG and Brown KH . (2003). Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and Nutrition Bulletin 24,* pp 5- 28.

Dewey, K. G. and Brown, K. H. (2002). Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food Nutrition Bulletin*; 24(1), 5–28.

Domellof M., Lonnerdal B., Abrams S.A., Hernell O (2002). Iron absorptionin breast-fed infants: effects of age, iron status, ironsupplements, and complementary foods. Am. *J. Clin. Nutr*; 76: 198–204

Dhingra, S. and Jood, S. (2001). Organoleptic and nutritional evaluation of wheat breads supplemented with soybean and barley flour. *Food Chemistry*; 77: 479 – 488.

Eka, O.U and Edijala, J.K. (1972). Chemical composition of some traditionally prepared Nigerian foods. *Nig. J. Sci*; 6:157-62.

Edmond K.M., Zandoh C., Quigley M.A., Amenga-Etego S., Owusu-Agyei S., Kirkwood B.R (2006). Delayed breastfeeding initiationincreases risk of neonatal mortality. *Paediatrics J*; 117: E380–E386.

Esders, T.W. and Michrina, C.A (1979). Triglyceride assay. J. *Biol. Chem*. 254:2710

Elegbede, J. A. (1998). Legumes. In: Nutritional quality of plant foods. Eds. Osagie, A. U. and Eka, O. U. Benin City. Ambik Press. 53 – 83pp.

Ezeocha, V. C. and Onwuka, G. I. (2010). Effect of processing methods on the physic-chemical and nutritional quality of maize and soybean based complementary blends. *Nigerian Food Journal*; 28(2), 210 – 216.

FAO. (1970). Amino Acid content of foods and Biological Data on Proteins. Rome.*FAO Nutritional studies*; 24.

FAO. (1994). Fats and oils in human nutritio*n.* Rome: FAO.*Food and nutrition paper* .

FAO. (1997). *Preventing Micronutrient malnutrition: A guide to food-based approaches. A manual for policy makers and programme planners.* Washington DC. Food and Agricultural Organization of the United Nations and International Life Science Institute.

FAO/WHO. (1991). Expert Consultation: Protein quality evaluation, FAO/WHO Nutrition Meetings, Report series 51, Food and Agricultural Organization / World Health Organization, Rome.

FAO/WHO. (2002). Human vitamins and mineral requirements. Report of a joint FAO/WHO expert consultation on zinc. FAO Food and Nutrition paper 56, FAO/WHO, Rome, Italy.

FAO. (2010). *Fats and Fatty Acids in Human Nutrition. Rome: FAO Food and nutrition paper # 91.* Geneva, : Report of an expert consultation. .

FAO/WHO. (1998). Preparation and use of Food-Based Dietary Guidelines. *A report of a Joint FAO/WHO Consultation.* Geneva. WHO Technical Report Series 880.

Fashakin, J.B. and Ogunshola,F. (1982). The Utilization of local Foods in Fermentation of complementary foods. *Trop. Paed. J,* 28:93-6.

Fashakin, J.B. Awoyefa M.B., Furst p. (1986). Z. Ernahrungsroissenschaft. *The Application of protein concentrate from locally available legumes in the development of complementary foods.*, 220-227 .

Fernandez, D.P; Vanderjagt, D.J; Williams, M; Huang, Y.S; Chuang, L; Millson, M; Andrews, R; Pastuszyn, A. and Glew, R.H. (2002). Fatty acid, amino acid and trace mineral analyses of five complementary foods from Jos, Nigeria. *Plant Foods for Human Nutrition.*, 57:257-274.

FMOH, F. M. (1999). *Food-based Dietary Guidelines for Nigeria.* Abuja.: Nutrition Division,.

Gabriele A, Schettino F: (2008). Child malnutrition and mortality in developing countries: Evidence from a cross-country analysis. *Analyses of Social Issues and Public Policy*, 8 (1): 53-81. 10.

Gibbs M, Barley KB, Lander RD, Fahmida U, Perlas L, Hess ST, Loechl CU, Winichagoon P and Gibson RS (2011). The adequacy of micronutrient concentrations in manufactured complementary foods from low income countries. *J Food Compos Anal*; 24:418-426.

Gibney, M. (1995). Consumption of sugars. Workshop on the Evaluation of the Nutritional and Health Aspects of Sugar. *Am J. Clin Nutr,* 62: (suppl.) 1985-1945.

Gibson, R. S. (2000). The Adequacy of Micronutrients in Complementary Foods. *Pediatrics J*; 106(5), 1298 – 1299.

Gibson RS, Barley KB, Gibbs M and Ferguson EC. (2010). A review of phytate, iron, zinc and calcium concentrations in plant based complementary foods used in low income countries and implications for bioavailability. *Food and nutrition Bulletin,* 31, S134- S.

Grantham- McGregor S, Cheung TB, Gueto S, Glewwe P, Richter L, Strupp B (2007). Child development in developing countries – Developmental potential in the first 5 years for children in developing countries. *Lancet*; 69 (9555) 60-70

Greiner R, Konietzny U, Janyk- D (2006). Phytate- An undesirable constituent of plant based foods.*Journal fur Ernahrungsmedizin;* 8(3): 18-28

Guptill K.S., Esrey S.A., Oni G.A., Brown K.H., Evaluationof a face-to-face weaning food intervention in Kwara State, Nigeria:Knowledge, trial, and adoption of a home-prepared weaningfood (1993). *Soc. Sci. Med*; 36: 665–672.

Gurney, M, Jelliffe, D.B. and Harland, E. (1985). *Protein- Energy malnutrition In: D.B Jelliffe (ed). Child Health in the Tropics 5th edn.* London: English language Book society/ Edward Arnold publishers.

Guthrie, A. (1989)). Introductory Nutrition. (7th edn). Times Mirror/Mosby College Publishing, Pp. 485-576.

Harrison, G.G, G.F. Jr. Combs; R.M. Welch; J.M. Duxbury, N.T. Uphoff, M.C. Nesheim . (1996). Potential for changing food consumption patterns. In: (eds). Food- Base Approches to preventing micronutrient Malnutrition. *An international Research Agenda.* . Cornell .

Hussein A.K., Breastfeeding and complementary feeding practicesin Tanzania (2005). *East Afr. J. Public Health*; 2: 27–31.

Hoppe, C., Molgaard, A., Schack-Nielsen. L., Barkholt, V. and Michaelsen, K. F. (2003). Animal protein intake, s-IFG-1 and growth in healthy 2½ year old children. *FASEB Journal*; 17(4), A729.

ICN (1992). Caring for the socio-financially Deprived and Nutritionally Vulnerable. . *International Conference on Nutrition. Theme paper No. 3 FAO/WHO,* Rome.

Idowu, M. A., Adeyemi, I. A., and David, M. (1993). Sensory evaluation and nutrient composition of weaning food from pre-gelatinized maize-potato mixture. *Plant Foods for Human Nutrition*; 44, 149 – 155

Igyor, M. A., Yusufu, P. A. and Sengev, I. A. (2010). Evaluation of physicochemical, functional and sensory properties of fermented fura powder supplemented with soy. *Nigerian Food Journal*; 28(2), 454 – 462.

Ihekoronye, A. I. and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the tropics. London. Macmillan Press Ltd.

IITA. (2004). *Summary proceedings of the stakeholder meeting for the project on micronutrient enrinchment of maize and plantain: A sustainable approach to mitigate hidden hunger.* International Institute of Tropical Agriculture.

Ijarotimi O.S and Olopade A.J (2009). Determination of amino acid contentand protein quality of complementary food produced fromlocally available food materials in Ondo State, Nigeria. *Malaysian J. Nutr*; 15, 93–101.

Institute of Medicine (IOM) (2006). *Dietary reference intakes: the essential guide to nutrient requirements.* Washington D.C.: National Academics Press,.

Institute of Medicine IOM (2005). Panel on Macronutrients, Panel on the Definition of Dietary Fiber.Subcommittee on Upper Reference Levels of Nutrient, . *Subcommittee on Interpretation and Uses of Dietary Reference Intakes, and the Standing Committee on the scientific evaluation of dietary reference intakes*. Washington, DC: The national academic press. 880, Geneva.

Ikegwu, O. J. 2010). Effect of processing on the physicochemical and pasting properties of *Brachystegia eurycoma* flour. *Nigerian Food Journal*; 28 (2), 193 – 202.

Ikujendola, V. A. and Fashakin, J. B. (2005). The physicochemical properties of a complementary diet prepared from vegetable proteins. *Journal of Food Agriculture. Environment*; 3 (3 and 4), 23 – 26.

Islam, M.M; Peerson, M.J; Ahmed, T; Dewey, G.K and Brown, H.K. . (2004). Effect of Energy Density of Complementary Foods on total Energy intakes. *Centre for Health and Population Research Publication Dhaka, Bangladesh*.

JK, K. (2003). The chemical composition and nutritional adequacy of complementary foods in developing countries: a case for Uganda. Abstract accepted for Food, Nutrition and Health. *Food Africa, Cameroon*.

Jones, G., Steketee, R.W., Black, R.E., Bhutta, Z.A., Morris, S.S., (2003). How many child Deaths can we prevent this year.*Lancet*, 362 (9377), 65-71.

Jonsyn, F. (October, 1985). Fungi associated with selected fermented foodstuffs in Sierra Leone; *In: IFS/UNU Workshop book of proceeding*. Development of indigenous fermented food and food technology in Africa. Duala.

Juke, M., Mcguire Method, F., and Sternberg, R. (2002). Nutrition Education in Nutrition: A Foundation for Development. Geneva.

Kalanda B.F., Verhoeff F.H., Brabin B.J (2006). Breast and complementaryfeeding practices in relation to morbidity and growth in Malawianinfants. *Eur. J. Clin. Nutr*; 60, 401–407.

Karen L Schumacher, Barbara J Stewart, Patricia G Archbold Marylin J Dodd (2000). Research in nursing and health . 23 (3), 191-2-3.

Keku, K.O. (2006). Production, Chemical Composition and Storage Stability of “Ampla”. A Breakfast Meal Form Mixture of Roasted Maize and Soybean. University of Abeokuta, Nigeira, *M.Sc. Dissertation*, Unpublished.

Kelly, M. G. (1992). *Introduction to Statistics and Experimental Design for the Life Sciences.* Enugu: ABC Publishers.

Kennedy, E., Mannar, V. and Iyengar, V. (2003). Alleviating Hidden Hunger: Approaches that work. *AEA Bulletin No. 45.*

Kikafunda J.K., Abenakyo L., Lukwago F.B. (2006). Nutritional and sensory properties of high energy/nutrient dense composite flour porridges from germinated maize and roasted beans for child-weaning in developing countries: a case for Uganda. *Ecol. Food Nutr., 2*, 45, 279-294.

Kumar V, Sinha AK, Makkar HPS, Becker K (2010). Dietary role of phytate and phytase in human nutrition.*A review. Food chem*, 120:945-959.

Ladeji, O; Temple, V.J and Solomon, M. . (2000). Chemical evaluation of the nutritional potential of two locally formulated Complementary foods. *West Afr. J. Biol. Sci:*, 25-32.

La Roche, F. (1990). Vitamins and Carotenoids in Pasta. Basel Switzerland.

Lartey A, Manu A, Brown KH, Peerson Jm, Dewey KG . (1996). Vitamin A status of Ghanian breastfed infants 6- 12 months fed improved complementary foods. *FASER J*, 12(5): A648.

Latham, M. and Preble, E. (2000). Appropriate Feeding Methods for infants of HIV- infected mothers in sub- Saharan Africa. . *British Medical Journal*.

Layman, D. K. (2003). The role of leucine in weight loss diets and glucose homeostasis. *Journal of Nutrition*; 13, 261S – 267S

Lorri, W. (1996). Potential for developing new Home- Based Food processing and preparation techniques to improve micronutrients nutrition In: G.F. Jr Food- Based Approaches to preventing micronutrient malnutrition. *An International Research Agenda. Cornell University, Ithaca NY*.

Lutter, C. (2003). Meeting the challenge to improve complementary feeding. In: Moreira (ed). Meeting the challenge to improve complementary feeding. *SCN News. UN Systems Standing Committee on Nutrition*, pp. 4-10. UK: Lavenhem Press.

Lutter, K.C. and Rivera, A.J (2003). Nutritional Status of infant and young children and characteristic of their diets. *J. Nutr;*133:2941S-2949S.

Lutter, C. K. and Dewey, K. G. (2007). Proposed nutrient composition for fortified complementary foods. *American Journal of Clinical Nutrition*; 86(2), 412 – 420.

Martin, H., Laswai, H. and Kulwa, K. (2010). Nutrient content and acceptability of soybean based complementary food. *African Journal of Food, Agriculture, Nutrition and Development*; 10(1), 1684 – 5358.

Marcos, S. R; Siad, A.K; Gabriel, G.N and Hady, N.E (1983). Supplementary and Complementary Foods for the Egyptian Child. In: A.F Walker (ed) The contribution of complementary foods to Protein-energy malnutrion.*Nutr. Res. Review*; 3(37): 199.

Mertz, W. (1980). The Essential Trace Elements. *Science J;* 213: 1332

Michaelsen KF, Larnkjaer A, Molgaard C (2012). Amount and quality of dietary proteins during the first two years of life in relation to NCD risk in adulthood . *Nutr Metab Cardiovasc Dis*, 2:781–6.

Moreira (eds) Meeting the challenge to improve complementary feeding. *SCN News United Nations System Standing Committee on Nutrition*, Lavenhem Press, UK. pp. 10-17.

Muhimbula H.S., I.A. (2011). Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa, Tanzania. *Afri. J. Food Sci.*, 5, 26–31.

Naismith, D. (1973). Kwashiorkor in Western Nigeria: a Study of Traditional complementary foods with particular respect toenergy andlinoleoc acid. *Br. j Nutri*, 80:567-76.

National Advisory Committee on micronutrient Deficiency (NACMD) (2003). Papers Distributed/ presented at the meeting of the NACMD. 27- 28 March, 2003 Abuja

NBS [Tanzania] and ORC Macro (2005). Tanzania Demographic and Health Survey (TDHS) 2004–05. Dares Salaam, Tanzania: National Bureau of Statistics and ORC Macro.

Nduka, N. (1999). Clinical Biochemistry for students of Pathology. Longman Nigeria PLC; pp 57-73.

Ngwu, E.K. (2005). Innovative Infant Feeding Practices and Nutrition. *Journal of Home Economics Research*; 6(2), 25 – 32.

Nigeria Demographic and Health Survey (2013), Fifth Round. NGA_2013_DHS_v01_M

Nigeria Nutrition Network (2000). Communiqués and Papers presented/distributed at the 1st Annual Nigeria Nutrition Network (NNN) meeting. 12-13 Dec. 2002, Abeokuta.

National Population Commission, 2008a, 2007 Nigeria demographic and health survey, MD USA, NPC and ORC Macro Calverton, p.163-174

National Population Commission (NPC) and ICF Macro (2008) Nigeria Demographic and Health Survey, Calverton, Maryland, USA: NPC and ICF Macro

NPAN (2002). National Plan of Action on Food and Nutrition (NPAN) in Nigeria National Planning Commission, Abuja

Nnam, N.M (2002). Evaluation of complementary foods based on maize, groundnut, pawpaw and mango flour blends. *Nig J. Nutri. Sci*;23 (1and2) 8-18.

Nout M.J.R., Processed weaning foods for tropical climates (1993). *Int. J. Food Sci.Nutri*; 43, 213–221.

Odunfa S.A and Adeyele S. (1985). Microbiological changes during the traditional production of ogi-baba, a West African fermented sorghum gruel. *Journal of Cereal Science;*3(2), 173-180

Oginni, L.M, Worsfirld, M; Oyelami, O.A.; Sharp, C.A; Powell, D.E and Davie M.W.J. (1996) Etiology of Rickets in Nigerian Children. *J. Pediatr.* 128: 692- 694

Okoh, P. N., Nwasike, C. C. and Ikediobi, C. D. (1985). Studies on seed proteins of millet. In: Amino acid composition of protein fractions of early and late maturing varieties. *Journal of Agriculture Food Chemistry*; 33, 55 – 57.

Okoh, P.N. (1998) Cereal grains. In: A.U. Osagie and O.U Eka (eds). Nutritional Quality of plant foods. Post-harvest Research unit. Unversity of Benin, Benin City. PP 32-52.

Okonofua, E. (2002.) Calcium and Vitamin D nutrition in Nigerian women and Children. A paper presented at the Workshop on Nutritional Rickets in Nigerian Children: The Way Forward. 13-15 March 2002, Abuja.

Okoye Z.S.C (1992). Biochemical Aspects of Nutrition. Prentice-Hall of India, New Delhi PP 147-195

Okoye (2003) Iodine Deficiency Disorders. Paper Distributed/presented at the meeting ofthe National Advisory Committee on Micronutrient Deficiencies. 27-28 March, 2003 Abuja.

Okungbowa, P. (1986). Nigerian complementary diets for use by community health workers and mothers. *Federal Nutrition Division. FMOH*, Lagos.

Oliveira, M. B., Rui Alves, M., and Ferreira M. A. (2000.) Multivariate analysis of fatty acid cis and trans isomers in margarines determined by HRGC/FID/capillary column. *J. Chemom*; 15:71–84.

Olusanya, J. O. (1998). Nutrient evaluation of some home prepared multimixes for use as weaning food in Nigeria. University of Ibadan, Ibadan, Nigeria, *Ph.D. Thesis.* Unpublished.

Omueti, O., Oguntona, E. B., Jaiyeola, O. and Ashaye, O. A. (2000). Nutritional evaluation of home-prepared soy-corn milk – A Protein Beverage. *Nutrition and Food Science;* 30(3), 128 – 132.

Onabanjo, O. O. (2007). Formulation and Biological Evaluation of Weaning Foods from Cassava (*Manihot esculenta*), soybean (Glycine max), groundnut (*Arachis hypogaea*), Cassava leaves, and Carot (*Daucus carota*). University of Abeokuta, Nigeria, *Ph.D. Dissertation*, Unpublished.

Onabanjo, O. O., Oguntona, C. R. B., Maziya-Dixon, B., Olayiwola, I. O., Oguntona, E. B. and Dixon, A. G. O. (2008). Nutritional Evaluation of four Optimized Cassava-Based Complementary Foods. *Africa Journal of Food Science*; 2, 136 – 142.

Onofiok, N. O. and Nnanyelugo, D. K. (2007). Weaning Foods in West Africa: Nutritonal Problems and Possible Solutions. www.unu.edu/unupress/food/v191e/begin.htm. Accessed end June 2009.

Onofiok, N.O and Nnanyelugo, D.O (1998).Complementary foods in West African. *Food and Nutrition Bulletin*. The UN University.

Onyango A.W. (2003). Dietary diversity, child nutrition and health in contemporary African communities. *Rev. Comp. Biochem. Physiol*; 136, 61–69.

Onuorah, C. E. and Akinjide, F. A. (2004). Comparative evaluation of four formulated weaning foods and a commercial product. *Nigerian Food Journal*; 22, 48 – 53

Osagie, A.U and Eka, O.U. (1998) Nutritional quality of Plant Foods. Post-Harvest Research Unit. University of Benin, Benin City Nigeria.

Oshaug, A. and Haddad, L. (2002). Nutrition and Agriculture in Nutrition: A foundation for development, Geneva.

Omoruyi, F, Osagie, U.A and Adamson, I, (1994). Blood Proteins and Tissue enzymes in malnourished rats rehabilitated with corn-crayfish-protein diet. *Bioscience Research Communications*, 6:1-8. 157

Owolabi, A.O; Mac-Inegite, J.O; Olowoniyan, F.O. and Chindo, H.O (1996). A Comparative Study of the Nutritional Status of Children in Villages in Northern Nigeria using and not using Soya beans. *Food Nutr. Bull*, 17:42-48.

Oyeleke, A.O (1984). Outlines of food analysis. Department of Biochemistry. Ahamadu Bello University, Zaria.

Oyeleke, A.O Morton I.D and Pender, A.E (1985). The use of cowpea (Vigna unguiculata) in improving a popular Nigeria complementary food. *Brit. J Nutr*; 54:343.

Penny M., Kriss-Etherton, Jessica, Greiger Terry A, Etherton D. (2009). Dietary reference intakes for DHA and EPA

Picciano, M.F. (1987). Nutrients needs of infants. *Nutrition Today;* 22:8- 10

Reeds, P. J. and Garlick, P. J. (2003). Protein and amino acid requirements and the composition of complementary foods. *Journal of Nutrition*; 133, 2953S – 2961S.

Roe, J.H and Kuether, C.A (1943). Photometric assay of Vitamin C. *J. Biol. Chem*;147:399.

Ruel, M.T. (2003). Milk intake is associated with better growth in Latin America: Evidence from the demographic and health survey. FASEB Journal; 17(4): A1199 (abs).

Sandberg A-S, Andersoson H, Carlsson N-G, Sandston B. (1987). Degradation products of bran phytate formed during digestion in the human small intestine: Effect of extrusion cooking on digestibility. *J Nutr;* 117:2061-2065.

Sandoval-Priego AA, Reyes-Morals H, Perez-Cuevas, D, Abrego-Blass R, Orrico-Torres ES (2003). Family strategies of life associated with malnutrition in children less than 2 years of age. *Salud publica de Mexico;* 44(1): 1-9

Sanni, A. I., Onilude, A. A. and Ibidapo, O. T. (1999). Biochemical composition of infant weaning food fabricated from blends cereals and soybean. *Food Chemistry*; 65, 35 – 39.

Sanni, L. O., Ikuomola, D. P. and Sanni, S. A. (2001). Effect of length of fermentation and varieties on the qualities sweet potato gari. Proceeding 8th triennial symposium of the international Society for tropical root Crops Africa Branch (ISTRC-AB). Ed M. O. Akoroda, IITA, Ibadan, Nigeria, November 12 – 16. 208 -211pp

Sanni, L. O., Kosoko, S. B., Adebowale, A. A. and Adeoye, R. J. (2004. The influence of palm oil and chemical modification on the pasting and sensory properties of fufu flour. *International Journal of Food Properties*; 7(2), 229 – 237.

Saskia de Pee, Martin W. Bloem (2009). Current and Potential Role of Specially Formulated Foods and Food Supplements for Preventing Malnutrition among 6- to 23-Month-Old Children and for Treating Moderate Malnutrition among 6- to 59-Month-Old Children.

SCN (1995). Behavioural changes and nutrition Programmes. *Standing Committee on Nutrition (SCN) News # 13*. Geneva.

SCN (2004). Nutrition for Improved Development Outcomes. *5th Report on the World Nutrition Situation Standing Committee on Nutrition (SCN)*. Geneva

Shordt, K., Cairncross, S (2004). Sustainability of hygiene behaviour and the effectiveness of change interventions, London School of Hygiene and Tropical Medicine Research Online. Pg 34-48. Available fromwww.researchonline.lshm.ac.uk. (Accessed 1st March 2013).

Sparkman, D.H, Stein, E.H and Moore, S (1958). Automatic recording apparatus for use in the chromatography of amino acids Analytical Chemistry, 30:1190-1991.

Stenberg, D. (1991). Antioxidants and atherosclerosis: A current assessment

Stroebecker, R. and Henning M.H (1965). Vitamin Assay-Tested Methods. Verlag Chemic GMBH Welnheim/ Bergstr.

Stevens, G.A., James E.B., Quentin, H., Yuan Lu Luz (2015). Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countyries between 1991 and 2013: a pooled analysis of population based survey. *The lancet global health* 3(9), 2015

Solomon, N.W. (2000) plant-based diets are traditional in developing countries. 21st century challenges for better nutrition and health. Asia Pac. *J Clin. Nutri*; (Suppl) 541-5-54

Thacher, T.D; Fischer, P.R Pettifor, J.M; Lawson, J.O; Isichei, C.O and Chan G.M. (2000). Case Control Study of factors Associated with Nutritional Rickets in Nigerian Children. *J Pediatr* 137:367-373

Temple, V.J; Badamosi, E.J; Ladeji, O and Solomon, M. (1996) Proximate chemical composition of three locally formulated complementary foods. West Afr. J. Biol Sci. 5:134-143.

Uauy, R. and Castillo, C. (2003). Lipid requirements of infants: implications for nutrient composition of fortified complementary foods. *Journal of Nutrition*; 133, 2962S – 2972S.

UNAIDS/WHO/UNICEF (1997) HIV and infant feeding: A policy statement developed collaboratively by UNAIDS WHO and UNICEF. UNAIDS: Geneva.

UNAIDS/WHO/UNICEF (2010) HIV and infant feeding: A policy statement developed collaboratively by UNAIDS WHO and UNICEF. UNAIDS: Geneva.

UNICEF (1997). The care initiative: Assessment Analysis and Action to improve care for Nutrition. New York: UNICEF

UNICEF (1999) Preventing Iron Deficiency in women and children. Technical consensus on key issues. Technical workshop, October 7-9, 1998. Boston and Ohawa. *International Nutrition and MI.*

UNICEF (2010) Guidelines on HIV and infant feeding 2010: Principles and Recommendations for infant Feeding in the context of HIV and a summary of Evidence.

Uphoff, N T. (1993) Monitoring and evaluating population participation in World Bank – assisted project. In B. Bhatangar and A. Williams (eds) Participatory Development and the World Bank: Potential directions for change. World Bank Disc. Paper No 183. World Bank, Washington DC.

Uwaegbute, A.C., Nnanyelugo, D.O. (1989). Towards improving the nutritional value of traditional weaning foods. *Proccedings of the workshop on present knowledge on weaning foods in Nigeria.* Lagos.

Walker A.F (1990). The contribution of *Complementary* foods to Protein energy Malnutrition. *Nutr. Res. Rev* 3:25-47.

Walker A.F and Pavitt F (2007). Energy density of third world weaning foods. *Nutr Bull*; 14(2):88-101.

Walraven MR, Femmie J, Rene AC. (1997). Early intervention in adoptive families supporting maternal sensitive responsiveness, infant-mother attachment and infant competence. *Journal of child psychology and psychiatry*; 38(8): 1039-1050.

WHO/OMS (2000). Child and Adolescent Health and Development:Nutrition and Infant Feeding. Pan American Health Organization/WHO. Guiding principles for complementary feedingof the breastfed child.

World Health Organization (2000). WHO Collaborative study team on the role of breastfeeding on the prevention of infant mortality effect of breastfeeding on infant and child mortality due to infectious diseases in less developed countries: A pooled analysis. *Lancet*, 355 (9202): 451-455.

World Health Organization (1991). Infant and young child nutrition: *Global strategy for infant and young child feeding*, Geneva.

World Health Organization (2010). Data Bank on Infant and Young Child Feeding on Nigeria.

WHO/FAO/UNU (2007). Protein and amino acid requirements in human nutrition. Geneva, Switzerland.

WHO (1981). International Code of Marketing of Breastmilk Substitutes,*World Health Organization.* Geneva.

WHO (1997). Global Database on Child Growth and Malnutrition Geneva: WHO

WHO/ UNICEF (1998). Complementary Feeding of Young Children in Developing Countries: *A Review of Current Scientific Knowledge*. WHO/NUT/98.1. World Health Organization. Geneva.

WHO (2000). Working group on the growth reference protocol and WHO task force on methods for the natural regulation of fertility growth patterns of breastfed infants in seven countries. *Acta Paediatric;* 89:215-222.

WHO (2003). Guiding principles for complementary feeding of the breastfed child. (WH/A56/INFO.DOC.) Geneva, Switzerland.

World Health Organization (2001). Infant and young child nutrition: Global strategy for infant and young child feeding.

WHO (2002) Working group on the growth reference protocol and WHO task force on methods for the natural regulation of fertility growth patterns of breastfed infants in seven countries. Acta Paediatric 89:215-222

World Health Organization(2002). Complementary feeding: report of the global consultation. Summary of guiding principles for complementary feeding of the breastfed child. WHO, Geneva.

Yeung, D.L (1998). Iron and Micronutrient: Complementary food fortification. *Foodand Nutrition Bulletin;*9(2): 159-163

Zere, E., McIntyre, D., 2003, Inequities in under five child malnutrition in South Africa, International Journal for Equity in Health, 2003, 11(2), 7

APPENDIX 1

MINISTRY OF HEALTH AND HUMAN SERVICES
KADUNA STATE, NIGERIA

MOH/ADM/744/VOL.1/351 — 17th NOV, 2015

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NOTICE OF APPROVAL AFTER FULL COMMITTEE REVIEW

NUTRITIONAL COMPOSITION OF COMMONLY USED AND ESHA FORMULATED COMPLEMENTARY FOODS FROM AVAILABLE FOODSTUFFS IN KADUNA

Name of Principal Investigator:	MOHAMMED AISHA KABIR
Address of Principal Investigator:	Dept. Of Biochemistry Faculty of Science, A.B.U, Zaria.
Date of receipt of Application	19th Oct, 2015
Date of Ethical Approval	13th November, 2015

This is to inform you that the Research described in the submitted Protocol, the Consent forms, advertisements and other participant information materials have been reviewed and given full approval by the Health Research Ethics Committee (HREC).

If there is delay in starting the research or any change, inform the HREC so that the dates of approval can be adjusted accordingly.

However, Researcher is kindly requested to submit a copy of his/her findings to the State Ministry of Health, please.

DR. BUTAWA NUHU N.
SECRETARY
FOR: CHAIRMAN

KADUNA STATE ... HEALTH
OPEN REGISTRY
DESPATCHED
SIGN ... DATE 16/12/15

APPENDIX 2

QUESTIONNAIRE

Background Information

WARD-- Community-----------------

Household #-----------------------

Interview date: -----------------/------------------/----------------------- (dd/mm/yyyy)

SURVEY OF THE COMMONLY USED COMPLEMENTARY FOODS IN KADUNA NORTH LGA

PARENTS OF CHILDREN AGED 6TO 23 MONTHS

Introduction and Consent

Informed Consent

Hello. My name is -- and I am from ABU Zaria. I am conducting a survey t understand the commonly used complementary foods and the methods of preparation at the community level inorder t improve the health of children 6 to 23 months old and also reduce the rate of malnutrition in the community. This study ha been granted approval by the school and the state ministry of health.

Whatever information you provided was kept strictly confidential and will not be shown to other persons. Participation i this survey is voluntary and you can choose not to answer any individual question or all of the questions. However, w hope that you will participate fully in this survey since your views are important.

At this time, do you want to ask any question about the survey?

May I begin the interview now?

Signature of interviewer-- Date----------------------------------

Respondent agrees to be interviewed-------------1- Continue

Respondent does not agree to be interviewed---2- End

SECTION 1: CHILD INFORMATION

1. Name of Child---
2. Sex of child---
3. Child's birth date:-----------------/---------------------/----------------------- (dd/mm/yyyy)

SECTION 2: RESPONDENT INFORMATION/ SOCIOECONOMIC STATUS

4. Have you ever attended school?

   Yes---1

   No---2 **GO TO Q8**

5. What is the highest level of school you attended?

   Primary--1

   Secondary--2

   Higher---3

6. What is the highest (class/form/year) you completed at that level

   Class/form/year---_____________

7. What is your employment status?

   Full time---1

   Part time---2

   Other (**Specify** :___________________________) ---------------------------------88

8. How many other people live in the same house with you?

   None---1

   One--2

   Two---3

Other (**Specify** :_________________________) -------------------------------88

9. How many people in this house earn an income

    All---1

    None---2

Other (**Specify** :_________________________) ------------------------------88

10. What is the main source of your financial support? _________________________________

11. What is your Household monthly income? _________________________________

12. Do you have outstanding debts? If so how much? ____

SECTION 3: INFANT AND YOUNG CHILD FEEDING PRACTICE

13. Did you ever breastfed (NAME)?

    Yes---1

    No--2 **GO TO Q15**

14. How long after birth did you first put ***<u>(NAME)</u>*** to the breast?

    If respondent reports she put the infant to the breast immediately after birth, circle '000' For 'Immediately'. If less than 1 hour, circle '1' for hours ANDRECORD'00' hours.

    If less than 24 hours, circle '1' and record number of completed hours, from 01 to 23. Otherwise, circle '2' and record number of completed days.

IMMEDIATELY---000

HOURS---1 |___|___|

DAYS-- 2 |___|___|

15. Was ***(NAME)*** breastfed yesterday during the day or at night?

Yes---1

No--2

16. Which of the following did you give to your child that is less than 6 months?

Water Yes No

Infant Formula Yes No If y pecify name----

Milk Yes No If s, Specify fresh, tinned, pasteurized, commercial.

17. When do you usually introduce water to your children?

From birth--1

From 6 months---2

Any other time (Specify)---

18. When do you usually introduce other foods, apart from breastmilk to your children?

< 3 months--1

Between 3 and 6 months---2

From 6 months---3

Others Specify--

19. Please I would like to know all the ingredients and how this food is prepared.

Food	Ingredients	Preparation methods

THANK YOU!!!

…………………………………………..

APPENDIX 3

DIETARY REFERENCE INTAKE OF INFANTS

Nutrient	0-6 Months	7-12 Months	1-3 Years
Energy (calories)	520-570	676-743	992-1046
Protein (grams)	9.1	13.5	13
Vitamin A (mcg RE)	400	500	300
Vitamin D (mcg)	10	10	15
Vitamin E (mg alpha-TE)	4	5	6
Vitamin K (mcg)	2	2.5	30
Thiamin (mg)	.2	.3	.5
Riboflavin (mg)	.3	.4	.5
Niacin (mg NE)	2	4	6
Pantothenic Acid	1.7	1.8	2
Vitamin B6 (mg)	.1	.3	.5
Folate (mcg)	65	80	150
Vitamin B12 (mcg)	.4	.5	.9
Choline (mg)	125	150	200
Biotin (mcg)	5	6	8
Vitamin C (mg)	40	50	15
Calcium (mg)	200	260	700
Phosphorus (mg)	100	275	460
Magnesium (mg)	30	75	80
Iron (mg)	.27	11	7
Zinc (mg)	2	3	3

Iodine (mcg)	110	130	90
Selenium (mcg)	15	20	20
Calcium (mg)	200	260	700
Phosphorus (mg)	100	275	460
Magnesium (mg)	30	75	80
Iron (mg)	.27	11	7
Zinc (mg)	2	3	3
Iodine (mcg)	110	130	90
Selenium (mcg)	15	20	20
Copper (mcg)	200	220	340
Manganese (mg)	.003	.6	1.2
Chromium (mcg)	0.2	5.5	11
Potassium (mg)	400	700	3,000
Sodium (mg)	120	370	1,000

Source: Dietary Reference Intakes (DRIs): Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs), Food and Nutrition Board, Institute of Medicine, National Academy of Sciences (NAS), 1998 - 2010.

APPENDIX 4

ESHA NUTRIENT ANALYSER INVOICE

Download link: https://esha.com/products/food-processor-nutrition-analysis-software/

remit to: **ESHA Research, Inc.**
4747 Skyline Rd. S Ste. 100
Salem, OR 97306

Federal ID: 93-0777 394
Phone: 800-659-3742 or 503-585-6242
Fax: 503-585-5543

Invoice

Invoice Number	174745
Customer Number	32200
Date	10/21/2015
Sales Person	Stephanie Fitch
Payment Method	Credit Card
Purchase Order Num	

Bill To	Ship To
	Aisha Mohammed Kabir
Aisha Mohammed Kabir	Aisha Mohammed Kabir
No 118/3 School Lane	Nothing to ship. Electronic Download will be sent to main contact's email inbox.
Jos, Plateau 13196	
Nigeria	
32200	

Quantity	Product	Unit Cost	Line Cost
1	Food Processor Student Subscription (Monthly) Includes 1 license and preferred Priority Support (technical, database, nutrition, and updates) for the duration of the subscription. Application will be disabled at end of subscription term, or in the event of non-payment.	$19.00	**$19.00**

Date	Payment	Amount
10/21/2015	MC.... 1727 Food Processor student subscription (1) month	$19.00

Grand Total

Currency:	USD	Subtotal:	$19.00
Shipping Provider:	No Shipment - Electronic Download	Shipping:	$0.00
		Total:	**$19.00**
		Payment(s)	-$19.00
		Total Due	**$0.00**

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APPENDIX 5

ESHA developed Complementary Food recipe

Sorghum	40g
Soya beans	30g
Groundnut	25g
Crayfish	5g