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Food Science and Nutrition Program

Nutrient density and energy relation of selected traditional weaning foods in three food insecured kebeles of Demba Gofa Woreda, Southern Ethiopia

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirement for the Degree of Master of Science in Food Science and Nutrition

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List of abbreviations

AAU	Addis Ababa University
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
Ca	Calcium
CHO	Carbohydrate
cP	Centipoises
CSA	Central Statistical Agency
DNA	Deoxyribonucleic acid
EBF	Exclusive breastfeeding
EDHS	Ethiopia Demographic and Health Survey
EFSA-	European Food Safety Authority
FAO	Food and Agricultural Organization
IYCF	Infant and young child feeding
LSD	Least Significance Difference
MOH	Ministry of Health
NHMRC	National Health and Medical Research Council
nm	Nanometer
PUFA's	polyunsaturated fatty acids
RDA	Recommended Daily Amount/ Allowance
SE	Standard Error
SNNPR	Southern Nations, Nationalities, and People's Region
SPSS	Statistical Product and Service Solutions
TAGs-	Triacylglycerols

UNICEF	United Nations International Children's Emergency Fund
USA	United States of America
WHO	World Health Organization

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Abstract

Types, preparation, ingredient proportions, IYCF practices and Nutrient compositions of commonly used traditional weaning foods in three kebeles (Dakisho Subo, Uba Phizgo and Falka Tsawaye) were studied. Data were collected using structured questionnaire from mothers with children older than 6 months but younger than 24 months and evaluated for its nutrient components using standard procedures. Gruels prepared from cereal flour were the first foods introduced to children in the kebeles and analysis results showed that, Crude protein was ranged from 1.45 - 4.27g/100 g with the crude fat ranged from 1.49 - 3.69g/100 g. The ash content ranged from 1.63 - 3.20g/100 g with the fiber content ranged from 2.37 - 5.27g/100g. The carbohydrate and gross energy contents were ranged from 85.64-90.23g/100g and 379.87–396.85kcal/100g. Minerals calcium, iron and zinc contents ranged from 41.43 - 148.85mg/100g; 24.80 - 39.95mg/100g and 0.74 - 2.76mg/100g respectively. Antinutritional factors, Phytates ranged from 237.94 - 299.70mg/100g and Tannins ranged from 33.92 - 81.69mg/100g. There was low protein intake by children in the kebeles since their weaning foods were mainly based on cereals with no other supplementation.

Germination and roasting were used for the preparation of formulated weaning foods from low cost locally available ingredients and the nutrient compositions were analysed for protein ranged from 10.81 - 15.81g/100g with the fat content were ranged from 1.48 - 4.03g/100g. The ash content ranged from 2.28 - 2.57g/100g with the fiber content ranged from 1.96 - 4.04g/100g. The carbohydrate and gross energy contents were ranged from 75.92– 81.61g/100g and 381.08–403.19kcal/100g. Minerals; calcium, iron and zinc ranged from 15.38 - 56.61mg/100g, 8.60 - 17.87mg/100g and 1.72 - 5.18mg/100g respectively. Antinutritional factors: Phytic acid ranged from 191.61 - 269.75mg/100g and tannin ranged from 12.55 - 41.45mg/100g. The sensory acceptance tastes for formulated weaning foods showed that panelists scored like moderately to like very much in all attributes and the protein contents also were higher than traditional weaning foods. Therefore all the blends can be used as alternatives to the weaning foods in the kebeles as well as in the Woreda to improve the nutritional status of children and help to tackle malnutrition.

Chapter 1

1. Introduction

1.1 Background of the study

The nutritional status of children is directly related to their food intakes and key determinants of their environment. Improvement in nutrition and health increase the chances of child survival and is a precondition for economic development (UNICEF, 1998). The determinants of under nutrition related to the social, economic, cultural, and political structure of society. These define what resources are controlled by individual families including access to information and education, household food security, care of women and children, access to health and healthy environment. It is within this context that children have inadequate access to food in terms of quantity and quality; in addition, infection will further compromise nutrition by augmenting nutrient losses and increasing nutrient needs (UNICEF, 1998).

Malnutrition is responsible, directly or indirectly, for over half of all childhood deaths in the world. Infants and young children are at increased risk of malnutrition from six months of age onwards, when breast milk alone is no longer sufficient to meet all nutritional requirements and complementary feeding needs to be started. During this period, gastric capacity limits the amount of food that a young child can consume during each meal and repeated infections reduce appetite and increase the risk of inadequate intakes. Infants and young children need a caring adult or other responsible person (WHO, 2003).

Under nutrition is the major problem confronting infants and young children in the developing countries. The rate of childhood malnutrition in Ethiopia is highest in the world comparing to developing countries (UNICEF, 1998). Infant feeding and rearing practices have a major effect on short term and long-term nutritional status of children, as most of under nutrition is associated with faltering practices that occur in weaning period. Faulty feeding practices as well as lack of suitable weaning foods are responsible for under nutrition in children under five (Sadana, 2004)

Recent findings have shown that malnutrition is increasing in some part of the world, particularly in developing countries, and that infections and unsatisfactory feeding practices, or more often a combination of the two, are the major causative factors of children's death (WHO, 2000). As other developing countries, in Ethiopia adult foods are the most commonly used foods to wean children. This is less nutritious and not suitable for children to eat. Feeding was also very infrequent and no child was fed FAFA, a commercial weaning food of Ethiopia, or any other formula products. Vegetable and fruit consumption was also very rare (Wolde-Gebriel, 2000).

1.2 Statement of the problem

As children get older the energy and nutrient contribution from complementary food becomes increasingly important for meeting their daily requirements. For many infants and young children in developing countries, however, the small quantities of cereal-based porridges commonly fed to them do not contain enough energy and micronutrients to meet daily requirements (UNICEF, 2003).

Due to low socio-economic and educational status, mothers are not adequately knowledgeable about the available nutrients and the anti-nutritional factors in the raw materials (Oyarekua, 2010). So gruels prepared from cereals are of high viscosity and low in energy density; therefore, they are not potentially nutritious enough to be used as complementary foods. Consumers do not always produce foods hygienically specifically in relation to the production of home produced weaning foods (Worsfold, 1996).

Generally, foods eaten in developing countries contain high levels of carbohydrate with very low or no proteins due to the high cost of protein rich foods and some negative traditional beliefs on feeding infants with high protein foods (Ijarotimi et al., 2009). Therefore, it is important to have energy dense, hygienic and low cost nutritional weaning foods which can be produced easily at home level from locally available raw materials in developing countries hence this research paper will focus on feeding frequency, practices and nutritional analysis of traditional weaning foods given to children in three food insecured kebeles of Demba Gofa Woreda and to formulate energy dense weaning foods from low cost locally available raw materials.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this study was to assess the Nutrient density and energy relation of selected traditional weaning foods in three food insecured kebeles of Demba Gofa Woreda, southern Ethiopia

1.3.2 Specific objectives

- ➢ To identify traditional weaning foods and the proportion of their ingredients in three food insecured kebeles of Demba Gofa Woreda
- ➢ To evaluate infant and young child feeding (IYCF) practices (frequency, amount) in the area
- ➢ To evaluate proximate composition, antinutritional factors (phytic acid and tannin), some essential mineral contents (Ca, Fe, Zn), energy density and viscosity of traditional weaning foods
- ➢ To recommend weaning foods developed from low cost locally available raw materials using appropriate proportions of ingredients

1.4 Significance of the study

This study will have the following application:

- ✓ Provide necessary information about the traditional weaning foods and their nutritive value
- ✓ Help to identify ingredients used and their energy density
- ✓ Help Researchers and policy makers in child feeding and child care for strategic plan and weaning food improvements in similar settings.
- ✓ It can also be used as a base line for further research in the same area

Chapter 2

2. Literature Review

2.1 Weaning Foods, Weaning and Weaning Period

WHO defines, Weaning or Complementary foods are any food other than breast milk given to a breastfeeding child. A weaning food is normally a semi-solid food that is used in addition to breast milk and not only to replace it. Weaning foods are mostly prepared in the form of thin porridges or gruels (Wharton, 1989). Development of complementary foods is guided by: high nutritional value to supplement breastfeeding, acceptability, low price, and use of local food items. During formulation of any weaning foods made from locally available raw materials, the techniques of food processing, storage and distribution; cultural and religious factors of consumers; sensory properties; and food quality and safety issues should be taken in to account (Amuna et al., 2000; Onweluzo, 2009).

To meet their evolving nutritional requirements after 6 months, infants should receive nutritionally adequate, age appropriate and safe complementary foods while breastfeeding continues for up to two years of age or beyond (UNICEF, 2010). Practically, in developing countries commonly-used weaning foods are prepared from flours of starchy staples, cereals and legumes, such as rice, millet, sorghum, or maize. Cereals and legumes are the most common first weaning foods (Wharton, 1989).

Weaning foods should ideally be easily digestible, have high energy density and low bulk (Ijarotimi, 2006). It is a gradual withdrawal of breast milk and introduction of other foods including suitably prepared adult foods and the milk of other animals. In short, it is the process of introducing semisolid or solid foods to the breast- or formula-fed child to meet the extra nutritional needs for rapid growth and development. But this process can be influenced by socioeconomic status, cultural and religious beliefs and practices of societies (Wharton, 1989; Umeta et al., 2003; Amankwah et al., 2009).

The weaning period is seen universally as a crucial period in the development of infant. Inadequate child care at the infancy stage influences later adult health. When infants transfer from nutritious and uncontaminated breast milk to the regular family diet, they become vulnerable to malnutrition and infection or disease (Wharton, 1989; Ikpeme-Emmanuel et al., 2009).

The age of initiation of weaning varies substantially among societies. physiologic and anthropologic factors are important in determining the age to wean. Weaning in developing countries is later than that of developed countries (Wharton, 1989). When weaning is started too late, the infant's energy requirements will not be met and this result in deceleration of infant growth and increased risk of malnutrition and micronutrients deficiencies and an older infant is less likely to be willing to try new flavors and other food. On the other hand, if it is started too early, it reduces the duration of breastfeeding and interferes with absorption of important nutrients from breast milk. It also increases the risk of contamination and allergic reactions. So the baby may suckle less resulting in a decrease of breast milk supply (Wharton, 1989).

2.2. Breast feeding

Breastfeeding is ideal food for the healthy growth and development of infants; it is also an integral part of the reproductive process with important implications for the health of mothers. Breast milk is the healthiest source of nutrition for infants and universally endorsed by the world's health and scientific organizations as the best way of feeding infants. For children, breastfeeding supports optimal development and protects against acute and chronic illness unless lack of breastfeeding increases risk of disease and death (WHO, 2002).

Exclusive breastfeeding (EBF) has been defined by WHO as the situation where the infant has received only breast milk from his/her mother or a wet nurse, or expressed breast milk and no other liquids, or solids, with the exception of drops or syrups consisting of vitamins, minerals supplements, or medicines. EBF is adequate in quality as well as quantity in terms of energy, protein, nutrients, water etc. for an infant's need under six months of age (WHO, 2002).

Breastfeeding should be initiated within the first hour after birth and infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health (UNICEF, 2010). The low prevalence of EBF in most developing countries is attributed to various maternal and child factors such as place of residence, sex and age of the child. mother working outside home, maternal age and educational level, access to mass media and economical status as reported by several researchers (Morisky et al., 2002). Exclusive breastfeeding at 6 months is not a common practice in developed countries, and it is rarer still in developing countries. There is also a serious lack of measurement, which impedes evaluation, of the human milk intakes of 6-month-old exclusively breastfed infants from developing countries (WHO, 1991).

2.3. Responsive feeding

Responsive feeding is a method a mother or child caretaker can use to encourage the child to eat and to finish his/her meals. It applies the principles of psycho-social care (Engle et al., 2000). Specifically, feed infants directly and assist older children when they feed themselves, feed slowly and patiently encouraging them to eat without forcing, if children refuse many foods, experiment with different food combinations, tastes, textures and methods of encouragement, minimize distractions during meals if the child loses interest easily and remembering that feeding times are periods of learning so love - talk to children during feeding, with eye to eye contact (WHO, 2001).

2.4. Hygiene and safe preparation of weaning foods

In spite of improving epidemiological knowledge in relation to child health, the challenge of promoting the survival and quality of life of infants and children in most parts of the developing world remains an abiding public health problem. There is also limited research into the causes of food poisoning caused by infant weaning foods, mainly because of a failure to recognize food poisoning as a major cause of infant diarrhoea (Kaferstein, 2003). Specific research into the microbiological quality of infant weaning foods has focused on less developed countries where kitchen facilities and levels of hygiene fall below western standards and this is often reflected in the microbiological quality and safety of the food (Seth et al., 2000; Badau et al., 2006).

2.5. Family skills of weaning foods

Adoption of recommended breastfeeding and complementary feeding practices and access to the appropriate quality and quantity of foods are essential components of optimal nutrition for infants and young children (Lutter and Rivera, 2003). In Nigeria the complementary foods are often of families; hence many depend on inadequately processed traditional foods consisting mainly of unsupplemented cereal porridges made from maize, sorghum and millet (Nnam, 2002; Compaoré et al., 2011).

Among rural communities in developing countries, homemade foods are likely to be composed of locally grown products and in these circumstances, the choice of ingredients is often severely limited and the ability to mix the food into a nutritious combination is hampered by the mother's lack of knowledge (Gugsa, 1999). Compounding the problem is that except cow's milk, the complementary foods given to children are plant sources. Feeding with animal products was very low. Vegetable and fruit consumption is also low. This may be attributed to lack of mother's knowledge on the importance of enriching complementary diets (Beka, 2009).

The purpose and type of processing applied in preparing complementary foods for infants should be for separation and purification of the edible parts of raw material and most importantly it should also improve the nutritional qualities by enrichment and inactivation of the anti-nutritional factors. The low socio-economic status mothers are not adequately knowledgeable about the available nutrients and the anti-nutritional factors in the raw materials (Oyarekua, 2010).

2.6. Nutritional composition and Energy density of traditional weaning foods

Complementary foods should be varied and include adequate quantities of meat, poultry, fish or eggs, as well as vitamin A-rich fruits and vegetables every day. Where this is not possible, the use of fortified complementary foods and vitamin mineral supplements may be necessary to ensure adequacy of particular nutrient intakes. As infants grow, the consistency of complementary foods should change from semisolid to solid foods and the variety of foods offered should increase. By eight months, infants can eat 'finger foods' and by 12 months, most children can eat the same types of food as the rest of the family (WHO, 2003).

According to WHO/UNICEF (1998) the latest estimated energy requirements from complementary foods, assuming an average breast-milk intake, are 200 kcal/day for infants aged 6–8 months, 300 kcal/day for infants aged 9–11 months and 550 kcal/day for children aged 12–23 months. But as dietary reference intakes published by the Institute of Medicine, USA shows that the diets of infants and young children in most populations in low-income countries are consistently deficient in some nutrients, including iron, zinc and vitamin B6. Cereals have low content of proteins and fat while legumes are low in fat. Weaning foods from plant sources are also high in antinutrients content which decreases nutrients bioavailability. The bulkiness of traditional weaning foods and the presence of high concentration of crude fiber and absorption inhibitors (antinutritional factors like phytic acid and tannin) are major factors reducing their nutritional benefits (Wharton, 1989; Michaelsen and Friis, 1998).

Foods are rarely modified at the household level to increase nutrient density to meet the needs of infants (Dewey and Brown, 2003). Traditional infant foods made of cereals or tubers may be low in several nutrients including protein, vitamin A, zinc and iron; these nutrients are of special importance due to their impact on physical and cognitive development (Krebs and Westcott, 2002). Generally, foods eaten in developing countries contain high levels of carbohydrate with very low or no proteins due to the high cost of protein rich foods and some traditional beliefs about feeding infants with protein foods.

2.7. Feeding frequency

Increase the number of times that the child is fed complementary foods as he/she gets older. The appropriate number of feedings depends on the energy density of the local foods and the usual amounts consumed at each feeding. For the average healthy breastfed infant, meals of complementary foods should be provided 2–3 times per day at 6–8 months of age and 3–4 times per day at 9–11 and 12–24 months of age. Additional nutritious snacks (such as a piece of fruit or bread or chapatti with nut paste) may be offered 1-2 times per day, as desired. Snacks are defined as foods eaten between meals, usually self-fed, convenient and easy to prepare. If energy density or amount of food per meal is low, or the child is no longer breastfed, more frequent meals may be required (WHO, 2002). In many countries faulty complementary feeding practices - primarily nutritionally inadequate and frequently contaminated foods that are introduced too early or too late - are a major contributing factor to infant and young child malnutrition, growth failure, and high morbidity and mortality (WHO/UNICEF, 1998).

2.8. Viscosity of Traditional weaning foods

Weaning foods prepared traditionally from locally available ingredients such as cereal and/or legume flours have a high viscosity when reconstituted, which limits the total food intake by the infants. During cooking or reconstitution process of staple-based weaning foods, the starch granules swell and bind a large volume of water, resulting in gruels of high viscosity. Gruels of suitable feeding consistency contains a great amount of water and large in volume relative to its contents of solid matter. If solids in gruels are increased to improve the nutrient and energy density, the gruel will be too thick and viscous for a small child to eat easily. This high volume or high viscosity characteristics of weaning foods referred to as dietary bulk, is responsible for the occurrence of malnutrition in areas where cereals and starchy staples are the major foods (Kulkarn et al., 1991).

Porridge play an important role in the weaning diets of children in most developing countries but their energy density is often low because large amount of water are added during preparation to achieve a thin, drinkable consistency. Infants may not be able to consume sufficient quantities of these porridges to meet their energy requirements. Increasing the energy density of weaning foods is therefore considered a high priority in many health and nutrition programs (WHO, 1992).

2.9. Traditional weaning foods in Ethiopia

Studies show that malnutrition is a significant health problem for infants and young children in Ethiopia. Though poverty is the underlining cause of malnutrition, sup-optimal infant caring practice and limited access to water and sanitation services are also important causes of child malnutrition (MOH, 2006).

The prevalence of stunting was as high as 64 % and malnutrition was equally highly prevalent or even worse in the food surplus regions like Gojam and Gamo Gofa regions than the food deficit regions of the time. A wide range of harmful infant feeding practices were also documented such as sub optimal breast feeding, late introduction of weaning foods, giving milk of other animals and butter before 6 months according to National strategy for child feeding (2004).

In Ethiopia, the introduction of other liquids such as water, juice, and formula takes place earlier than the recommended age of about 6 months. Even among the youngest breastfeeding children (<2 months), 10% consume other liquids, and 12% drink milk other than breast milk. Consumption of milk other than breast milk and infant formula, peaks at 6-8 months (48%) and then declines thereafter (CSA, 2005).

According to the findings of EDHS (2005), the overall prevalence of stunting among Ethiopian children is 47 percent, 38 percent of the Ethiopian children are underweight (low weight-for-age) and about 11 percent of the children under five years of age were also wasted (thin for their height). This is indicated by IYCF and the three practices are: continued breastfeeding or feeding with appropriate calcium rich foods if not breastfed; feeding solid or semi-solid food for a minimum number of times per day according to age and breastfeeding status; and including foods from a minimum number of food groups per day according to breastfeeding status. The level of stunting, underweight, and wasting are higher for rural children than urban children (Lindsay and Gillespie, 2001).

According to Woldemariam and Genebo (2002), the age at introduction of weaning foods is of public health importance because of the risk of diseases, particularly diarrhea, from contaminated weaning foods and the risk of growth faltering and malnutrition from delayed weaning. The study has also indicated that exclusive breastfeeding up to 6 months of age is not widely practiced nor is the timely introduction of weaning foods at about 6 months. Only 54.6 percent of the children under 5 months of age and 44 percent of those under 7 months were found to be exclusively breastfed. The study has also shown a high risk of stunting among children age 12-23 months as compared with children in the age group 6-11 months. This may be an indication of either inappropriate food supplementation in quantity and/or quality during the weaning period, or exposure to disease. Among regions, Tigray, Amhara and SNNP were found to be the most affected by child stunting.

2.10. Formulation of Weaning Foods from locally available ingredients

The widespread problem of infant malnutrition in the developing world has stirred efforts in research, development and extension by both local and international organizations. Weaning foods prepared commercially are not available and if available, unaffordable for the Poor in developing countries. As a result, the formulation and development of nutritious weaning foods from local and readily available raw materials have received a lot of attention in many developing countries (Umeta et al., 2003). To overcome this problem, combination of commonly used cereals with inexpensive plant protein sources like legumes can be used. Cereals are deficient in lysine but have sufficient sulphur containing amino acids which are limited in legumes (Shewry, 2007) whereas legumes are rich in lysine. The effects of the supplementation are highly beneficial, since nutritive value of the product is also improved. A mutual complementation of amino acids and consequent improvement in protein quality is therefore achieved when legumes are blended with cereals in the right proportions (Ghasemzadeh, 2011).

2.11. Macronutrients in weaning foods

Macronutrients are carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids and particularly fats and carbohydrate, play a role in the risk of chronic diseases. Total energy intake because of its requirement, in a classical sense, is not independent of other energy fuel sources or of the total energy requirement of the individual. Each must be expressed in terms relative to each other (Food and Nutrition Board, 2005). Energy is not a nutrient but is required in the body for metabolic processes, physiological functions, muscular activity, heat production, growth and synthesis of new tissues. It is released from food components by oxidation. The main sources of energy are carbohydrates, proteins, fats and, to a lesser degree, alcohol (NHMRC, 2005).

The growth of children may be compromised by low-energy cereal foods. Weaning foods introduced to supplement human milk should have sufficient energy and protein to cover an infant's requirements. Satisfying energy needs is critical, because if energy intake is insufficient, then protein will be used as an energy source and will not be available for growth and maintenance. Proteins, fat, and carbohydrates are important quantitatively in the diet and as carriers for the essential micronutrients. Excess and deficiency of the macronutrients are concerns for people's health; too many calories lead to obesity and too few calories result in undernourishment. Both have serious health implications (Walker, 1990)

2.11.1. Crude Protein

Crude protein is an estimate for total protein. A crude protein contains nitrogen from not only protein but non-protein sources as well. Protein is the most abundant nitrogen-containing compound in the diet and in the body. After consumption of a meal, protein is broken down into its basic components amino acids. Some amino acids, such as glutamine, play multiple roles. It is not surprising, therefore, that inappropriate intakes of proteins and/or of specific amino acids can have important consequences for tissue and organ function, and the maintenance of health and the well-being of the individual (Gibney et al., 2009).

Proteins are very important in foods, both nutritionally, and as functional ingredients. The primary roles protein plays in the growth, and development of body building, repairing muscle, and connective tissues, aiding immune system function, preserving muscle mass, building enzymes, and making hormones. They play an important role in determining the texture of a food. They are complex molecules, and it is important to have an understanding of the basics of protein structure to understand the behavior of many foods during processing. Protein also provides the body with energy (Voet, 2004).

Dietary proteins provide approximately 8% of the exclusively breastfed infant's energy requirements and the essential amino acids (obtained from animal sources except some legumes) necessary for protein synthesis. Thus, the quantity and quality of proteins are both important. Because protein may serve as a source of energy, failure to meet energy needs decreases the efficiency of protein utilization for tissue accretion and other metabolic functions. Protein undernutrition produces long-term negative effects on growth and neurodevelopment (WHO, 2002).

Protein deficiency is one of the commonest forms of malnutrition worldwide. In children, acute protein–energy malnutrition (caused by recent severe food deprivation) is characterized by a low weight-for-height index (wasting), while the chronic condition (caused by long-term food deprivation) is characterized by a low height-for-age index (stunting). Severe protein–energy malnutrition results in the clinical syndromes of marasmus, kwashiorkor or marasmic kwashiorkor. All three conditions are compounded by a range of nutritional disorders, including micronutrient deficiencies (WHO, 2000)

2.11.2. Crude Fat

Like other organic compounds, all lipids (fats and oils) are composed of a carbon skeleton with hydrogen and oxygen substitutions. Nitrogen, sulfur, and phosphorus are also present in some lipids. Water insolubility is a key but not absolute characteristic distinguishing most lipids from proteins and carbohydrates (Gibney et al., 2009). Crude fat is the term used to refer to the crude mixture of fat-soluble material present in a sample. Fats are esters of fatty acids with glycerol. They usually occur as triesters or triacylglycerols (TAGs), although monoacylglycerols and diacylglycerols occur during fat digestion and are used in food processing. Most common dietary fats contain a mixture of 16- to 18-carbon saturated and unsaturated fatty acids (Gibney et al., 2009).

Fat is a major source of fuel energy for the body and aids in the absorption of fat-soluble vitamins and carotenoids. Dietary fats provide the infant and young child with energy, essential fatty acids and the fat soluble vitamins A, D, E and K. Fats also heighten the palatability of food, thereby promoting greater energy intake. Furthermore, several fatty acids, especially the long-chain polyunsaturated fatty acids, have specific and essential physiological functions. Fats from animal produce (for example, cow's milk and meat) tend to contain saturated fatty acids, while those from plants and fish tend to contain monounsaturated or polyunsaturated fatty acids. In adults, saturated fats are associated with an increase in cardiovascular diseases, but there are no data to suggest that saturated fat intake during the first years of life contributes to this problem. In contrast, unsaturated fat consumption is associated with a lower prevalence of cardiovascular disease in adults (WHO, 2000).

2.11.3. Crude Fiber

Dietary Fiber is defined as the sum of the plant nonstarch polysaccharides and lignin and/or the remnant of plant foods resistant to hydrolysis by the alimentary enzymes of humans. The major portion of dietary fiber (soluble fibers) in foods is derived from the plant cell walls in foods and most crude fiber contains one-seventh to one-half dietary fiber. A wide range of plant organs and types of tissue is consumed in the human diet, although highly lignified (woody) tissues are rejected during food preparation (Spiller, 2001).

Crude fibers obtained from different sources vary considerably in their chemical composition: insoluble/soluble dietary fiber ratio, particle size and physicochemical characteristics which results in different physiological effects. The variations in chemical composition of fiber affect their ability to bind minerals during intestinal digestion of foods. One of the most important properties of dietary fiber is the cation exchange. Therefore, poor mineral utilization from certain types of fiber rich foods is probably due to the binding of minerals and electrolytes on fiber source (Olivares et al., 2001).

2.11.4. Total Carbohydrate

Carbohydrates are organic compounds containing carbon, hydrogen, and oxygen. They may be simple or complex molecules including sugars, starch and cellulose. Important food carbohydrates include Sugars, Dextrins, Starches, Celluloses, Hemicelluloses, Pectins, and Gums. Carbohydrates hold a special place in human nutrition. They provide the largest single source of energy in the diet, and satisfy our instinctual desire for Sweetness. Glucose is the essential fuel for the brain, growing fetus, and is the main source of energy for the muscles during strenuous exercise. Carbohydrates may be used as sweeteners, thickeners, stabilizers, gelling agents, and fat replacers (WHO/FAO, 1998).

Energy is required for tissue maintenance and growth, to generate heat (thermogenesis) and for physical activity. Weight gain is a sensitive indicator of the adequacy of energy intake in young children. The energy requirement is the amount of dietary energy needed to balance the energy expended and that deposited in new tissue (growth). The factors limiting energy intake of an infant weaned with low energy weaning food gruels are the volume that the child can consume at one time and the frequency of feeding (WHO, 2000)

Infants and young children have an energy intake per kg body weight some 2–3 times that of adults. A key determinant of energy intake is the energy density of complementary foods. Energy density is increased by raising the content of fat and sugar, while high amount of water content will decrease energy density. Energy intake is increased through complementary food with a high energy density, more frequent meals and an increased intake of breast-milk. Energy intake will be reduced if complementary foods are very viscous, which is typically the result of high starch content (WHO, 2000)

2.12. Micronutrients in weaning foods

Micronutrients include all vitamins and minerals required in only tiny amounts, they are nonetheless essential for life and needed for a wide range of body functions. They are essential for optimal human growth and development, and healthy maintenance of the body over a life span (Ruel, 2001). Although less prevalent in higher-income populations, these deficiencies do occur in such groups, especially among premature infants, infants, children, and the elderly (Siekmann et al., 2003). Micronutrients are needed to maintain strong bodies and mental sharpness, to fight against disease, and bear healthy children. Their deficiencies can cause learning disabilities, mental retardation, decreased immunity, low work capacity, blindness, and premature death (Gibson and Ferguson, 1998).

Minerals in the diet are responsible for several existing problems relating to human health (Milton, 2003). The human body requires more than twenty-two mineral elements that can be supplied by an appropriate diet in varying amounts for proper growth, health maintenance, and general well-being (FAO/WHO, 1998). Deficiency diseases could be prevented by sufficient intake of specific nutrients/minerals that are involved in many biochemical processes. Root and tuber crops are one of important sources of minerals that are linked to prevent deficiency diseases such as Anemia and Rickets and daily consumption of these foods is being encouraged (Leterme, 2002).

2.12.1 Calcium

Approximately 99% of total body calcium is found in the skeleton, with only small amounts found in the plasma and extravascular fluid. Understanding calcium needs for different age groups requires a consideration of the variable physiologic requirements for calcium during development as American Academy of Pediatrics (1999) reported. In the body calcium regulates critical functions including nerve impulses, muscle contractions and the activities of enzymes and plays an important role for structure and strength of bones. The element is present in two body parts mainly: bone and teeth. Sufficient calcium intake is essential for obtaining optimal peak bone mass in youth and for minimizing bone loss later in life (Gurr., 1999; Grinder et al., 2004).

The concentration of calcium in breast milk declines as the duration of breast feeding increases. Consequently, the continuous lactation of the mother would have resulted in a relatively low calcium concentration of her breast milk. Cereal porridges used in weaning, possibly with high phytate content, would have further aggravated a marginal calcium intake. Researchers proposed that the calcium intake of many infants who were wet-nursed and weaned to cereal porridges was insufficient to permit adequate bone mineralization (Thacher, 2007). On the other hand, Cereals such as millet and sorghum contain high levels of phytates and oxalates, which bind calcium and other essential nutrients causing their decreased bioavailability (UNICEF, 1990).

Calcium is by far the most important mineral that the body requires and its deficiency is more prevalent than many other mineral. Calcium deficiency can be seen in older infants and preschool children in association with Vitamin D deficiency. Artificially fed children are more prone to develop calcium deficiency (Gurr, 1999). Though rare in breastfed infants, calcium deficiency can occur in such infants whose mothers are deficient in calcium and Vitamin D. Calcium deficiency appears to occur after birth when infants are weaned and start to become mobile and their bones thus become weight bearing. Mineral deficiencies, such as calcium, are a world-wide problem particularly in developing countries (Boukari et al., 2001).

2.12.2. Iron

Iron is an essential micro-nutrient for almost all organisms. Its essentiality is largely based on its ability to exist in two redox states (Fe^{2+} / Fe^{3+}), which makes it ideal to act as a catalytic molecule in numerous biochemical reactions. The transport of oxygen in the blood and its storage in tissues, the transfer of electrons in the electron transport chain to supply cells with energy, and DNA synthesis, all require iron (Minihane and Rimbach, 2002). Iron is the fourth most abundant and one of the cheapest elements in the Earth's crust but iron deficiency is still the most prevalent nutritional disorder in the world (Lind, 2004). Dietary iron contributes to the formation of iron-containing enzymes that are important for energy production, immune defense and thyroid function. Iron has a role in healthy physical growth, the immune system, reproductive outcomes, and in cognitive performance (Kayode, 2006).

Breast milk may not provide sufficient iron and zinc for some infants between the age of 4 and 6 months, and these infants will require complementary foods. Iron deficiency in fully breast-fed 6 month old infants is more likely to occur in boys and in infants with a birth weight of 2500-2999 g (EFSA, 2009). Iron nutrition is particularly important during the weaning period, when the infant is growing rapidly, and has a high demand for Iron. Cereal porridges are common complementary foods during the weaning period and often provide much of the dietary Iron intake, because the Iron contribution from human milk is low. Because of the high Phytate content of cereal porridges, Iron absorption of native Iron and fortification Iron may be very low (Hurrell et al., 2003).

Iron is one of the micronutrients that are most often deficient in developing countries, with children and women of reproductive age especially at risk of such deficiencies and is the most important cause of nutritional anaemia (Umeta et al., 2005). Children in rural Ethiopia are especially very prone to deficiencies of minerals and trace elements, as they eat from the family dish and often cannot meet their specific nutrient needs (Umeta et al., 2000).

The main causative factors of iron deficiency are poor iron content of the diet, low bioavailability of iron in the diet, or both. Food components such as phytate, tannins, and selected dietary fibers, which bind iron in the intestinal lumen, can impair iron absorption. Phytate has the greatest effect on iron status because many plant foods have high phytate content that can severely impair iron absorption (Mendoza et al., 2001). Severe iron deficiency can cause retarded mental development, which may be irreversible (Walker et al., 2007). Iron deficiency anaemia in infancy is associated with significant loss of cognitive abilities, decreased physical activity, and reduced resistance to diseases (Kayode, 2006). In school-age children, Iron deficiency anaemia may affect school performance; in adulthood, it can cause fatigue and reduced work capacity (Ruel, 2001).

2.12.3. Zinc

Zinc is one of the most essential trace elements in human nutrition because it is a component of over 200 metalloproteins with a wide range of biochemical functions, involving enzymes, structural proteins and hormones. The ability of zinc to participate in an impressive range of biochemical functions is partly due to its flexible and easily exchangeable ligand binding with biomolecules. Zinc is a relatively safe element when compared with iron and copper, especially because of its lack of oxidant properties (Delvin, 1993). Zinc plays vital role in cell division and protein synthesis which makes infants, children, adolescents, and pregnant women at risk for an inadequate zinc intake (WHO, 1996). Zinc is ubiquitous within the body and is vital to cellular differentiation. Studies in children have demonstrated the important roles of zinc in relation to development (Brown et al., 2002). Zinc plays an important role in a recognized action on more than 300 enzymes by participating in their structure or in their catalytic and regulatory actions. It is a structural ion of biological membranes (Salgueiro et al., 2002).

In many developing countries, zinc deficiency is due to the low consumption of animal source foods, which are rich in zinc, and a high intake of cereals and legumes, which contain substantial amounts of phytate (Romana, 2003). Zinc deficiency is a public health problem, and is associated with poor growth, decreased immune function, increased susceptibility, severity of infections, adverse outcomes of pregnancy, and neurobehavioral abnormalities (Walingo, 2009). Deficiency of Zn is highly prevalent in developing countries, but also in vulnerable groups with high requirements in industrialized countries, such as women of fertile Age, Infants and Adolescents (Sandberg, 2002).

Approximately one third of children in low-income countries are stunted. Zinc deficiency is presumed to be the underlying cause of stunting and delayed sexual maturation. In children zinc deficiency has been shown to poor growth, impaired immunity, increased morbidity from common infectious disease, and increased mortality (Walingo, 2009). Chronic diarrhea causes zinc deficiency, and zinc deficiency in turn can contribute to diarrhea. Zinc loss during bouts of diarrhea is comparable to the daily absorption requirement. Duration and severity of diarrheal illnesses among infants from developing countries suffering from malnutrition and impaired immune status are greater than in well-nourished children. All these factors may be associated with zinc deficiency because zinc supplementation has resulted in amelioration of these episodes. In addition, the impact of zinc supplementation on recovery from diarrhea was greater in stunted children, which is also related to zinc deficiency (Salgueiro et al., 2002).

From six months to two years of age, adequacy of zinc intake becomes highly dependent on the amount and bioavailability of zinc from complementary foods. Thus, prolonged breastfeeding without adequately prepared complementary foods may reduce an infant's zinc intake, thereby increasing the risk of zinc deficiency (Allen, 1998; Lind et al., 2003).

2.13. Antinutritional factors

Anti-nutrients are chemical substances in food that do not offer nourishment to the body e.g. phytic acid and tannin. The effect of these anti nutrients in the body depends on the type and the concentration in which it is present in the food material. However, the presence of antinutritional factors (tannins and phytates) limits the utilization of the legumes as a main source of protein (Alonso et al., 1998).

Anti-nutritional factors are compounds which reduce the nutrient utilization and/or food intake of plants or plant products used as human foods or animal feeds and they play a vital role in determining the use of plants for humans and animals (Soetan and Oyewole, 2009). Legumes contain significant amounts of bioactive compounds with toxic and/or antinutritional properties that can alter the body metabolism of consumers and exert a negative impact on the nutritional quality of the seed protein (Becker-Ritt et al., 2004).

To select new food sources for wider utilization it is necessary not only to obtain information concerning their chemical composition but also to analyze the amino acid profile and the presence of antinutritional and/or toxic components, such as lectins, protease inhibitors, goitrogens, allergens, antivitamins, saponins, tannins, phytate and toxin, factors that limit the use of some food sources (Benevides et al., 1998).

2.13.1 Phytic acid

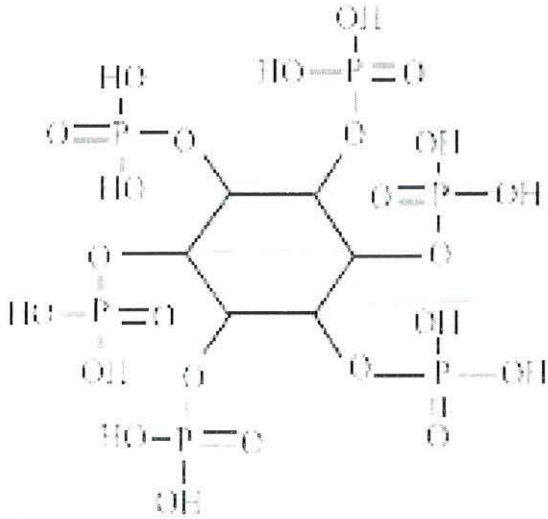


Figure.1 Structure of phytic acid

Source, Am. J. plant nutr. Fert. Technol., 1(1): 1-22, 2011

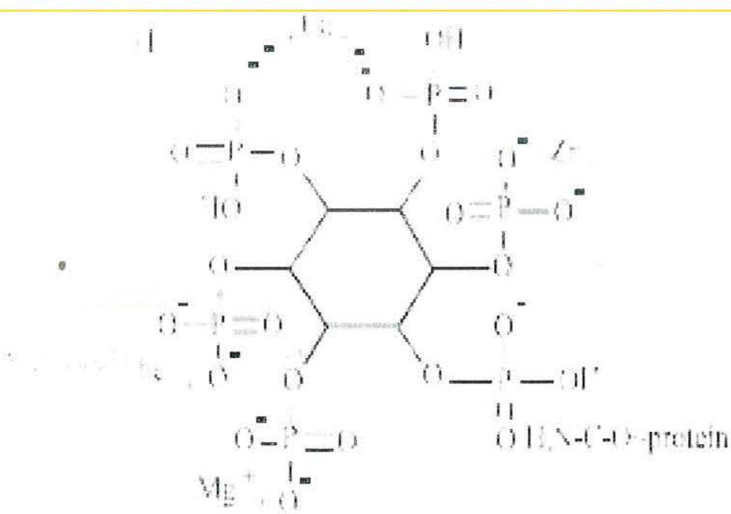


Figure.2 Structure of phytic acid with the different possibilities to interact with both metal cations (minerals) as with protein residues

Source, Am. J. plant nutr. Fert. Technol., 1(1): 1-22, 2011

Phytate (myo-inositol (1, 2, 3, 4, 5, 6) hexakisphosphate), a naturally compound formed during maturation of plant seeds and grains is a common constituent of plant-derived foods. The major concern about the presence of phytate in the diet is its negative effect on mineral uptake. Minerals of concern in this regard would include Zn^{2+}, $Fe^{2+/3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+}. Especially zinc and iron deficiencies were reported as a consequence of high phytate intakes (Greiner et al., 2006). Among all the antinutritional components, phytic acid is of prime concern for human nutrition and health management. It therefore adversely affects the absorption and digestion of these minerals by animals (Kumar et al., 2010).

The high intakes of phytate relative to zinc in the diet of children from many countries, but predominantly developing countries, suggest that these children are at great risk for inadequate zinc nutriture, with all the consequences that this may provoke for child health. However, it is important to remember that high cereal intake is inclusive to diets of developed countries. Thus: it is noteworthy that mild, growth-limiting zinc deficiency might be prevalent in healthy children and in developed countries (Salgueiro et al., 2002).

2.13.2 Condensed Tannin

Tannic acid (TA) is naturally occurring plant phenol present in fruits and vegetables (Block et al., 1992). Polyphenols are secondary metabolites of plants and are widely distributed in plant-derived foods, such as cereals, legumes, nuts, vegetables, fruits, and in beverages such as green or black tea, wine, fruit juice, beer and so on. The essential polyphenols in foods are flavonoids and condensed tannins (Nakamura et al., 2001). Tannic acid chelates iron due to its ten galloyl groups and it diminishes intestinal non-heme iron and Zinc absorption (Lopes et al., 1999). A complementary food made from cereals is often low in mineral content and contains significant quantities of mineral absorption inhibitors such as condensed tannins.

Tannins inhibit the digestibility of protein and have the ability to precipitate certain proteins they combine with digestive enzymes thereby making them unavailable for digestion. Tannins form insoluble complexes with proteins, carbohydrates and lipids leading to a reduction in digestibility of these nutrients (Abara, 2003).

2.14. Sensory evaluation

Sensory evaluation is defined as a scientific application used to evoke, measure, analyze, and interpret responses to food attributes or characteristics as they are perceived through a person's sense of sight, smell, hearing, touch, and taste in forming a food perception (Stone and Sidel, 1993). It is a science of measurement. Like other analytical test procedures, sensory evaluation is concerned with precision, accuracy, sensitivity and avoiding false positive results (Meiselman, 1993). Most sensory tasting is preformed in an industrial setting where business concerns and strategic decisions enter the picture. It is also a way of reducing risk and uncertainty in decision making. It is also used in product (complementary food) development and may provide information to other corporate departments (Lawless and Klein, 1989).

Product evaluation is a multi-step process in which a group of individuals respond to stimuli (a set of products) by marking a scorecard according to a specific set of instructions. These individuals are participating in this test because of their demonstrated sensory skills with that particular category of products. The responses are usually marks on the scorecard (Joel, 2004). In sensory evaluation, judges are asked to score the products for appearance, color, flavor, taste and overall acceptability using a scorecard of Hedonic Rating Scale. This test relies on people's ability to communicate their feelings of like or dislike. Hedonic testing is popular because it may be used with untrained people as well as with experienced panel members. A minimum amount of verbal ability is necessary for reliable results (Sadana and Chabra, 2004).

Chapter 3

3. Materials and methods

3.1 Study Area

Demba Gofa Woreda is located in SNNPR, Gamo Gofa zone and it is predominantly of the Gofa ethnic group. The Woreda is located at $6^0$18'N and $36^0$53'E. According to CSA (2007), the Woreda population size is 81,158 (male, 40,335 and female, 40,823). The Woreda had three food insecured kebeles with current evidences among 38 kebeles. These kebeles were Uba Phizgo, Dakisho Subo and Falka Tsawaye and their population is 3071. The capital of the Woreda, Sawla, is at 525 km far from Addis Ababa. The altitude of the woreda ranges from 1000 to 3200 meters above sea level. Farming is the main means of subsistence of the three kebeles followed by livestock farming.

3.2 Study design

A cross sectional study was conducted by means of structured questionnaire and administered to the nursing mothers to obtain information of their demographic data (age, occupation, monthly income, education), demographic data of the infants (sex, age) frequency of breast feeding, types of weaning foods used, source of water and if any method of water treatment. The age range of the study mothers was between 15 and 45 years and that of children was between 6 months and 2 years. Information on the recipes and method of preparation of the traditional weaning foods was collected from the mothers. 10% were collected and subjected to chemical analysis from prepared weaning food samples (about 0.20 kg from each). Additional 8 kg samples of commonly used (used by almost all mothers) raw materials (Cereal grains; maize, Sorghum and barley and legume broad bean) were purchased from common local markets to develop formulated weaning foods.

3.3 sample size

Three food insecured kebeles of Demba Gofa Woreda were selected from total 38 kebeles purposefully because of their low productivity by the year due to different invironment factors like the shortage of rain fall. A total of 116 mother-child pairs were selected randomly for the study from 233 total populations. Mother-child pairs were also selected randomly from each kebele based on their population proportion to collect laboratory samples. The samples (12 samples) were taken from traditional weaning foods prepared for the children. The study was carried out having information from extension workers of the health centers of the selected kebeles and house to house observation.

Table 1. Description of the three kebeles

No	Name of kebele	Agroecology	Population	Sample	10% Lab sample	remarks
1	Dakisho Subo	W/ dega	76	38	4	
2	Falka Tsawaye	Kola	86	43	4	
3	Uba Phizgo	Kola	71	35	4	
4	Six formulated samples from common ingredients				6	
Total			**233**	**116**	**18**	

W/ dega* between low land and high land

Kola* low land

Population* children b/n 6 months and 2 years

Sample* 50% of the population

The sample size was determined by: Sample size = n/[1+(n/population)], In which n = Z * Z [P (1-P)/(D*D)]

Where: P = Expected Frequency Value = 10%

D = (Expected Frequency - Worst Acceptable) = 14%-10%=4%, OR 10%-6%=4%

Z = 1.960 with Confidence Level of 95%

Samples were coded as: P_1, P_2, P_3 and P_4 = samples 1, 2, 3 and 4 of Uba Phizgo kebele;

D_1, D_2, D_3 and D_4 = samples 1, 2, 3 and 4 of Dakiso Subo kebeles and

F_1, F_2, F_3 and F_4 = samples 1, 2, 3 and 4 of Falka Tsawaye kebele

3.4 Data collection

Quantitative data was collected using structured questionnaire with regard to ingredient and processing method and common practices by the mothers contributing to the Nutrient composition and energy density of traditional weaning foods and the questionnaire was prepared in English and used to collect data. It was pre-tested among 10 women in Turga kebele of the

Woreda before the actual work begins. The laboratory samples were collected and placed in polyethylene containers, by ice box and the common ingredients were also placed in polyethylene bag and then transported to Addis Ababa University (Food Science and Nutrition Program) for laboratory analysis.

3.4.1. Sample preparation

The traditional weaning food samples were divided into two portions one for viscosity measurement (about 80ml) and the other for the rest chemical analysis. The first portions were deep freezed until the viscosity measured and the second portions were spread onto a plastic tray and pressed with a spatula to produce a 1-2 mm thick layer. Each preparation was then oven dried at 60^0c. The flakes were then scraped onto a stainless steel tray and cooled to room temperature (Hashim and Pongjata, 2000; Fasasi et al., 2005). After completely dried, the samples were milled and placed in a plastic bag for laboratory analysis.

3.5 Chemicals and reagents

All chemicals and reagents were used in laboratory analysis were of analytical grade or American Chemical Society reagents.

Chemicals: Distilled water, deionized water, diethyl ether, HNO_3, Sulphuric acid, Hydrogen peroxide, catalyst (0.5g of selenium metal with 100g of potassium sulfate), Boric acid. Sodium hydroxide, acetone, Hydrochloric acid (HCl), Lanthanum chloride ($LaCl_3$), Nitrates of Ca, Fe and Zn, $FeCl_3.6H_2O$, Salfosalicilic acid, Sodium phytate, methanol, vanillin. Potassium hydroxide, D-catechin

3.6 Laboratory analysis

3.6.1 Proximate composition determination

Each laboratory determination was carried out on three separate fresh samples (in triplicate). Proximate chemical analysis of all the samples were determined by using standard methods and total carbohydrate was then calculated by difference.

3.6.1.1 Determination of moisture content

A clean box on its inverted lid was dried in the drying oven at 105°c for 1 hr. The box with the lid was covered and cooled in the desiccators for 30 minutes and weighted. Then 5g (W_1) sample was transferred to the drying box, put on the lid and weighted. The box with the sample was dried at 105°c for 3 h. The box with lid was taken out on and cooled in a desiccator for 30 minutes and weighted. To check that the sample was completely dried, the sample was placed in the drying oven at 105°c for another 1 hour putting the lid underneath it (AOAC, 2005;Adebayo et al., 2010). Then it was Cooled and weighted (W_2) after two successive weightings show a negligible loss in weight. The moisture content was determined by using:

$$\%\ of\ moisture = \frac{W1-W2}{SW}\ X\ 100$$

Where SW is sample weight

3.6.1.2 Determination of total ash content

Forcelain dishes were placed in a muffle furnace for 30 min at 550°c. The dishes were cooled in desiccators for about 30 min at room temperature and weighted to the nearest milligram (M_1). About 2.5 g of fresh sample was placed in dish and weighted (M_2). Dishes were placed on a hot plate under a fume-hood and the temperature was slowly increased until smoking ceases and the samples become thoroughly charred. The dishes with sample were placed inside the muffle furnace at 550°c for 5 hours and cooled in desiccators for 1 hour. The ash was clean and white in appearance. When cooled to room temperature, each dish with ash was reweighted to the nearest milligram (M_3) (AOAC, 2005).

$$\%\ \text{Of total ash} = \frac{M3-M1}{M2-M1}\ X\ 100$$

Where: (M_3-M_1) is sample mass in gram on dry base and

(M_2-M_1) mass of ash in gram

3.6.1.3 Determination of crude fat

A clean extraction flask was dried in the drying oven at 105°c for for 30 minutes. The extraction flask was cooled in the desiccators for 30 minutes and weighted (W_1). About 2g of sample was extracted (W_3) with 50ml of diethyl ether for a minimum of 4 hours (2 hrs for soaking and 2 hrs for extraction) in the soxhlet extractor. The solvent was then evaporated in drying oven and the extracted fat was cooled in desiccators and weighted (W_2) (Manual, 1979). The crude fat was determined using:

$$\% \; of \; crude \; fat = \frac{M3-M1}{M2-M1} \; X \; 100$$

Where:

W_1=Weight of the extraction flask

W_2=Weight of the extraction flask plus the dried crude fat

W_3=Weight of sample plus Weight of the extraction flask

3.6.1.4 Crude protein determination

Digestion: About 0.5g of fresh samples (in triplicate) were taken in a tecator tube and 6ml of concentrated sulfuric acid was added and left for 12 hours until completely mixed, and 3.5ml of 30% of hydrogen peroxide was added step by step. As soon as the violent reaction had ceased, the tubes were shaken and placed back to the rack. 3gm of catalyst mixture (ground 0.5g of selenium metal with 100g of potassium sulfate) was added in to each tube, and allowed to stand for about 10 minutes before digestion. The tubes were placed in to the digester and the temperature of the digester attained 370^0c. The digestion was continued until a clear solution was obtained, about 4 hours. The tubes in the rack were cooled in a fume hood; 25ml of distilled water was added and shaken to avoid precipitation of sulfate in the solution. Again 25 ml of sodium hydroxide was added carefully by the wall of the tecator tube.

Distillation and titration: The digested and diluted sample solution was distilled using boric acid and the distillate was titrated using 0.1N hydrochloric acid until reddish color is appeared (methyl red indicator was used) (Manual, 1979). The crude protein was determined using:

$$\% \; of \; Nitrogen = \frac{V \; of \; HCl \; x \; N \; of \; HCl \; x \; 14}{Wo} \; x \; 100$$

Where: V is volume of HCl in milliliter consumed to the end point of titration,

N is the normality of HCl,

W_o is sample weight on dry matter basis and 14 is the molecular weight of nitrogen.

The % of nitrogen is converted to % of protein by using approximate conversion factor

Protein (%) = 6.25 x % of Nitrogen

3.6.1.5 Determination of crude fiber content

Digestion: About 1.7 g of fresh sample (W_3) was placed in to 600ml beaker; 200ml of 1.25% H_2SO_4 was added, and boiled gently for 30 minutes while watch glass was placed over the mouth of the beaker. During boiling, the level of the sample solution was kept constant with hot distilled water. After exactly 30 minutes heating, 20ml of 28% KOH was added and boiled gently for further 30 minutes, occasional string.

Filtration: the bottom of a sintered glass crucible was covered with 10mm sand layer and wetted with distilled water. The solution was poured in to sintered glass crucible and filtered with the aid of vacuum pump (high performance vacuum pump, Robin air way, SPX Corporation, montplier, USA). The wall of the breaker was rinsed with hot distilled water several times; washings were transferred to the crucible and filtered.

Washing: The residues in the breaker were washed with hot distilled water and filtered (twice). The residue was washed with 1% H_2SO_4 and filtered, and then washed with hot distilled water and filtered; and again washed with 1 % of NaOH and filtered. The residue was washed with hot distilled water and filtered; and again washed with 1 % of H_2SO_4 and filtered. Finally, the residue was washed with water free acetone.

Drying and combustion: The crucible with its content was dried in a drying oven for 2 hours at 130^0c and cooled for 30 minutes in a desiccators (with granular silica gel), and then weighted (W_1). The crucible was transferred to muffle furnace and heated for 30 minutes at 550^0c. The crucible was cooled in desiccators and weighted (W_2) (AOAC, 2005)

$$\%\ of Crude\ Fiber = \frac{W1-W2}{W3}\ x\ 100$$

Where: W_1= weight of crucible with sample after drying

W_2 = weight of crucible with sample after ashing

W_3 = fresh sample weight

3.6.1.6 Determination of total carbohydrate

The Carbohydrate content was determined by difference (EHNRI, 1998).

Carbohydrate (g/100g) = 100 – (% crude protein + % crude fiber + % total ash+ % crude fat).

3.6.1.7 Determination of gross energy content

The gross energy content was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors; 16.7 kJ/g (4kcal/g) for protein, 37.4 kJ/g (9 kcal/g) for fat and 16.7 kJ/g (4 kcal/g) for carbohydrates and expressed in calories (EHNRI, 1998; Guyot *et al.*, 2007). The mathematical expression of Gross Energy is as follow, and the result is shown in Gross energy (Kcal/100g) = (9 x crude fat %) + (4 x crude protein %) + (4 x carbohydrate %).

$$1KJ/100g = 4.18\ kcal/100\ g$$

3.6.2 Mineral determination

Ash was obtained from dry ashing of food samples (2.50g). The ash was wetted completely with 5 ml of 6N HCl, and dried on a low temperature hot plate. 6ml of 3 N HCl was added to the dried ash and heated on the hot plate until the solution just boils. The ash solution was cooled to the room temperature in a hood and filtered in to 100ml graduated flask using a filter paper (whatman42, 125mm). 5ml of 3 N HCl was added in to each crucible dishes and heated until the solution just boils, cooled, and filtered in to the flask. The crucible dishes were again washed three times with deionized water; the washing was filtered in to the flask. A 5ml of 10% lanthanum chloride solution was added in to each graduated flask. Then, the solution was cooled and diluted to 100ml with deionized water. A blank which contains 11 ml (3 N HCl and 6N of HCl) and deionized water in 100 ml volumetric flask was also prepared.

Standard solutions: four series of working standard metal solution was prepared by appropriate dilution of the metal stock solution (nitrate of the metal) with deionized water containing 2.4ml 3N HCl in 10 ml volumetric flask. After manipulating the instrument operation procedure, calibration graph (concentration versus absorbance) for each element using the prepared standard solutions was prepared.

The sample concentration was analyzed using flame atomic absorption spectrophotometer (Varian SpectraAA-20 plus, Varian Australia Pty., Ltd., Australia) by aspirating deionized water.

Sample blank solution was run with the sample solution. A single mineral hollow cathode lamp was used for each element (Osborne and Voogt, 1978).

Table.2 Standard concentration of minerals

No	Element	Concentration of standard solution, µg/ml
1	Ca	0.00, 1.00, 1.50, 2.00, 2.50
2	Fe	0.00, 0.50, 1.00, 1.50, 2.00
3	Zn	0.00, 0.50, 1.00,1.50, 2.00

$$metal\ content\ (\frac{mg}{100g}) = \frac{[(a-b)x\ V]}{10W}$$

W = weight of sample in gram, a = concentration of sample solution

V = 100ml volume of extract, b = concentration of blank solution

3.6.3 Determination of Anti-nutritional factors

3.6.3.1 Determination of phytate

About 0.0300 g of fresh samples was extracted with 10 ml 0.2N HCl for 1hour at a room temperature. The extract was centrifuged at 3000 rpm for 30 minute (Dynac II centrifuge, Clay Adams, Bacton, Dickinson and cOmpany, USA). The clear supernatant was used for phytate estimation. One ml of Wade reagent (containing 0.03% solution of $FeCl_3.6H_2O$ and 0.3% of sulfosalicilic acid in water) was added to 3 ml of the sample solution (supernatant) and the mixture was mixed on a Vortex for 5 seconds. The absorbance of the sample solutions were measured at 500 nm using UV-VIS spectrophotometer.

A series of standard solutions were prepared containing 0, 4.5, 9, 18, 24, 30 and 36 µg/ml of phytic acid (analytical grade sodium phytate) in 2.4% HCl. Three ml of the standard solution was added into 15ml of centrifuge tubes. Three ml of distilled water was used to serve as standard blank. One ml of the Wade reagent was added to each test tube and the solution was mixed on a

Vortex mixer for 5 seconds. The mixture was centrifuged for 10 minutes and the absorbance of the solutions (both the sample and standard) was measured at 500 nm by using deionized water as sample blank (Latta and Eskin, 1980)

Phytic acid in μg/g = {[(absorbance-intercept)/ (slope x density x weight of sample)] x10}/3

Absorbance = blank absorbance – sample absorbance

3.6.3.2 Determination of tannin:

About 0.5000 g of fresh sample was weighed in screw cap test tubes (in triplicate). The samples were extracted with 10 ml of 1% HCl in methanol for 24 hours at room temperature with a mechanical shaking. After 24 hours shaking, the solution was centrifuged at 1000 rpm for 5 minutes. One ml of supernatant was taken and mixed with 5 ml of Vanillin-HCl reagent (prepared by combining equal volume of 8% concentrated HCl in methanol and 4% Vanillin in methanol).

D-catechin was used as standard for condensed tannin determination. Forty mg of D-catechin Was weighed and dissolved in 100 ml of 1% HCl in methanol, which was used as stock solution. Exactly 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of stock solution was taken in test tubes and the volume of each test tube was adjusted to 1.0 ml with 1% HCl in methanol. Five ml of Vanillin-HCl reagent was added into each test tube.

After 20 minutes, the absorbance of the solutions and the standard solution were measured at 500 nm by using deionized water as blank, and the calibration curve was constructed from a series of standard solution using SPSS Version 15. Concentration of tannin was read in mg of D-catechin Per gm of sample (Maxson and Rooney, 1972).

Tannin in μg/g = [(absorbance-intercept)/ (slope x density x weight of sample)] x 10

Absorbance = sample absorbance – blank absorbance

3.7. Viscosity determination

The apparent viscosity was measured on approximately 45 ml of traditional weaning foods using the sine wave vibro-viscometer A&D SV- 10 (A&D Company Ltd., Japan), which measures viscosity by detecting the driving electric current needed to resonate two sensor plates at a constant frequency of 30 Hz and amplitude of less than 1 mm in AAU of technology. Viscosity measurements were carried out at 25^0C for 2 mins twice. The viscosity was measured in milipascal second (in centipoises, cP).

3.8. Preparation of weaning formula from locally available cereals and legume

3.8.1. Preparation of composite flours

Cereal grain (maize, Sorghum and barley) and broad bean used for this work were purchased from local markets of the Woreda. All the grains and legume samples were manually cleaned by removing manually the ones that were mouldy or broken. Two methods were used for the preparation. For germination, the cereals were soaked separately in potable water for eighteen hours, drained, then germinated at 28^0c for 48 hours and the broad bean was used as shown in the figure. The germinated seeds were rinsed and dried in the sun for 36 hours to facilitate removal of the hulls by mortar (Yewelsew et al., 2006). For roasting, the method was also used as shown in the figure. The dehulled grains and broad bean were milled and placed in a plastic bag for the preparation.

3.8. 2. Flow chart of germination and roasting for the preparation of weaning formula

1- Germination

Maize, Sorghum and barley
↓
Cleaning
↓
Soaking
(18 h, 25-30°C)
↓
Germination
(48 h)
↓
Separation of sprouts
↓
Sun Drying
(36 h)
↓
Grinding
↓
Sieving through a 0.425-mesh screen
↓
Packing
↓
Blending
(75%)

Bean
↓
Cleaning
↓
Separation of husks
↓
Grinding
↓
sieving through a 0.425-mesh screen
↓
Packing
↓
Blending (25%)

The composite flours of the three complementary foods were formulated as follows:

Diet 1: maize: broad bean (75:25: % w/w) (G-Mb)

Diet 2: sorghum: broad bean (75:25 % w/w) (G-Sb)

Diet 3: barley: broad bean (75:25% w/w) (G-Bb)

2 - Roasting

Maize, sorghum and barley
↓
Cleaning,
↓
Roasting
↓
Dehulling
↓
Separation of husks
↓
Grinding
↓
Sieving through a 0.425-mesh screen
↓
Packing
↓
Blending (75%)

Bean
↓
Cleaning
↓
Roasting
↓
Separation of husks
↓
Grinding
↓
Sieving through a 0.425-mesh screen
↓
Packing
↓
Blending (25%)

The composite flours of the three complementary foods were formulated as follows:

Diet 1: maize: broad bean (75:25: % w/w) (R-Mb)

Diet 2: sorghum: broad bean (75:25 % w/w) (R-Sb)

Diet 3: barley: broad n bean (75:25% w/w) (R- Bb)

3.8.3. Blends and Preparations of formulated weaning foods

The blends were formulated based on the protein contents (Solomon, 2005). For the preparation of recipes the ingredients were mixed thoroughly into smooth homogenous powder and then cooked after mixing the powder in cold tap water. The powder concentration and cooking time of the gruels of each formulated complementary foods were made based on Complementary Feeding Recipes for Ethiopian Children 6-23 Months Old, A Practical Cooking and Feeding.

Flour water Ratio	Cooking Time
Maize- broad bean flour = 55g/280ml	10 minutes
Sorghum- broad bean flour = 60g/280ml	10 minutes
Barley- broad bean flour = 40g/280ml	11 minutes

The processed complementary foods were analyzed for their chemical compositions by the standard procedures mentioned above.

3.8.4. Sensory evaluation of formulated weaning foods

Gruels of the six formulated weaning foods were prepared by mixing 15 g of composite flour with 100 ml water and cooked for 10 minutes. Panelists were selected from the staff members and students of Food Science and Nutrition program of Addis Ababa University. The panelists were instructed about the purpose and objective of the test, and those chosen were interested and willing to serve, available during the sensory evaluation period and apparently healthy that means they had no food allergies and/or no frequent illness and nonsmokers.

In the sensory evaluation session, the panelists were seated in an open well illuminated laboratory and the formulated porridges were served by spoon from each weaning food containing glass. Before presenting foods to each panel, the formulated porridges containing glasses were kept in water base at 40°C until tasting completed. The porridges were served with identical transparent glasses coded with 3-digit random numbers. Necessary precautions were taken to prevent bias of tasting by ensuring that consumers rinsed their mouth with water before and after each tasting of sensory evaluation (Inyang And Idoko, 2006).

The panelists were instructed to rank the formulated weaning porridges on the basis of appearance (color), taste, odor and texture (mouth feel) using a nine point hedonic scale. (where 1 = dislike extremely and 9 = like extremely). Overall acceptability of the formulated weaning porridges was also rated on the same scale with 9 = extremely acceptable and 1 = extremely unacceptable (Temple et al., 1996). The formulated porridges were tasted by twenty panelists of 9(45%) males and 11(55%) females and whose ages were between 22-32 years.

3.9. Data management and statistical analysis

Each determination was carried out in triplicate (minerals in duplicate) and results were reported as an averaged value (mean ± standard error). Data was analyzed by the one-way analysis of variance (ANOVA) model using SPSS Version 15.0. Differences between treatments were determined by using Duncan's multiple comparison tests. Statistical significance was set at $p<0.05$.

Chapter 4

4. Results and discussions

4.1. Base line data analysis through questionnaire

4.1.1. Socio demographic information

Table 3. Socio demographic information of mothers and children in three kebeles, 2012

No	Description	Percentage (%)	No	Description	Percentage (%)
1	Age of mothers		6	Educational level of mothers	
	15-25 years	34.88		Illiterate	58.14
	26-35 years	60.47		1- 4 grade	37.21
	36-45 years	4.65		5- 8 grade	4.65
2	Age of infants		7	Educational level of husband	
	6- 9 months	20.93		Illiterate	34.88
	10- 12 months	25.58		1- 4 grade	46.51
	13- 18 months	30.23		5- 8 grade	13.95
	19- 23 months	23.26		9-12 grade	4.65
3	Number of children		8	Land owning	
	One	93.23		Owned	67.44
	Two	6.77		Rented	23.26
4	Ethnic group		9	Land size	
	Gofa	95.35		Less than 0.5 hectare	45.76
	Gamo	2.33		0.6-1 hectare	17.13
	Amhara	2.33		1.1-2.0 hectares	37.11
5	Religion				
	Orthodox	34.88			
	protestant	65.12			

4.1.2. Breast feeding practices and initiation of complementary feeding

Almost all of the children were fed with colostrums. This may be due to the attitudinal change of mothers or societies by the health extension workers in the kebeles. Many infant (70.69%) received breast milk exclusively. But (29.31%) receive fluids other than breast milk like butter, water, fenugreek water, rue water and diluted cow milk.

Table 4. The rate of exclusive breast feeding of three kebeles in 2012

kebeles	Exclusively breastfed	Not exclusively breastfed
Uba Phizgo	26 (74.29%)	9 (25.71%)
Dakisho Subo	27 (71.05%)	11 (28.95%)
Falka Tsawaye	29 (67.44%)	14 (32.56%)
Total	82 (70.69%)	34 (29.31%)

Two women from Falka Tsawaye kebele had given immediately after birth and before the initiation of breastfeeding, the new-born infant butter. This is assumed to relax the throat of the infant. A small amount of water was also given, either mixed with fenugreek, rue or alone by some mothers. Several factors must be considered with regard to supplementary foods: for example, nutrient value, ease of preparation, hygiene, digestibility, and density (Amuna et al., 2000). But the practice of supplementation, frequency, adequacy and consistency of feeding traditional weaning foods needs a great attention in three kebeles.

Breast milk constituted the major part of the infant's diet for about the first 6 months. Breastfeeding was generally continued, together with the provision of cereal-based weaning gruels, until the child was 2 years old. As Osuhor (1980) reported the introduction of complementary foods was between 5-9 months, and thin guinea-corn, millet or maize gruel was mainly used in Hausas. The same thing in Uba Phizgo kebele for example, 3% children received only breast milk until they begin to eat adult foods due to refusal of late introduction of complementary foods. There is a tendency to observe toward early cessation of breastfeeding in 2 women where milk was relatively abundant in Falka Tsawaye kebele and toward prolonged breastfeeding in Uba Phizgo kebele where animal milk was relatively scarce. Prolonged breastfeeding without an appropriate and timely introduction of complementary foods is one of the factors contributing to infant malnutrition. Weaning that begins too early involves the risk of infection; weaning that begins too late leaves the infant with an inadequate intake of nutrients and, thus, is also harmful to his or her growth and development. There are various disadvantages of early weaning. Weaning early in age is harmful in many ways as food and water if not well processed are well recognised vehicles of Diarrhoea infection caused by bacteria, virus and protozoa (Singh, 2010).

The age of introduction of weaning foods, was not the same in three kebeles. It varied considerably with the degree of remoteness from urban areas and the socioeconomic status of the families. In general, infants in the remote area (Falka Tsawaye kebele) started very late from 7 to 10 months of age when compared to other two kebeles. Mothers of Dakisho Subo and Uba Phizgo kebeles had begun relatively at about 6 months. In general, 81.43% were introduced at 6 months, 9.2% were introduced early and 9.37% were introduced late. 16.28% of mothers left their infants to family food at the age between 13 – 18 months. The same thing was reported by Osuhor (1980) the weaning age amongst the Hausas was found to be 12-18 months, rather than between 22-24 months. The reasons for weaning a child were found to include the attainment of the traditional age of weaning, observed normal physical and mental developmental processes, onset of another pregnancy, severe illness and/or death of the mother, and the husbands' unwillingness to observe the traditional abstinence from sexual intercourse during lactation. In this study 83.72% introduced their infants to family food at 19 – 23 months and beyond. When mothers introduce solid foods to their infants after one year, they give gruel conditionally and soon afterwards, the child was introduced to an adult diet, consisting mainly 'kita'(a bread made of unfermented flour mainly from maize or sorghum with moringa), potato, cassava and legumes like kidney bean. Wherever available, butter was added to moringa during the preparation.

4.1.3. Existing local complementary foods, preparation and consumption

Gruels ("ware") in low dry matter consistency and sometimes cow milk were traditional weaning foods used in most households of the three kebeles. The length of weaning foods given was varied as well. Most of the traditional weaning gruels were prepared from a variety of cereals, mainly sorghum, barley, maize, "tef" and wheat. But few mothers of Dakisho Subo kebele used infant diets that were prepared from Enset ('kocho') for children aged one and above.

Figure 3. "Ware" (gruel) preparation of the area

The way of feeding was the same in all three kebeles which did not consider the interest of the child. Mothers pour the very dilute gruel to their hands which was placed at the mouth of the child and when he/she refused they touch his/her nose to drink making not to breathe.

Figure 4. Serving practice of "ware" (gruel)

The responsivelity of the children was most probably loaded on mothers about 93% and the rest were other family members like older children and grand mothers. Since all the kebeles were of rural communities, no electricity and other source of energy, therefore, wood was the common source of energy for cooking traditional weaning gruels.

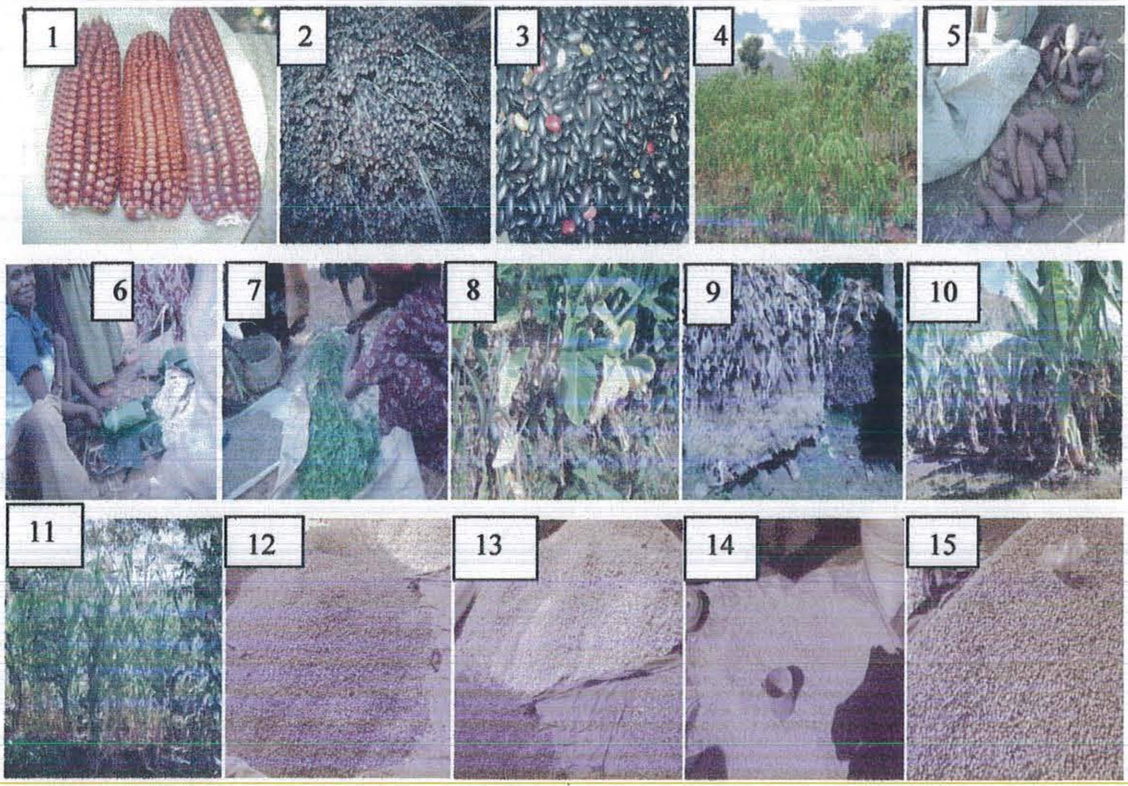
The proportion of ingredients by estimation was used almost in equal proportion of cereals and legume. The amount cooked for a day varies from kebele to kebele as well the amount given; however, in one day averagely children consumed 275 (90 to 460) ml of the gruel ("ware") depending on the age level and interest. Frequency of feeding daily was 3 times by almost all mothers. The source of water used for the preparation of weaning food 86% was tap water and the rest 14% was river. Concerning treating drinking water in the households, the majority (89.7%) did nothing to the water to make it safer to drink. And (69%) households had never been told by extension health workers about how to make water safe to drink. Even though all of the mothers of the three kebeles informed by the health extension workers about washing hands with ash or soap before serving infants, 83% mothers washed hands before feeding children with water only.

The source of most ingredients was garden but some others were obtained from common local markets. Due to 69.77% of households were food insecured, the availability of ingredients throughout the year was limited for different reasons. According to mothers the affordability of ingredients depends on the rain fall condition of the area and when they face shortage they increase the portion of the available ingredient as coping mechanism. House hold salt which was used to cook the meal was not iodized and none of the mothers used in weaning foods. The preparation of the flour was milled by commercial millstone after the ingredients proportioned by the mothers. Concerning the pretreatment, except slightly roasting other effective methods like germination and fermentation were not known to the mothers.

As literature reports, nutrition education can easily be incorporated into primary health care programmes. Health workers and nutritionists can educate rural mothers about the importance of adequate weaning foods and practices, infant health, host defense systems, home-scale drying, processing, and so on. The importance of varying the baby's diet and practicing good hygiene when handling and storing the baby's food can be included as well. The teaching and training of rural mothers can have a long-term impact on weaning practices and nutritional status of children (Onofiok and Nnanyelugo, 1998). Concerning the availability of cow milk, which varied greatly from kebele to kebele, diluted milk and milk products were given from the age of 5 months and continued at least to 1-2 years of age; these feedings take place daily or several times each week in addition to 'ware'.

In the kebeles, taboos exist around certain foods, preventing them being given to infants and young children: cabbage and meat believing that the infant could not chew, honey and sweat things and salt are forbidden, in the belief that it will develop worms. There were also mothers who did not include certain legumes, moringa and cereals, such as kidney bean and wheat, in their infants' diet because of the belief that these legume and moringa will create flatulent and cereals will enlarge the abdomen. Goat milk is believed that if infants consume early ages of life, their bones break easily at later age. Some believe that if infants are introduced earlier, the stool has unpleasant smell. As Onofiok and Nnanyelugo (1998) had suggested that ignorance and food taboos in children can result in weaning foods of poor nutritional quality. Improving the nutritional value of the weaning 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.

Figure 5. Locally growing food crops



1. Maize 2.Sorghum 3.Kideny Bean 4.Cassava plant 5.Sweet Potato 6.Kocho 7.Moringa 8.Godere (tuber) 9.Tef 10.Enset 11.Maize plant 12.Peanut 13.Cassava flour 14.Barley 15.Broad Bean

The major growing cereals and legumes of the three kebeles were maize, sorghum, "tef", barley, broad bean and kidney bean. Even though they had common local and woreda market places; maize, cassava and sweet potato are common to the three kebeles and barley and broad bean were dominantly at Dakisho Subo kebele, as sorghum dominates in Uba Phizgo and Falka Tsawaye kebeles. Vegetables like cabbages and moringa were common to the areas, but they were not commonly used as weaning food and it was true for fruits like mangoes, oranges and tomatoes. Because the concept of preparing infant foods from a mixture of cereals, legumes, and other food items had not yet spread through kebeles of the woreda.

All mothers responded that they were not familiar with factory level complementary foods. Concerning community level complementary foods, 21% of mothers use powders prepared by local women who mixed cereals and legumes and milled in commercial mill and sold at open markets. 17% of mothers were also using powders prepared by micro and small scale enterprises which were obtained from local kiosks and the majority of mothers (87%) prepared the blended cereals and legumes by themselves and milled using commercial mill.

4.2. Proximate composition of traditional weaning foods

Table 5. Proximate composition of traditional weaning foods (g/100 g dry matter).

Type	Dry matter	Protein	Fat	Ash	Fiber	CHO	Energy*
P_1	12.34 ± 0.13^{d}	4.27 ± 0.25^{a}	1.49 ± 0.04^{f}	2.20 ± 0.00^{cd}	3.69 ± 0.01^{e}	88.35 ± 0.45^{b}	383.89 ± 0.13^{g}
P_2	13.76 ± 0.05^{b}	3.82 ± 0.08^{ab}	2.49 ± 0.13^{ab}	1.63 ± 0.04^{e}	4.30 ± 0.14^{d}	87.76 ± 0.79^{bc}	388.73 ± 0.09^{c}
P_3	10.29 ± 0.09^{g}	2.08 ± 0.17^{e}	1.86 ± 0.07^{e}	2.09 ± 0.00^{d}	3.74 ± 0.03^{e}	90.23 ± 0.23^{a}	385.98 ± 0.15^{e}
P_4	10.78 ± 0.06^{f}	3.91 ± 0.08^{c}	2.13 ± 0.01^{de}	2.18 ± 0.24^{cd}	5.02 ± 0.06^{ab}	86.76 ± 0.09^{cd}	381.85 ± 0.17^{i}
D_1	16.69 ± 0.05^{a}	2.66 ± 0.01^{cd}	3.36 ± 0.29^{a}	2.60 ± 0.00^{bcd}	5.10 ± 0.24^{bc}	86.28 ± 0.19^{d}	386.00 ± 0.08^{e}
D_2	10.46 ± 0.08^{g}	2.22 ± 0.09^{de}	2.59 ± 0.05^{ab}	2.49 ± 0.01^{bc}	4.59 ± 0.09^{cd}	88.11 ± 0.43^{b}	384.63 ± 0.11^{f}
D_3	10.94 ± 0.04^{f}	2.71 ± 0.10^{c}	3.51 ± 0.12^{a}	3.10 ± 0.00^{a}	4.32 ± 0.11^{d}	86.36 ± 0.71^{d}	387.87 ± 0.07^{d}
D_4	7.32 ± 0.01^{j}	3.14 ± 0.02^{c}	2.75 ± 0.01^{b}	3.20 ± 0.01^{a}	5.27 ± 0.05^{a}	85.64 ± 0.06^{d}	379.87 ± 0.03^{j}
F_1	12.50 ± 0.05^{c}	3.65 ± 0.11^{b}	2.34 ± 0.00^{cd}	2.09 ± 0.01^{d}	3.86 ± 0.13^{e}	88.06 ± 0.21^{b}	387.90 ± 0.05^{d}
F_2	8.89 ± 0.04^{i}	1.45 ± 0.18^{f}	2.35 ± 0.06^{cd}	2.16 ± 0.06^{d}	5.05 ± 0.07^{ab}	88.99 ± 0.13^{b}	382.91 ± 0.01^{h}
F_3	11.70 ± 0.18^{e}	4.18 ± 0.18^{a}	3.69 ± 0.02^{a}	2.39 ± 0.01^{bcd}	3.01 ± 0.11^{f}	86.73 ± 0.07^{cd}	396.85 ± 0.11^{a}
F_4	9.30 ± 0.06^{h}	4.06 ± 0.26^{ab}	2.27 ± 0.02^{cd}	2.67 ± 0.03^{b}	2.37 ± 0.08^{g}	88.63 ± 0.31^{b}	391.19 ± 0.05^{b}

Values within the same column with different superscript letters are significantly different from each other ($p < 0.05$) * Energy in kcal/100g

P_1, P_2, P_3 and P_4 = samples 1, 2, 3 and 4 of Uba Phizgo kebele; D_1, D_2, D_3 and D_4 = samples 1, 2, 3 and 4 of Dakiso Subo kebele; F_1, F_2, F_3 and F_4 = samples 1, 2, 3 and 4 of Falka Tsawaye kebele

4.2.1. Dry matter

Table 5 showed result of proximate composition of the traditional weaning foods. The mean value of D_1 (16.69±0.05%) had significantly higher ($p < 0.05$) dry matter content and whereas D_4 (7.32±0.01%) had significantly ($p < 0.05$) lower value. As Afolayan et al. (2010) noted that ogi or pap is a semi solid food made from cereals (commonly Sorghum, Maize and Millet) were called by different names such as 'Eko', 'Agidi', 'Akamu', 'Koko' in Nigeria and the service could be very thick as in 'Agidi' - a gel like food with 12-15% dry-matter concentration, or very watery as in 'Koko' – a porridge having 7 -10% dry-matter concentration. The dry matter contents of traditional weaning gruels of the kebeles were comparable to this result.

Mothers add water to the gruel before serving the child to have drinkable consistency. High moisture contents of the traditional weaning gruels affect the energy density of the foods. High moisture content in foods also encourages microbial growth (Compaoré et al., 2010). This is an important consideration in local feeding methods in the area, because most mothers often prepare large quantities of gruels and keep in traditional containers, to avoid frequent processing, in order to have spare time and energy for other domestic activities. Therefore, it is better to increase the energy density with low viscosity using germination which also increases the dry matter content and can provide daily calorie requirement of the infant as the same time can be properly kept, for relatively longer time.

4.2.2. Crude protein

The mean value of P_1 (4.27±0.25%) and F_3 (4.18±0.18%) had significantly ($p < 0.05$) higher crude protein contents and F_2 (1.45±0.18%) had significantly ($p < 0.05$) lower value recorded. In Nigeria the traditional weaning food is a thin cereal gruel (which is deficient in protein) usually made from maize, millet or guinea corn (Sorghum spp) called akamu; 'ogi' or 'koko' depending on the cereal reported by Anigo et al. (2009) which ranged from 1.38±0.30% to 7.16±0.02% in Kebbi state and 2.53±0.03% to 3.15±0.01% in Niger state. Comparable results were obtained from kebeles. The traditional method of their preparation is accompanied by severe nutrient loss which aggravates the poor nutritional quality of the diet, thus leading to a vicious circle of malnutrition and infection, possibly leading to death, resulting in high infant mortality and morbidity amongst weaning age children (Ikpeme-Emmanuel et al., 2009). It was also true for traditional weaning gruels of the kebeles as reported. The low content of protein may be due to the absence of protein rich ingredients or non germinated ingredients as Osman (2007) reported the protein content increases by germination.

If a gruel contained 10% (often gruels contain much lower levels of solids) cereal flour, then an infant may only consume 20 g of flour at each feed of 200 ml. Infants in the developing world may only be fed two or three times a day,' therefore, the maximum quantity of flour eaten would be 60 g per day. Assuming that the average protein content is 8 g/100 g, and then an infant eating only gruel would be receiving 4.8 g of protein per day. At 6 months of age, the RDAs for protein for an infant of 7 kg would be 13.0 g." Thus, a diet consisting only of traditional cereal gruel would be totally inadequate for an infant (Walker and Pavitt, 1989). The protein content of traditional weaning gruels had lower value because for instance, the daily requirement of children 7–12 months is 11 g/day.

4.2.3. Crude fat content

The mean crude fat content of F_3 (3.69±0.02%), D_3 (3.51±0.12%) and D_1 (3.36±0.29%) had significantly higher ($p < 0.05$) values, however, P_1 (1.49±0.04%) had significantly lower value ($p < 0.05$) recorded. When this result compared to (Ketiku and Olusanya, 1986) that ranged from 0.6 g/100 g to 4.6 g/100 g, the Crude fat content of the traditional weaning gruels were also in this range. This result had also similar value with Anigo et al. (2009) Nutrient composition of commonly used complementary foods in North western Nigeria ranged from 0.95±0.36 to 2.93±0.39g/100g.

The mean fat content of the traditional weaning gruels were relatively similar with formulated porridges, and but still did not meet the recommended dietary allowance (RDA). This could be attributed to the absence of oil seeds that were used as ingredient for the gruels. This result does not agree with the recommendations of WHO/FAO (1998) which ranged from 15g to 25 g per day; however, if oils or butter included in foods for infants and children, which will not only increase the energy density, but also be a transport vehicle for fat soluble vitamins. The fat can also provide essential fatty acids like that of n-3 and n-6 Polyunsaturated Fatty Acids (PUFA's) needed to ensure proper neural development (Solomon, 2005).

4.2.4. Crude ash

The mean crude ash content of D_3 (3.10±0.00%) and D_4 (3.20±0.01%) were significantly ($p < 0.05$) higher values and P_2 (1.63±0.04%) had significantly ($p < 0.05$) lower value. P_1 (2.20±0.00%), P_4 (2.18±0.24%), D_1 (2.60±0.00%), D_2 (2.49±0.01%), F_3 (2.39±0.01%) and P_3 (2.09±0.00%) which were comparable to each other or not significantly different. This result agreed with the values reported by Anigo et al. (2009) which ranged from 1.06±0.02% to 2.60±0.41% in Kebbi state and 0.63±0.01% to 3.41±0.46% in Niger state.

4.2.5. Crude fiber

The mean crude fiber content of D_4 (5.27g/100g) had significantly higher ($p < 0.05$) and F_4 (2.37g/100g) had significantly lower ($p < 0.05$) value. This result had higher value compared to the result reported by Anigo et al. (2009) which ranged from 0.65±0.03% to 1.51±0.06% in Kaduna State. The results on the proximate composition of the traditional weaning gruels showed lower value than the findings presented by Afolayan et al. (2010) which reported as 6.3g/100g. The bulkiness of traditional weaning gruels and high concentrations of fiber and inhibitors are major factors reducing their nutritional benefits (Hurrell, 2003). The increased fiber contributed by ingredients required addition of more water during cooking to make porridge of a consistency that the mothers deemed suitable which is another reason for the reduced energy density of the local supplemented foods (Yewelsew et al., 2006).

4.2.6. Total carbohydrate

The mean carbohydrate content of P_3 (90.23±0.23g/100g) had significantly higher ($p<0.05$) value and D_1 (86.28±0.19g/100g), D_3 (86.36±0.71g/100g) and D_4 (85.64±0.06g/100g) had significantly lower ($p<0.05$) values. This result had comparable value with the result reported by Anigo et al. (2009) which ranged from 87.44±0.34g/100g to 96.69±0.62g/100g but had higher value when compared to Ketiku and Olusanya (1986) where eight different multimixes prepared and were analysed for their nutrient contents and the values ranged from 72.8 g/100 g to 82.1 g/100 g. This was expected as these diets were the nonprotein diets as the result showed. The carbohydrate content of the reference children 7–12 months is 95g/day and this could be achieved since the traditional weaning gruels made of cereal sources.

4.2.7. Gross energy

The Gross energy value of traditional weaning gruels D_4 (396.85±0.11) had significantly higher ($p<0.05$) value and D_4 (379.87±0.03) had significantly lower ($p<0.05$) value. To understand whether the infant consumed enough weaning foods to satisfy daily calorie requirements, the dry matter content and the nutritional value of the gruel are very important. If a gruel contained 10% (often gruels contain much lower levels of solids) cereal flour, then an infant may only consume 20 g of flour at each feed of 200 ml. Infants in the developing world may only be fed two or three times a day,' therefore, the maximum quantity of flour eaten would be 60 g (600ml. which is impossible the infant to consume) per day. Assuming that the average energy content of the flour is 1464 kJ/100 g or 350.24kcal/100g, and then an infant eating only gruel would be receiving 878.40 kJ or 210.05kcal/100g of energy per day. At 6 months of age, the RDAs for energy for an infant of 7 kg would be 770.34kcal or 3220 kJ." Thus, a diet consisting only of traditional cereal gruel would be totally inadequate for an infant (Walker and Pavitt, 1989). Energy requirements from complementary foods are 200kcal, 300kcal and 550kcal for ages 6 - 8, 9 -11 and 12 -23 months respectively (Lutter and Dewey, 2003). For instance, the total energy requirement of reference child of 7 month is 688 and the traditional weaning gruels contained lower energy value.

WHO/UNICEF (1998) have also recommended that foods fed to infants and children should be energy-dense ones. This, according to the recommendation, is necessary because low energy foods tend to limit total energy intake and the utilization of other nutrients. However, the total calculated energy values of the traditional weaning gruels fell below the RDA level. This suggests that infants may have to consume more quantities of the diets to meet their energy needs, which is often an impossible task considering the size of their stomach (Solomon, 2005). Therefore, increasing the dry matter content, formulating with high energy density and lowering the viscosity of the weaning foods may be necessary to achieve the daily calorie requirement of the infant.

4.3. Mineral content of traditional weaning foods

Table 6. Mineral content of traditional weaning foods (on dry matter).

Sample type	Ca in mg/100g	Fe in mg/100g	Zn in mg/100g
D_1	128.82 ± 1.07^{b}	26.67 ± 0.30^{c}	2.76 ± 0.02^{a}
D_2	129.24 ± 1.63^{b}	39.95 ± 0.10^{a}	2.03 ± 0.01^{b}
P_1	41.43 ± 1.44^{e}	24.92 ± 0.46^{d}	0.99 ± 0.02^{d}
P_3	55.63 ± 0.54^{d}	24.80 ± 0.57^{e}	0.74 ± 0.01^{e}
F_1	148.85 ± 0.35^{a}	31.89 ± 0.63^{b}	1.54 ± 0.05^{c}
F_3	86.90 ± 0.26^{c}	24.80 ± 0.82^{e}	0.75 ± 0.04^{e}

Values within the same column with different superscript letters are significantly different from each other ($p < 0.05$)

D_1 and D_2 = samples 1, 2, 3 and 4 of Dakiso Subo kebele; P_1 and P_3 = samples 1, 2, 3 and 4 of Uba Phizgo kebele; F_1 and F_3 = samples 1, 2, 3 and 4 of Falka Tsawaye kebele

4.3.1. Calcium

The mean calcium content of F_1 (148.85mg/100g) had significantly higher ($p < 0.05$) value and P_1 (41.43±1.44mg/100g) had significantly lower ($p < 0.05$) value. This result was comparable to the Calcium amount reported by Anigo et al. (2009) which ranges from 31.90mg/100g to 87.11mg/100g; the value reported by Toure et al. (2007) which was 139.15±0.03mg/100g but lower than RDA value 400mg/100g for children up to one year. The high content of anti-nutritional factors and poor bioavailability of minerals in plant-based foods as well as losses during processing play a vital role in micronutrient deficiency. It is therefore obvious that even the low calcium contents in the local diets may not be available or utilized completely by the child (Solomon, 2005). The calcium content of reference children of 7–12 months is 270 mg/day and when compared to this value the traditional weaning gruels contained lower calcium content.

4.3.2. Iron

The mean iron content of traditional weaning gruels showed D_2 (39.95mg/100g) had significantly higher ($p < 0.05$) value whereas P_3 (24.80±0.57mg/100g) and F_3 (24.80±0.82mg/100g) significantly lower ($p < 0.05$) values. This result had comparable value with Anigo et al. (2009) which ranges from 17.82mg/100g to 33.88mg/100g in North Western Nigeria. The traditional weaning gruels were observed to be higher in iron contents when compared to Toure et al. (2007) which was reported as 3.60±0.005mg/100g and also higher relative to the RDA's which is 6mg/100g for the children up to one year. But the high content of anti-nutritional factors and poor bioavailability of minerals in plant-based foods as well as losses during processing play a vital role in micronutrient deficiency (Solomon, 2005). The traditional weaning gruels had lower iron content for example; the RDA value of children 7 - 12 months is 11 mg/day.

4.3.3. Zinc

From the laboratory result the Zn content of D_1 (2.76mg/100g) had significantly higher ($p < 0.05$) value and P_3 (0.74mg/100g) and F_3 (0.75mg/100g) had significantly lower ($p < 0.05$) values recorded. This result had comparable value to Frontela et al. (2008) reported in the range 0.61 to 1.240mg/100g. The result had lower value when compared to Anigo et al. (2009) which ranges from 4.16mg/100g to 7.47mg/100g. The traditional weaning gruels were observed to be lower in zinc contents relative to the RDA's which is 5mg/100g for the children up to one year. Cereals and tuber-based foods constitute the main staples for most populations of the world at risk of micronutrient deficiencies (FAO/WHO, 2001) which is what was showed by this study. A lack of sufficient micronutrients in the diet affects the health and development of children and results in potentially life-threatening deficiency diseases (FAO, 2001). The zinc content of traditional weaning gruels had lower value when compared to the RDA value for a child 7–12 months is 3 mg/day.

4.4. Anti-nutritional factors of traditional weaning foods

Table 7. Phytic acid and condensed tannin concentration of traditional weaning foods (on dry matter).

Sample code	Phytate in mg/100g	Tannin in mg/ 100g
D_1	261.24±1.28[b]	33.92±0.09[e]
D_2	299.36±4.16[a]	81.69±0.15[a]
P_1	237.94±2.13[c]	52.22±0.38[d]
P_3	239.58±1.78[c]	34.82±1.04[e]
F_1	255.03±0.47[b]	58.36±2.07[c]
F_3	299.70±1.72[a]	63.67±1.49[b]

Values within the same column with different superscript letters are significantly different from each other ($p< 0.05$)

D_1 and D_2 = samples 1, 2, 3 and 4 of Dakiso Subo kebele; P_1 and P_3 = samples 1, 2, 3 and 4 of Uba Phizgo kebele; F_1 and F_3 - samples 1, 2, 3 and 4 of Falka Tsawaye kebele

4.4.1. Phytic acid in traditional weaning foods

The mean phytic acid content of D_2 (299.36mg/100g) and F_3 (299.70mg/100g) were significantly ($p < 0.05$) higher value while P_1 (237.94mg/100g) and P_3 (239.58mg/100g) had significantly ($p < 0.05$) lower values. This results had similar value with Tizazu et al. (2010) reported the phytic acid content in blended sorghum-based complementary foods using germination. But it had much higher value when comparable to Anigo et al. (2009) ranged from 0.04±0.01mg/100g to 0.12±0.02mg/100g. This may be due to the fermented ingredients lowered the phytate content or the type of ingredients used made a difference. According to Almana (2000) the food recipes and baking conditions or cooking procedures are the main factors that affect the extent of phytate degradation. Anti-nutrients are known to reduce the maximum utilization of nutrients especially proteins, vitamins, and minerals (Ugwu and Oranye, 2006). So that, the levels of anti-nutritional factors in the cereal based traditional weaning foods are important in the assessment of its nutritional status.

4.4.2. Condensed Tannin in traditional weaning foods

The mean tannin content of traditional weaning gruels showed D_2 (81.69mg/100g) were significantly ($p < 0.05$) higher value whereas D_1 (33.92mg/100g) and P_3 (34.82mg/100g) had significantly ($p < 0.05$) lower value. This result had comparable value with the result reported by Anigo et al. (2009) ranged from 23.76±11.59mg/100g to 68.83±5.79mg/100g in Kebbi State. Tannins have the ability to precipitate certain proteins they combine with digestive enzymes thereby making them unavailable for digestion (Abara, 2003). Tannins are polyhydric phenols which form insoluble complexes with proteins, carbohydrates, and lipids leading to reduction in digestibility of these nutrients. Other effects that have been attributed to tannins include damage to the intestinal tract and interference with the absorption of iron and a possible carcinogenic effect (Ekop et al., 2008).

4.5. Viscosity measurement of traditional weaning foods

Table 8. Viscosity measurement of traditional weaning gruels

sample	Viscosity (mpa.s/ cp)
D_1	30.06 ± 0.12^{a}
D_2	7.69 ± 0.07^{c}
D_3	9.10 ± 0.06^{b}
P_1	4.21 ± 0.01^{ef}
P_2	4.68 ± 0.03^{e}
P_3	5.53 ± 0.04^{d}
F_1	7.58 ± 0.20^{c}
F_2	3.87 ± 0.50^{f}
F_3	3.88 ± 0.30^{f}
F_4	9.14 ± 0.40^{b}

Values in the column with different superscript letters are significantly different from each other ($p< 0.05$)

D_1, D_2 and D_3 = samples 1, 2, 3 and 4 of Dakiso Subo kebele; P_1, P_2 and P_3 = samples 1, 2, 3 and 4 of Uba Phizgo kebele; F_1, F_2, F_3 and F_4 = samples 1, 2, 3 and 4 of Falka Tsawaye kebele

The viscosity of traditional weaning gruels had much lower value. This may be due to low content of dry matter. F_2 and F_3 had significantly lower ($p < 0.05$) viscosity measurement. On other hand side, the viscosity measurement of D_1 was significantly higher ($p < 0.05$) value. This results had almost similar value with Joung et al. (2003) reported 9.92± 2.14 cp the viscosity of brown rice gruel in the Korean Diet. This analysis result had also comparable value with Coda et al. (2011) which the viscosity of beverage ranges from 1.35 to 30.5 cp using the same instrument for measurement. But the dry matter contents of beverages were higher than traditional weaning gruels because of fermentation which decreases the viscosity even with the same dry matter content.

Actually, porridges play an important role in the weaning diets of children in most developing countries but their energy density is often low because large volumes of water are added during preparation to achieve a thin, drinkable consistency. Infants may not be able to consume sufficient quantities of these porridges to meet their energy requirements (Stephenson et al., 1994). All traditional weaning foods tend to be in the form of a gruel made from the local staples (maize, sorghum, barley, oat, tef, enset and some legumes) which were mainly carbohydrate sources.

When a slurry of starch granules in water is heated beyond a critical temperature, the gelatinization temperature, the granules swell and the starch polysaccharides, amylose and amylopectin, are released and become solubilized. The resulting viscous paste is a dispersion of the swollen gelatinized starch granules in a macromolecular viscous solution. The type of starch, the amylose/amylopectin proportion, starch concentration and temperature all have effects on the rheological behaviour of the starch pastes (Nguyen et al., 1998). Therefore, the viscosity parameters during pasting are cooperatively controlled by the properties of the swollen granules and the soluble materials leached out from the granules (Sandhu and Singh, 2006).

For the state of development of the structures of the mouth in the young child is such that only a gruel of fluid consistency can be swallowed without shocking. Hence there is a limit to which the gruel can be thickened and consequently most traditional weaning gruels do not contain more than 10 -12% of flour. The rest is water (Ebrahim, 1983).

4.6. Proximate composition of Formulated weaning foods

Table 9. Proximate composition of formulated weaning foods (g/100 g dry matter).

Type	Dry matter	Protein	Fat	Ash	Fiber	CHO	Energy*
G-Mb	19.41±0.16^{c}	15.81±0.29^{a}	4.03±0.03^{a}	2.28±0.06^{c}	1.96±0.02^{e}	75.92±0.06^{f}	403.19±0.07^{a}
G-Sb	19.87±0.15^{b}	11.99±0.27^{c}	2.63±0.03^{c}	2.38±0.02^{abc}	2.66±0.05^{c}	80.34±0.04^{c}	392.99±0.03^{c}
G-Bb	19.15±0.40^{d}	11.48±0.05^{c}	2.03±0.05^{d}	2.57±0.02^{a}	3.91±0.01^{b}	80.01±0.02^{d}	384.23±0.04^{e}
R-Mb	19.36±0.16^{c}	14.04±0.10^{b}	3.83±0.07^{b}	2.26±0.01^{abc}	2.51±0.03^{d}	77.36±0.09^{e}	400.07±0.01^{b}
R-Sb	20.08±0.09^{a}	11.33±0.03^{de}	2.00±0.01^{d}	2.32±0.01^{bc}	2.74±0.04^{c}	81.61±0.03^{a}	389.76±0.03^{d}
R-Bb	19.19±0.50^{d}	10.81±0.01^{e}	1.48±0.03^{e}	2.54±0.01^{ab}	4.04±0.02^{a}	81.13±0.07^{b}	381.08±0.02^{f}

Values within the same column with different superscript letters are significantly different from each other ($p < 0.05$)

* Energy in kcal/100g

The porridge prepared from: G-Mb = germinated maize and broad bean flour; R-Mb = roasted maize and broad bean flour; G-Sb = germinated sorghum and broad bean flour; R-Sb = roasted sorghum and broad bean flour, G-Bb = germinated barley and broad bean flour and R-Bb = roasted barley and broad bean flour

4.6.1. Dry matter

Table 9 showed result of proximate composition of the formulated complementary porridges from germinated and roasted cereal-legume blends. The mean value of R-Sb (20.08±0.09%) had significantly higher ($p < 0.05$) dry matter content and G-Bb (19.15±0.40%) had significantly lower ($p < 0.05$) dry matter content. This result was comparable to Nout and Ngoddy (1997) to supply daily 717.70kcal or 3000 kJ of energy in four feedings of 250 ml each, weaning food porridge must have approximately 20% dry matter content for the development of complementary foods on the nutritional requirements of children aged 6-12 months.

The germinated blends were as thin porridge of traditional weaning gruels when compared to roasted blends. As Onofiok and Nnanyelugo (1998) reported germination can improve the nutritional value of weaning foods by reducing the water-binding capacity of cereal flour. This allows the porridge to have a free-flowing consistency even with a high proportion of flour. Germination also converts insoluble proteins to soluble components and increases the levels of some essential amino acids as well as vitamins. The dry matter contents of the formulated complementary porridges ranged from 19.15±0.40% to 20.08±0.09%. When compared to 7.32±0.01% to 16.69±0.05% as observed in traditional weaning gruels commonly used as complementary foods in the kebeles and this can be an improvement in the nutrient density of the complementary foods which may lead to improved nutrient intake which means more nutrients for same quantity taken and may contribute to solving the problem of malnutrition.

FAO (2001) reported that staple foods such as millet, maize and sorghum are high in starch hence absorbed a lot of water during cooking which make them bulky hence infants need to consume large quantities to get enough energy and nutrients but it is difficult because they have small stomach but the problem is solved if families feed children with weaning foods prepared from germinated cereal flour and enrich bulky foods. Malting reduces viscosity of the foods and hence a child can eat more at a time (Ikujenlola and Fashakin, 2005).

4.6.2. Crude protein

The mean crude protein content of G-Mb (15.81±0.29%) was significantly ($p < 0.05$) higher value but R-Bb (10.81±0.01%) had significantly ($p < 0.05$) lower value. The crude protein values obtained from some (except G-Mb and R-Mb) formulated complementary porridges were lower than RDA value 13 to 14 g (Guthrie, 1989) recommended for infants up to one year. But this value even may be able to meet 80% of the RDA's. However, concentrations of crude protein in the formulated complementary porridges were much higher than traditional weaning gruels whose protein content ranged from 1.45±0.18% to 4.27±0.25%. The mean content of crude protein of formulated complementary porridges were higher than the value reported by Anigo et al. (2010) ranged from 6.37 ± 0.23 to 7.88 ± 0.28g/100 g Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. From the analysis, germinated blends in comparison with roasted blends in each pair showed higher protein contents. This could be explained by the inclusion of enzymes during germination. But all the six formulated porridges can be recommended for infant feeding due to their positive contribution to protein nutrition levels.

4.6.3. Crude fat

The mean Crude fat content of G-Mb (4.03±0.03%) was significantly higher ($p < 0.05$) value and R-Bb (1.48±0.03%) had significantly lower ($p < 0.05$) value. This result had comparable value with Anigo et al. (2010) whose value ranged from 1.05% to 2.06%. The fat content of the formulated porridges were relatively comparable to the traditional weaning gruels, but does not meet the recommended dietary allowance (RDA). This could be attributed to the absence of fat containing ingredients in the formulated foods.

4.6.4. Crude ash

The mean ash content of G-Bb (2.57±0.02%) was significantly ($p < 0.05$) higher value when compared to G-Mb (2.28±0.06%) and G-Sb (2.38±0.02%). This result had comparable value with Solomon (2005) the result ranged from 2.05% to 2.60%. It had also similar value reported by Anigo et al. (2010) which ranged from 1.03% to 2.69%. The result had also comparable value with the traditional weaning gruels.

4.6.5. Crude fiber

The mean Crude fiber content of R-Bb (4.04±0.02%) was significantly higher ($p < 0.05$) value and G-Mb (1.96±0.02%) had significantly lower ($p < 0.05$) value. The crude fiber content was much lower than that reported by Solomon (2005) which ranged from 9.07% to 10.8% but it was higher than the value reported by Anigo et al. (2010) which ranged from 0.99% to 1.74%. This difference may be due to the use of different ingredients as well as proportions in formulations. The crude fiber content of G-Bb (3.91%) and R-Bb (4.04%) had relatively higher value when compared to others. This may be due to the higher fiber content of barley than sorghum and maize. The crude fiber content of formulated weaning porridges had relatively lower value when compared to traditional weaning gruels. The difference might be due to the degree of dehulling and the removal of some water-soluble oligosaccharides such as the raffinose families and the indigestible carbohydrates.

4.6.6. Total carbohydrate

The total carbohydrate content of R-Sb (81.61%) was significantly higher ($p < 0.05$) value and G-Mb (75.92%) had significantly lower ($p < 0.05$) value. This result had higher value when compared to Essien et al. (2010) which ranged from 34.10g/100g to 79.10g/100g but lower value compared to Anigo (2010) which reported as 88.75g/100g to 90.89g/100g. When compared to traditional weaning gruels it had lower value. This finding was also similar with the result reported by Egounlety (2002) and ranged from 71.11- 83.39g/100g of for nutritive value of high-protein-energy legume-fortified weaning flours. The high carbohydrate content of the formulations was due to the high carbohydrate content in the cereals that were the principal ingredients in the formulations (Kanu et al., 2009).

4.6.7. Gross energy

The gross energy content of G-Mb (406.95±0.07g/100g) had significantly ($p < 0.05$) higher value when compared to R-Bb (391.24±0.02g/100g) which had significantly lower ($p < 0.05$) value. The energy content of traditional weaning gruels and formulated porridges prepared from low cost locally available ingredients was comparable in dry matter base. But we can determine the daily calorie requirement of the infant from actual consumption of the gruel/ porridge. Assuming 250ml of the gruel is consumed by the infant daily, for example, D_4 (7.32±0.01g/100g) dry matter has 18.3g dry matter content. For formulated porridge R-Sb (20.08±0.09g/100g) had 50.2g dry matter content. When the energy content of traditional weaning gruels and formulated porridge from low cost locally available ingredients, using the conversion factor 7.32/100 and 20.08/100 become 379.87 x 7.32/100 = 27.81kcal and 389.76 x 20.08/100 = 78.26kcal respectively. Therefore, having 250ml gruel/porridge daily consumption the infant will get 69.53kcal from traditional weaning gruels which were much lower than RDA 200kcal and 195.65kcal from formulated porridge which had comparable value to RDA recommendation for infants 6 to 9 months.

As WHO/UNICEF (1998) recommended foods fed to infants and children should be energy-dense ones. This, according to the recommendation, is necessary because low energy foods tend to limit total energy intake and the utilization of other nutrients. However, the total calculated energy values of the formulated weaning porridges fell slightly below the RDA level. This suggests that infants may have to consume more quantities of the formula to meet their energy needs, which is often an impossible task considering the size of their stomach (Solomon, 2005). Therefore, reformulation of the formulated porridges may be necessary to increase the fat content of the formulas incorporating fat rich plant sources, which is particularly low in formulated weaning porridges.

4.7. Mineral contents of formulated weaning foods

Table 10. Mineral contents of formulated weaning foods (on dry matter).

Sample type	Ca in mg/100g	Fe in mg/100g	Zn in mg/100g
G-Mb	15.38 ± 0.41^{f}	12.26 ± 0.51^{c}	1.72 ± 0.06^{c}
G-Sb	56.61 ± 0.70^{a}	17.20 ± 0.54^{a}	5.18 ± 0.92^{a}
G-Bb	35.73 ± 0.61^{c}	17.87 ± 0.29^{a}	1.80 ± 0.00^{c}
R-Mb	23.94 ± 0.37^{e}	8.60 ± 0.09^{d}	2.39 ± 0.00^{bc}
R-Sb	28.42 ± 0.66^{d}	15.07 ± 0.42^{b}	1.99 ± 0.08^{c}
R-Bb	44.20 ± 0.46^{b}	11.71 ± 0.40^{c}	3.68 ± 0.20^{b}

Values within the same column with different superscript letters are significantly different from each other ($p < 0.05$)

The porridge prepared from: G-Mb = germinated maize and broad bean flour; R-Mb = roasted maize and broad bean flour; G-Sb = germinated sorghum and broad bean flour; R-Sb = roasted sorghum and broad bean flour, G-Bb = germinated barley and broad bean flour and R-Bb = roasted barley and broad bean flour

4.7.1. Calcium

Calcium concentrations showed that G-Sb (56.61mg/100g) which had significantly ($p < 0.05$) higher value. Whereas G-Mb (15.38mg/100g) had significantly ($p < 0.05$) lower value. The Calcium content of three formulations was comparable with the value reported by Solomon (2005) the nutritive value of three potential complementary foods based of cereals and legumes which ranged from 31.0mg/100g to 185.6mg/100g and the result was comparable to the value reported by Elemo et al. (2011) ranged from 32.63 to 33.39mg/100g. In another paper eight different multimixes prepared and were analysed for their nutrient content by Ketiku and Olusanya (1986), Calcium content was ranged from 9.2 mg/100 g to 48.5 mg/100 g and this had also comparable result. The result had also comparable value with Anigo et al. (2010) which ranged from 27.68mg/100g to 47.95mg/100g. The calcium contents were lower in formulated weaning porridges compared to traditional weaning gruels. The low concentration of calcium in formulated weaning porridges may be due to the limited blends of ingredients or the traditional weaning gruels contained calcium from other sources like water. Or this decrease was observed due to the degree of removal of outer layer of the grains because bran contains major portion of the minerals (Rehman et al, 2006). Solomon (2005) reported that Foodstuffs and water used in the preparation of complementary foods must be properly processed and treated respectively in order to reduce the level of goitrogens, and water pollutants.

4.7.2. Iron

The result also indicated that the mean iron content of G-Bb (17.87mg/100g) and G-Sb (17.20mg/100g) were significantly ($p < 0.05$) higher while R-Mb (8.60mg/100g) had significantly ($p < 0.05$) lower value. The iron content of formulations was higher value compared to Solomon (2005). This research result had higher value when compared to Ketiku and Olusanya (1986) which ranged from 1.2 mg/100 g to 3.6 mg/100 g. This result was also comparable with the value reported by Eshun et al. (2011) which ranged from 10.78mg/100g to 19.42mg/100g. The result was higher when compared to the value reported by Elemo et al. (2011) ranged from 4.01 to 6.40mg/100g. The iron content of formulated weaning porridges was lower than that of traditional weaning gruels. This difference may be due to the degree of removal of outer layer of the grains because bran contains major portion of the minerals (Rehman et al, 2006). Or as Park and Brittin (2000) reported Cooking food in iron utensils increased iron in food.

4.7.3. Zinc

There were significant differences ($p < 0.05$) in Zinc content of G-Sb (5.18mg/100 g) which had higher value and G-Mb (1.72mg/100 g) that had lower value. The zinc content of formulations was comparable to Solomon (2005) the value recorded as 1.01mg/100g to 2.08mg/100g). This research result had also comparable value with Compaoré et al. (2010) nutritional properties of enriched local complementary flours but was lower than the RDA value that is 5mg/100g for children up to one year. Some results of this paper were also comparable with the value reported by Elemo et al. (2011) ranged from 3.69 to 4.10mg/100g. The zinc content of formulated weaning porridges was higher than the traditional weaning gruels. This may be due to the extent of binding ability depends on the affinity of phytate to bind with minerals which depend on the valency of cations, which increases from mono to multivalent cations (Na^{+}, Zn^{2+}, Fe^{3+}) (Persson et al.,1998). As Afsana et al. (2004) also reported that the dietary tannic acid did not decrease zinc, copper and manganese, in contrast to the clear reduction in iron absorption.

4.8. Anti-nutritional factors of formulated weaning foods

Table 11. Phytic acid and condensed tannin concentration of formulated foods (on dry matter).

Sample code	Phytate in mg/100g	Tannin in mg/100g
G-Mb	191.61 ± 0.87^{f}	12.55 ± 0.54^{d}
G-Sb	218.56 ± 2.24^{e}	41.45 ± 0.57^{a}
G-Bb	228.86 ± 1.82^{d}	25.89 ± 0.68^{c}
R-Mb	254.31 ± 1.93^{b}	14.60 ± 0.45^{d}
R-Sb	244.47 ± 3.58^{c}	32.51 ± 0.92^{b}
R-Bb	269.75 ± 2.57^{a}	15.11 ± 1.02^{d}

Values within the same column with different superscript letters are significantly different from each other ($p < 0.05$)

The porridge prepared from: G-Mb = germinated maize and broad bean flour; R-Mb = roasted maize and broad bean flour; G-Sb = germinated sorghum and broad bean flour; R-Sb = roasted sorghum and broad bean flour, G-Bb = germinated barley and broad bean flour and R-Bb = roasted barley and broad bean flour

4.8.1. Phytic acid in formulated weaning foods

Levels of antinutrients in the formulated complementary porridges revealed that R-Bb (269.75 mg/100g) had significantly higher ($p < 0.05$) phytate concentration while G-Mb (191.61mg/100g) had significantly lower ($p < 0.05$) phytate concentration. This result had comparable value to Frontela et al. (2008) reported on the Effect of roasting on the inositol phosphates content in raw flours and infant cereals which ranged from 45.4±0.9 to 300.8±5.1mg/100g. The germinated formulated weaning porridges had lower phytate content than the traditional weaning gruels this may be due to the a pronounced increase in phytase activity accompanied with a decrease in phytic acid content by germination (Tajoddin et al., 2011) but the roasted blends had similar phytate content. For the pre treatment of cereals and legumes, germination was effective than roasting as the result showed. As Bau et al. (1997) the removal of phytate from cereals and legumes during germination is attributed to enzymatic hydrolysis of phytate followed, by diffusion.

Phytates strongly inhibit iron absorption in a dose dependent fashion, though small amounts of phytates have a marked effect but germination has been reported (Anigo et al., 2010) to reduce the concentration of antinutritional factors like phytates in malted grains hence improves its nutritional quality. Decrease in phytic acid has been attributed to leaching-out effect during hydration (Beleia et al., 1993). The soaking medium enhances loss of phytate and increases ionic concentration (Van der Poel, 1990).

The mean phytate content of R-Bb (269.75±2.57) roasted barley- bean blend had significantly higher ($p < 0.05$) concentration and can be undesirable in the diet as phytate binds essential, nutritionally- important divalent cations, such as, iron, zinc, magnesium and calcium and forms insoluble complexes, making the minerals unavailable for absorption (Van der Poel, 1990). Actually, roasting had also shown a decrease in phytic acid concentration when compared to traditional weaning gruels. The apparent decrease in phytate during hydrothermal processing of legume seeds is attributed to formation of insoluble complexes between phytate and other components such as phytate-protein and phytate-protein-mineral complexes or to hydrolysis of inositol hexaphosphate to penta- and tetra phosphates (Bau et al., 1997).

4.8.2. Condensed Tannin in formulated weaning foods

The tannin concentration of G-Sb (41.45mg/100g) had significantly higher ($p < 0.05$) value while G-Mb (12.55mg/100g), R-Mb (14.60mg/100g) and R-Bb (15.11mg/100g) had significantly lower ($p < 0.05$) value. This results had comparable value with Anigo et al. (2010) reported which ranged from 12.95±5.79mg/100g to 59.27±9.46mg/100g. An enzymatic hydrolysis by polyphenolase causes loss of tannins in grains during germination (Sangronis and Machado, 2007) and therefore, the tannin concentration of the formulated porridges had shown lower value when compared to the traditional weaning gruels.

Reduction of polyphenols during roasting could be attributed to thermal degradation and denaturation, changes in chemical reactivity or to formation of insoluble complexes during heating (Siddhuraju and Becker, 2001), this may be the possible reason observed in this study. Tannins are known to inhibit the activities of digestive enzymes and nutritional effects of tannin are mainly related to their interaction with protein. Tannin protein complexes are insoluble and the protein digestibility is decreased (Bello et al., 2008).

4.9. Sensory results for acceptance taste

Table 12. Sensory results for acceptance taste

Sample Code	Taste	Colour	Aroma	Texture	Overall Acceptability
G-Mb	6.15±0.23 [ab]	6.80±0.36 [abc]	6.45±0.36 [b]	6.30±0.28 [c]	6.55±0.29 [b]
G-Sb	5.65±0.34 [b]	6.55±0.29[bc]	6.20±0.28 [b]	6.40±0.25 [c]	6.55±0.28 [b]
G-Bb	6.10±0.36 [ab]	7.30±0.29 [ab]	6.25±0.31 [b]	6.60±0.34[bc]	6.85±0.31 [b]
R-Mb	6.30±0.29 [ab]	7.25±0.22 [ab]	6.95±0.35 [ab]	7.25±0.20 [ab]	7.20±0.29 [ab]
R-Sb	5.80±0.25 [b]	6.25±0.38 [c]	6.95±0.24 [ab]	7.00±0.31 [abc]	7.25±0.28 [ab]
R-Bb	6.85±0.31 [a]	7.55±0.29 [a]	7.70±0.21 [a]	7.70±0.18 [a]	7.75±0.26 [a]

Values within the same column of each attribute with different superscript letters are significantly different from each other ($p < 0.05$)

The porridge prepared from: G-Mb = germinated maize and broad bean flour; R-Mb = roasted maize and broad bean flour; G-Sb = germinated sorghum and broad bean flour; R-Sb = roasted sorghum and broad bean flour, G-Bb = germinated barley and broad bean flour and R-Bb = roasted barley and broad bean flour

The taste of roasted barley and bean blend (R-Bb) porridge was liked moderately by panelists whereas germinated sorghum and bean blend porridge (G-Sb) and roasted sorghum and bean blend porridge (R-Sb) were liked slightly. The color of the porridge made from roasted barley and bean flour (R-Bb) was most preferred (like very much) by the panelists, while the porridge prepared from roasted sorghum and bean blend flour (R-Sb) was least preferred (liked slightly). For Aroma, highest score was obtained for porridge prepared from roasted barley and bean flour (R-Bb) (liked very much) and the porridge prepared from germinated sorghum and bean blend flour (G-Sb) was least preferred (liked slightly). Panelists liked slightly the aroma of porridge prepared from all the germinated blends and the porridge prepared from roasted blends were preferred relatively (liked moderately and liked very much).

Texture for the roasted barley and bean (R-Bb) porridge was most preferred (liked very much) by panelists. The texture of porridge prepared from germinated maize and bean blend (G-Mb) and germinated sorghum bean blend (G-Sb) flour were least preferred (both liked slightly). Overall acceptability of porridge prepared from roasted barley and bean blends (R-Bb) flour was most accepted (liked very much). For acceptability, porridges prepared from all germinated blends were least acceptable (liked moderately).

The sensory quality of roasted blends of formulated complementary porridges was more acceptable when compared to the germinated blends of formulated weaning porridges. According to Compaoré et al. (2011) the so-called physical attributes of products are key measures of quality, including the sensory or organoleptic parameters such as color, aroma, consistency and texture, plus appearance (size, weight, packaging condition, conditions of use, and hygiene) and overall acceptability using standard methods. Infants have many other needs, of course, but the simple availability of sufficiently dense and digestible nutrients can be a limiting factor on child growth and development (William et al., 2011). Therefore, feeding infants with improved complementary foods as formulated in this study for children in the kebeles may cause improvement in their growth.

Chapter 5

5. Conclusion and Recommendation

5.1. Conclusion

- The common weaning food given for the children in three kebeles was a gruel made of cereals in different dry matter consistency.
- The frequency of feeding was three times and the amount given daily varies from 90ml to 460ml depending on the age and the interest of the children.
- The way of serving gruel was shocky and generally did not consider the principles of responsive feeding methods completely.
- The traditional weaning gruels had showed lower crude protein since it is cereal based and lower energy density due to the inclusion of large amount of water intended to have thin drinkable consistency.
- There was improvement in the protein quality of the formulated complementary foods with good acceptability comparable to that commonly used in the kebeles which can contribute to the reduction of malnutrition in children.
- The results of this study showed that formulated weaning porridges contained appreciable quantity of crude Protein, carbohydrate, energy, crude fiber, zinc and low levels of antinutrients (phytic acid and tannin) when compared to traditional weaning gruels.
- This study also indicated that formulated weaning porridges from germinated blends had relatively higher protein contents but panels accepted more the roasted blends in all attributes. Therefore roasting the simple traditional processing method is also effective technique and need to be encouraged in terms of consumers' acceptance of the formulated weaning porridges.
- The results from this study suggest that proper reformulation of these formulated weaning porridges can provide nutritious foods that are suitable not only for weaning, but also as rehabilitation diet to malnourished children that can be more cost effective.

5.2. Recommendation

The following recommendations are made based on the findings

- The traditional weaning gruel preparation needs a great attention of selecting the type and the proportion of ingredients.

- Serving should be based on the principles of responsive feeding methods and the amount given should be based on the age to satisfy the daily nutrient requirements of the children.

- Traditional weaning gruels need a great attention of improvement of its low nutrient contents like protein and high amount of antinutritional factors.

- All methods of traditional weaning gruel preparation were ineffective in reducing the levels of anti-nutritional factors and may increase the loss of nutrients. Therefore, there should be an improvement of method of preparation and pretreatment of the ingredients.

- Future works need to focus on identification and quantification of locally available low cost ingredients in the woreda level.

- Further study should be undertaken for new product development using nutrient rich blends based on local weaning foods composition and proportions of ingredients.

- Moreover, the effect of pre treatment, processing, blending and storage times, on the nutritional and antinutritional factors of traditional weaning gruels should be intensively studied.
- This study revealed that complementary food products formulated from low cost locally available food ingredients, can meet the nutritional needs of infants and children. However certain aspects like bio-availability of the nutrients in these foods need further investigations.

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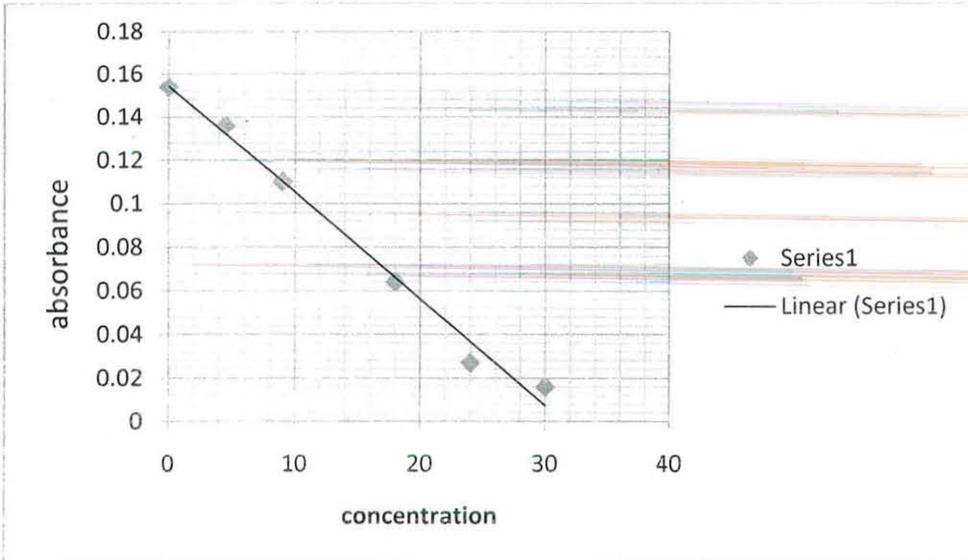
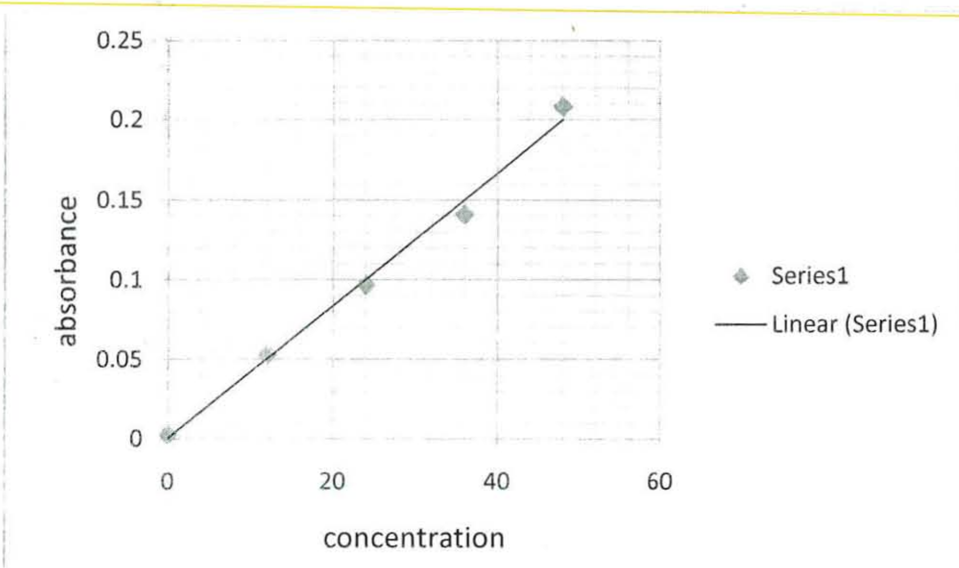
Appendices

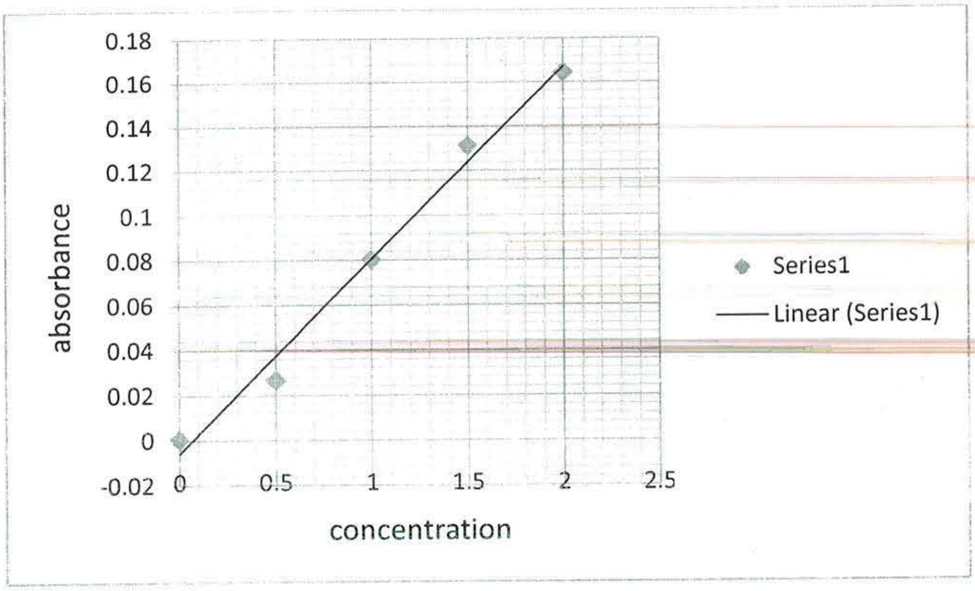
Appendix I. Standard curve for the determination of Phytate concentration



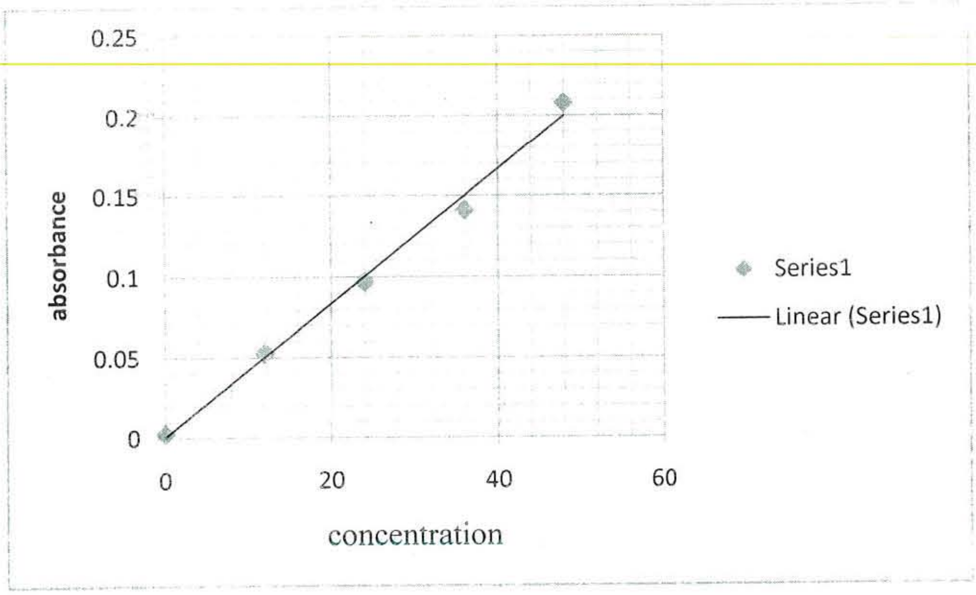
Appendix II. Standard curve for the determination of tannin concentration



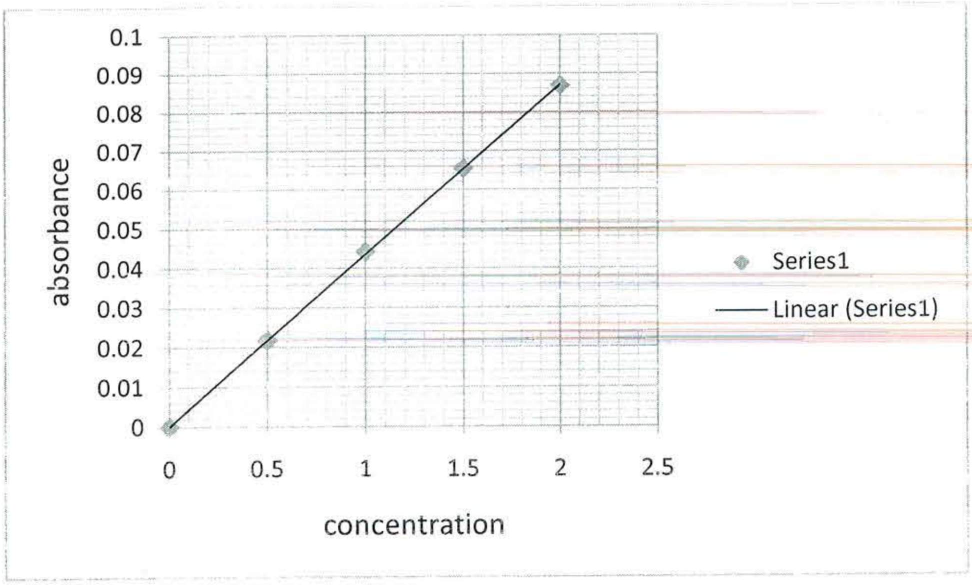
Appendix III. Standard curve for the determination of iron concentration



Appendix IV. Standard curve for the determination of calcium concentration



Appendix V. Standard curve for the determination of zinc concentration



Appendix VI. Sensory score sheet

Panelists were asked to rinse their mouth with water before starting and between each tasting and Tasted the samples according to the numbers indicated and give value from 1-9 for each attribute based on the key given below.

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neither like nor dislike
6. Like slightly
7. Like moderately
8. Like very much
9. Like extremely

	Sample code					
Attributes	**321**	**322**	**323**	**324**	**325**	**326**
Taste						
Colour						
Aroma						
Texture						
Over all acceptability						

Comments: ---

Appendix VII. Proximate composition of traditional weaning gruels /100g (on wet basis)

Table Proximate composition of traditional weaning gruels /100g (on wet basis)

pe	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy*
	88.01 ± 0.78^{de}	0.53 ± 0.03^{a}	0.19 ± 0.01^{f}	0.27 ± 0.00^{cd}	0.46 ± 0.01^{c}	10.91 ± 0.06^{c}	47.38 ± 0.02^{d}
	86.24 ± 0.05^{f}	0.53 ± 0.01^{a}	0.35 ± 0.02^{c}	0.23 ± 0.01^{f}	0.59 ± 0.02^{b}	12.08 ± 0.11^{b}	53.49 ± 0.01^{b}
	89.71 ± 0.09^{c}	0.22 ± 0.02^{f}	0.19 ± 0.01^{f}	0.22 ± 0.00^{f}	0.39 ± 0.01^{d}	9.29 ± 0.03^{f}	39.72 ± 0.02^{i}
	89.22 ± 0.06^{c}	0.42 ± 0.01^{cd}	0.23 ± 0.00^{ef}	0.24 ± 0.03^{ef}	0.55 ± 0.01^{b}	9.35 ± 0.01^{ef}	41.17 ± 0.02^{g}
	83.31 ± 0.05^{g}	$0.45\pm0.01b^{c}$	0.56 ± 0.05^{a}	0.43 ± 0.00^{a}	0.85 ± 0.04^{a}	14.40 ± 0.03^{a}	64.43 ± 0.02^{a}
	89.54 ± 0.08^{c}	0.23 ± 0.01^{f}	0.28 ± 0.01^{cde}	0.26 ± 0.00^{cd}	0.48 ± 0.01^{c}	9.22 ± 0.05^{f}	40.23 ± 0.01^{h}
	89.06 ± 0.04^{c}	0.30 ± 0.01^{e}	0.39 ± 0.02^{bc}	0.34 ± 0.00^{b}	0.87 ± 0.02^{c}	9.45 ± 0.08^{e}	42.44 ± 0.01^{f}
	92.68 ± 0.01^{a}	0.23 ± 0.00^{f}	0.20 ± 0.00^{f}	0.24 ± 0.01^{ef}	0.39 ± 0.01^{d}	6.27 ± 0.01^{i}	27.81 ± 0.01^{l}
	87.50 ± 0.05^{e}	0.46 ± 0.02^{bc}	0.29 ± 0.00^{d}	0.26 ± 0.00^{cde}	0.49 ± 0.02^{c}	11.01 ± 0.03^{c}	48.49 ± 0.01^{c}
	91.11 ± 0.04^{b}	0.13 ± 0.02^{g}	0.21 ± 0.01^{f}	0.19 ± 0.01^{g}	0.45 ± 0.01^{c}	7.91 ± 0.01^{h}	34.04 ± 0.01^{k}
	88.30 ± 0.18^{d}	0.49 ± 0.02^{ab}	0.43 ± 0.01^{b}	0.28 ± 0.01^{c}	0.36 ± 0.02^{d}	10.15 ± 0.01^{d}	46.43 ± 0.01^{e}
	90.70 ± 0.06^{b}	0.38 ± 0.03^{d}	0.21 ± 0.01^{f}	0.25 ± 0.01^{def}	0.22 ± 0.01^{e}	8.24 ± 0.03^{g}	36.38 ± 0.01^{j}

Values within the same column with different superscript letters are significantly different from each other ($p< 0.05$) * Energy in kcal/100g

Appendix VIII. Proximate composition of formulated weaning porridges/100g (on wet basis)

Table Proximate composition of formulated weaning porridges /100g (on wet basis)

Type	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy*
G-Mb	80.59 ± 0.16^{a}	3.07 ± 0.06^{a}	0.79 ± 0.01^{a}	0.44 ± 0.01^{c}	0.38 ± 0.01^{e}	14.74 ± 0.02^{f}	78.26 ± 0.02^{a}
G-Sb	80.13 ± 0.15^{a}	2.39 ± 0.05^{c}	0.53 ± 0.01^{c}	0.48 ± 0.01^{ab}	0.53 ± 0.01^{c}	15.97 ± 0.01^{b}	78.09 ± 0.01^{b}
G-Bb	80.85 ± 0.40^{a}	2.20 ± 0.01^{d}	0.39 ± 0.01^{d}	0.49 ± 0.01^{a}	0.75 ± 0.01^{b}	15.33 ± 0.01^{d}	73.58 ± 0.01^{d}
R-Mb	80.64 ± 0.16^{a}	2.72 ± 0.02^{b}	0.75 ± 0.02^{b}	0.44 ± 0.01^{c}	0.49 ± 0.01^{d}	14.98 ± 0.02^{e}	77.46 ± 0.01^{c}
R-Sb	79.92 ± 0.09^{a}	2.28 ± 0.01^{cd}	0.40 ± 0.01^{d}	0.47 ± 0.01^{b}	0.55 ± 0.01^{c}	16.39 ± 0.01^{a}	78.27 ± 0.01^{a}
R-Bb	80.81 ± 0.50^{a}	2.08 ± 0.01^{e}	0.29 ± 0.01^{e}	0.49 ± 0.01^{ab}	0.76 ± 0.01^{a}	15.57 ± 0.01^{c}	73.13 ± 0.01^{e}

Values within the same column with different superscript letters are significantly different from each other ($p< 0.05$) * Energy in kcal/100g

Appendix IX. Quantitative questionnaire

Questionnaire for the assessment of traditional weaning foods production and consumption in three food insecured kebeles of Demba Gofa Woreda, southern Ethiopia

1. Background information about the area

1.1 woreda -------------------------

1.2 Agroecological character a) kola b) woynadega c) dega

1.3 Kebele ---------------------------

2. Socio demographic information

2.1 Age of the mother/care giver

Date ---------------, month ----------------, year ------------------

2.2 Ethnic group a) Gofa b) Gamo c) Amhara d) other

2.3 Religion a) orthodox b) protestant c) Muslim d) other

2.4 Occupation a) unemployed b) laborer c) farmer d) petty trade e) other

2.5 Education level a) illiterate b) grade 1-4 c) grade 5-8 d) grade 9-12 e) higher

2.6 Occupation of husband a) unemployed b) laborer c) farmer d) petty trade e) other

2.7 Husband' educational level a) illiterate b) grade 1-4 c) grade 5-8 d) grade 9-12 e) Higher level

2.8 land owned a) yes owned b) yes rented c) no land owned

2.9 hectare of the land a) < 0.5 b) 0.5-1 c) 1- 2 d) 2- 3 e) above

2.10 number of animals a) Cows -------------------------

b) Oxen --------------------------

c) Goat/ sheep --------------------

d) Chicken ------------------------

e) Transport animal ------------

f) Other --------------------------------

2.11 Numbers of children under 2 years a) one b) two c) if other specify

2.12 Name of the child ---------------

2.13 Age of the child date ------------ month ------------- year ---------------------

2.14 Gender of the child a) male b) female

3. Breast feeding practice and initiation of complementary feeding

3.1 Exclusive breastfed a) yes b) no

3.2 Used colostrums a) yes b) no

3.3 Still breast feeding a) yes b) no

3.4 Number of breast feeding daily --------------------------

3.5 When become pregnant a) continue breast feeding b) stop breast feeding

3.6 Age of complementary food started -------------------------

3.7 The food taken last night ------------------------

3.8 The food taken today ---------------------------

3.9 Complete transitions to family food a) yes b) no

3.10 If yes at what age? -------------------- Months

4. Existing local complementary foods, preparation and consumption

4.1 Type of food commonly used 1, --------------------------------

2, -------------------------------

3, ---------------------------------

4, --------------------------------

4.2 The form of food given a) soft b) semi solid c) solid

4.3 The major ingredients 1, ---------------------------

2, ---------------------------

4.4 proportions of ingredients estimated -------------------------------------

4.5 Amount cooked for one day estimated ------------------ (in liter/gram)

4.6 Frequency of feeding daily --------------------------- times

4.7 The source of water used a) tape b) river c) ground d) other

4.8 Amount given once estimated ------------------ gram/liter

4.9 Type of food varied (diversified) in three days

a) The day before yesterday | b) yesterday | c) today

1, ------------------------- 1, ----------------------- 1, ------------------------

2, ------------------------- 2, ------------------------ 2, ------------------------

3, ------------------------- 3, ------------------------ 3, ------------------------

4.10 Ingredients obtained

a) From garden 1, ----------------------------2, --------------------------- 3, ------------------------

b) From market 1, --------------------------2, ----------------------------3, ------------------------

c) From other sources 1, ------------------ 2, ---------------------------- 3, ------------------------

4.11 The availability of ingredients throughout the year a) yes b) no

4.12 specify the limited ingredients 1, ---------------------------

2, ----------------------------

3, ----------------------------

4.13 Coping mechanism during ingredient shortage 1, --

2, --

4.14 Ingredients from market are affordable a) yes b) no

4.15 The household food insecured a) yes b) no

4.16 The source of food aid a) government b) NGO c) other

4.17 Use of salt a) table b) iodized c) not known

4.18 The flour prepared by a) millstone b) commercial mill c) purchased

4.19 pre treatments of cereals and legumes a) yes b) no

4.20 If yes, which method? A) Fermentation b) soaking c) germination d) other

4.21 Method of storage the complementary food prepared ----------------------------------

4.22 Time of serving the single cooked food ------------------------------

4.23 Washing hands before preparation regularly a) yes b) no c) sometimes

4.24 The way of feeding the child a) with finger b) with spoon c) other specify

4.25 Source of fuel used a) wood b) charcoal c) kerosene d) other

4.26 The responsibility of child feeding mostly a) mother b) father c) care giver e) other

4.27 Attending vaccination programmes a) yes b) no

5. Food taboo to young children

5.1 Food not given to the child 1, ---------------------------

2, ----------------------------

3, ------------------------------

5.2 Why not 1, ---

2, --

6. Locally consumed foods

6.1 Commonly consumed cereal 1, ---------------------- 3, -------------------------

2, ---------------------- 4, ------------------------

6.2 Commonly consumed legume 1, ---------------------- 3, -------------------------

2, ---------------------- 4, ------------------------

6.3 The most commonly staple diet 1, ---------------------- 3, -------------------------

2, ---------------------- 4, ------------------------

6.4 Total ingredients of daily foods 1, ---------------------- 3, -------------------------

2, ---------------------- 4, ------------------------

7. Consumption of complementary foods produced at factory or community level

7.1 Use of factory complementary food a) yes b) no

7.2 If yes, what brand? 1, ---

2, ---

7.3 Use of community level complementary food a) yes b) no

7.4 If yes, what type? 1, ---

2, ---

Respondent' signature --------------------------

Thank you for your participation

Declaration

I, the undersigned, hereby declare that this thesis is my original work, has not been presented for a degree in any other university and all source of materials used for the study have been correctly acknowledged.

Name: Tadele Tuba Tringo

Signature_______________________

Place: Addis Ababa University

Date of submission________________

The thesis has been submitted with my approval as supervisors

Name: Nigussie Retta (professor)

Signature__________________

Date______________________

Mr. Tilahun Bekele

Signature__________________

Date______________________