NUTRITIONAL STATUS AND DIETARY DIVERSITY OF UNDER-TWO CHILDREN IN SELECTED DISTRICTS OF JIMMA ZONE, SOUTH WEST ETHIOPIA

M.Sc. THESIS

BY

NEJAT KIYAK TSEGAYE (BSc)

APRIL 2015

JIMMA UNIVERSITY

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Nejat Kiyak Tsegaye (BSc)

Submitted to the Department of Post-Harvest Management, College of Agriculture and Veterinary Medicine, Jimma University, In Partial Fulfillment of the Requirements for the Degree of Master of Science in Post-Harvest Management (Perishable Crops)

Major: Advisor: Prof. Dr. Tefera Belachew/ Prof. Dr. Oliver Hensel

Co-Advisor: Sirawdink Fikreyesus (PhD Scholar)

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JIMMA, ETHIOPIA

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I have completed my thesis research work as per the approved proposal and it has been evaluated and accepted by my advisers. Hence, I hereby kindly request the Department to allow me to present the findings of my work and submit the thesis.

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Chairperson, CGS **Signature** **Date**

DEDICATION

This thesis is dedicated to my mother, Alima Muhaba, who played indispensable role for all the sacrifices, wishes and praiseworthy to my success in all my endeavors.

STATEMENT OF THE AUTHOR

I declare that this Thesis is my work and is not submitted to any institution elsewhere for the award of any academic degree, diploma or certificate and all sources of materials used have been duly acknowledged. This Thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree in post harvest management at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to borrowers under the rules and regulations of the university and the library.

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BIOGRAPHICAL SKETCH

The author Nejat Kiyak Tsegaye was born to her mother Mrs. Alima Muhaba and her Father Mr. Kiyak Tsegaye in Jimma town, Jimma zone of Oromia region on January 21 1991. She attended her elementary and secondary school at Jimma University Community School from 1998 to 2007and high school at Jimma preparatory school from 2008 to 2009. She joined College of Agriculture, Mizan-Tepi University in 2010 and graduated with a degree in Horticulture in July 2012. Then she directly joined the School of Graduate Studies of Jimma University on September 2012 to pursue her studies for Master of Science in Post Harvest Management.

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LIST OF ACRONOMYS AND ABBREVIATIONS

µg/g	Micro gram per gram
µg/ml	Micro gram per milliliter
AOAC	Association of Analytical Chemists
AOR	Adjusted Odds Ratio
BFP	Breast feeding practice
CF	Complementary food
CFP	Complementary feeding practice
CSA	Central statistics authority
DFATD	Department of Foreign Affairs, Trade and Development
EBF	Exclusive breast feeding
EDHS	Ethiopian Demographic Health Survey
EHNRI	Ethiopian Health and Nutrition Research Institute
EPHI	Ethiopian Public Health Institute
FAO	Food Agricultural Organization
FMOH	Ethiopian Federal Ministry of Health
FoNSE	Food and Nutrition Society of Ethiopia
HAZ	Height for age z-score
IDA	Iron Deficiency Anemia
IDD	Iodine Deficiency Disorder
IYCF	Infant and Young Child Feeding
JUCAVM	Jimma University College of Agriculture and Veterinary medicine
Kcal	Kilo calorie
MAM	Moderate Acute Malnutrition
MDG	Millennium Development Goal
N	Normality
PE	Petroleum Ether
PEM	Protein Energy Malnutrition
RELOAD	Reduction of Losses and Adding Value in East African Food Value Chains
RHBs	Regional Health Bureaus
SAM	Sever Acute Malnutrition
SNNP	South nations, nationalities and people
SPSS	Statistical Package for Social Scientists
SSA	Sub Saharan Africa
UNICEF	United Nations Children‘s Fund
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VAD	Vitamin A Deficiency
WAZ	Weight for age z-score
WFP	World Food Program
WHO	World Health Organization
WHZ	Weight for Height Z-score

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NUTRITIONAL STATUS AND DIETARY DIVERSITY OF UNDER-TWO CHILDREN IN SELECTED DISTRICTS OF JIMMA ZONE, SOUTH WEST ETHIOPIA, MARCH-MAY, 2014: A CROSS-SECTIONAL STUDY

ABSTRACT

Undernutrition remains a pervasive problem in developing countries, where poverty is a basic determinant contributing to household food insecurity, poor child care, maternal undernutrition, unhealthy environments, and poor health care. The prevalence of chronic malnutrition among under-five children remains persistently high in Ethiopia. According to the last Ethiopian Demographic Health Survey, nearly half (47 percent) of Ethiopian children were stunted, 11 percent wasted, and 38 percent underweight. All ages are at risk of nutritional deficiencies, but the period from pregnancy to two years of age provides a crucial window of opportunity to minimize undernutrition and its adverse effect. It is during this time that proven nutrition interventions can offer children the best chance to survive and reach optimal growth, health and development. This study aims to assess the nutritional status and dietary diversity of under-two children and identify predictors of nutritional status of under-two children in three districts of Jimma zone, Southwest Ethiopia (namely Dedo, Omo-Nada and Mana). A cross-sectional study was conducted with a total of 558 mothers and their index children aged 0-24 months. All mothers from selected kebelles were included in the study through simple random sampling technique. Structured interview was conducted and mothers were asked about the socioeconomic, demographic and dietary conditions. Height and weights of under-two children were measured and converted to Z-Scores using WHO Antro2004. A multivariable logistic regression technique was used to analyze the data with 95% CI. Of the 558 children in the study 73 (13.1%), 142 (25.4%) and 54 (9.7%) were underweight, stunted and wasted respectively. Risk factors for stunting include gender, age, place of residence and complementary feeding. Urban children were more likely to be stunted as compared to their rural counterparts and male children were more likely to be stunted as compared to their female counterparts. Majority of children were exclusively breastfed and the diets of children in age group of 7-24 were predominantly based on starchy staples (Atmit) which was poor in nutrient density and the dietary diversity score was extremely low and children did not achieve recommended feeding frequency for their age. There is a high prevalence of stunting among under-two children in Jimma Zone and this is mainly associated with poor complementary feeding practice. So, Complementary feeding improvement should be of highest priority for nutrition of infant and young children because of its crucial role in preventing mortality and enhancing child development.

1. INTRODUCTION

1.1 Background

Ethiopia is the second-most populous country in Africa, at nearly 96 million. Approximately 14% are children under five years of age. These children suffer disproportionately from the poor health and nutrition situation in the country (EDHS 2005). The prevalence of chronic malnutrition among under-five children remains persistently high in Ethiopia. Undernutrition includes being underweight for one's age, too short for one's age (stunting), dangerously thin for one's height (wasting) and deficient in vitamins and minerals (micronutrient deficiencies) (UNICEF, 2009). In fact, malnutrition is the underlying cause (57%) of child deaths in Ethiopia with some of the highest rates of stunting and underweight in the world (SCUK 2009). According to the last Ethiopian Demographic Health Survey (EDHS 2005), nearly half (47 percent) of Ethiopian children were stunted, 11 percent wasted, and 38 percent underweight.

The causes of malnutrition are more complex and interrelated than just lack of sufficient food. These causes range from national factors such as political instability to those specific as diarrheal disease (Seid, 2013). The principal reasons for the high prevalence of malnutrition include poor access to food and inadequate feeding, foods with low energy and nutrient density, poor processing methods and microbial contamination, absolute poverty and fluctuations in incomes, poor health and sanitary conditions and limited knowledge of nutritional matters among households (Mugula and Lyimo, 1999 and Melkei, 2007). Poverty is a basic determinant contributing to household food insecurity, poor child care, maternal under nutrition, unhealthy environments, and poor health care (WHO, 2002).

Child malnutrition may lead to higher levels of chronic illness and disability in adult life which may have intergenerational effects as malnourished females are more likely to give birth to low-weight babies (Silva, 2005). And also there is evidence that under-nutrition in infants and young children contributes more to a country's overall disease burden than under-nutrition in adolescents, for example. According to Glewwe and Miguel (2008), in SSA, nutritional problems in children aged 0-4 years contribute twice as much to the overall burden of disease than they do in children aged 5-14 years. During this period, nutritional deficiencies have a significant

adverse impact on children's survival, growth and development, which in turn negatively affects children's ability to learn in school, and to work and prosper as adults (WHO, 2002). It can also suffer from impaired physical development and limited intellectual abilities, which in turn may diminish their working capacity during adulthood and have negative effects on national economic growth (Alderman et al, 2004).

Economic growth and human development require well nourished population who can learn new skills, think critically and contribute to their communities (UNICEF, WHO & World Bank, 2012). Nutrition has increasingly been recognized as a basic pillar for social and economic development. The reduction of infant and young child malnutrition is essential to the achievement of the Millennium Development Goals (MDGs) particularly those related to the eradication of extreme poverty and hunger (MDG 1) and child survival (MDG 4) since one of the indicators used to assess progress towards MDGs is the prevalence of children who are underweight. All the Millennium Development Goals are connected, so failing to achieve these goals jeopardizes the achievement of other MDGs which are crucial for national progress and development (FMOH and RHBs, 2011).

However, undernutrition continues to be widely prevalent in both developing and industrialized countries, to different degrees and in different forms (UNICEF, 2009). Many people in the developing world, particularly children, and women continue to suffer from undernutrition. It is the most recognizable and perhaps most untoward consequence of poverty in children. It contributes to more than one third of all deaths in children under the age of five years. Currently, 195 million under-five children are affected by malnutrition worldwide; whom 90% of them live in sub-Saharan Africa and South Asia (Mann and Truswell, 2001). Latest available data shows that in the developing world the number of children under 5 years old who are stunted is close to 200 million, while the number of children under 5 who are underweight is about 130 million (UNICEF, 2009). Of the estimated 178 million, 90 percent live in 36 countries, one of which is Ethiopia (Black, 2008).

In most low-income countries, including Ethiopia, growth faltering begins in the first six months of life; age specific malnutrition rates generally increase until about two years of age and then

level off (Shrimpton et al., 2001). Underweight is most prevalent among children under five years of age, especially in the period of complementary feeding (6–24 months) (WHO, 2002). All ages are at risk of nutritional deficiencies, but the period from pregnancy to two years of age provides a crucial window of opportunity to minimize under nutrition and its adverse effect. It is during this time that proven nutrition interventions can offer children the best chance to survive and reach optimal growth, health and development (Ismail and Suffla, 2013). Most often, malnutrition during infancy starts when children transition from nutritious breast milk to thin cereal or starch- based gruel usually fed in bottle, which can result in complications and diarrheal diseases because of poor sanitation (FDREMH, 2011). So, The National Nutrition Strategy (NNS) gives a great emphasis for under five children in general and for children less than two years in particular as this is where it is possible to break the intergenerational cycle of malnutrition.

Although, Ethiopia has witnessed encouraging progress in reducing malnutrition over the past decade and there has been some improvement in this indicator of long term nutritional deprivation in recent years but still baseline levels of malnutrition remain so high. The national prevalence rate of 52 percent in 2000 was still significantly above the sub-Saharan average of 34 percent. This could negatively impact on the human development targets of the Millennium Development Goals, the poverty reduction targets of the Sustainable Development and diminishes any objective of accelerated income growth. However, even if, information on the feeding practices, nutritional status and associated issues of infants and under-two children are needed to prioritize problems and design intervention strategies, little research based information on the nutritional status of under-two children as well as from the study communities as is limited. So, this study was undertaken to assess the anthropometric and dietary pattern of under-two children among the communities of the study area.

1.2. Research questions

The research objectives were achieved by the following research questions:

1. What is the nutritional status of under-two children in the study area?
2. What are the potential determinants that currently influence the nutritional status of under-two children?
3. What are the types, frequency and diversity of foods consumed by under-two children in three districts of Jimma zone?
4. What is the nutritional composition of the complementary foods and which macro and micro nutrient is lacking in the foods?

1.3. Objectives

1.3.1 General objective

- ✓ To assess the nutritional status, dietary diversity of under-two children and nutritional composition of complementary foods and to identify predictors of nutritional status of under-two children in three districts, Dedo, Omo-Nada and Mana, of Jimma zone, Southwest Ethiopia.

1.3.2 Specific objectives

- ✓ To determine the nutritional status of under-two children.
- ✓ To describe diversity, type and composition of predominantly consumed complementary foods by under-two children.
- ✓ To identify demographic and socio-economic predictors of nutritional status among under-two children.

1.4. Significance of the study

Although Ethiopian Government has developed various nutrition strategies, programs and guidelines and deployed Health Extension workers, Malnutrition persists still in a significant proportion, information on the feeding practices, nutritional status and associated issues of under-two children are needed to prioritize problems and design intervention strategies, research based information regarding under-two children as well as from the study communities are limited. Although there are several studies on child undernutrition in Ethiopia, there is no any study that documented nutritional status together with the assessment of nutrient contents of commonly used foods. So, this study will contribute to research literature about nutritional and dietary assessment and serves as a spring board for those who want to conduct research in the same area. The study is also significant for principals of health offices of the study area to plan in the future to address nutritional problems, for principals of health offices of Jimma Zone to recognize the major problems associated with nutrition and factors affecting, for policy-makers to better promote change and improve children's wellbeing in deprived communities. In addition, it will encourage researchers for further work especially to those needs a baseline to continue with product development awareness creation.

2. LITERATURE REVIEW

2.1. Food and nutrition

Nutrition may be defined simply at the utilization of foods by living organisms for normal growth, reproduction, and maintenance of health. The compounds that are classed as nutrients include water, carbohydrates, proteins or amino acids, lipids, vitamins and mineral. These nutrients make up living tissues whether they are plant, animal or microbes. Thus, these nutrients are obtained by intake of food and are then used by human body to build and maintain its own tissues (Martha, 2000).

Nutrition is the interaction between food and the body. It is about the nutrients contained in food, and their action, interaction and balance in relation to health and disease. Nutrition (also called nourishment or aliment) describes the processes whereby cellular organelles, cells, tissues, organs, systems, and the body as a whole obtain and use necessary substances obtained from foods (nutrients) to maintain structural and functional integrity (Gibney et al., 2009).

Nutrition is the provision of adequate energy and nutrients (in terms of amount, mix, and timeliness) to the cells for perform their physiological function (of growth, reproduction, defense, repair, etc.). It is a scientific discipline, concerned with the access and utilization of food and nutrients for life, health, growth, development and well-being. Nutrition is important for everyone because food gives our bodies the nutrients they need to stay healthy, grow, and work properly (FoNSE, 2010). It is a critical component in laying a solid foundation for good health and development. Good nutrition builds up the immune system, strengthens the body, and plays an essential role in a healthy and productive lifestyle (MDHS, 2005).

Balanced nutrition is important especially during periods of infancy and childhood where there is a rapid growth and development (Haynes, 2008). For the first 6 months of a baby's life, breast milk alone is enough for good growth. However, Complementary nutrient dense foods are required after 6 month of age to satisfy the need for additional energy and nutrient requirements and to supply several micronutrients, notably iron, zinc, calcium and vitamin A (Andre et al., 2003). So, nutrition during infancy is fundamental to growth and development. To have adequate

and regular weight gain, children need enough good-quality food to meet their nutritional requirements. When developing infants are fed the appropriate types and amounts of foods, their health is promoted (USDA &WIC, 2009). Inadequate nutrition during infancy can result in stunted growth, low body weight, delayed cognitive and physical development and even death (Coleman, 2014). It also affects physical growth, morbidity, mortality, cognitive development; reproduction, and physical work capacity (Mahgoub et al., 2006).

2.2. Nutritional requirements during infancy and childhood

Requirements for energy and micronutrients change throughout the life cycle. Small children and infants do not have a well-developed body nutrient store, and therefore are more vulnerable to infection. In addition they have a larger surface area compared to their body size, there is rapid cell division occurring during growth, which requires protein, energy and fat (USDA &WIC, 2009). All these factors increase their basal metabolic rate (BMR), resulting in an increased requirement for nutrients (FMOH and RHBs, 2011).

Requirements for macronutrients (proteins, carbohydrates and fats) and micronutrients are higher on a per kilogram basis during infancy and childhood than at any other developmental stage. Increased needs for these nutrients are reflected in daily requirements for these age groups (USDA &WIC, 2009). There are increased requirements of energy, protein, essential fatty acids, calcium and phosphorus during infancy and childhood. As children grow older, they need to eat more food each day (FMOH and RHBs, 2011). Adequate nutrition is essential in early childhood to ensure healthy growth, proper organ formation and function, a strong immune system and neurological and cognitive development (UNICEF, WHO & World Bank, 2012).

2.2.1. Nutritional Requirements of children Under the Age of 6 Months (Infancy)

Interest in infant feeding centers around two principal objectives: the promotion of normal growth and brain development and the prevention of illness during the first years of life. Infants grow and develop rapidly in the first two years, making them particularly vulnerable to nutritional inadequacies. Breast-feeding, followed by the introduction of a wide variety of solid

foods provides the best opportunity for optimal growth and health during infancy (Mann and Truswell, 2001).

2.2.1.1. Breast feeding

During the first six months Babies need exclusive breastfeeding which is defined as giving only breast milk and no other food or fluid including water except medication. This is needed at least eight to ten times each day. The mother should allow the infant to breastfeed on demand (as often as the infant wants). This means breastfeeding every two to three hours (8–12 times per 24 hours) or more frequently if needed, especially in the early months (Zewditu et al., 2003)

Breastfeeding is associated with reduced risk for obesity, a wide range of allergies, hypertension, and type 1 diabetes. It is also linked with improved cognitive development; and with decreased incidence and severity of infections (FMOH and RHBs, 2011). Other benefits include convenience, safety, and cost. With the exception of vitamins D and K, breast milk produced by adequately nourished mothers provides all the nutrients needed by a normal healthy full-term infant for the first four to six months of life (Mann & Truswell, 2001).

The Academy of Nutrition and Dietetics recommends infants consume breast milk only for the first six months of life. Mothers who choose not to, or are unable to breastfeed, can offer their baby infant formula in place of breast milk. Infants from 0 to 6 months old should drink breast milk or infant formula every few hours, or on demand, to help meet nutritional requirements. Infant formulas and breast milk generally contains all the water and nutrients that an infant needs to satisfy its hunger and thirst with the exception of vitamin D and iron, which are low in breast milk. However, if all babies are to be healthy and grow well, they must be fed breast milk (Coleman, 2014).

Human milk is specifically composed to meet the nutritional requirements of the human infant and is considered the optimal nutrition source for healthy newborns, as well as many newborns with medical conditions (Mann and Truswell, 2001). Breast milk provides complete nutrition for an infant and offers immunological and nutritional benefits specially Colostrum. Colostrum is the compositionally distinctive milk which is produced in the first few days after birth.

Colostrum has higher protein content than mature milk. Colostrums has a lower fat content and therefore lower energy density, than mature milk and is also rich in minerals and vitamins A, D and B12 (Thompson, 1998).

2.2.2 Nutritional Requirements of children in Age of 6-12 Months

Throughout the first year, many physiological changes occur that allow infants to consume foods of varying composition and texture. As an infant's mouth, tongue, and digestive tract mature, the infant shifts from being able to only suckle, swallow, and take in liquid foods, such as breast milk or infant formula, to being able to chew and receive a wide variety of complementary foods (USDA &WIC, 2009).

2.2.2.1. Complementary feeding

Complementary feeding is the gradual withdrawal of breast milk and introduction of other foods, including suitably prepared adult food and the milk of other animals. The child is transited from the breast or formula milk and introduced to semi-solid or solid food, which become the source of energy and nutrient intake. Transition from maternal milk onto food occurs towards the middle of the first year. An energy gap may develop from that stage (Eastwood, 2003). It is the process of expanding the diet to include food and drinks other than breast milk or infant formula. It is a time of nutritional vulnerability. It represents a period of dietary transition just when nutritional requirements for growth and brain development are high (Thompson, 1998).

The usual practice in Western countries is complementary feeding before 6 months; earlier feeding is practiced in some in urban areas. This may be related to the need for women to return to paid employment. In Europe and North America more than 90% of children receive some semi-solid food by the age of 9 months, supplemented by breast milk or a modern infant formula. The age of complementary feeding in developing countries may be different to that in developed countries. The usual recommendation is that babies should be offered a mixed diet not later than the age of 6 months (Eastwood, 2003).

There are many differences in the approach to complementary feeding in different countries. The recommendations are based on energy and protein content per unit weight or per unit energy. There is often fortification of natural foods. A nutritionally adequate complementary feeding is essential for achieving optimum growth in the first year. There are important nutritional and developmental reasons for introduction of solid foods (Thompson, 1998).

Nutritional

- After six months of age, breast milk alone cannot meet an infant's energy requirements.
- Birth stores of Zinc and Iron are likely to be depleted by six months. These minerals must then be supplied in the diet.

Developmental

- Introduction of different tastes and textures promotes biting and chewing skills
- Chewing improves the mouth and tongue co-ordination which is important for speech development
- Failure to introduce different textures and tastes by 6-7 months can result in their rejection later.

Both the quantity and quality of complementary feeding (giving solid or semisolid food to a child in addition to breast milk) are important to ensure good health and development for the baby and young child. Infants older than six months should eat a variety of nutrient-rich foods, including animal products (e.g. eggs, beef, chicken, lamb, milk, cheese and butter), fruits, and vegetables. They need small meals, which are not bulky, three to five times a day. It is usually not possible for an infant to consume sufficient quantities of plant foods to meet their needs for iron, zinc and calcium. Therefore, the addition of animal source foods enables the different nutrients to be absorbed more easily. Maximizing intake of nutrient-rich foods, particularly vegetables, fruits, legumes and whole grains, foods that keeps energy intake within reasonable bounds (FMOH and RHBs, 2011).

The complementary food given to the child should be varied as much as possible, increasing the quantity, frequency and density of the food as the child gets older. The IOM recommends infants

ages 7 to 12 months consume at least 95 grams of carbohydrates, 11 grams of protein, 30 grams of total fat and 500 milligrams of omega-3faty acid every day (Coleman, 2014).

2.2.3 Nutritional Requirements of Children in age of 12-24 months

Optimal feeding of children during the first two years is critical to break the cycle of malnutrition from generation to generation. The first 24 months is recognized as being the most important window of opportunity for establishing healthy growth. Children need breast milk until they are at least two years old. They need at least three mixed meals and two snacks each day. It is especially important for the meals to be clean and not to contain parasites or microorganisms that could cause diarrhea or other infection (FMOH & RHBs, 2011).

As the child grows, the mother or caregiver should give the child more food. One way to know children are getting enough food is to put their portions in separate bowls and to help them eat. This is known as responsive feeding. Table 1 summarizes the frequency of meals, and their number according to the age of the child (FMOH and RHBs, 2011).

Table 1: Recommended amount and frequency of meals according to the age of the child

AGE	Frequency	Amount at each meal
6 month	2 times per day plus frequent breastfeeds	2-3 tablespoonfuls
7-8 months	3 times per day plus frequent breastfeeds	Increasing gradually to 2/3 of 250 ml cup
9-11 months	3 meals plus 1 snack between meals plus breastfeeds	¾ of a 250 ml cub/bowl
12-24 months	3 meals plus 2 snacks between meals plus breastfeeds	A full of 250 ml cup/bowl

Source: FMOH and RHBs, (2011)

2.3. Nutritional problems in children

2.3.1. Malnutrition

Malnutrition is a serious medical condition marked by a deficiency of energy, essential proteins, fat, vitamins, and minerals in a diet. Malnutrition is a broad term commonly used as an alternative to under nutrition, but technically it also refers to over nutrition. People are

malnourished if their diet does not provide adequate nutrients for growth and maintenance or they are unable to fully utilize the food they eat due to illness (under nutrition). They are also malnourished if they consume too many calories (over nutrition) (Mann and Truswell, 2001).

The concept of nutrition and its manifestation as malnutrition (both under and over nutrition), involves complex processes at multiple levels, from individual to the household to the community to the national and international levels. A UNICEF Policy Review paper states that, from the perspective of developing countries, "malnutrition results from inadequate intake of nutrients and/or from disease factors that affect digestion" among which protein energy malnutrition (PEM), nutritional anemia, vitamin A deficiency, and iodine deficiency disorders (IDD) are the most serious nutritional problems (UNICEF 1990) cited in Solomon, (2005).

Malnutrition is not synonymous with a lack of food. In an individual, malnutrition is the outcome of insufficient food intake, inadequate care and infectious diseases (UNICEF, 2009). These in turn derive from a combination of food, health, and care related causes at the household and community level. Major food-related causes of malnutrition include inadequate feeding, foods with low energy and nutrient density, low bioavailability of nutrients, poor access to food, use of poor processing methods and microbial contamination (Mugula and Lyimo, 1999).

Absolute poverty, poor health and sanitary conditions, limited knowledge of nutritional matters among certain households, and fluctuations in incomes are some of the principal reasons for the high prevalence of malnutrition. There could be several underlying and basic causes for the problem some of which could be due to low agricultural production, low and inadequate food consumption, disease and falling gross national product per capita. Drought, civil war and political instability are also the major contributing factors (Melkei, 2007).

Under nutrition, defined in public health by poor anthropometric status, is mainly a consequence of inadequate diet and frequent infection, leading to deficiencies in calories, protein, vitamins and minerals. There are two types of growth failure associated with malnutrition: Wasting (acute malnutrition) and stunting (chronic malnutrition). These can be measured and classified by anthropometry, or using body measurements to assess nutritional well-being (Benson, 2005). In

children, malnutrition is usually indicated by growth failure. Malnourished children are shorter and lighter than they should be for their age. Though many people still refer to growth failure as "Protein-Energy Malnutrition", or PEM, it is now recognized that growth may fail as a result of deficiencies of various micronutrients, not just the macronutrients energy and protein (WHO, 2002).

2.3.1.1. Macronutrient deficiency or Protein-Energy Malnutrition

Protein-Energy Malnutrition is the most common form of malnutrition occurring among infants and young children. Mild PEM manifests itself mainly as poor physical growth, whereas individuals with severe PEM have high case fatality rates. Marasmus and kwashiorkor are the two forms of protein-energy malnutrition. Both conditions may be distinguished by their own particular clinical characteristics (Benson, 2005).

2.3.1.2. Micronutrient malnutrition

Micronutrient deficiencies are widespread and affect large numbers of people in developing countries. Approximately 2 billion people worldwide suffer from some kind of micronutrient deficiency, causing a wide array of disorders and increasing the risk of death, disease and disability (Callanan, 1998).

Micronutrient deficiency occurs when the body does not have sufficient amounts of a vitamin or mineral due to insufficient dietary intake and/or insufficient absorption and/or suboptimal utilization of the vitamin or mineral. The poor especially often suffer from a basic lack of protein and energy, the adverse health effects of which are frequently compounded by deficiencies in micronutrients, particularly iodine, iron, vitamin A and zinc. Deficiencies in the diet of vitamin A, iodine, iron, and zinc are still widespread and are a common cause of excess morbidity and mortality, particularly among young children (UNICEF, 2009).

2.4. Brief overview of the child nutrition situation in Ethiopia

Ethiopia faces four major forms of malnutrition: acute and chronic malnutrition, iron deficiency anemia (IDA), vitamin A deficiency (VAD), and iodine deficiency disorder (IDD) of which the most serious nutritional deficiency in infants and young children is protein energy malnutrition (PEM); which contributes to more than 50% of childhood mortality in developing countries (Thaoge et al., 2003 and Walker, 1990).

While episodes of severe hunger, such as the 2002 drought emergency, receive immediate attention, chronic malnutrition poses a silent and relentless obstacle to economic development in Ethiopia. The prevalence of malnutrition imposes significant costs on the Ethiopian economy as well as society. The high mortality due to malnutrition leads to the loss of the economic potential of the child. Malnutrition is one of the major public health problems in Ethiopia (Christiaensen and Alderman, 2004). The prevalence of stunted children in Ethiopia - the percentage of children under five years of age with abnormally low height for their age - is among the highest in the world (Benson, 2005).

Among children under age five, 47% were stunted (height-for-age Z score below minus two standard deviations from the WHO median reference population) and 24% were severely stunted (height-for-age Z score below minus three standard deviations). Similarly, nearly one-out-of-ten (10.5%) children under age five were thin-for-height (wasted, weight-for-height Z score below minus two standard deviations) and 38% of under-five children were underweight (weight-for-age Z score below minus two standard deviations), 11% were severely underweight (weight-for-age Z score below minus 3 standard deviations) (CSA and ORC Macro, 2006).

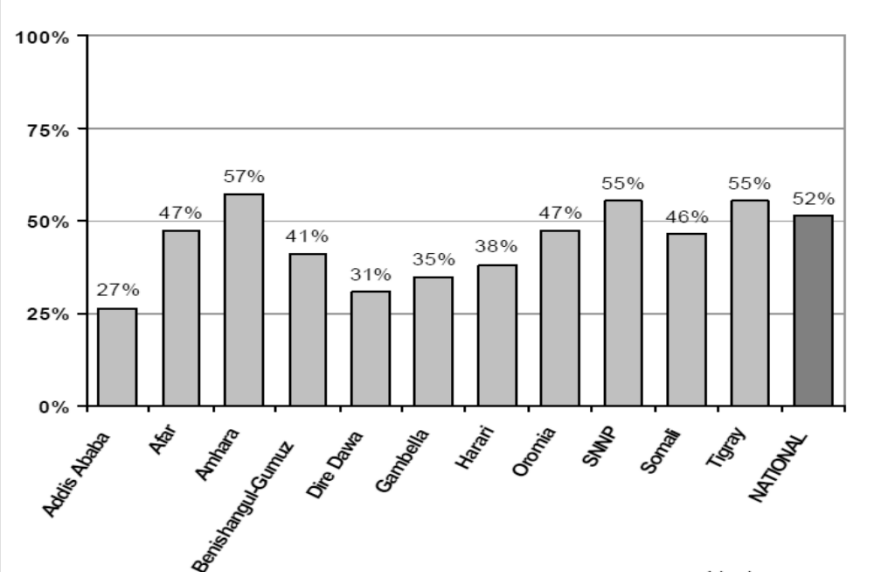
A study conducted in five regions of the country also indicated that 40% of children aged 6-18 months were underweight while 38% and 14% were stunted and wasted, respectively (Mekonnen et al., 2005). Similarly, other studies conducted at macro and micro levels showed problem of child malnutrition in Ethiopia (Christiaensen and Alderman, 2004; Amsalu and Tigabu, 2008).

According to EDHS 2005, there were substantial regional differences. Stunting prevalence is higher than the national average in Southern Nations, Nationalities, and People's Region

(SNNPR) at 51.6 percent compared to 41.1 percent in Tigray. Wasting was higher in Tigray at 11.6 compared to 6.5 percent in SNNPR. Underweight was higher than the national average at 42 percent in Tigray and lower in SNNPR at 34.7 percent. At the same time, according to EDHS (2005), infant and young child feeding practices were suboptimal, and, in particular, complementary feeding practices among children 6-23 months of age were particularly low.

According to the Central Statistical Authority (CSA, 2000), the prevalence of underweight, stunting and wasting among pre-school children (6-59 months) is 45%, 56.7% and 9.6% respectively. The level of PEM is still among the highest in the world, and its recent trend is on the increase to an extraordinary level. The situation is worse in areas where there is recurrent drought and famine for years such as in North Wollo administrative region (Abate et al, 2003).

According to Gugsa et al. (2003), study conducted in North wollo showed that, Overall sampled children, a quarter (25.0%) of the children were underweight (low weight-for-age), about half (44.5%) were stunted (low height-for-age) while 9.0% were found wasted (low weight-for-height). In general, the poor nutritional status found in the area is attributed to the low energy and nutrient intakes as evidenced from the dietary data. Moreover, as indicated in Figure 1, malnutrition is pervasive; no region is exempt from this problem (Benson, 2005).



Source: Ethiopia DHS 2000

Figure 1: Stunting among children under-five, by region

The conventional measures of child anthropometrics show that Ethiopia ranks among those countries in sub-Saharan Africa with the high prevalence of child malnutrition. In 2003, 52% of children were suffering from chronic malnutrition (stunting), 11% from acute malnutrition (wasting) and 47% from underweight. During the same period, the average prevalence of stunting, wasting and underweight for African countries were 39%, 9% and 29%, respectively (Alemayehu, 2005). A recently completed survey in Ethiopia, the 2005 EDHS, shows a similar profile of under-five malnutrition

Based on nationwide data coverage, the analysis profile and the results of the Ethiopia DHS 2000 survey, the prevalence rate of stunting (shortness in relation to age) of children up to the age of 5 years was found to be about 57 percent as compared to the figure of 66.6 percent in 1995/96. A declining trend is shown between the two survey years. Between 2000 and 2011 the prevalence of both underweight and stunting declined 32 and 23 percent, respectively. While this trend is clearly progressing in the right direction, Ethiopia needs to accelerate efforts to reach the Health Sector Development Plan's (HSDP IV) target of reducing the prevalence of stunting to 30 percent by 2015.

Known high impact nutrition interventions must thus be scaled up and intensified. One of the interventions still high in terms of priority in the Nutrition Strategy and Program is the Community Based Nutrition which addresses the high level of chronic malnutrition. In the Nutrition Program, the aim is to cover the 560 rural districts with the community based nutrition project by 2013. Currently, about 103 districts (14% of all districts) have either started to implement or have secured funding to implement this activity and hence gaps remain in rolling out this strategy to the remaining districts.

2.5. Negative consequences of malnutrition in children

Good nutritional status is a cornerstone that affects the health of all people, enabling us to reach our fullest potential as individuals and societies. Health and nutrition are closely linked: disease contributes to malnutrition, and malnutrition makes an individual more susceptible to disease. Severe malnutrition especially increases the incidence, duration, and severity of infectious

disease. The most common types of disease suffered by young children in both stable and emergency situations are: diarrhoea, acute respiratory infections, measles, and malaria. All of these conditions may contribute to malnutrition through loss of appetite, mal-absorption of nutrients, loss of nutrients through diarrhoea or vomiting, or through altered metabolism (which increases the body's need for nutrients) (Benson, 2005).

An undernourished child struggles to withstand an attack of pneumonia, diarrhoea or other illness and illness often prevails. The children who survive may become locked in a cycle of recurring illness and faltering growth, diminishing their physical health, irreversibly damaging their development and their cognitive abilities, and impairing their capacities as adults. During this period, nutritional deficiencies have a significant adverse impact on children's survival, growth and development, which in turn negatively affects children's ability to learn in school, and to work and prosper as adults (FoNSE, 2010).

Under nutrition in children under age 2 diminishes the ability of children to learn and earn throughout their lives. Nutritional deprivation leaves children tired and weak, and lowers their IQs, so they perform poorly in school. As adults they are less productive and earn less than their healthy peers. Children who are weakened by nutritional deficiencies cannot stave off illness for long, and the frequent and more severe bouts of illness they experience make them even weaker. Chronic under nutrition in early childhood also results in diminished cognitive and physical development, which puts children at a disadvantage for the rest of their lives. For girls, chronic under nutrition in early life, either before birth or during early childhood can later lead to their babies being born with low birth weight, which can lead again to under nutrition as these babies grow older. Thus a vicious cycle of under nutrition repeats itself, generation after generation (UNICEF, 2009).

As noted earlier, nutritional status in young children is significantly related to their subsequent cognitive development and labor productivity. For example, Alderman et al., (2009) showed that in Northwest Tanzania, malnourished children are more likely to delay entry into school and perform worse at school than their well nourished counterparts.

Malnutrition represents a massive drain on human and societal resources. A malnourished child is more prone to illness and more likely to die than a well-nourished child. Malnutrition adversely affects cognitive development and thus educational achievement, and it reduces an individual's ability to work effectively. Finally, recent studies have linked childhood malnutrition with increased chances for diabetes, heart disease and cancer in an individual's middle-aged years (Gibney et al., 2009). Malnutrition also reduces work productivity, as stunted; less educated and mentally impaired adults are less productive. It has been estimated that the annual value of the loss in productivity that can be attributed to child stunting is 2.92 billion ETB (Ethiopian Birr). Moreover, iodine deficiency, which results in irreversible impairment of intellectual capacities, has been estimated to cost the Ethiopian economy 1.35 billion ETB per year. The productivity losses due to malnutrition in Ethiopia over the next ten years will be 144 billion ETB. When aggregated, the effects on illness, education and productivity have an enormous impact on the economic growth and poverty reduction effort of the country (FMOH and RHBs, 2011).

The greatest functional consequences of malnutrition for children are increased risk of illness, and death; and for those who survive mental impairment and reduced capacity to produce and contribute to the economy of the country. These consequences of malnutrition are often not fully appreciated because they are hidden. Based on a national study, malnutrition contributes to an estimated 270,000 deaths of under-five children each year; and VAD contributes to 80,000 children's lives lost every year. As malnutrition and VAD weaken the immune system of children, they will be susceptible to common childhood infections and more liable to suffer from serious complications (FMOH and RHBs, 2011).

The government of Ethiopia has made great strides in improving the health and nutrition status of under-five children over the past two decades. However, performance measured by some indicators show that several challenges remain to be addressed (UNICEF, 2013). So, the consequences of malnutrition for Ethiopia if no action is taken are enormous.

3. MATERIALS AND METHODS

The study was conducted in three districts of Jimma Zone of south west Ethiopia, from March-May, 2014. The nutritional analysis part was done at EPHI (Ethiopian Public Health Institute), Ethiopia. The study area is characterized by household food insecurity (Belachew et al, 2013).

3.1. Description of the study sites

Jimma zone is located in Oromia regional state 356 km away from Addis Ababa in south west direction at the latitude of about 7°13´ N and 8°56´ N, and longitudes 35° 49´ E and 38°38´ E. The zone has elevation ranging from 900 to 3360 m.a.s.l. It experiences annual average rainfall of 1060 mm for 8 to 10 months. The temperature of Jimma varies from 9.5°C to 28°C with annual average temperature of 20°C. The lowlands agro-ecology have altitude range of 900 to 1500 m.a.s.l., the intermediate lands 1500 to 2500 m.a.s.l. and highlands 2500 to 3360 m.a.s.l. (Zonal Finance Planning Department, 2009). Table 4, summarizes the geographical description of Jimma Zone and the three selected Disticts; Mana, Dedo and Omo-Nada. Figure 2, shows the map of the study areas pointing out of the country and Jimma Zone.

Table 2: Geographical description of the study area

Descriptions	Jimma Zone	Dedo	Mana	Omo-Nada
Location	Oromia region	Jimma Zone,	Jimma Zone,	Jimma Zone,
Coordinates	7^o13'N -8^o56' and 35^o49'-38^o38'E	713'-739'N and 36.443'-3712'E	7^o38-7^o54'Nand 36.38'-3653'E	7^o17-7^o49N and 3700'-3728'E
Elevation	900-3360m.a.s.l	200-1500 m.a.s.l	1470-2610 m.a.s.l	880-3344 m.a.s.l
Average rainfall	1060 mm	1300-1700mm	1467mm	900-1600mm
Temperature	9.5^0C -28 ^{0}C	18^0C -22 ^{0}C	13^0C -24.8^0C	11.8^0C -26.8^0C
Crop production		Vegetables	Cash crops	Cereal crops

Source: Zonal Finance Planning Department, 2009

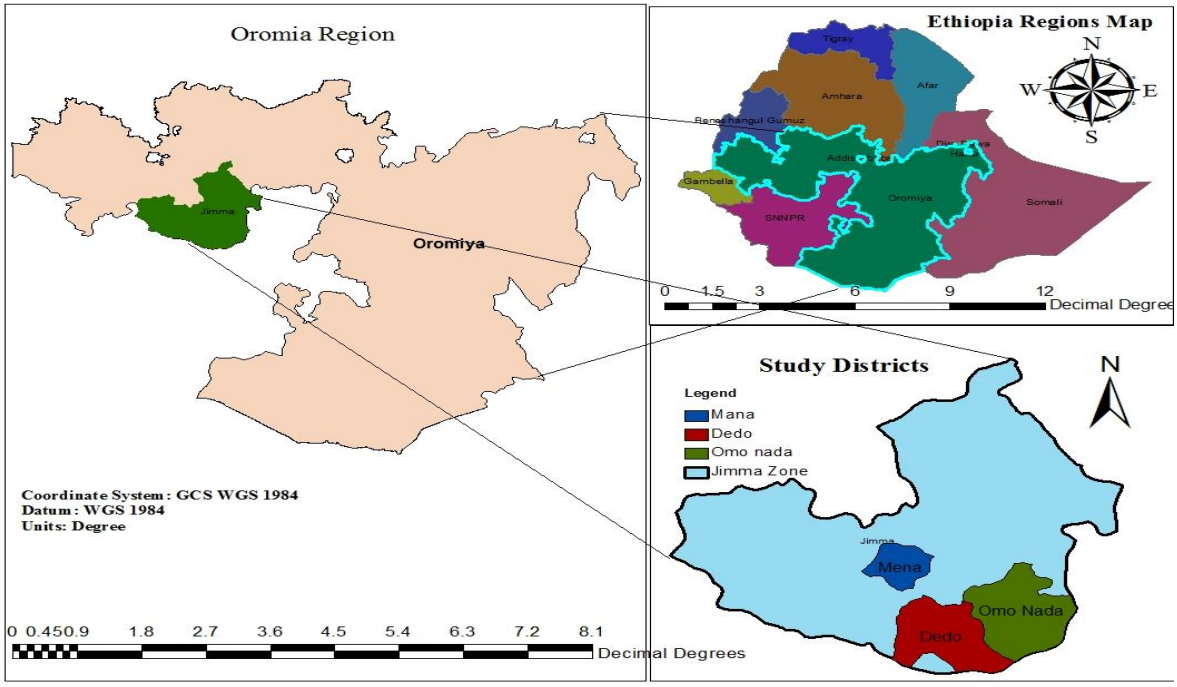


Figure 2: Map of the study area

Source: Melkamu Mamuye, department of natural resource management

3.2. Study design and subject

A cross-sectional descriptive study involving qualitative and quantitative variables was conducted.

3.3. Sample size

The sample size was determined using G-power 3.0 statistical power analyses software for windows (Faul, Erdfelder, Lang & Buchner, 2007). The sample size was calculated using single population proportion formula with 95% confidence level, irrespective of the value of population proportion of variable of interest, and assuming a design effect of two for cluster sampling, 5% margin of error, 44.4% estimated prevalence of stunting in the study area. Accordingly, the total sample size was 278. Since there are some clusters left unselected the total sample size was multiplied by the design effect of two and the final sample size was 556 under two years and their index mothers/care givers. But this sample size was made 558 in order to divide across all kebelles equally.

Design effect provides a correction for the loss of sampling efficiency resulting from the use of cluster sampling instead of simple random sampling. It may be thought of as the factor by which the sample size for a cluster sample would have to be increased in order to produce survey estimates with the same precision as a simple random sample. Ideally, an estimate of design effect for the indicators of interest could be obtained from a prior survey in a given setting. Unfortunately, such guidance is often not available and thus a default value of 2.0 is commonly used, especially for anthropometric and immunization surveys (Magnani, 1997).

Analysis: A priori: Compute required sample size

Input:	Tail(s)	=	One
	Effect size	=	0.3
	α err prob	=	0.05
	Power (1-β err prob)	=	0.8
	Allocation ratio N2/N1	=	1
Output:	Non centrality parameter δ	=	2.501000
	Critical t	=	1.650393
	Df =		276
	Sample size group 1	=	139
	Sample size group 2	=	139
	Total sample size	=	278
	Actual power	=	0.802340

3.4.Study population and sampling

The study population comprised under-two children (children aged 0-24 months). Stratified cluster sampling technique was used to make a sample from Zone to kebelles. The total districts in Jimma zone were initially stratified using purposive sampling, based on agro ecology and crop production (Table 4). Also the total kebelles in each district were initially stratified in to rural and urban areas. Then nine kebelles (three from urban and six from rural kebelles) were selected. Systematic sampling was used to select household with under-two children through the guidance of health extension workers in each kebelle and a sampling frame was prepared by registering all

the identified eligible participants. Finally, simple random sampling was used to select the required number of participants.

A sample size of 186 children under two years and their index mother/care givers were recruited from each district and distributed to three sampled kebelles using non- proportional to size sampling technique which makes the sample size of each kebelles 62.

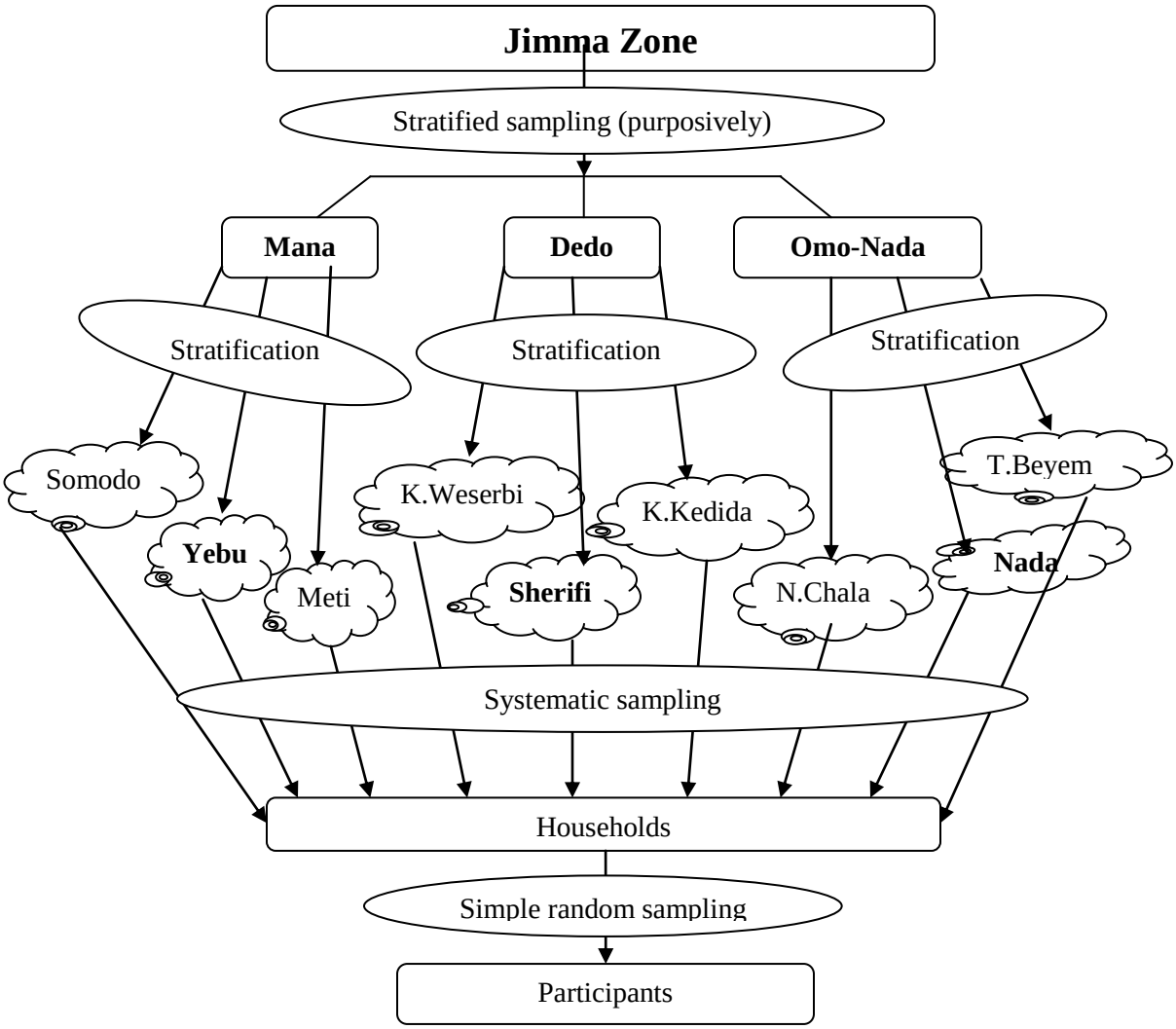


Figure 3. Flow chart of sampling procedure

3.4. Inclusion criteria

At the time of administering the questioner and collecting the food samples there were some criteria considered. The study included subjects;

1. Who were healthy and not on medication,
2. Who gave informed consent to participate in the study,
3. Who have been resident in that location for the past three years,
4. Whose consumption was not affected by ill-health, fasting, national holidays, and festive celebrations

3.5. Determination of household wealth

Household wealth was determined based on the household fixed assets grouped in to two categories; productive and nonproductive assets (Apendix 5). Principal Component Analysis (PCA) was used as data reduction tool to calculate wealth of households (Filmer and Pritchett, 2001). The main aim of creating the index was to categorize households in to socioeconomic status (SES) groupings to compare the difference in anthropometric and dietary pattern between the groups of the lowest and highest SES.

3.6. Data collection method

Data were collected from mothers or care givers of the infants and children using face-to-face interviews using a semi-structured questionnaire. A standard sample data sheet modified from Gibson (2008) was used in the interviews.

The variables were categorized as dependent and independent variables. The dependent variable was nutritional status of the under-two children i.e. weight and height and Dietary intake of under-two children and independent variables were socio-economic and demographic factors.

3.6.1. Demographic and Socioeconomic Factors

This included household identification, household composition, age, household size, highest educational level attained by mothers and fathers, primary occupation of mothers and fathers, wealth of the house hold and source of income, source of drinking water and availability of toilet facility, availability of health facilities and educations or trainings given on health and nutrition. Beyond these breastfeeding and complementary feeding practices were also measured.

3.6.2. Anthropometric assessments

The study included anthropometric measurement; measurement of length in meters and weight in kilogram of the children. Nutritional status was measured in terms of height-for-age Z-scores (HAZ), weight-for-age Z-scores (WAZ) and weight-for-height Z-scores (WHZ). Both Height and weight measures were taken using recommended procedures (WHO, 1995). Weight for children was measured to the nearest 0.1 kg on a battery powered digital scale (Seca 770, Hanover Germany) and length was measured to the nearest 0.1 cm using wooden sliding length board lying down on the board (Recumbent length) (WHO, 2008).

In measuring weight of children, mother removed her shoes and step on the scale and adjusted any long garments that could cover the display and solar panel of the scale to be weighed alone first. After the mother's weight appears on the display her child was given to her to hold until weight of both mother and child appeared on the display. Finally the child's weight was calculated with the formula below and recorded. Height was measured with bare leg and light wearing also if the child had braids or hair ornaments that interfere with length measurements, all were removed before the measurement was done.

Weight of child = (weight of mother + child) – weight of mother

3.6.3. Assessment of dietary intake

The dietary assessment was performed using single 24-hours recall method (Gibson, 2008). Over a period of 4 weeks single 24-hour dietary recall interviews was carried out on mothers of

sample infants and children less than two years old. The single 24- hour recall method was selected as the most appropriate method of assessing the average intake of nutrients in the sample groups due to the low cost and less time consuming compared to other dietary assessments.

The dietary diversity score was calculated by summing the number of food groups derived from guideline of USDA, (2005) for measuring household and individual dietary diversity. A scale of seven food groups was used to assess the dietary diversity of food consumed over the last 24-hours. The 24-hour recall aimed to provide a complete record of all food and drink eaten on the previous day between midnight and midnight. DDS was considered optimal when a child is fed $\geq$4 food groups per day according to the recommendation of USDA, (2005). The food groups considered were;

- ✓ Cereals and Grains,
- ✓ Dairy Products,
- ✓ Fruits,
- ✓ Vegetables,
- ✓ Oil and Fat,
- ✓ Protein Rich Foods and
- ✓ Discretionary Calorie Food

The data on food intake collected using interviews was used as a basis to select foods for nutrient analyses.

3.6.4. Nutritional analysis

The AOAC (official) methods of nutrient analysis were used to analytically determine the composition of the food that is eaten by children. Once in the laboratory of EPHI, the food samples were assayed for proximate analysis (total energy, moisture, ash, dietary fiber, carbohydrate, protein, fat, and minerals (iron, zinc, calcium and phosphorous) and anti-nutritional analysis (phytate, tannin).

The steps and procedures for sample collection and preparation was done as described by Pomeranz Meloan (1994).

Accordingly,

- ✓ Foods predominantly fed to children were identified first and the dominant food was Atmit according to the data.
- ✓ Atmit samples were collected all along the study area (from each kebelles) directly from the randomly selected households. These samples were taken from food prepared for the children.
- ✓ In average six samples per Atmit type were collected to reflect variability in food composition.
- ✓ Approximately 10 gram of each sample was collected in closed plastic bottles (15cm by 10 cm)
- ✓ Finally, the sample was transported to JUCAVM post harvest laboratory in the same day to pass through first phase of sample preparation.

The collected Atmit samples were with different recipes since mothers use different combinations of ingredients in preparing the Atmit flour. However, analysis of each and every Atmit types was impossible due to the limitations of time and budget as well as the sample size was so little to perform analysis for each. So, Atmits were categorized to groups in which different Atmits fall in. The groups were based on the ingredients used. These groups were

- ✓ C- Atmits made of only cereals
- ✓ CP- Atmits made of cereals and pulses
- ✓ CO- Atmits made of only cereals and oil seeds
- ✓ CPO- Atmits made of cereals, pulses and oil seeds
- ✓ CPS- Atmits made of cereals, pulses and spice
- ✓ COPS- Atmits made of cereals, oil seeds, pulses and spices

The collected samples were then prepared for the second steps by taking a portion of composite sample as follows:

- Samples were dried at 95- 100^0c in vacuum oven to constant weight.
- Edible portion of sub-samples was grounded and combined in their respective groups to form composite sample.
- Composite Samples were packed and stored in such a way that no significant changes occur from the moment of sampling until the analysis is completed.
- Coding was done for each sample before they were transported to EPHI for analysis.

3.6.4.1. Proximate composition analysis

Proximate composition of each food samples was determined. These were done in duplicate.

Determination of Moisture Content

Moisture of the sample was determined with air oven method according to AOAC, 2011, 925.10. The metal dish was dried at 130^{o}C ± 3^{o}C for 1hr in drying oven and placed in desiccators for 30 minutes and weighted after was cooled. About 5g of well mixed sample was weighted and transferred to drying dishes. Then the dishes with samples were put in the oven for 1 hr provided with opening for ventilation and maintained at 130^{o}C ± 3^{o}C. Finally, the dishes were taken out and transferred to desiccators and weighted soon after reaching room temperature. Then, the moisture content was estimated by the formula:-

$$Moisture(\%) = \frac{(M_{intial} - M_{dried})}{SW} x100\%$$

Where

M_{intial}: Weight of metal dish and fresh sample

M_{dried}: Weight of metal dish and dried sample

SW: sample weight

Determination of Crude Fiber

The crude fiber was determined by the non-enzymatic gravimetric method (AOAC, 2000, 920.168). About 2gram of the sample was weighed and placed into 600 ml beaker and 200 ml of 1.25% $H_2SO_4$was added. Then the beaker was placed on digestion apparatus and boiled exactly

for 30 min., while shaking at 5 min intervals and keeping the solution on the standard level. Then after exactly 30 minute, 20 ml of 28% KOH was added and boiled for further 30 minute. The solution was passed through screen sieve and the digested sample was decanted. The digestion beaker was washed with 3 x 50 ml portion of near boiling point water and each transferred into the screen for filtration. The residue left on the screen was transferred into 600 ml digestion flask by washing the screen with 200 ml (50mlx4) 1 % NaOH. Then it was placed on digestion apparatus and boiled for 30 min. while shaking at 5 min interval. The digested sample was filtered in coarse porosity (75µm) crucible in apparatus at a vacuum of about 25mm. The residue was dried at 130^{o}C for 2 hours and cooled in desiccators and weighed (m_1). The dried residue was ignited for 2 hrs at 600±15^{o}C until ashing was completed and then was cooled in desiccators and reweighed (m_2).

$$Crudefiber\ \% = \frac{M1 - M2}{weightofsample}\, x\ 100$$

Where,

M_1 = mass of crucible and residue before ignition

M_2 = mass of crucible and residue after ignition

Determination of Crude Protein

Protein content was determined according to Kjeldahl method of crude protein analysis (AOAC, 2000, 979.09).

Digestion

About 0.1-1g of the food sample was weighed on an analytical balance into the digestion flask or larger test tube. Then the sample was digested by addition of small volume (3-5ml) of concentrated H_2SO_4 (an oxidizing agents which digests the food), anhydrous Na_2SO_4 or K_2SO_4 that speed up the reaction by raising the boiling points of H_2SO_4 and a catalyst ($CuSO_4$, selenium, titanium or mercury) to speed the reaction. About 1 g of catalyst mixture made of Na_2SO_4 or K_2SO_4 with anhydrous $CuSO_4$ in the ratio of 10:1 was used. Digestion converted any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia and

other organic matter to CO_2 and H_2O. In acidic solution, ammonia doesn't liberate as gas because rather it exists as ammonium sulfate salt.

N (in food) $\longrightarrow$ $(NH_4)_2\ SO_4$

Distillation

After digestion was completed, the content in the flask was diluted by water and a concentrated NaOH (40%) solution. It was added to make the solution slightly alkaline and to liberate ammonia gas. The ammonia was then distilled into receiving flask that consist, a standardized strong acid, solution of excess boric acid (4%) for reaction with ammonia or sulfuric acid.

Titration

The borate ion was titrated with standard acid (0.1N HCI).

$NH_3 + H_3BO_3$ (boric acid) $\longrightarrow$ $NH_4 + H_2BO_3$ (borate ion)

$H_3BO_3 + H^+ \longrightarrow H_3BO_3$

Calculation =Total nitrogen, percent by weight

$$Totalnitrogen = \frac{(T-B)xNx14.007\ x\ 100}{w}$$

Where:

T-Volume in ml of the standard acid solution used in the titration for the test material

B - Volume in ml of the standard acid solution used in the titration for the blank determination

N - Normality of standard sulphuric acid

W - Weight in grams of the test material

Crude protein = 6.25 * total nitrogen

Determination of Crude Fat

Crude fat was determined using soxhlet extraction methods according to AOAC, 2011, 2003.06. About 1-5g of sample was weighed and put into a thimble. The thimble and contents were placed into a 50 ml beaker and dried in an oven for 2 hr at 102 ± 2^oC. Thimble and contents were transferred in to extraction apparatus. The beaker was rinsed for several times with the solvent hexane. The sample contained in the thimble was extracted with the solvent hexane in a Soxhlet

extraction apparatus for 6-8 hr. At the completion of the extraction, the extract was transferred from the extraction flask into a pre-weighted evaporating small beaker with several rinsing with the solvent. The hexane was evaporated until no odor of it was detected. The beaker and contents was dried in the oven for 30 minutes at 102^{o}C ± 2^{o}C to remove moisture. Then it was removed from the oven and cooled in desiccators. Finally, the beaker and contents were weighed and crude fat was calculated with formula below.

$$Crudefat(\%) = \frac{W2 - W1}{Weightofsample} x\ 100\%$$

Where:

W_1= Weight of extraction flask before extraction

W_2 = Weight of extraction flask after extraction.

Determination of Total Ash

Total Ash was determined according to AOAC, 2011, 923.03. The crucibles used for the analysis were cleaned by drying at 120^{o}C and igniting at 550^{o}C in furnace for 3 hours. Then the crucibles were removed from the furnace and cooled in desiccators .The mass of the crucible was measured by analytical balance (M1).About 3-5g of the sample was weighed in to crucibles (M2).The sample was dried at 120^{o}C for 1hr in drying oven. The sample was removed from the drying oven and carbonized by blue flame of Bunsen burner by placing the sample dish on wire gauze. The sample then placed in furnace at about 550^{o}C until free from carbon and the residues appear grayish white (about 8 hours).The sample was removed from the furnace and was moisten by the few drops of water to complete the ashing and placed in an oven at 120^{o}C for 1hr and re-ashed at 550^{o}C until white ash color is obtained. After complete ashing, it was removed from the furnace and placed in the desiccators and weighed (M3).

$$Totalash(\%) = \left(\frac{M3 - M1}{M2 - M1}\right) x100$$

Determination of Crude Carbohydrate

Total carbohydrate content of the samples was determined by subtraction of the above tests parameters from 100%.

$$CHO(\%) = 100 - (\%moisture + \%\, fat + \%Ash + \%Crudefiber + \%Crudeprotein)$$

Determination of Calorific Value/Energy Value Calculation

Calorific value of food (in Kcal) was determined by multiplying each gram of protein, fat and carbohydrate obtained from laboratory analysis by their respective conversion factor.

$$Caloricvalue = (protein \times 4) + (carbohydrate \times 4) + (fat \times 9)$$

3.6.4.2. Mineral Analyses

The Mineral analyses were done by Atomic Absorption spectrophotometer method according to AOAC, 2011, 985.35. 1.5 g of sample was putted in the oven at 100^{o}C for 30 min. when dry, was heated on hot plate until smoke was finished and then the dish was placed in 525^{o}C furnace (carefully avoiding ignition) for minimum time necessary to obtain ash that is white and free from Carbon normally 3-5h but ≤ 8h. The dish was removed from furnace and cooled. The ash was dissolved in 5ml 1M HNO_3 warming on steam bath or hot plate 2-3 min to aid in solution. The solution was added in to 50ml volumetric flask and repeated with 2 additional portion of 1M HNO_3 (Nitric acid).

The minerals were determined by adding $LaCl_3$ (Lanthanum chloride) solution to final dilution of standard and test solution to make 0.1% (w/v) La for determination of Ca and Mg only. Calibration curve (concentration vs absorbance) was prepared for each mineral to be determined using wavelength for Ca 422.7nm, Fe 248.4nm, Mg 285.2nm and Zn 213.9nm and flame for Ca reducing air C_2H_2 and for Mg, Zn and Fe oxidizing air C_2H_2.

3.6.4.3. Anti-nutritional factors analysis

Determination of Phytate

The method described by Vaintraub and Lapteva, (1988) was used for phaytate determination. 5g of dried sample was weighed and extracted with 10ml of 0.2N HCl for 1 hr at an ambient

temperature and centrifuge (3000rpm/30minut). The clear supernatant was used for the phytate estimation. Then 2 ml of wade reagent was added to 3ml of the supernatant sample solution then homogenize and centrifuged the solution (3000rpm/10minut). The absorbance at 500nm was measured using UV-Vis spectrophotometer. The phytate concentration was calculated from the difference between the absorbance of the blank (3ml of 0.2N HCl +2ml of wade reagent) and that of assayed sample. The amount of phytic acid was calculated using phytic acid standard curve and result was expressed as phytic acid in µg/g fresh weight.

Standard solution Preparation

A series of standard solution was prepared containing 4-40 µg/ml phytic acid in 0.2N HCl. 3ml of standard was pipette in to 15 ml centrifuge tubes with 3ml of water used as a zero level (blank).Then 2ml of the Wade reagent was added to each tube and the solution was mixed on a vortex mixer for 5 seconds. The mixture was centrifuged for (3000rpm/10min) and the supernatant read at 500nm by using water to make zero the spectrophotometer. Using SPSS plot the calibration curve (absorbance Vs concentration) and find out the slope and intercept.

Calculation: $phytic\ acid\ in \frac{\mu g}{g} = \frac{Absorbance - Intercept}{Slope \times Density \times weight\ of\ sample}$

Determination of condensed tannin

The method described by Maxson and Rooney, (1972) was used for condensed tannin determination. 1g of sample weighed in a screw cap test tube and 10ml 1%HCl added in methanol to the tube containing sample, then lid put in the tube on mechanical shaker for 24 hr at room temperature and centrifuged at 1000 G for 5minute. 1ml supernatant taken and mixed with 5ml of vanillin-HCl reagent in another test tube t for 20 minute to complete the reaction then the absorbance at 500nm was read.

Standard solution Preparation

D- Catechin was used as the standard value of tannin in mg D- Catechin /g of sample. 40 mg of D- Catechin was weighed and dissolved in 100ml of 1%HCl in methanol (stock) then 0, 0.2, 0.4, 0.6, 0.8 and 1ml of stock solution was taken in a test tube. Volume of each tube was adjusted to 1ml with 1% HCl in methanol. 5ml of vanillin-HCl reagent was added in each tube for 20 minute

to complete the reaction. The absorbance at 500nm was read. Reference curve was prepared from the series of standard solution.

$$\text{Tannin in mg/g} = \frac{\text{Absorbance-Intercept}}{\text{Slope x Density x weight of sample}}$$

3.7. Data quality

A pre-test of the interview among five mothers who have child in the age of 0-24 months in every nine kebelles was carried out before the actual interviews were started. The interviews were carried out by the study researcher and the supervisor together with health extension worker using structured questionnaire. Health extension workers (HEW) (native and spoke the local language) were recruited from each kebelle (a total of nine HEW were recruited) to select households with under-two children through house-to-house visit and to contribute in the study to make the respondents feel free and volunteer to make the interview. Training was given for the HEW on the purpose of the study, method used for the study and questions on the questioner. The local language was chosen to make it easier for the respondents to freely express themselves and feel comfortable so translation and back translation was done by the researcher. The respondents were permitted to mention foods in any order.

3.8. Data analysis

The data collected for the study was entered and documented electronically using Epidata version 3.1 (Lauritsen & Bruus, 2008). Statistical Package for Social Sciences software version 20 (SPSS Inc., Chicago, IL, USA) was used to conduct all the statistical analyses and indicators of malnutrition were calculated using WHO Athro-Plus software. Thus, those below -2 standard deviations of the NCHS median reference for height-for-age, weight-for- age and weight-for-height were defined as stunted, underweight and wasted respectively (WHO, 2006). Before performing the anthropometric calculation, the data were cleaned to remove the outliers as described by Saaka (2014). For all statistical tests, a P value < 0.05 was considered for statistical significance. For the analysis purposes, descriptive statistics such as mean, median, range, percentages, tabular presentation, pie charts, bar graphs, mapping and figures were used and binary multivariable logistic regression models were fitted to identify variables that predict

nutritional status of children. Principal Component Analysis (PCA) was used as data reduction tool to calculate wealth of households (Saaka, 2014).

3.6. Ethical considerations

In conducting this study, emphasis was given to every important ethical issue. First, before entering in to the actual data collection, a formal letter of ethical clearance was sought and obtained from JUCAVM research and ethical review board then the letter was personally handed to the health office head. A similar procedure was followed and a letter was taken from the health office head and provided to sampled districts and kebelles health offices and letter for health extension workers was written from each kebelles principals to conduct the research in the study area. In the same vein, people were participated with their full permission. Accordingly, oral consent was obtained by telling participants objectively and honestly about the purpose, nature and importance of the research, their freedom to refuse participation and of any possibility of psychological discomfort. Every effort was made to keep participant anonymous, and confidential further more every source was acknowledged.

3.7. Limitations of the study

This study has some limitations; it doesn't include, measurement of portion size, analysis for the vitamins (beta- carotene), analysis for complementary foods next to Atmit in the list, analysis for each Atmit recipes, the effect of processing on the nutritional composition was not included and the nutritional composition of Atmit from urban and rural residences was not seen separately because of challenges faced from EPHI, cost and time limitation and also the behavior of the study participants. So it needs further studies focusing on these gaps.

3.8. Strength of the study

This study has more strengths than the limitations; it was totally original study, it included different aspects which are related to nutritional status of children, shows the brief over view of the study area regarding breastfeeding practice, complementary feeding practice, child care, nutritional composition of complementary foods, dietary diversity and frequency. Beyond these the study identifies the predictors of nutritional status of under-two children.

4. RESULTS AND DISCUSSION

4.1. Socio-demographic and economic characteristics of mothers, children and households

A total of 558 mothers who had children aged 0-24 months were interviewed and all agreed to participate in the study which made the response rate 100%. Majority 372 (66.7) of the participants were from the rural part of the study area, were Muslims in religion 516 (92.5%), Oromo in ethnicity 486 (87.1%), married and living together 501(89.8%) and 336 (60.2%) were uneducated. A large amount of the families belong to lower middle class of socio economic status because most of them were engaged in petty business and many 436 (78.1%) were housewives (Table 3).

Table 3: Socio-demographic characteristics of mothers (N=558) in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables	Categories		Frequency (N=558)	Percentage (%)
Place of residence	Rural		372	66.7
	Urban		186	33.3
Religion	Muslim		516	92.5
	Orthodox		33	5.9
	Protestant		9	1.6
Ethnicity	Oromo		486	87.1
	Amhara		20	3.6
	Guraghe		8	1.4
	Tigray		3	0.5
	Yem		15	2.7
	Others		26	4.7
Educational Status	Informal Education		336	60.2
	Formal Education	1- 4	97	17.3
		5 – 8	85	15.2
		9 -10	29	5.9
		Preparatory/TVET	9	1.16
		Diploma	2	0.35
Age (Year)	15-19		26	4.7
	20-29		360	64.5
	30-39		161	28.9
	40-49		11	2.0
Median	26 years			
Marital status	Single		33	5.9

	Married &Living together	501	89.8
	Married but not Living Together	16	2.9
	Widowed	5	0.9
	Divorced	3	0.5
Occupation	House Wife	436	78.1
	Farmer	3	.5
	Government Employee	7	1.3
	NGO Employee	1	0.2
	Merchant	83	14.9
	Daily Laborer	25	4.5
	Other (broker, home servant, and self employed)	3	0.5

Those 501 married respondents provided information on the educational status and occupation of their respective husbands/partners. In view of that, 235 (42.1) of the husbands/partners were uneducated or had only informal education while the others were educated formally. Occupation wise, the majority of the husbands/partners, 342 (61.3%) were farmers (Table 4).

Table 4: General characteristics of husbands (N=501) in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables	**Categories**		**Frequency (N=501)**	**Percentage (%)**
Husband's Educational Status	Informal Education		209	41.7
	Formal Education	1- 4	80	16.0
		5 – 8	151	30.14
		9 -10	39	7.78
		Preparatory/TVET	18	3.59
		Diploma	4	0.79
Husband's Occupation	Farmer		318	63.5
	Government Employee		32	6.4
	NGO Employee		8	1.6
	Merchant		59	11.8
	Daily Laborer		63	12.6
	Other(driver, jobless, self employed, broker, and student)		21	4.2

The median age of mothers was 26 years (Table 3). About half of the mothers 306 (54.8%) have 3 and above children. The mean number of children per mother for this study found to be 1.55 (SD±0.5) which range 1-8 children. The data is presented by the following age categories: 0–6

months (N= 155), 7–12 months (N= 196), and13–24 months (N= 207). The mean age of index children was 11.41 (SD±6.5) months, which range 1-24 months. Of the whole children, children in age group 13-24 months score high with percentage of 37.1%. Of the total children participated, 302 (54.1%) were males while the rest 256 (45.9%) were females. Regarding the birth order of the index child, 306 (54.8%) had third and above birth orders (Table 5).

Table 5: General characteristics of index children aged 0-24 months (N=558) in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variable	Categories	Frequency (N=558)	Percentage (%)
Sex Of Index Children	Male	302	54.1
	Female	256	45.9
Age of Index children	0-6 months	155	28
	7-12 months	196	35
	13-24 months	207	37
Mean	11.41 (SD±6.5)		
Birth Order Of The Index Children	First	128	22.9
	Second	124	22.2
	Third & Above	306	54.8
Number of children per mother	1-2 children	252	45.2
	3 and above children	306	54.8

Most 254 (45.5%) of the households have family size of 5-7 members making their incomes mostly 347 (62.2%) by farming. Of the total households, 183 (32.8) of them fall in the medium status of wealth while 186 (33.3) of them were poor. Most of the households used protected well as the major 230 (41.2%) source of drinking water and 280 (50.6%) of them have ventilated improved pit. Most of the respondents 348 (62.4%) access shops near to their home beside the presence of market place in most 372 (66.7%) of kebelles (Table 6).

Table 6: Characteristics of the households (N=558) in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variable	Categories	Frequency (N=558)	Percentage
Family Size	2-4 Members	201	36.0
	5-7 Members	254	45.5
	8-9 Members	81	14.5
	10 and Above Members	22	3.9
Main Source of House Hold Income	Farming	347	62.2
	Cattle Production	1	0.2
	Business	90	16.1
	Salary	44	7.9
	Wedge	67	12.0
	Other (pension, money from abroad, nothing, commission)	9	1.6
Wealth Of The House Hold	Poor	186	33.3
	Medium	189	33.9
	Rich	183	32.8
Source of House Hold Drinking Water	Protected Well	230	41.2
	Protected Spring	217	38.9
	Pipe	39	7.0
	Unprotected Well/Spring/River...	72	12.9
Presence of Toilet Facilities	No	5	.9
	Yes pit latrine	273	49.4
	ventilated improved pit	280	50.6
Presence of Market in Respective Kebeles	No	186	33.3
	Yes	372	66.7
Presence of Shops near to Home	No	210	37.6
	Yes	348	62.4

The respondents were inquired about the ownership of agricultural land and livestock their households possess based on the understanding that such parameters have prominent economic and nutrition implications.

About 342 (61.3%) of the represented households had either private or rented agricultural land. 216 (38.7%) of the households had no agricultural land. Concerning livestock ownership, in average each household owned 1.6 cows, 1.8 oxen, 2.1 goats 4.3 chickens, 2.3 sheep, and 3.6 horses/donkeys/mules.

4.2. Facilities and health education

The respondents were asked about the educations and facilities given by the health extension workers since such parameters have direct relation with child nutrition. According to the study vast of the respondents, 544 (97.5), 449 (80.5), 549 (97.8), 489 (87.6), 470 (84.2), 469 (84.1) and 499 (89.4) were aware or had taken the education given about family planning, early initiation of breast feeding, exclusive breast feeding for the first six months, continued breast feeding up to 2 years, dietary diversity and frequency of complementary food and consumption of complementary food respectively but minimum count of mothers had practiced the education they had taken, respectively (Table 7).

Table 7: Educations taken and practiced by mothers of the children in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables	**Educated**		**Practiced**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Family Planning	544	97.5	343	61.5
Early initiation of breast feeding	449	80.5	488	87.5
Exclusive breast feeding	546	97.8	496	88.9
Continued breast feeding up to 2 years old	470	84.2	422	75.6
Dietary diversity	469	84.1	255	45.7
Feeding frequency	469	84.1	385	90.8
Consumption of complementary food	499	89.4	258	46.2

There are health center and/or health posts in each study kebelles. According to the study there is health center in the urban kebelles while there is health post in the rural kebeles. So, most of the mothers had access to health post rather than health centers (Table 8).

Table 8: Health Facilities present in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables	Categories	Frequency
Presence of Health center	Yes	186 (33.3)
	No	372 (66.7)
Presence of Health post	Yes	434 (77.8)
	No	124 (22.2)

4.3. Breastfeeding practices

World Health Organization (2010) and Food Science and Nutrition Program (2010) recommended that, breastfeeding should start immediately within one hour following of delivery for the baby to get colostrums, the infant should thereafter be exclusively breastfed for up to six months of life, day and night on child's demand and breastfeeding should still continue until the child is two years of age.

Accordingly, the study signified that optimal breastfeeding practice is in a good condition. All (100 %) of the children were being fed at the time of the study. About 87.5% of the mothers initiated the breastfeeding within the first hour after birth and 58.1 % of them fed colostrums to their baby while the remaining squeeze out or discard the colostrums. And also 88.9 % and 75.6 % of the total mothers provided breast milk exclusively for the recommended duration of 6 months and continued to breastfeed their child up to 2 and more years respectively. Mothers also claimed to breastfeed the children day and night according to the demand of the children accordingly the median duration of breast feeding frequency between sun set and sun rise was 7 times (Table 9).

Table 9: Breast Feeding, Complimentary Feeding and Diet Diversity Practices of under age of two children in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variable	Categories	Frequency (N=558)	Percentage (%)
Time of initiation of breast feeding	Within the first 1 hr	488	87.5
	After the first 1 hr	70	12.5
Colostrums feeding	Yes	324	58.1
	No	234	41.9
Exclusive breast feeding	Yes	496	88.9
	No	62	11.1
Continued breast feeding up to 2 or more years old	Yes	422	75.6
	No	136	24.4
Frequency of breast feeding from sun rise to sun set (6Am-6PM)	1-7 times a day	282	50.5
	8-24 times a day	276	49.5
Time of initiation of complimentary feeding	Before 6 month	49	11.6
	Just at 6 month	350	82.9
	After 6 month	23	5.5
Preparation of special complimentary food	Yes	258	46.2
	No	300	53.8
Preparation of special food during sickness or recovery	Yes	47	8.4
	No	511	91.6
Feeding frequency	>2 times a day	39	9.2
	3-4 times a day	326	76.9
	3-4 times + 1-2 snack	59	13.9
Dietary diversity score	< 4 food groups per day	303	54.3
	≥ 4 food groups per day	255	45.7

This result was in line with Food Science and Nutrition Program (2010) which reported that nearly all, 839 (99.3%), of the included children were ever breastfed and 780 (92.3%) were being fed, two in three children, 549 (65.4%), initiated the breastfeeding within the first hour after birth and among 839 mothers who ever breastfed, 530 (62.7%) fed Colostrums to the baby and the result of EDHS (2005) which reported that in rural areas of Ethiopia 96.0% of children were ever breastfed, 69.5% initiated breastfeeding within the first 1 hour after birth and the average frequency of breastfeeding per day was 12.3 times.

According to WHO (2010), among the three recommended breastfeeding practices, continued breastfeeding at one year is most commonly reported at high rates in all regions except the

European Region, followed by early initiation of breastfeeding. The least frequent practice is exclusive breastfeeding up to 6 month of age.

4.4. Complementary feeding practices

World Health Organization recommends the introduction of solid food to infants around the age of 6 months because by that age breast milk by itself is no longer sufficient to maintain a child's optimal growth. Seventy five point six percent of the children had started to have a complementary food at the time of survey. Both early and late initiation of complementary food were common in the study areas but most 350 (82.9 %) of the mothers started to feed their child just at six month. However, most of the mothers 300 (53.8 %) do not prepare any special complementary food other than the common family dish while the rest prepare some other additional foods of which 'Atmit' is the predominant one. At the same point 511 (91.6 %) of the mothers do not prepare any special food to their child during sickness or recovery from sickness. Even though, the study signified that child feeding frequency is in a good condition that 322 (96.7 %) of the mothers feed their child 3-4 times a day (Table 9).

In line with this, several studies in developing countries showed that both too early and too late introduction of complementary food was common. Mothers in South Africa started complementary feeding wit in 2-3 months in 2003. Again in Uganda 44.1% and 27% mothers started complementary feeding wit in 2-3 months in1997 and2005 respectively (Sanusi Rasaki, 2010).

It was contrary to the recommended practice of complementary feeding at or after sickness. According to WHO (2009) and Brown (2001), during an illness, the need for fluid often increases, so a child should be offered and encouraged to take more. However, feeding frequency of the children in the study area was optimal for children in age group of 7-12 but not for those in age group of 13-24 months according to the recommendation of WHO (2001) and Ethiopian national strategy for IYCF (2010) which states for healthy breastfed infant, the minimum recommended number of meals per day should be 2 to 3 times at 6 to 8 months, 3-4 times at 9-11 months, and 3-4 times with 1-2 additional nutritious snacks at 12 to 23 months of age.

As shown below in table 10, the predominant complementary food fed to children in the study areas is gruel or 'Atmit' ranking first in the all of the three districts. Potato, milk and egg are the other predominantly consumed complementary foods by children in the study area.

This is comparable to the statement of FDREMH (2011) which states that traditional infant foods are thin gruels, locally named 'Atmit', made of cereals or tubers. In the same line with regards to complementary feeding, Zewditu et al. (2003) investigated that only cereal based complementary foods in the form of Kitta (Unleavened bread), gruel (liquid drink made of cereals) and porridge was given to 56% of the children in Tigray.

Table 10: Common complementary foods fed to children 6- 24 months in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Food Types	**Frequency (%)**			**Total**
	Mana	Omo-Nada	Dedo	
Gruel /Atmit	74(39.8)	72(38.7)	96(51.6)	242(43.4)
Potato	20(10.8)	26(14.0)	35(18.8)	81(14.5)
Egg	18(9.7)	18(1.0)	25(13.4)	61(10.9)
Rice	1(0.5)	1(0.5)	8(4.3)	10(1.8)
Milk	23(12.4)	29(15.6)	20(10.8)	72(12.9)
Fenugreek	1(0.5)	1(0.5)	2(1.1)	4(0.7)
Beso	2(1.1)	1(0.5)	1(0.5)	4(0.7)
Porridge	14(7.5)	7(3.8)	8(4.3)	29(5.2)
Pastini	0(0.0)	3(1.6)	2(1.1)	5(0.9)
Baby Food	4(2.2)	3(1.6)	1(0.5)	8(1.4)

Even if "Atmit" is the predominant complementary food fed to children in the study area, there are about 62 listed combinations of ingredients (recipes) to prepare the atmit flour. So in this study the most common ingredients of Atmit flour were identified and their nutrient compositions were referred from the book of food composition table for use in Ethiopia, part III. So, the most common crops used as ingredients (cereals, pulse, oil seeds & spices) of different Atmit types prepared for children under-two in the study area and their perspective nutrient compositions is given in the Table 11.

Table 11: Nutrient composition of dominantly used crops for Atmit flour preparation in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014*

Crops	Energy	Protein	Fat	CHO	Fiber	Ash	Ca	P	Fe
Barley	368	8.5	2.0	79	2.2	1.4	17	294	6.3
Teff	358.8	9.3	2.4	75	2.0	2.4	130	354	23.4
Oat	379.7	12.7	2.5	76.6	2.5	1.6	12	342	7.0
Bean	349.8	23.1	1.4	61.2	1.3	2.6	49	338	6.1
Lentil	356.6	21.8	0.6	66.0	2.3	2.2	27	262	8.5
Peanut	612.5	30.6	45.2	20.9	4	1.6	79.0	383	7.0
Linseed	620.2	16.3	47	33.0	6.8	2.8	504	483	8.0
Fenugreek	382.4	19.3	7.2	60.1	8.3	2.6	173	283	11.2
Black cumin	504.6	13.8	32.2	39.9	16.4	7.6	519	594	17.0

*Compiled from EHNRI (1997)

4.5. Dietary diversity

The average diet diversity score (DDS) out of seven diet categories was 3. Nearly half of the children had sub-optimal dietary diversity score that 255 (45.7%) of the mothers feed their child 4 or more than four food group in the preceding day of the survey (Table 9). This result was supported by the result reported by Food Science and Nutrition Program (2010) which was region wise, the highest mean diversity score of 3.4 was observed in Oromia region, followed by Tigray (2.9) Amhara (2.7) and SNNP (2.6) regions. In Oromia region nearly half (49.4%), of the children had suboptimal diet diversity.

There is a significant association ($P< 0.00$) between child dietary diversity and child age. Among children aged 0-6 months, the mean DDS of 1.1 was witnessed. Of these age groups 131 scored 0 DDS that means that they do not start having a meal while the mean DDS for children aged 7-12 months and 13-24 months were 3.4 and 4.3, respectively. In age category of 7-12 months, most of the children were fed with poorly diversified diet of less than four DDS while children in age category of 13-24 months had optimal diet diversity of four and above four DDS.

Dietary diversity is also influenced by different factors. This study showed the distribution of dietary diversity over different influencing factors. Accordingly Dietary diversity score was significantly (P<0.05) influenced by number of children per mother and the wealth status of the household. And also even if not statistically significant (P>0.05), it was affected by place of residence and district. The higher the dietary diversity was scored in households with higher wealth status and in children from mothers having only 1 or 2 children. Also it was higher in Dedo district and urban kebelles of the study areas (Table 12).

Table 12: Distribution of DDS by different Variables in Jimma Zone, South West Ethiopia

Variables	Categories	Zero	<4 food groups	≥ food groups	χ2 (P-value)
Child age group	0-6 month	131(84.5%)	19 (12.5%)	5 (3.2%)	
	7-12 months	5 (2.6%)	99 (50.5%)	92 (46.9%)	
	13-24 months	1 (0.5%)	48 (23.2%)	**158 (76.3%)**	
Districts	Mana	42 (22.6%)	61 (32.8%)	83 (44.6%)	
	Omo-Nada	57(30.6%)	44 (23.7%)	85 (45.7%)	
	Dedo	38 (20.4%)	61(32.8%)	**87 (46.8%)**	0.93
No of children per mother	**1-2 children**	52 (20.6%)	65(25.8%)	**135 (53.6%)**	
	3 and above children	85(27.8%)	101(33.0%)	120 (39.27%)	**0.03**
Place of residence	**Rural**	92 (24.7%)	115 (30.9%)	165 (44.4%)	0.61
	Urban	45 (24.2%)	51(27.4%)	**90 (48.4%)**	
Wealth of households	Poor	50 (26.9%)	66 (35.5%)	70 (37.6%)	
	Medium	52 (27.5%)	50 (26.5%)	87 (46.0%)	
	Rich	35 (19.1%)	50 (27.3%)	**98 (53.6%)**	**0.02**

This result was contrary to other studies. According to Belachew et al., (2013), it was observed the proportion of food insecure adolescents was significantly high among urban adolescents (23.5%) compared to (20.2%) in the semi-urban areas and 17.9% in the rural areas (P=0.028). in the statement of World Bank (2012), Agriculture is the main occupation of 80% of poor populations in rural areas, Agriculture systems have a crucial role in provision of food, livelihoods, and income and in the same vain Hadley et al., (2011) stated that the ability to produce sufficient foods for one's household at home and to generate sufficient income to

purchase foods on the market are ways that a household could achieve food security. The former represents the rural farmer and the latter the urban dweller but Ethiopia experienced particularly dramatic increases in food prices, resulting food crisis to the urban dwellers.

This study signified that according to the 24-hour recall conducted higher percentage of the children in the study area were fed cereals and grains (90.6%) followed by discretionary calorie foods (70.7%), protein rich foods (59.0%), oil and fats (53.2%), vegetables (50.6), fruits (37.0%) and dairy products (23.6%) (Table 13).

Table 13: Food types consumed in the preceding day of survey by under-two children in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Food groups	**Percentage**	**Food groups**	**Percentage**
Cereals and Grains	**90.6**	**Protein rich foods**	**59.0**
Wheat	36.4	Bean	31.5
Sorghum	35.3	Egg	6.1
Oat	28.5	Nut and seeds	11.1
Teff	46.4	lentil	32.1
Barley	35.1	Others	0.8
Others	34.2		
Fruits	**37.0**	**Dairy products**	**23.6**
Mango	2.9	Milk	**17.4**
Avocado	17.7	Others	0.9
Banana	12.2	**Oil and fats**	**53.2**
Others	3.5	Oil	37.8
		Butter	7.5
Vegetables	**50.6**	Others	0.4
Potato	17.6	**Discretionary calorie foods**	**70.7**
Onion	30.6	Sugar	47.0
Kale	5.0	Biscuits	15.4
Pepper	20.4	Others	7.7
Others	13		

However, even if the figures are so large the consumption was not fairly distributed within each food groups. In the cereals and grain group teff (46.4%), wheat (36.4%), sorghum (35.3%) barley (35.1%) and oat (28.5); in discretionary calorie group only sugar (47.0%) and commercial biscuits (15.4%); in protein rich food group bean (31.5%), lentil (23.1%) and nut and seeds (11.1%); in oil and fat group only oils (37.8%) and butter (7.5%); in vegetable group onion

(30.6%), pepper (20.4%) and potato (30.6%); in fruit group only avocado (17.6) and banana (12.2) and in dairy group only milk (17.4%) were the dominant food types consumed while the rest of food types listed in every groups scored insignificant percentage (<10%) (Table13).

This is in argument with the result of EDHS (2005 and 2000) which indicated that in Ethiopia at age of 6-23 months, the proportion of children consuming foods made from grains (70 percent) is the highest, compared with the consumption of other types of solid or semisolid foods and The majority of children consumed foods made from grains (59 percent) respectively. In the same way study conducted in Nigeria by Sanusi Rasaki (2010), reported that the predominant food groups in the diet were cereal/grains (92%).

The consumption of these food groups is affected by child's sex and age as shown in figure 4 below. There was higher consumption of all the types of foods by male children who were 12-24 months of age except for dairy products which was highly consumed by children in age group of 7-12 month. In this study intra family gender inequalities in food distribution have been observed.

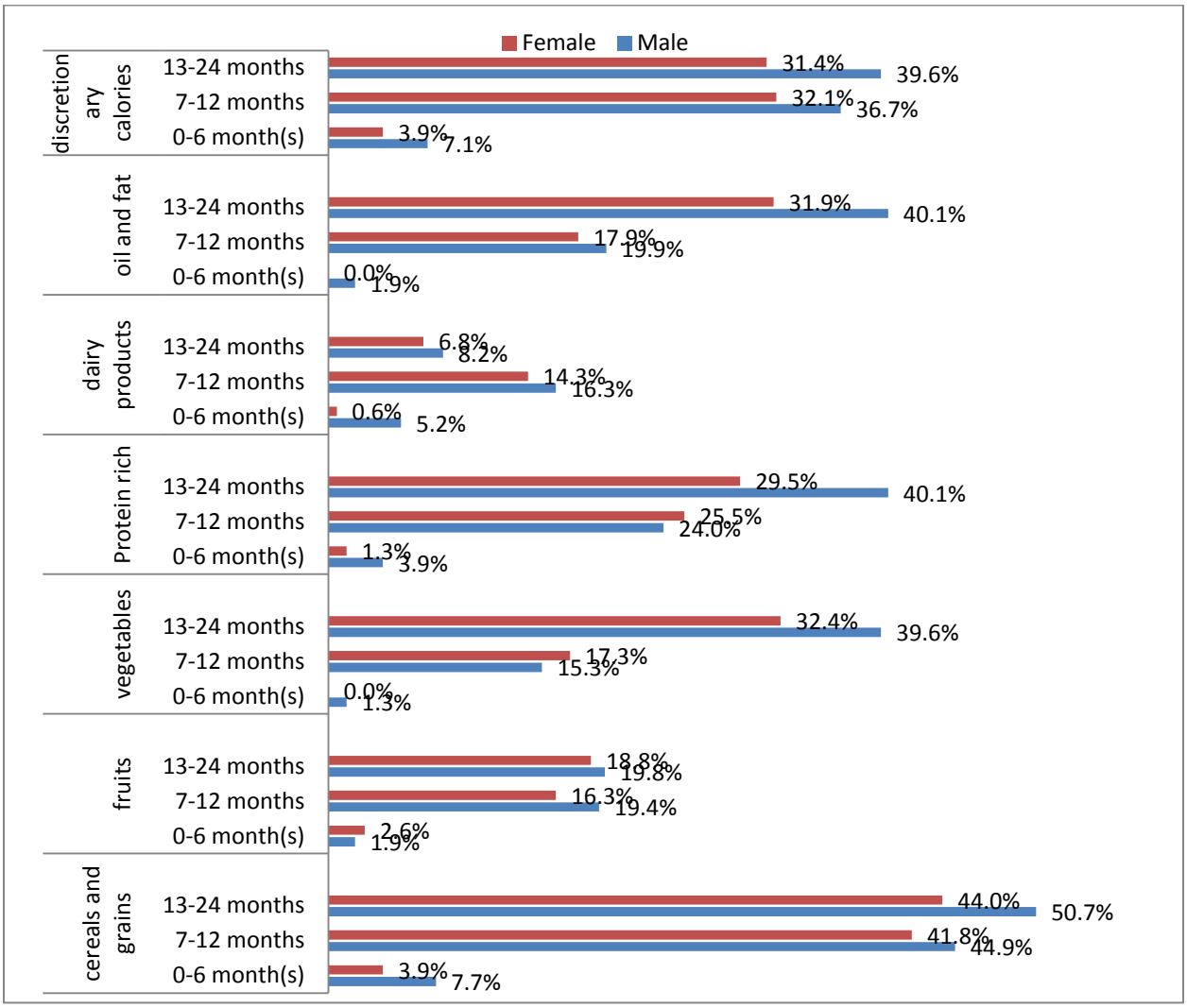


Figure 4: Daily consumption of food groups by under-two children in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

In same line, according to the Food and Agricultural Organization, FAO (2013), Social and economic inequalities between men and women often stand in the way of good nutrition. This condition is seen in South Asian and African communities, where boys and men are culturally selected to eat more nutritive foods such as eggs. A similar male gender bias in the intra-household distribution of food and other resources have been reported from Ethiopia (Hadley et al., 2008) indicating that girls are less favored in the resource constrained environments.

It is also in argument to the result of study conducted in Jimma Zone, Southwest Ethiopia by Belachew et al., (2013) which reported, with regard to exposure of adolescents to food insecurity

over time, 15.9% of the girls and 12.2% of the boys (P=0.018) were food insecure both at baseline and after year 1 survey. In general, a significantly (P=0.045) higher proportion (40%) of girls experienced food insecurity at least in one of the survey rounds compared with boys (36.6%). Reports from other studies also showed that girls suffered from low dietary diversity more than their boy counterparts

4.6. Anthropometric measurements

According to the World Health Organization (WHO), malnutrition has three commonly used comprehensive types named stunting, wasting and underweight measures by height for age, weight for height and weight for age indexes respectively.

Accordingly the study assessed the prevalence of these three types of malnutrition. All (100%) of the sampled children had measurement on their height and weight to ascertain their nutritional status. Of these According to the NCHS reference standard taking –2.S.D as cutoff point, the study children who fell below –2 SD of the indicators (Underweight, Stunted, and Wasted)were computed as 73 (13.1%), 143 (25.6%) and 54 (9.7%) respectively (Figure 6).

The under Two children of this study area were in a better condition compared to malnutrition reported by a number of other studies. (Melkei, 2007) reported underweight, stunting, and wasting rates of 28.5%, 24% and 17.7%, respectively and also EDHS (2005) indicated that underweight, wasting and stunting rates of 35.7, 9.7 and 51.3%, respectively. Similarly, a quarter (25.0%) of children in North Wollo were underweight, about half (44.5%) were stunted while 9.0% were wasted (Abate et al., 2003).

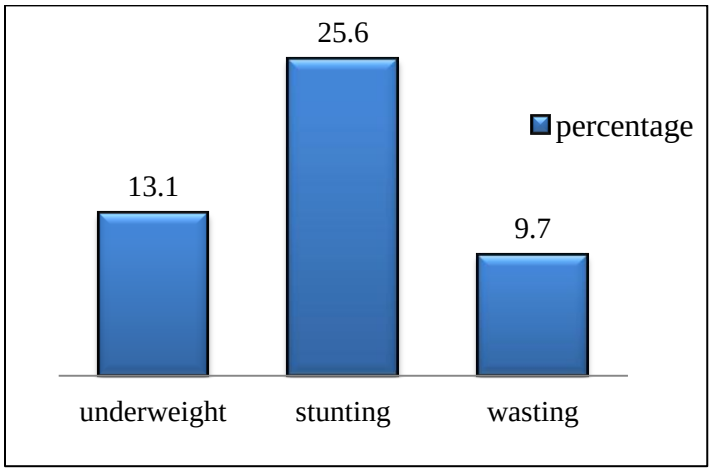


Figure 5: Percentage of malnutrition in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Even if it is no statistically significant the prevalence of underweight and wasting was higher in Dedo followed by Omo-Nada but lower in Mana, while the prevalence of stunting had similar figure in all the three districts. The prevalence of all types of malnutrition; underweight, stunting and wasting were significantly ($p<0.05$) higher among boys compared to girls 16.3, 32.4, 10.7 versus 9.4, 17.6, 8.2 percent respectively. Stunting significantly increases with the age of the child (higher in the age groups 13-24 months, followed by 7- 12 months but lower in infancy 0-6 months; 40.6, 21.5 versus 10.5 percent respectively), while underweight and wasting were bold in age group of 7-12 months (Table 14).

Analogous to this Mahgoub et al. (2006) reported that in Botswana by all the three types of malnutrition were significantly ($p < 0.01$) more prevalent among boys than among girls. It is also in argument with the result of study conducted in two rejoins of Ethiopia (SNNP and Tigray) by Disha et al., (2011), which indicated that in general, male children had slightly worse nutritional status compared to their female counterparts; mean HAZ and WAZ were lower in males than females for most of the period of infancy and early childhood. It is also in accordance with the observation of Jyothi et al., (2003) which is a higher proportion of female children had normal weight/age and weight/height ratios than their male counterparts. Still it is in harmony with the result of Kandala et al. (2011) which indicated that the chances of being stunted are significantly higher among male children than the young females. This difference among boys and females

may be due to the fact that the male children are more active and hence there is more energy expenditure Abate et al. (2003).

In the same vain according to Kandala et al., 2011 the prevalence of stunting has an inverse linear association with the age of the child (higher in the age groups ranging from 4 years, followed by 3 years, 2 years, 1 years but lower in the younger age (0 year): 55.1, 49.4, 48.5, 46.5 versus 23.1 percent). Similarly EDHS (2005) indicated that stunting increases with the age of the child; this is evidenced by the increase in stunting from 27 percent among children age 6-8 months to 62 percent among children age 18-23 months. High prevalence of underweight and wasting at the age of 7-12 months was may be due to inappropriate and/or inadequate feeding practices because the levels of children underweight and wasting coincides with the age at which normal complementary feeding starts (EDHS, 2005). The period children start complementary feeding is a very vulnerable period. It is the time when malnutrition starts in many infants. Complementary foods are often of inadequate nutritional quality, or they are given too early or too late, in too small amounts, or not frequently enough. Premature cessation or low frequency of breastfeeding also contributes to insufficient nutrient and energy intake in infants beyond 6 months of age (WHO, 2009).

As shown in Table 14 even if it was not statistically significant, all types of child malnutrition (under weight, stunting and wasting) were higher in children whose birth order was 3 and above 3 (14.7, 27.1 and 10.4 respectively) and lower in those whose with first birth order (10.1, 21.8 and 9.6 respectively). Similarly higher in children from mothers having three or more children (14%, 27.1% and 10.1% respectively)

This is in argument with result of study done in Botswana by Mahgoub et al., (2006) which is the percentage of underweight children among households with two children under three years old (27.8 %) was significantly ($p < 0.01$) higher than the percentage of underweight children among households with one child (14.8 %). Parallel to this Girma and Genebo (2002), reported that highest level of stunting was observed among children whose birth order was 4 or 5 (54%), followed by birth order 6 and more (53%). i.e. smaller percentage (47%) of children of low birth order are malnourished compared to those of higher birth orders, EDHS, (2005) Indicated that

stunting increases with increasing birth order of the child at the same time the percentage of children classified as wasted is highest among children of birth order 4 and 5 (13%) and Jyothi et al., (2003) also reported that the proportion of children with normal weight/age reduced two-fold when the birth order increased from one to above three.

Table 14: Distribution of malnutrition by child characteristics in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables	Categories	Underweight	Stunting	Wasting
Age	0-6 months	8	16	9
	7-12 months	**34**	43	**31**
	23-24 months	31	**84**	13
$\chi 2$ (P-value)		**0.002**	**<0.001**	**0.001**
Sex	Male	**49**	**98**	**32**
	Female	24	45	21
$\chi 2$ (P-value)		0.11	**<0.001**	0.19
Birth order	First	13	28	14
	Second	15	32	10
	Third & above	**45**	**83**	**29**
$\chi 2$ (P-value)		0.411	0.52	0.739
No of children per mother	1-2 children	28	60	22
	≥3 children	45	83	32
$\chi 2$ (P-value)		0.13	0.2	0.3

Underweight and wasting were higher in rural areas compared with urban areas (15.6% and 10.5% versus 8.1% and 8.1%) respectively while stunting was higher in urban areas (23.4% versus 30.1%). At the same time all types of child malnutrition were inversely associated with wealth of households and maternal education, higher among poor households and in children from non educated mother than in middle and rich households as well as in children from educated mothers i.e. under weight, stunting and wasting rates were 15.2%, 27.1% and 11.3% respectively among children from non educated mothers while 9.9%, 23.4% and 7.3% among children from educated mothers (Table 15).

In contrary to this, in Ethiopia, children in rural area are especially prone to nutrient deficiencies as they eat from the family dish, which is predominantly plant-based (Melaku et al., 2005). Girma and Genebo, (2002) also reported the prevalence of stunting was significantly higher in rural areas (52%) as compared with urban areas (42%). Similarly Kandala et al., (2011) reported

the higher prevalence of stunting in rural areas compared with urban areas (48.4 versus 37.2 percent) and EDHS (2005), in addition reported that rural children are more stunted (48 percent) than urban children (30 percent). This is still contrary to the result of this study but again the same study reported that the proportion of children wasted is higher in rural areas (11 percent) than in urban areas (6 percent) which is opposing to the finding.

Kandala et al., 2011 and EDHS, 2005 reported that stunting was linearly associated with maternal education (higher among children from non-educated mother, followed by children from mothers with primary education but lower among children from mothers with secondary or higher education: 49.8, 47.0 versus 35.2 percent). Girma and Genebo (2002) correspondingly reported children whose mothers have no education or who have some primary education are 1.8 times more likely to be stunted than children whose mothers have some secondary or higher education. Likewise, Kandala et al., 2011 showed that stunting was linearly associated with socio-economic status of the household (higher among children from the poorest household, followed by children from poor, middle or rich households but lower among children from richest households: 49.8, 48.0, 45.5, 43.9 versus 28.7 percent). Girma and Genebo (2002), also argued with this result stating that as compared with children residing in households with medium or higher economic status, children residing in very poor and poor households were two times more likely to be stunted. In the same way Janevic *et al.* (2010), reported that children in the lowest quintile were four times more likely to be stunted (AOR = 4.1, 95%CI = 2.4, 6.9) compared to the highest quintile. EDHS (2005) as well reported that the relationship between stunting and wealth status is not uniform, though children in the highest wealth quintile are least likely to be stunted compared with those in the other wealth quintiles. Again the same study reported that the level of wasting decreases with increasing wealth which is in argument with this study.

Table 15: Distribution of malnourished children by selected variables in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Variables		Under weight	Stunting	Wasting
Residence	Rural	58 (15.6)	87 (23.4)	39 (10.5)
	Urban	15 (8.1)	56 (30.1)	15 (8.1)
$\chi 2$ (P-value)		**0.008**	**0.054**	0.24
Wealth	Poor	31 (16.7)	50 (26.9)	25 (13.4)
	Medium	26 (13.8)	46 (24.3)	16 (8.6)
	Rich	16 (8.7)	47 (25.7)	13 (7.2)
$\chi 2$ (P-value)		0.07	0.85	0.10
Maternal education	Uneducated/ informal	51 (15.2)	91 (27.1)	38 (11.3)
	Formal education	22 (9.9)	52 (23.4)	16 (7.3)
$\chi 2$ (P-value)		**0.04**	0.19	0.07

4.7. Risk factors of malnutrition in infants and under-two children

On multivariable logistic regression model, after adjusting for various variables, there is significant association between district and wasting children from Omo-Nada were more than 3 times more likely to be wasted as compared to the others [AOR=3.34, 95% CI (1.38, 8.07)]. Similarly, there is significant Association between wasting and wealth of household as well as age of child. Children in poor households were more than 6 time more likely to be wasted [AOR=6.19, 95% CI (2.17, 17.72)] while those in medium households were more than 2 time more likely to be wasted [AOR=2.67, 95% CI (2.67, 7.47)] and as a single unit increase by age of child the child is more probably to be wasted [AOR=0.894, 95% CI (0.833, 0.96)] (Table 16).

Table 16: Multivariable logistic regression model predicting wasting among children below 24 months in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

PREDICTORS	B	P	AOR	95% C.I	
Wealth Index					
Poor	1.824	**<0.001**	**6.197**	2.167	17.723
Medium	0.984	**0.061**	**2.675**	0.957	7.477
Rich (referent)			**1**		
Birth order	-0.863	0.098	0.422	0.152	1.172
No of children	1.269	0.188	3.558	0.538	23.509
District					
Mana	-0.321	0.566	0.726	0.242	2.172
Omo-Nada	1.207	**0.007**	**3.342**	1.385	8.068
Dedo (referent)			**1**		
Place of Residence					
Rural	0.14	0.975	1.014	0.423	2.430
Urban (referent)			1		
Child sex					
Male	0.190	0.582	1.209	0.615	2.379
Female (referent)			1		
Child age	-0.112	**0.002**	**0.894**	0.833	0.960
Maternal education					
Illiterate/ informal education	0.226	0.593	1.254	0.547	2.875
Formal education (referent)			1		
Time of continued BF	-0.085	0.853	0.919	0.374	2.259
Time of BF initiation					
Initiated BF with in the first hr after delivery	-0.191	0.724	0.826	0.286	2.387
Initiated BF after the first hr after delivery			1		
Family size	-0.168	0.602	0.845	0.450	1.589
Frequency of feeding (1)	-1.180	0.134	0.307	0.066	1.439
Constant	-0.826	0.485	0.438		

Note: P = P-value; AOR = Adjusted Odds Ratio; CI = Confidence interval

Children from Omo-Nada were more likely to be wasted as compared to the two other districts because of the high prevalence of different factors associated with malnutrition of children. In Omo-Nada most of the households were in the lowest wealth quintile (poor), had three and above three children, had pit latrine toilet type, use protected well as a source of drinking water and had low accesses to health posts. Also majority of the mothers were uneducated, had poor family planning and practiced pre-lacteal feeding. And most of the index children were with third and

above birth order, had poor feeding frequency, started complementary feeding out of the recommended period and were not fed with colostrums (Figure 6).

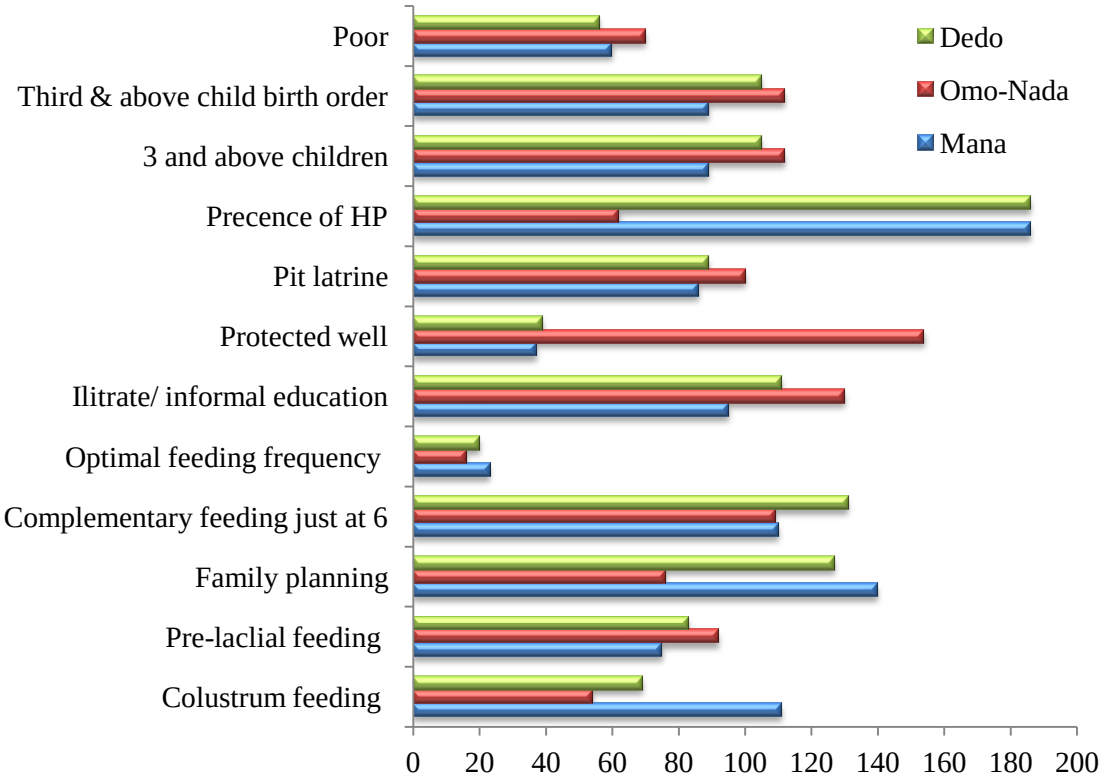


Figure 6: Distribution of factors associated with child malnutrition among children below 24 months in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Different studies argued that these factors are associated with malnutrition of children. The bivariate analysis of Girma and Genebo (2002), showed a positive association between child nutritional status and the availability of safe drinking water or toilet facility. According to Beka *et al.* (2009), Colostrums provides protective effect to the newborn and infants who did not receive colostrums may have high incidence, duration and severity of illnesses such as diarrhea which contribute to malnutrition. Also Abate *et al*. (2003), reported that significantly higher proportion of children who received weaning foods less frequently are found to have been malnourished in comparison with the young children who received weaning foods four or more times per day. Furthermore, Zewditu *et al.* (2004) demonstrated that malnourishment is highest in children who are given pre-lacteal feed and Abate *et al*. (2003) confirmed that significantly

high proportion of children in households, who have more than one child under five are found underweight and wasted. This could be attributed to the inability of mothers to provide adequate care for their young children. In addition, Girma and Genebo (2002), the level of stunting, underweight, and wasting are also higher for rural children than urban children.

In the same way after adjusting for various variables, there is significant association between underweight and wealth of household, sex of child and time of initiation of breast feeding. Children in poor households were more than 2 time more likely to be under weight [AOR=2.173, 95% CI (1.021, 4.624)], Male children were more than 2 times more likely to be under weight as compared to females [AOR=2.09, 95% CI (1.179, 3.703)] and children who initiated BF after the first 1 hr after birth were more than 2 times more likely to be under weight as compared to those initiated in the first 1 hr [AOR=2.059, 95% CI (1.011, 4.193)] (Table 17).

This result is supported by Asfaw *et al*. (2015) who reported that male children were 2.5 times (AOR=, 95% CI: 1.5-4.1) more likely to be underweight than female children and by Mussie *et al.* (2014) who demonstrated that initiation of breastfeeding after 6hrs after birth were 13 times more likely underweight as compared with children who feed, breastfeeding within 1hr [AOR= 12.94, (CI 95% 4.04, 41.49)].

Table 17: Multivariable logistic regression model predicting underweight children below 24 months in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

PREDICTORS	B	P	AOR	95% C.I	
Wealth Index					
Poor	0.776	**0.044**	**2.173**	1.021	4.624
Medium	0.45	**0.231**	**1.569**	0.751	3.274
Rich			1		
Birth order	-0.061	0.892	0.941	0.393	2.252
No of children	0.565	0.452	1.76	0.404	7.677
District					
Mana	0.427	0.311	1.533	0.671	3.504
Dedo	0.568	0.139	1.765	0.832	3.744
Omo-Nada			1		
Child sex					
Male	0.737	**0.012**	**2.09**	1.179	3.703
Female			1		
Child age	0.026	0.298	1.027	0.977	1.079
Maternal education					
Illiterate/ informal	0.334	0.33	1.396	0.714	2.73
Formal education			1		
Time of continued BF	-0.057	0.887	0.944	0.43	2.073
Time of initiation of breast feeding					
Initiated within 1 hr	0.722	**0.046**	**2.059**	1.011	4.193
Initiated after 1 hr			1		
Family size	-0.239	0.344	0.788	0.48	1.292
Frequency of feeding	-1.015	0.108	0.362	0.105	1.249
Constant	-4.032	0	0.018		

Note: P = P-value; AOR = Adjusted Odds Ratio; CI = Confidence interval

Moreover, there is a significant association between stunting and sex, age of child and place of residence. Male children were more than 2 times more likely to be stunted as compared to females [AOR=2.601, 95%CI (1.681, 4.025)], children from rural residence were more probably to be stunted as compared to those from urban residence [AOR=0.526, 95%CI (0.323, 0.857)] and as there is a unit increase by age of child the more probably the child get stunted (Table 18).

This is comparable to the statement of Asfaw *et al*. (2015), regarding stunting, male children were 2.8 times (AOR =2.8, 95% CI: 1.5-5.3) more likely to be stunted compared with female

children and Mussie *et al*. (2014), Female children's were less likely stunted [AOR= 0.47, (CI 95% 0.31, 0.72)] as compared to male children. Also according to Girma and Genebo (2002), the level of stunting, underweight, and wasting are also higher for rural children than urban children

Table 18: Multivariable logistic regression model predicting stunting children below 24 months in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

PREDICTORS	**B**	**P**	**AOR**	**95% C.I**	
Wealth of household					
Poor	0.223	0.417	1.250	0.730	2.141
Medium	0.401	0.161	1.494	0.853	2.618
Rich			1		
No of children					
1 and 2 children	0.368	0.103	1.445	0.928	2.249
3 and more children			1		
DISTRICT					
Omo-Nada	0.046	0.861	1.047	0.628	1.745
Dedo	0-.238	0.362	0.788	0.472	1.316
Mana			1		
Sex of child					
Male	0.956	**<0.0001**	**2.601**	1.681	4.025
Female			1		
Age of child	0.128	**<0.0001**	**1.137**	**1.099**	1.175
Time initiation of BF					
Initiated with in 1 hr	-0.367	0.267	0.693	0.362	1.325
Initiated after 1 hr			**1**		
Place of residence					
Rural	-0.642	**0.010**	**0.526**	0.323	0.857
Urban					
Constant	-2.984	<0.0001	0.051		

Note: P = P-value; AOR = Adjusted Odds Ratio; CI = Confidence interval

4.8. Macro and micronutrient content of complementary food samples

4.8.1. Proximate composition of "Atmit" samples

Of the total 37 Atmit samples collected from the nine study kebeles, macro and micronutrient contents of 6 composite food samples were determined at EHNRI and the data are presented in table 22. Dietary adequacy was determined using the Recommended Daily Allowance (RDA) and Dietary Reference Intake (DRI) for age group (0–6 months, 7–12 months, and 1–2years). When the RDA was not available, as for fiber, Adequate Intake (AI) was used.

The total energy content of the food samples ranged from 27.87cal in Atmit type CPO to 162.57cal in Atmit type COPS (Table 19). Energy was higher in COPS Atmit type which had higher concentration of fat and protein too this makes the COPS to have higher energy content since energy comes from foods containing carbohydrate, protein, or fat (USDA &WIC, 2009).

The values in all types of Atmits were below the daily requirement as a complementary food. According to WHO/ UNICEF (1998), the average breast milk energy intake is 413, 379 and 346 kcal/day at age of 6-8, 9-11 and12-23 months, respectively and the total energy requirements of health breast feeding infants are proximately 615kcal/day, 686kcal/day and 894kcal/day for children 6-8, 9-11 and 12-23 months of age (Dewey and Brown, 2002). So, the average energy required from Complementary food is estimated by subtracting average breast milk energy from the total energy requirement at each age (WHO/ UNICEF 1998). Accordingly the energy required from complementary food found to be 202kcal, 307kcal and 548kcal at age of 6-8, 9-11 and12-23 months, respectively.

The Atmits based on fat content can be arranged **COPS (8.49%),** CP (4.49%), CPS (2.49%), CPO (1.27%), C (1.33%) and **CO (0.86%)** in decreasing order (Table 19). The concentration of fat was higher in COPS Atmit type which was made up of cereals, oils seeds, pulses and spices. Maximum concentration of fat was recorded because of the high concentration of fat in the oil seeds mainly Peanuts (45.2g/100g) and Linseed (47g/100g) and spices mainly Black cumin (32.2g/100g) & Fenugreek (7.2g/100g) according to food composition table for use in Ethiopia Part III (1997).

The highest and lowest values were in between the range of the recommended daily requirement of fat as a complementary food, 0.34%, 5.38% and 17.42%, at age of 6-8, 9-11 and12-23 months, respectively. So, the fat contents from all Atmit types were adequate for children in age of 6-11months but inadequate for those in the age of 12-24 months (WHO/ UNICEF 1998).

The Atmits based on carbohydrate content can be arranged **C (24.44 %), CO (10.02%)** CP (9.78%), CPOS (9.67%), CPS (5.58%), and CPO (**4.29%)** in decreasing order. The highest concentration of carbohydrate was reported from C Atmit type which is made of only cereals (Table 19).. The dominantly used cereals in the Atmit flour were barley, oat and teff with CHO concentration of 79g, 76.6g and 75g, per 100 gram of edible portion, respectively according to food composition table for use in Ethiopia Part III (1997).

As the recommendation of (FNB, 2001 and 2011), children need to take carbohydrate at a quantity of 60g/ day, 95 g/ day and 130 g/ day at the age of 0-6months, 7-12months and 1-3years, respectively. So in order to get this much gram of carbohydrate per day children the age 0-6months, 7-12months and 1-3years, respectively should consume 245.5g/day, 388.7g/day, 531.9g/day of C Atmit (Atmit with the highest CHO content) type respectively. Even more for the other types of Atmits which is practically impossible and contradictory to the recommendation of WHO (2000) which stated that the approximate quantity of complementary foods that would meet the energy need of infants and young children in developing country is 137g/day-187g/day, 206g/day-281g/day and 378g/day-515g/day in age of 6-8 months, 9-11 months and 12- 24months, respectively. This shows that the content of carbohydrate present in all Atmit types was insufficient to satisfy the need of children in all age categories.

Table 19: The nutritional composition of sampled complementary foods (Atmits) in three districts of Jimma Zone, Southwest Ethiopia from March-May, 2014

Atmit types	Fiber	Fat	Ash	Protein	CHO	Calorific Value	Moisture	Iron	Zinc	Calcium	Phosphorous	Phytate	Tannin
C	**2.28**	1.33	5.34	**8.21**	**24.44**	142.57	**58.4**	30.34	**1.78**	177.57	245.32	70.68	1.17
CO	2.65*	**0.86**	3.78	10.49	10.02	89.78	72.2	33.86	2.86	206.18	257.62	96.33	7.22
CPO	6.99	1.27	**8.03**	8.4	**4.29**	**27.87**	**79.6**	**42.39**	2.81	**168.41**	**225.56**	BDL	22.36
CPS	**8.19**	2.49	4.9	10.77	5.58	87.81	67.8	36.52	2.9	198.12	272.44	BDL	45.5
CP	6.41	4.49	5.15	9.67	9.78	118.21	64.5	29.2	3.03	178	**317**	**117.72**	19.67
COPS	5.73	**8.49**	**2.94**	**11.87**	9.67	**162.57**	61.3	**22.48**	**4.14**	**250.4**	259.48	-	**75.17**

*Calculated from EHNRI (1997)

Note: BDL= below detectable level; C= Atmit made of cereal; CO= Atmit made of cereal and oil seed; CPO= Atmit made of cereal, pulse and oil seed; CPS= Atmit made of cereal, pulses and spice; CP= Atmit made of cereal and pulse; COPS= Atmit made of cereal, oil seed, pulses and spices.

The results for Fiber, Fat, Ash, protein and moisture are in percentage (%), for calorific value is Kcal/100g, while for the rest is in mg/100g.

Protein content of the Atmit types ranged from 8.21% for C to 11.87% for COPS which is too little in all cases. COPS Atmit type was with the higher protein concentration than the others because of the pulses, oils seeds and spices added to the flour of Atmit (Table 19). There is high concentration of protein in the pulses majorly bean (23.1g/100g) and lentil (21.8g/100g), oil seeds majorly peanut (30.6g/100g) & linseed (16.3/100g) and in spices majorly Black cumin (13.8g/100g) & Fenugreek (19.3g/100g) according to food composition table for use in Ethiopia Part III (1997).

The quantity of protein required is 20g/day between 6 months and 3 years. As an indication, the mother who gives 800ml of milk provides her child with just 8g of protein a day. The complementary food thus has to supply the child with the missing 12g of protein (WHO/ UNICEF 1998). And according to the Protein Advisory Group guidelines for weaning foods, protein content should be 20% (Eschleman, 1991).

The Atmits based on fiber content can be arranged **CPS (8.19 %),** CPO (6.99%), CP (6.41%), CPOS (5.73%), CO (2.65*) and **C (2.28%)** in decreasing order. There was higher fiber content in CPS which was made of cereals, pulses and spices than in the others because spices have higher fiber content than the others (Table 19). Of the spices majorly used for the preparation of Atmit flour, the dominant ones fenugreek and black cumin have fiber content of 8.3g/100g and 16.4g/100g, respectively according to food composition table for use in Ethiopia Part III (1997).

No adequate intake (AI) for fiber has been established but it has been recommended that from 6-12 months whole-grain cereals, green vegetables, and legumes be gradually introduced to provide 5 grams of fiber per day by 1 year of age (USDA and WIC, 2009). So, children in the study area had higher amount of fiber which is out of the recommended one specially children who consumed Atmit type CPS and those who consumed larger quantity than 100g/day.

Ash content in COPS Atmit type was the least (2.94%) while CPO Atmit type had the highest content (8.03%) comparison (Table 19). Ash refers to any inorganic material, such as minerals, present in food. It's called ash because it's residue that remains after heating removes water and organic material such as fat and protein. Food scientists "ash" foods so that they can examine this

leftover material to better determine a food's content. Ash can include both compounds with essential minerals, such as calcium and potassium, and toxic materials, such as mercury. Generally, any natural food will be less than 5 percent ash in content, while some processed foods can have ash content of more than 10 percent (Michael, 2011). Also according to the Protein Advisory Group guidelines for weaning foods, total ash not more than 5% is recommended (Eschleman, 1991). So accordingly the Atmit types had ash content in between the range and also according to the Protein Advisory Group guidelines for weaning foods moisture content of 5% to 10% are recommended (Eschleman, 1991) but the moisture content of the Atmits ranges from 58.4% to 79.6%, respectively in those C and CPO Atmit samples (Table 19).. This amount of moisture content shows that the Atmits were very thin or liquid in viscosity.

4.8.2. Mineral composition of "Atmit" types

Iron content was minimum (22.48 mg/100g) in Atmit type of COPS and maximum (42.39 mg/100g) in Atmit type of CPO (Table 19). In which is both are more than the average amount of iron required by infants and young children according to the recommendation of FNB (2001and 2011). The Atmits based on Zinc content can be arranged **CPOS (4.14 mg/100g),** CP (3.03 mg/100g), CPS (2.9 mg/100g), CO (2.86 mg/100g), CPO (2.81mg/100g) and **C (1.78 mg/100g),** in decreasing order (Table 19). Atmit type CPOS appeared to contain adequate zinc for infants and young children dietary Zinc requirement while CP also found to be adequate for children in 6-12 age groups if it is consumed in higher quantity (FNB, 2001and 2011).

The Atmits based on calcium content can be arranged **CPOS (250.4 mg/100g),** CO (206 mg/100g), CPS (198.12 mg/100g), C (177.57 mg/100g), CP (178 mg/100g), and **CPO (168.41mg/100g)** in decreasing order (Table 19). These amounts of calcium in all Atmit types were below the average amount of calcium required by infants and young children (FNB, 2001and 2011). The Atmits based on Phosphorous content can be arranged **CP (317 mg/100g),** CPS (272.44 mg/100g), CPOS (259.48 mg/100g), CO (257.62 mg/100g), C (245.32 mg/100g), and **CPO (225.56 mg/100g)** in decreasing order (Table 19). These content of phosphorous in all Atmit types was below the average amount of phosphorous required by infants and young children except CP which found to be adequate for children less than 12 months of age (FNB, 2001and 2011).

4.8.3. Composition of anti-nutritional factors in “Atmit” types

Concentration of pyhtate was high (117.72 mg/100g) in CP Atmit type and below the detectable level in CPO and CPS Atmit types. Phytate was higher in Atmit type of CP because of the pulses added but as proportion of pulses added was reduced in scarifies of other ingredients like oilseed and spices the phytate composition of the Atmits reduced to undetectable level. Tannin content of Atmit types which have pulses (CPOS, CPS & CPO) was higher (75.1 mg/100g, 45.5 mg/100g & 22.36 mg/100g, respectively) than the others (Table 19). This is because pulses have higher inhibitors like tannin according to Thompson (1998).

Notwithstanding, phytic acid; a dietary factor found primarily in unrefined cereals, grains, legumes, and oil seeds are a potent inhibitor of iron, zinc, and calcium absorption. Hence, to ensure absorption of these minerals from a meal, it is important to consider the molar ratios of phytate: mineral of each plant based food in it. The desirable phytate: mineral molar ratios, for mineral absorption, are less than one for phytate: iron (Welch, 1995) and less than 0.17 for phytate: calcium (Krebs, 2002). Moreover, in Ethiopia, there is a lack of information on the phytate and mineral concentrations of infant cereals, despite their increasing use for infant feeding.

The overall nature of the nutrient analysis data showed high variability with no peculiar trend across Atmit types. It indicates that the macro and micronutrient density of the complementary foods (Atmits) were extremely low which resulted in under nourishment of children in the study area. This result is supported by FDREMH, (2011) which reported that traditional infant foods locally named ‘Atmit’ are very low in energy and the micronutrients needed to promote physical and cognitive development. Furthermore, the bulkiness of traditional infant foods and the concentration of fibers and inhibitors in staple food crops are major factors in reducing nutritional benefits of complementary foods. In the same line according to WHO (2002), most of the traditional complementary foods are predominantly made of starch based cereals like maize, sorghum, millets, etc and hence of poor nutritional value, they do not satisfy the infant basic needs of protein because they have limited levels of protein both qualitatively and quantitatively.

As well as macro and micronutrients may be insufficient to maintain growth and development this results poor nutritional status in children. Similarly Beka *et al.* (2009) demonstrated that in West Gojam it was noticed that about 51% of the children who were fed cereal gruel were stunted, whereas 47.6% of children who received injera were found to be stunted and children given cow's milk and mashed potato tended to be less stunted.

5. SUMMARY AND CONCLUSION

Even if nutritional status of children was in a better condition as compared to malnutrition reported by a number of other studies still there is higher rate of stunting in the study area. Infants 0-6 months of age are in good nutritional status due to the wide practice of exclusive breast feeding but after 6 month specially during the complementary feeding period (7-12 months of age) childrens were highly underweight and wasted while those in age group of 13-24 months were highly stunted which is associated with transition from nutritious breast milk to complemenatry food.

The overall complementary feeding practice in the study areas is profoundly sub-optimal in terms of nutrient content, diversity and frequency. But still gaps were observed in the complementary feeding practices of the communities. The overall quantitative evidences indicated that, nearly half and one in four of the mothers provided exclusive breast feeding for shorter and longer duration than the recommended 6 months, respectively. Infants and young children are fed traditionally with Atmit which was poor in nutrient density and the average DDS was extremely low and children did not achieve the recommended feeding frequency for their age.

On the other hand, nutritional status of children was affected by socio-demographic and socio-economic factors of the household. Male children were highly malnuritioed (underweight, wasted and stunted) than females, children in urban had a worse nutritional status than their rural counterparts and children of educated mother had good nutritional status than those of uneducated mothers. Despite the progress in the reduction of child malnutrition in ethiopia in the past 20 years, this study signified that stunting rate is still high in the study area.

6. FUTURE LINE OF WORK

Although Ethiopian government developed an infant and young child feeding guidelines since 2005 and deployed health extension workers in each kebele, child feeding practices in the study are area still suboptimal. As a result both acute and chronic forms of malnutrition are common among children under the age of two years. Therefore, stakeholders focusing on prevention of malnutrition should use integrated approach to include the most vulnerable, with special emphasis given to improving complementary feeding practices, awarness creation should still be implemented to fill the knowledge gap, the work of health extension workers should be motivated and hard working should be prometed to elimenate pooverty. Moreover further study is needed in order to identify the vitamin and iodine deficiency in the area and to see intake of children regarding with the portion size they had per day and similarly to give brief overview of urban and rural differences regarding nutrient intake.

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8. APPENDICES

Annex 1. Questioner used for the data collection

I am Nejat Kiyak from Jimma University. I am Msc student doing a research about nutritional assessment of infants and under-two children in Jimma Zone, selected districts. I got your name from the health extension worker.

Right now, I am going to give you information about my research project and invite you to be part of this research. As already mentioned, I am interested in better understanding of the nutrition of children who are under age of two. I believe that you can help me by telling what you know about foods that you feed to your child. Your participation in this research is entirely voluntary. It is your choice whether to participate or not. You are free to withdraw from the research at any time. Withdrawing from the research will have no negative implications to your work, or yourself or your family. The information that I collect from this research project will be kept private. I will not share information about you to anyone outside of the research team.
After the interviews, I will take your comments, and also I may take food samples from you after analyzing the collected data.

Do you have any questions about this research project?
Thank you for your cooperation and look forward to the work together.

Name of the Interviewer _____Date: (DD____/MM_____/YYYY)
_____
District _____
Kebele/Gott_____

Indicate time in 24 hour system

Start of Interview (HRS/MIN)_____
End of Interview (HRS/MIN) _____
Individual ID_____

Appendices table 1. Demographic and socio-economic part

	A. Background characteristics of woman and their husbands	Response
1.	What is your age? Age in Completed Years	_____Years
2.	What is your religion? 1. Muslim 2.Orthodox 3.Protestants 4.Catholic 5.other (specify)_____	_____
3.	What is your Ethnicity? 1.Oromo 2.Amhara 3.Guraghe 4.Tigray 5.Wolayta 6. Yem 7. Other(specify)----------	_____
4.	What is your Marital status 1. Single 2. Married and living together 3. Married but not living together 4. Widowed 5. Divorced	_____
5.	What is your educational status? 0. Illiterate/ informal education 1. Formal education, Grade____	_____
6.	Are you currently attending education? 0. No1. Yes	_____
7.	What is the level of educational you are attending? 0. informal education 1. Formal education, Grade_____	_____

8.	What is the educational status of your husband? 0. Illiterate/ informal education 1. Formal education, Grade_____	_____	
9.	What is your occupation? **1.** Housewife **2.** Farmer **3.** Government Employee **4.** NGO Employee **5.** Merchant **6.** Daily laborer **7.** Other (specify)_____	_____	
10.	What is the occupation of your husband? 1. Farmer 2. Government Employee 3. NGO Employee 4. Merchant 5. Daily laborer 6. Other (specify)_____	_____	
11	What is the household size (number of people living in the HH)?	_____	
12	Does this change throughout the year? 0. NO 1. YES	_____	
13	If yes, what is the reason? 1.With labor migration, 2.Agricultural season, 3. School semester? 4. Other (specify)_____		
14	How many of these are children?_____	_____	
15	Are all your children? 0. NO 1. YES *if NO, go to special questions	_____	
16	What is their age and sex? 1st child 2nd child 3rd child 4th child 5th child 6th child 7th child Other	Sex	Age
17	Where is the place of residence of the respondent? 1. Rural 2. Urban	_____	

	B. Household income	
1.	What is the main source of income for the household?1.Farming 2.Cattle production 3.Business 4. salary 5.wedge 6.Other (specify) _____	_____
2	Does the household have new or alternative income-generating activities? 1. Yes 0. No	_____
3	What is the new income generating activity? _____	
4	Who is making the money in the new income generating activity? 0. Husband 1. Wife	_____
	C. House hold Wealth	
1.	Does any member of this household have a land that can be used for agriculture? *That can be rent, borrow or community land 0. No 1. Yes	_____

Does the house hold have any of the following animals?		0.NO 1.YES	How many
12	Cows		
13	Oxen		
14	Goats		
15	Sheep		
16	Chicken		
17	Bees		
18	Donkeys		
19	Horses		
20	Donkeys		
21	Mules		
Does the household have any of the following properties?		0.NO	1.YES
22	Functioning radio/Tape recorder/CD player		

23	Functioning Television		
24	Watch (Hand/Wall)		
25	Sofa		
26	Chair/Stool		
27	Mattress		
28	Sponge/Foam mattress		
29	Cotton mattress		
30	Grass Mattress		
31	Refrigerator		
32	Gas Stove		
33	Electric stove		
34	Phone (Mobile or fixed)		
35	Bicycle		
36	Motor Cycle		
37	Cart/Gari		
38	Plough		

D. Facilities

1.	How does your household obtain drinking water? from 1.Under-ground water 2. Spring water 3.pipe 4. Unprotected well/spring/ river…..	_____
2.	Does your household have toilet facilities? 0. NO 1. YES	_____
3	If YES, what type is it? 1. Pit latrine 2. Ventilated improved pit 3. Flash type 4. Other (specify)	_____
4	Is there any health post or health center in your area? 0. NO 1.YES	_____
5	If YES, How much is it far from here/your home/kebele?	_____

6	Is there any market place in your kebele? 0. NO 1. YES	_____
7	If NO, where do you exchange goods?	_____
8	Are there any shops near to your home? 0. NO 1. YES	_____

Appendices table 2. Breastfeeding practice (0-6 month)

No	Questions	Responses	
1	Childs Sex	Male Female	
2	Child's age	_____months	
3	Child's Length	_____ :____Cm	
4	Child's Weight	_____ :____ Kg	
5	Are you breastfeeding (NAME)? 0. NO 1. YES	_____	
6. How long after birth did you first put (NAME)to the breast? In hour or minute		_____	
7	Did you squeeze out and throw away the first milk? 0. NO 1. YES	_____	
8	After delivery, was (NAME) given anything to drink other than breast milk? 0. NO 1. YES	_____	
If yes, what was given to drink		0. NO	1. YES
9	Milk (other than breast milk)		
10	Water		
11	Butter		
12	Syrup		
13	Sugar-salt-water		
14	Tea		
15	Coffee		
16	Other _____		
17	Are you still breastfeeding?		

18. If not, for how many months did you breastfeed?		_____months	
19. How many times did you breastfeed last night between sunset and sunrise?		_____Times	
20	Does (NAME) drink anything yesterday during the day or at night?	0. No	1. Yes
If yes what are they			
21	Fresh or powdered Milk		
22	Infant formula		
23	Water		
25	Tea		
26	Coffee		
27	Fruit juice		
28	Other (specify)….		
29	Does (NAME) eat anything yesterday during the day or at night?		
If yes what are they			
30	Porridge		
31	Comercialy fortified baby food		
32	Bread		
33	Biscut		
34	Other specify….		
35	Does your child started to have complementary food?		
36	Which food do you feed your child during sickness and after recovery from sick	_____	

Appendices table 3. Health Facilities and Educations

E. Trainings from governmental or non -governmental bodies			
Did the health extension officer (some other body) train you the following trainings?		**0.NO 1. YES**	**Adoption (Mark)**
1	Family planning		
2	Children's care		
3	Early initiation of breast feeding		
4	Exclusive breast feeding		
5	Continued breast feeding to 2 years		
6	Complementary food		
7	Dietary diversity and frequency		
8	Consumption of supplementary foods		
9	If they adopt Q#15, what are the supplementary foods you give to your child? _____	_____	
10	From where do you get supplementary foods? 0. Health center/post 1. Shops 2. Aid from other agents	_____	

F. Food consumption/ feeding habit of children				
		0. NO 1. YES	Ingredients **(list)**	method of processing **(circle)**
1	Is there any special food you prepare and feed your child? _____			Raw boiled roasted baked fried whole de-hull fermented germinated other (specify) _____
2	Is there any special food you prepare and feed your child during sickness? _____			Raw boiled roasted

				baked fried whole de-hull fermented germinated other (specify) _____
3	Is there any type of foods forbidden to feed to child due to your religion/ ethnicity?	0. NO	1. YES	List
Which starchy staple do you use dominantly		**Circle**		
4	Cereal Crops	Corn/maize Sorghum Wheat Teff Barley Millet Oat Rice,/Rye		
5	Root and Tuber Crops	Cassava Potato Sweet potato, Taro Tania Yam		
6	Fruit Crops	Banana		
7	Pulses	Chickpea Common bean Lentil Pea Soybean		

1. 24-HOUR DIETARY RECALL PART

I. Please describe the foods (meals and snacks) that your child ate or drank yesterday during the day and night, whether at home or outside the home. Start with the first food or drink of the morning.

Appendices table 4. Dietary diversity score (DDS) within 24-hour (under-two children)

Food group	**Break fast**	**Snack**	**lunch**	**snack**	**dinner**	**snack**	**score**
1. Cereals and grains Corn/Maize, Rice, Wheat, Sorghum, Millet Oats Teff							
2.Fruits Mango, Avocado, Orange, Papaya, Banana, Apple, Jack Fruit, Grape, Pineapple, Passion Fruits Peaches, Watermelon, Strawberry, Guava, Others							
3.Vegetables Tomato, Broccoli, Carrots, Squash, Sweet Potato, Potato, Beet Root, Eggplant, Green Pepper, Onion, Dark green Lettuce,							

Lettuce, Cabbage, Cucumber Mushrooms, Ginger Leeks Pumpkin Shallot Zuchinni Other_____							
4.protien rich foods Meat Beans Egg Fish Chicken Nuts and Seeds Lentils							
5. dairy products Milk Yogurt Cheese							
6.Oil and fat Butter, Animal Fat, Vegetable Oil, Commercial Oil							
7.Discretionary calorie foods Sugar, Honey, Soft drink, Juice Drinks, Chocolates, Candies, Cookies, Cakes, Other_____							

***When the respondent has finished, investigation for meals and snacks not mentioned was done.**

Appendices table 5. Variables used in principal component analysis (wealth index)

Variables	
Non productive assets	**Productive assets**
Radio/Tape recorder/CD player	Livestock
Watch (Hand/Wall)	Plough
Television	
Bicycle	
Motorbike	
Phone	
Sofa	
Chair/ Stool	
Sponge/Foam mattress	
Cotton mattress	
Grass mattress	
Refrigerator	
Gas Stove	
Electric stove	

Appendix Fig. **1 Data collection (Questioner)**

Appendix Fig. **2 Data collection (Recumbent)**