IMRPOVING NUTRIENT CONTENT OF THE FREQUENTLY USED COMPLEMENTARY FOODS FOR CHILDREN AGED 6-23 MONTHS IN ROMBO DISTRICT, KILIMANJARO

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ABSTRACT

Most of the complementary foods in Tanzania have been reported to be poorly prepared, low energy and nutrient density and low nutrients' bioavailability. This study was carried out in Rombo district with the aim to assess feeding practices, nutrient content of the frequently used complementary foods, identify nutrient gaps and then develop more nutritious recipes that may either fill or narrow the gaps. A cross-sectional study was conducted in three ra ndomly selected villages. Information on feeding practices and types of complementary foods was collected using questionnaires. Seven samples of complementary foods with high frequency were collected and analysed for proximate composition, vitamin A and C, iron, zinc, iodine and calcium and results were expressed per 100 g dry weight. They were then converted to the amount consumed per day and then subtracted from the recommended amount needed from complementary foods per day based on child's age in order to identify the gaps. Linear programming method was used to formulate the recipes, which were then taken to laboratory for analysis of the same parameters. Sensory evaluation was conducted to test the acceptability of the formulated recipes. The results showed poor feeding practices, gaps in energy, vitamin C, iron, zinc, calcium and iodine of the frequently used complementary foods. There was a significant ($p<0.05$) improvement in the nutrient content of the formulated recipes with the exception of zinc. Energy, vitamin A, vitamin C, iron, zinc, calcium and iodine content of the formulations ranged from 376.31-486.42 kcal, 1122-3622 µg, 65.05-124.07 mg, 8.08-53.05 mg, 2.29-8.68 mg, 333.98-1228.16 mg and 126.81-792.78 µg/100 g dry weight, respectively. There were significant differences ($p<0.05$) among formulations for all the sensory attributes. Linear programming was found to be a good method to improve nutrient content of complementary foods using low cost, locally available and cultural acceptable ingredients.

DECLARATION

1, Anna Peter Tesha, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted to any other institution.

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The above declaration is confirmed by

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(Supervisor)

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DEDICATION

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
AOR	Adjusted Odds Ratio
CF	Complementary Foods
CI	Confidence Interval
COR	Crude Odds Ratio
CP	Crude Protein
EBF	Exclusive Breastfeeding
FAO	Food and Agriculture Organization
HIV	Human Immunodeficiency Virus
IDA	Iron Deficiency Anaemia
IDD	Iodine Deficiency Disorders
IYCF	Infant and Young Child Feeding Practices
NBS	National Bureau of Statistics
PAHO	Pan American Health Organization
PEM	Protein Energy Malnutrition
RDA	Recommended Dietary Allowance
RCH	Reproductive and Child Health
UN	United Nations
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children's Fund
UNSSCN	United Nations Systems Standing Committee
USAID	United States Agency for International Development

VAD	Vitamin A Deficiency
WB	World Bank
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The first 1000 days of life, from conception until the child's second birthday, are considered the critical window of opportunity for preventing undernutrition and its long-term consequences (Hlaing *et al.,* 2015). Poor breastfeeding patterns, low nutrient density and poor quality of complementary foods account for nutrient deficiency, illness and infections in children, leading to malnutrition at an early age (Srivatsava and Sandhu, 2007). This in turn prevents children from reaching their full physical and mental potential later in life due to delayed physical growth and motor development, low intellectual quotient (IQ), greater behavioural problems, deficient social skills as well as their increased susceptibility to contracting diseases (Kandala *et al*., 2011). The common nutritional problems among children aged 6-23 months in many countries include protein-energy malnutrition (PEM), vitamin A deficiency (VAD), iodine deficiency disorders (IDD) and iron deficiency anaemia (IDA) (WHO, 1998; IFPRI, 2016).

Globally, an estimated 156 (23.8%), 95 (14%), 50 (7.5%) and 16 (2.4%) million children under-five years of age are stunted, underweight, wasted and severely wasted, respectively (UNICEF, 2015; IFPR1, 2016; UNICEF/ WB/ WHO, 2016). Also, over 160 million children worldwide are vitamin A deficient with a prevalence of about 30% in all developing countries and over 293 million (47.4%) of pre-school age children are anaemic worldwide (WHO, 2015; UNSCN, 2016).

In Africa, 58.5 (37%), 13.9 (28%) and 10.3 (25%) million children under the age of five years are stunted, wasted and overweight respectively (IFPRI, 2016; UNICEF/ WB/

WHO, 2015). According to International Food Policy Research Institute (2016), Tanzania ranks 105 out of 132 countries surveyed with stunting, wasting, underweight, severely underweight and anemia prevalence of 34.7, 3.8, 14, 3 and 39.6%, respectively (TFNC, 2014; IFPRI, 2016; NBS and ICF Macro, 2016).

Complementary feeding is an effective strategy in reducing the levels of malnutrition among children aged 6-23 months (Haile *et al*., 2015). Breast milk alone can be used to properly feed infants for the first six months of life, but as infants grow and become more active following the first 6 months of life, breast milk alone falls short of providing the full nutritional requirements and the gap keeps expanding with increasing age of the infants and young children and complementary feeding plays critical role in bridging these gaps (Monte and Giugliani, 2004; Abeshu, 2016). Major problems at this stage include poor timing of complementary foods introduction (too early or too late), poor food preparation and feeding practices, the use of complementary foods with low energy and nutrient density, low nutrients' bioavailability as well as poor processing methods and all of these are exacerbated by poverty and food insecurity (Hussein, 2005; Nyaruhucha *et al*, 2006; Kulwa *et al*., 2015; Williams *et al*., 2015). Formulation of high nutritional value, culturally acceptable, easily accessible, affordable and locally available complementary foods at household level is a long-term and durable strategy to reduce the rate of malnutrition among children aged 6-23 months (WHO, 1998: 2001).

1.2 Problem Statement

Kilimanjaro region, just like other regions of Tanzania has malnourished children of which 18.3, 3.9, 7.5, 1.8 and 4.0% of children less than five years are stunted, severely stunted, underweight, severe underweight and wasted respectively (TFNC, 2014). Also, 48.9% of children under this group are anaemic while 34.2% are vitamin A deficient (NBS, 2016). In Rombo district, the common causes of childhood mortality are pneumonia (20%), malaria (2%), undernutrition (4%) and diarrhoea (2%) (Rombo DC Profile, 2013).

Few studies conducted in Rombo district on child nutrition have identified several poor child feeding practices such as poor knowledge on exclusive breastfeeding, too early introduction of complementary foods, high level of microbial contamination as well as low dietary diversity (Leshabari, 2007; Kimanya *et al*., 2009; Mgongo *et al*., 2013, Mgongo *et al.,* 2014). In Rombo district, maize and banana are the main staple foods and the main complementary foods and this may translate to low dietary diversity and poor micronutrients' intake from complementary foods leading to an increased risk of malnutrition among children aged 6-23 months (Shirima *et al.*, 2000; Kimanya *et al.*, 2008: 2009).

Several studies conducted in other areas which are closer to Rombo district have also identified poor quality of complementary foods and feeding practices as well as low dietary diversity. For example, the study conducted in Manyara region (close to Northern Rombo) identified maize porridge as a common complementary food in which only 46, 3, 10.5, 3.8, 3.0 and 0.4% of the mother/caregivers add milk, beans flour, groundnuts, *dagaa* (sardines), fat/oil or eggs, respectively (Nyaruhucha *et al.*, 2006). Another study conducted in Kajiado and Loitoktok (Kenya) which is closer to Eastern Rombo on knowledge, attitude and practices on infant and young child feeding practices revealed that less than 50% of the mothers know that complementary foods need to be introduced at the age of 6 months and the frequently used complementary foods were maize porridge, animal milk and mashed bananas. All of these translates to poor dietary diversity and increased risk of malnutrition among children of this age group (CW, 2012).

1.3 Justification

In Rombo district, studies on complementary foods and feeding practices especially on dietary diversification and modification are very limited. Most of the studies conducted in Rombo district were on aflatoxins and fumonisms levels in complementary foods (Shirima *et al.*, 2000; Kimanya *et al.*, 2008: 2009: 2014; Acton, 2013). Another study was on prevalence and predictors of exclusive breastfeeding among women (Mgongo *et al.*, 2013).

Several measures have been taken by the government of Tanzania as well as non-government organizations (NGOs), faith-based organizations (FBOs), community-based organizations (CBOs) and other stakeholders to fight against malnutrition among children. Some of them include mass fortification such as salt iodization, home-point-fortification by the use of multiple micronutrients powders or sprinkles, micronutrients' supplementation and immunization (WHO, 2011). All of these measures are very expensive and questionable in terms of sustainability.

Therefore, dietary diversification or modification strategies at the household level will enhance sustainable utilization of complementary foods with a high content and bioavailability of nutrients. This can only be achieved if the modified complementary food ingredients are locally available, sustainable, affordable, safe and culturally acceptable (WHO, 2001; Dewey *et al.*, 2004; Muhimbula and Issa-Zacharia, 2010).

Findings from this study can therefore be used by the district authorities, other government officials and researchers to initiate efforts to improve nutritional status of children aged 6-23 months old children in the district. It will also contribute to the country's efforts towards achieving sustainable development goal number two

(End hunger, achieve food security and improved nutrition and promote sustainable agriculture) and the participants (mothers/caregivers) from this study are expected to disseminate the skills acquired (obtained during preparation and sensory evaluation of the formulated recipes) to other community members (UNDP, 2015; FAO, 2015).

1.4 Study Objectives

1.4.1 Overall objective

The overall objective of the study was to improve bioavailability and diversification of complementary foods given to children aged 6-23 months using low cost and locally available food ingredients at Rombo district.

1.4.2 Specific objectives

The following specific objectives were used to achieve the mentioned general objective of the study:

i. To identify the types of complementary foods, preparation methods and the existing feeding practices to children aged 6-23 months in Rombo district
ii. To identify the nutrients' gap in the complementary foods given to children aged 6-23 months in Rombo district.
iii. To develop more nutrient dense complementary food recipes based on the identified nutrients' gap for children aged 6-23 months in Rombo district.
iv. To test the acceptability of the developed complementary food recipes for children aged 6-23 months.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Infant and Young Child Feeding Practices (IYCF)

WHO/UNICEF have emphasized the first 1000 days of life (that is the 270 days in utero and the first two years after birth) as the critical window period for infant and young child nutrition interventions (Aggarwal *et al*., 2015). This is due to the fact that, the maximal brain growth occurs in this period and if malnutrition occurs at this time, it can lead to stunting and suboptimal developmental outcomes with major effects on short and long-term nutritional status of children (Parvin *et al.*, 2014). Optimal infant and young child feeding practices include initiation of breast-feeding within one hour of birth, exclusive breast-feeding for the first six months, and continuation of breastfeeding for two years or more, along with nutritionally adequate, safe, age appropriate, responsive complementary feeding starting at six months (WHO, 2001; Chandwani *et al.*, 2015).

2.1.1 Breastfeeding

Mothers' own milk is considered to be the best source of infant nutrition (Martin *et al*., 2016). It contains a variety of bioactive agents that promotes survival and healthy development of a child (Oftedal, 2012). It is recommended that breastfeeding should be initiated within 30 minutes of delivery (WHO/UNICEF, 2003; 2010). Exclusive breastfeeding means an infant receives only breast milk and no other liquids or solids, not even water, with the exception of oral rehydration solution, drops or syrups consisting of vitamins, minerals supplements or medicines (WHO, 2009). Breastfeeding should continue for two years and beyond (Das *et al.*, 2013). A longer duration of breastfeeding has been linked to reduced risk of childhood chronic illnesses, obesity and to improved cognitive outcomes (WHO, 2001). Table 1 shows variation in energy and micronutrient composition of different types of milk. Consumption of non-breast milks may result into over or under consumption of specific nutrients and that is why exclusive breastfeeding is recommended for the first six months of a child's life.

Table 1: Comparison of macro and micronutrients composition of different milk types

Nutrients (per 100 ml)	Colostrums (Human milk)	Mature milk (Human milk)	Cow's milk	Infant formula (Maximum)
Energy (kcal)	58	68	59-66	70
Protein (g)	2.3	0.9-1.2	3.2-3.4	3.0
Fat (g)	2.9-3.5	4.1	3.1-3.3	6.0
Vitamin A (µg)	189	60	30-46	180
Vitamin C (mg)	4.4	4.0	0.0-0.2	30
Iron (µg)	0.6	0.07	trace-0.2	1.3
Zinc (mg)	0.6	0.3	0.3-0.4	1.5
Calcium (mg)	23	25-35	91-120	140
Iodine (µg)	13	7	25.6-62.9	50

Source: Muehlhoff *et al.* (2013)**,** Ballard and Morrow (2014), Pereira (2014), Cralwley and Westland (2016) and Travnicek *et al.* (2016)

2.1.2 Complementary feeding

From the age of six months, an infant's need for energy and nutrients starts to exceed what is provided by breast milk, and complementary feeding becomes necessary to fill the energy and nutrients' gap (Dewey, 2003). Complementary feeding means giving infants other foods or fluids in addition to breastmilk. Complementary foods can be especially prepared for the infant or can be the same foods available for family members which are modified in order to meet the eating skills and needs of the infant (Monte and Giugliani, 2004). The target age range for complementary feeding is generally taken to be 6 to 24 months of age, even though breastfeeding may continue beyond two years (WHO, 2001). Complementary feeding should be timely (starting from six months onward) and adequate (in terms of amounts, frequency, consistency and diversified), safe, appropriate

(appropriate texture depending on the age of the child) and by applying responsive feeding following principles for psychosocial care (WHO, 2011; Abeshu *et al.,* 2016).

2.1.2.1 Energy and macronutrient requirement from complementary foods

Macronutrients namely carbohydrates, lipids and proteins are essential for energy and cell multiplication and repair. Inadequate intake of macronutrients can lead to PEM. There are two basic forms of clinical protein-energy malnutrition namely marasmus (characterized by severe wasting) and kwashiorkor (characterized by the presence of oedema) and intermediate states of marasmic-kwashiorkor (WHO, 1981).

An estimated 45% of deaths of children under age 5 are linked to malnutrition due to intake of poor quality diets, poor child care and feeding practices as well as poor-quality health and care environments and behaviours (IFPRI, 2016). Formulation of nutritious complementary food recipes using low cost, locally available ingredients should follow specific guidelines based on the amount of energy and macronutrients needed for children of different age groups (6-8, 9-11 and 12-23) and this will help to reduce the rate of protein-energy malnutrition as well as micronutrients deficiency (WHO, 1998).

(a) Energy

After 6 months of age, breastfed children receive a substantial part of their energy from breast milk but complementary nutrient-dense foods are required to cover additional energy needs in order to meet recommended dietary allowance depending on the age of the child (WHO 1998: 2001). Energy density and feeding frequency of complementary foods affect infants' total daily energy intake and breast milk consumption (Islam *et al.,* 2008). The recommended energy intake from complementary foods is 202, 307 and 548 kcal per day for children aged 6-8, 9-11 and 12-23 months, respectively as shown in

Table 2 (WHO, 1998; Abeshu *et al.*, 2016). The sources of energy in complementary foods include whole grains such as whole-wheat, rice or maize, oatmeal as well as barley, legumes (beans, peas and lentils), milk and milk products, fruits, starchy vegetables such as sweet potatoes, sugary foods and refined grains (O'Neil *et al.*, 2012).

(b) Carbohydrates

Carbohydrates are important sources of energy in human diets comprising 40 to 80% of total energy intake (FAO/WHO, 1998). The primary role of carbohydrate (sugars and starches) is to provide energy to the brain which is the only carbohydrate-dependent organ in the body (IOM, 2005). In food composition databases, carbohydrates are classified as total carbohydrate (calculated as 100 g food minus the sum of grams of water, protein, fat, alcohol and ash) and available carbohydrate (calculated by subtracting from total carbohydrate the dietary fibre value (Charrondiere *et al.*, 2004). Available carbohydrate represents that fraction of carbohydrate that can be digested by human enzymes, absorbed and enters into intermediary metabolism unlike total carbohydrate which includes dietary fibre such as cellulose, hemi-cellulose, lignin and pectins from the cell walls of plants as well as resistant starch and several other compounds that can be a source of energy only after fermentation (FAO, 2003). The major sources of carbohydrate in the human diet are cereals, root crops, sugar crops, pulses, vegetables, fruits and milk and milk products (Otten *et al*., 2006; Slavin and Carlson, 2014).

(c) Protein

Proteins are nitrogen-containing substances which function as a major structural component of muscle and other tissues, production of hormones, enzymes and haemoglobin as well as energy (Hoffman and Falvo, 2005). Foods rich in animal protein are meat, fish, eggs, poultry, and dairy products, while plant foods high in protein are mainly legumes, nuts, and grains (Delimaris, 2013). For children aged 6-23 months, their recommended dietary allowance for protein is 9.1, 9.6 and 10.9 g/d of which breast milk provides 3.9, 0.5 and 1.8 g/d and complementary foods should provide 5.2, 9.1 and 9.1 g/d for children aged 6-8, 9-11 and 12-23 months, respectively (Table 2) (WHO,1998).

(d) Fat

Fat is a good source of energy, essential fatty acids and carrier of fat soluble vitamins namely A, D, E, and K which are essential for infants and young children's growth and development. Breastmilk is an excellent source of fat but as the child starts to consume complementary foods and breastmilk intake declines fat intake also declines (FAO, 2010). Other dietary sources of energy for infants and young children includes corn, milk and milk products, meat, fish, nuts and seeds, plant oils and avocadoes (Uauy and Castillo, 2003). The recommended amount of fat in complementary foods for infants and young children taking average/low amount of breast milk with a normal fat concentration (38 g/L), is 0-34, 5-38 and 17-42% of daily energy requirements at 6-8, 9-11 and 12-23 months respectively (WHO, 2001). With adequate breast milk intake, however, the requirement from complementary foods is 0 g/day (0%) at 6–8 months, 3 g/day (5–8%) at 9–11 months, and 9–13 g/day (15–20%) at 12–23 months (Table 2).

Table 2: Recommended energy, protein and fat intake from complementary foods/day

	Breastfed child			Non-breastfed child		
Age (m)	**Energy (kcal)**	**Protein (g)**	**Fat (g)**	**Energy (kcal)**	**Protein (g)**	**Fat (g)**
6-8	202.0	5.2	0	616.0	9.1	20.5
9-11	307.0	6.7	3	686.0	9.6	22.9
12-23	548.0	9.1	9-13	894.0	10.9	29.8

Source: WHO (1998) and PAHO/WHO (2003)

2.1.2.2 Micronutrients requirement from complementary foods

Micronutrients are those vitamins and minerals needed in very small amounts that must be supplied by a variety of foods in the diet (UNICEF, 2012). Worldwide, the three most common forms of micronutrient deficiency are iron, vitamin A and iodine deficiency and they all affect at least one third of the world's population (Kini, 2016). In most developing countries, the prevalence of micronutrient deficiencies is high among infants and young children aged 6 to 23 months (Nestel *et al.*, 2003; IFPRI, 2015).

(a) Vitamins

Vitamins are organic nutrients needed in small quantities to perform specific functions and they do not provide energy but are necessary in the use of energy (Combs, 2008). They are divided into fat and water-soluble vitamins. Fat-soluble vitamins are vitamins carried in the fat and released as they are needed by the body and these includes vitamins A, D, E, and K while water-soluble vitamins are vitamins carried by water as it passes through the body and they need to be consumed every day and these include B vitamins and vitamin C (Campbell *et al*., 2006).

(i) Vitamin A

Vitamin A (retinol) is an essential nutrient needed in small amounts by humans for the normal functioning of the visual system, growth and development, maintenance of epithelial cellular integrity, immune function and reproduction. These dietary needs for vitamin A are normally provided for as preformed retinol (mainly as retinyl ester) and provitamin A carotenoids (FAO/WHO, 2004; Rodriguez-Amaya and Kimura, 2004). Preformed vitamin A is found almost exclusively in animal products, such as human milk, glandular meats, liver and fish liver oil, eggs especially egg yolk, whole milk and other dairy products while provitamin A carotenoids are found in green leafy vegetables (spinach, amaranthus, and young leaves from various sources), yellow vegetables (pumpkins, squash and carrots), and yellow and orange non-citrus fruits (mangoes, apricots and pawpaw) (Mbah *et al.*, 2013). Vitamin A deficiency (VAD) represents one of the major avoidable public health problems in the world and is one of the most important factors that contribute to the high morbidity and mortality rates among children in developing countries (Carvalho *et al*., 2014). Dietary requirement of vitamin A from complementary foods for children aged 6-8, 9-11 and 12-23 months as shown in Table 3 is 164, 214 and 313 µg RE to meet recommended dietary allowance of 350, 350 and 400 µg RE respectively (WHO, 1998; WHO, 2001).

(ii) Vitamin C (Ascorbic acid)

Ascorbic acid ($C_6H_8O_6$) is a water-soluble vitamin that plays a key role in the body's synthesis of collagen and nor-epinephrine by keeping the enzymes responsible for these processes in their active reduced form, maintain the skin and teeth, increased resistance to stress and infection, preventing scurvy as well as enhancing absorption of non-heme iron in the body (Hernández *et al.*, 2010). The human body cannot produce ascorbic acid, and so it must be obtained entirely through one's diet (Cramer and Kakuma, 2012). The good sources of vitamin C include citrus fruits and juices such as oranges, lemons, limes and tangerines, grapefruits, mangoes, pineapple, peas, pawpaw, tamarind, watermelon, strawberries, raspberries, baobab, bell peppers and dark leafy greens (FAO/WHO, 2004). Table 3 shows the recommended dietary allowance of vitamin C for children aged 6-8, 9-11 and 12-23 months which is 25, 25 and 30 mg/d of which breast milk provides 15, 11 and 7 mg/d and complementary foods provide 10, 14 and 23 mg/d, respectively (WHO, 1998; Lutter and Dewey, 2003).

(b) Minerals

Minerals are inorganic elements found in small amounts in all body tissues and fluids and their presence is necessary for maintenance of certain physicochemical processes which are essential to life (Soetan *et al.*, 2010). Minerals are divided into three groups namely macro-minerals (major) needed in amounts greater than 100 milligrams per day such as calcium, chlorine, magnesium, phosphorus, potassium, sodium, and sulphur, micro-minerals (trace) needed in amounts no more than a few milligrams per day and example include chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, and zinc and ultra-trace elements such as boron, silicon, arsenic and nickel (McMahon and Levetin, 2008).

(i) Iron

Iron is one of the trace elements that serves as a carrier of oxygen to the tissues from the lungs by red blood cell haemoglobin, transport medium for electrons within cells, and an integrated part of important enzyme systems in various tissues (FAO/WHO, 2004). Iron is absorbed from the diet as either heme or non-heme iron. Heme iron is typically derived from haemoglobin or myoglobin and is contained in foods such as red meats, fish, and poultry while non-heme iron can be obtained in foods of animal origin such as dark leafy green vegetables, legumes, grains and fruits. Recommended dietary allowance for iron for children depends on the bioavailability (Ross *et al.*, 2014). For the sources with low, medium and high iron bioavailability, 21, 11 and 7 mg/d is recommended for children aged 6-11 and 12,6 and 4 mg/d for children aged 12-23 months respectively (Table 3) (WHO, 1998).

(ii) Zinc

Inadequate intake of zinc for infants and young children makes them one of the vulnerable groups due to its key roles in cell division, protein synthesis, and growth in general (Thu *et al.*, 1999). Other roles of zinc include regulation of smell, taste and appetite, immune system, structural component of cell membranes, polynucleotide transcription (genetic expression), an essential catalytic component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids as well as in the metabolism of other micronutrients and severe zinc deficiency may lead to growth retardation, delayed sexual and bone maturation, skin lesions, diarrhoea, alopecia, impaired appetite as well as increased susceptibility to infections (FAO/WHO, 2004; Plum *et al.*, 2010). Food sources with high zinc concentration include lean red meat, whole-grain cereals as well as pulses and legumes. Others include processed cereals such as polished rice, lean meat or meat with high fat content, fish, roots and tubers, green leafy vegetables as well as fruits (Frassinetti *et. al.*, 2015). The body has no zinc stores and therefore it has to be provided in the diet (FAO/WHO, 2001). Table 3 shows the recommended zinc intake from complementary foods for children aged 6-8, 9-11 and 12-23 months (WHO, 1998; Dewey, 2003).

(iii) Calcium

Calcium is one of the key minerals needed to provide rigidity to the skeleton by virtue of the insoluble salts it forms with phosphoric acid, ensuring optimal bone, teeth and nail's health, regulation of nerve and muscle function, enzymes activation, blood coagulation and it can be especially important during growth spurts (Tubio-Lopez *et al.*, 2017). Calcium absorption requires calcium-binding proteins and is regulated by vitamin D, sunlight, parathyroid hormone and thyrocalcitonin (Soetan *et al.*, 2010). The sources of calcium include milk and milk products, dark green leafy vegetables, sardines, spinach, soya and tofu (McMahon and Levetin, 2008; Pereira *et al*., 2009). The recommended dietary intake for calcium for children aged 6-8, 9-11 and 12-23 months and the amount needed complementary foods are shown in Table 3 (FAO/ WHO, 2004).

(iv) Iodine

Iodine deficiency can be defined as the world's greatest single cause of preventable brain damage (Ghirri *et al.*, 2014). In Africa, over 40.0% of children aged 0-5 years are said to have low urinary iodine concentration. Iodine is a component of thyroid hormones that are essential for development and growth and severe iodine deficiency may lead to developmental brain damage (de Onis, 2016). Sources of iodine include iodized salt, milk, ground water, fish and other fortified products such as bread. According to WHO (1998), the recommended iodine intake from complementary foods for infants and young children aged 6-8, 9-11 and 12-23 months is 19, 30 and 51 µg/d and the rest is provided by breast milk to meet the RDA of 60, 60 and µg/d respectively (Table 3).

Table 3: Recommended micronutrients intake from complementary foods per day

Nutrient	**Age categories in months**					
	6-8		**9-11**		**12-24**	
	Non-breastfed	Breastfed	Non-breastfed	Breastfed	Non-breastfed	Breastfed
Vitamin A (µg/d)	350.0	13.0	350.0	42.0	400.0	126.0
Vitamin C (mg/d)	25.0	0	25.0	0	30.0	8.0
Iron (mg/d)	21.0	20.8	21.0	20.8	12.0	11.8
Zinc (mg/d)	5.0	4.2	5.0	4.3	6.5	5.8
Calcium (mg/d)	525.0	336.0	525.0	353.0	350.0	196.0
Iodine (µg/d)	60	19	60	30	70-90	51

Source: WHO (1998); FAO/WHO (2004); PAHO/WHO (2013)

2.2 Strategies to Improve Nutritional Status of Children in Tanzania

Under nutrition among children aged 0-5 years have been a major problem among many developing countries including Tanzania. Several efforts have been taken by the government of Tanzania to fight against malnutrition and these include the formation of Tanzania Food and Nutrition Centre (TFNC) in 1973, establishment of primary health care (PHC) and maternal health care (MHC) currently known as RCH unit, formulation of various nutritional policies such as agriculture policy, food and nutrition policy etc., integrating nutritional activities in other sectors, supporting nutrition researches as well the presence of the ministry of health, community development, gender, elderly and children (MOH, 1992; TFNC, 2014). Direct measures that have been taken to fight malnutrition include universal fortification in salt with salt, iron and vitamin A supplementation to children, immunization, fortification of cooking oils with vitamin A, promotion of home gardening and keeping small animals as well as provision of nutrition education in general (NBS and ICF Macro, 2016). Despite all these efforts, the problem of under nutrition is still high with stunting, wasting and underweight levels of 34.7, 3.8 and 14%, respectively (TFNC, 2014; IFPRI, 2016; NBS and ICF Macro, 2016). Food fortification and supplementation may be effective in reducing the levels of under nutrition but their questionable in terms of sustainability (Briend *et al.*, 2001).

2.3 Linear Programming as a Method of Balancing Nutrients in Complementary Foods

Linear programming analysis is a powerful approach for identifying a low-cost, locally available, culturally acceptable and nutritionally adequate diets avoiding a "trial and error" approach (Briend *et al.*, 2001; Dibari *et al.*, 2012). It is an algorithm for maximising or minimising a given (linear) objective function subject to a set of linear constraints on a list of decision variables (Parlesak *et al.*, 2016). In formulating complementary food recipes using linear programming method, it is important to find the recommended dietary allowance (RDA) for each nutrient based on the age of the child, list of all locally available ingredients to be included in the diet including their nutrient composition (can be obtained by using food composition tables or nutri-survey) and their cost as well as the maximum plausible intake per day (obtained by 24-hour dietary recall, food frequency questionnaires or food records) (Briend *et al.*, 2003).

CHAPTER THREE

3.0 METHODOLOGY

This chapter is divided into five sections. The first section describes the area in which the study was conducted while the second one explains the study design and sample selection. The third section is on procedures for data collection which involved information on how the questionnaire was administered as well as materials and methods used in the laboratory analysis of macro and micronutrient contents of the seven samples of frequently used complementary foods for children aged 6-23 months in Rombo district as well as that of the formulated recipes. The fourth section is about procedures employed in the formulation of improved complementary food recipes and the fifth part is about sensory evaluations procedures.

3.1 Description of the Study Area

The study was conducted at Rombo district, in Tarakea division and three villages namely Urauri, Kibaoni and Kikelelwa were involved. The district is located in the Eastern part if Tanzania between latitude: 3°09' South, longitude: 37° 33' East part and is among the seven districts of Kilimanjaro region. It has a total area of 1440 square kilometres (144 000 Hectares) of which 44 114 hectares are used for agriculture, 38 194 hectares are covered by forests and 16 692 hectares are used for infrastructure. Human settlements occupy 28 820 hectares while forest covers 1 341 hectares (Rombo DC Profile, 2013).

3.1.1 Population

Based on the population census report of 2012 Rombo district had a population of 260 963 whereby females were 136 435 and 124 528 were males (NBS, 2012). Also, the district has 5 divisions, 24 wards and 65 registered villages (Rombo DC profile, 2013).

3.1.2 Climate

Rombo district receives annual rainfall ranging from 500 to 1000 mm per annum and the mean monthly temperature is 22–26^0 C with maximum temperatures of 35^{o}C. The climate is favourable for growth of various types of food crops.

3.1.3 Economic activities

The main economic activity practiced in Rombo District is agriculture. This carries about 90% of the total activities while 7% of the residents are doing small businesses and 3% are the employed workers (Rombo DC Profile, 2013). Agricultural activities, fertile soil and favourable climatic conditions make it easy for the residents in Rombo to grow various crops that are rich in nutrients. The residents of Rombo produce both food and cash crops. Food crops include banana, maize, sorghum, sweet potatoes, cassava and legumes, fruits and vegetables; whereas the main cash crop is coffee.

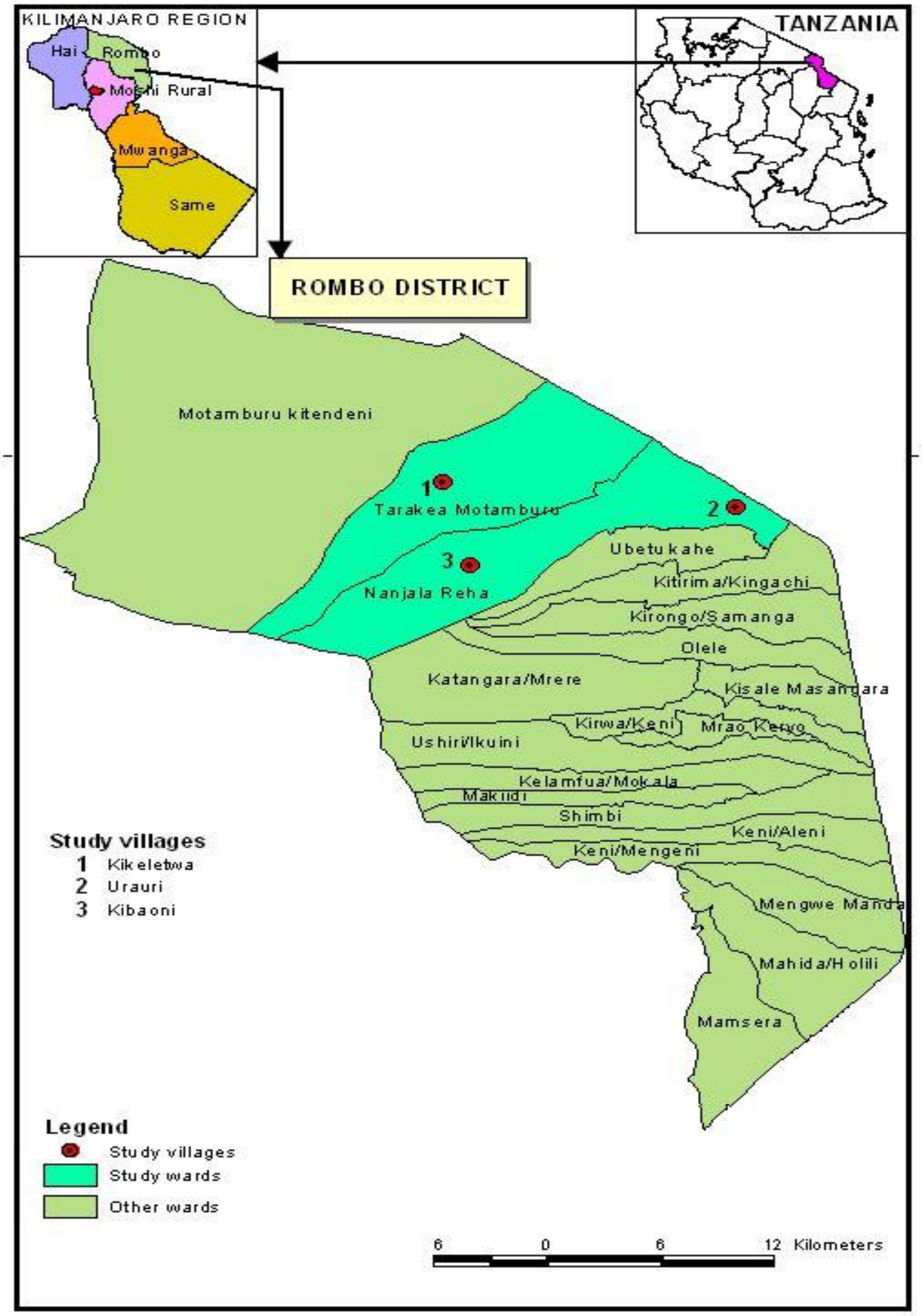

Figure 1: Map of Rombo District showing the study area

3.2 Study Design and Sample Selection

3.2.1 Study design

The study design used to collect data was cross-sectional design which was conducted between October and December, 2016. During this time, people were doing land preparation and planting various food crops such as maize, beans, potatoes, sunflower, sorghum and tomatoes. Sensory evaluation was done in April, 2017 when the residents were removing weeds (weeding) from bean plants because they normally plant beans and few maize plants in February-March and harvest from the end of May and the beginning of June.

3.2.2 Sampling frame

The study subjects were mothers/caregivers and their children who were 6 to 23 months old during the data collection period and they were from three villages namely Kikelelwa, Kibaoni and Urauri in Tarakea division in Rombo district.

3.2.3 Inclusion and exclusion criteria

This study included mothers/caregivers and their children who were aged 6 to 23 months at the time of data collection. Individuals who were excluded from this study were those children who were under special nutritional therapies, children with special medical disorders and those proven to be HIV positive (based on their clinic cards) during data collection period.

3.2.4 Sampling technique

Multistage sampling technique was used to select Kilimanjaro region and Rombo district and then three villages namely Kikelelwa, Kibaoni and Urauri. The study subjects were selected by using simple random sampling method using random numbers.

3.2.5 Sample size

A total of 230 respondents were involved in this study and they were from three villages namely Kikelelwa, Kibaoni and Urauri. The sample size was obtained from the general stunting percentage (18.3%) for children less than 5 years in Kilimanjaro region (TFNC, 2014). The formula used was adopted from SMART (2012) as shown below;

$$N = \frac{z^2 (p*q)}{d^2}$$

Where:

N = required sample size

Z=Standard normal deviate, set at 1.96 corresponding to 95% confidence level

p = Proportion of the target population estimate to have a particular characteristic

q = (1- p)

d^2 = Degree of accuracy desired set at 5% (standard value of 0.05).

Therefore,

$$1.96^2(0.183x\ 0.817) / 0.05^2 = 229.7 \approx 230$$

Therefore the sample size was 230 respondents

3.3 Procedures for Data Collection

3.3.1 Sources of data

Primary data were collected at the field by using questionnaires as well as collection of food samples for laboratory analysis and sensory evaluation.

3.3.2 Instrument for data collection

The questionnaire for data collection had both open and close ended questions divided in four sections (Appendix 6). Section A covered information about the child such as name, age and sex. Section B inquired information about social and demographic characteristics of the mother/caregiver. Section C was about breastfeeding and complementary feeding knowledge and practices while section D inquired information on the types of complementary foods and preparation methods as well as 24-hour dietary recall.

3.3.2.1 Training of enumerators and pre-testing of the questionnaire

Before administration of the questionnaires, five enumerators were enlightened on the main and specific objectives of the research, familiarized with data collection instruments as well as expected outcomes of the research. Pre-testing of the questionnaire was done at Mazimbu hospital (RCH unit) in Morogoro region before the beginning of data collection in a randomly selected sample of 10 individuals who were not included in the study but had similar characteristics to the study sample. After pre-testing the questionnaires, corrections were made to avoid misleading information, ambiguous sentences and repeated questions.

3.3.2.2 Administration of the questionnaire

Before the beginning of the interview, the enumerators introduced themselves, explained the purpose of the study as well as the potential benefits and risks and then the respondents were asked to voluntarily sign the consent form after reading and understanding it. For those respondents who were unable to read and write, they were helped by a closer relative, neighbour or the enumerator. The questionnaire was administered through face to face interview whereby the enumerator asked questions directly to the study mothers/caregivers and the answers were recorded in the questionnaire. The respondents were given freedom to ask questions and explanations were given to them.

3.3.3 Collection of food samples and laboratory analysis

Seven samples of frequently used complementary foods (based on the results from 24-hour recall) given to children aged 6-23 months were taken for laboratory analysis of proximate composition and vitamin A, vitamin C, iron, zinc, calcium and iodine contents.

3.3.3.1 Collection of cooked food samples

Before collection of cooked samples, there was a short discussion with women who came to clinic (RCH unit) at Tarakea health centre on how they prepared different types of complementary foods for their children (especially those foods which are frequently used according to 24-hour dietary recall). When the common procedures, ingredients, amounts, preparation and cooking methods were agreed, the ingredients such as meat, fish, milk, onions, tomatoes, rice, pumpkins and bananas were purchased at Tarakea market. Complementary foods from which the samples were taken, were prepared by seven randomly selected mothers/caregivers (one for each meal) at different households (mothers/caregivers from Urauri and Kibaoni villages prepared two complementary foods each while those from Kikelelwa prepared three) without the interference from the researcher. The task of the researcher was only to provide ingredients and record the procedures.

During preparation of complementary foods, the ingredients (name and amount used) were recorded first before cooking and then the mother/caregiver prepared and cooked the food while the researcher was observing and recording the procedures. When the food was ready, it was left to cool and then served in clean tight plastic food containers, weighed again and then stored in a cool box with iced water tightened in plastic bag then transported for analysis in the laboratory on the next day. The remaining foods and ingredients were given to the mothers/caregivers who prepared the foods. CAMRY kitchen weighing scale (Model: EK3651, Max. 5000g/11lb, Japan) was used to weigh the food samples after being placed on a hard background surface and calibrated (adjusted to zero) at the beginning and end of each measurement. Table 4 shows the types of complementary foods that are frequently given to children aged 6-23 months in Rombo district.

Table 4: Frequently used complementary foods in the study area selected for laboratory analysis

Name of the food sample	Swahili name (Local name)	Place of origin	State of the sample
Banana porridge with beef	*Mtori wa nyama (Mtori wa nyama)*	Home cooking (Mary Wolfgan)	Cooked
Banana porridge with fish	*Mtori wa samaki (Mtori wa samaki)*	Home cooking (Glory Antipas)	Cooked
Maize porridge (sugar and cooking oil added)	*Uji wa mahindi (Uji)*	Home cooking	Cooked
Banana porridge milk	*Mtori wa maziwa (kitawa/ kena)*	Home cooking (Rosalia Roman)	Cooked
Composite flour (maize, finger millet, rice, maize, groundnuts and soya beans) porridge	*Uji wa unga mchanganyiko / lishe*	Tarakea Women Sawmill (TAWOSA) Tarakea/Market	Cooked
Banana mixed with pumpkin porridge	*Mtori wa maboga (ngánde ya masidi)*	Home cooking (Mrs.Mkaili)	Cooked
Rice porridge (with milk added)	*Uji wa mchele/wali madida (Mshele)*	Home cooking (Mrs. J. Marandu)	Cooked

3.3.3.2 Laboratory work

The collected samples of frequently used complementary foods were analysed at the Department of Food technology, Nutrition and Consumer Studies laboratory at Sokoine University of Agriculture-Morogoro. Proximate analysis was done to determine macronutrients content of the food samples, vitamin A was determined by UV visible spectrophotometer, vitamin C by colorimetry (dichloroindophenol) method while iron, zinc, and calcium were determined using atomic absorption spectrophotometer (AAS) and iodine by automated spectrophotometric techniques.

(a) Sample preparation

The cooked food samples were stored in the freezer for ten days waiting for analysis at the Department of Food technology, Nutrition and Consumer Studies. During analysis, the food samples were thawed in running water and then mixed thoroughly (homogenization) while maintaining its representativeness.

(b) Nutrient composition analysis

Nutrient composition analysis was done in duplicate for all seven samples and the results were presented in grams (g) or micrograms (µg) per hundred grams.

(i) Proximate composition

The proximate composition (crude protein, ether extract (fat), crude fibre, dry matter and ash contents) of each of the frequently used complementary food samples and each formulated complementary food samples were determined by using the standard methods of AOAC (2000) and the results were presented as an average of the duplicate determinations.

Crude protein: Crude protein was determined by using Kjehdahl method (AOAC, 2000), official method 925.09. The procedure was divided into three parts/steps namely digestion, distillation and titration (Nielsen, 2010). In the first step, organic nitrogen was converted to ammonium in the presence of a catalyst at approximately 370°C. Approximately 0.3g of each of the food samples were weighed into digestion tubes and then 12g of a catalyst (mixture of 10 g potassium sulphate, 1.0 g copper sulphate and 1.0

g selenium powder) was added into each tube with samples followed by 6 ml of concentrated sulphuric acid. The samples were then taken to the Department of Animal Science at Sokoine University of Agriculture for digestion using Tecator digestion system 40 (model 1016 digester, Sweden) overnight to obtain a clear greenish solution of digest. After digestion, the samples were left to cool and then returned to the Department of Food Technology, Nutrition and Consumer Sciences laboratory for distillation process. In this step, the digested sample was made alkaline by adding 30 ml of distilled water followed 30mls of 40% NaOH and the nitrogen was distilled off as NH3 which was collected in a 2% boric acid solution using a distillation unit (Foss Tecator, model 2200 Kjeltec auto distilling unit, Sweden). In the last step, the distillate was titrated against 0.1N standard hydrochloric acid. Blank determination was carried out in the same manner using the same reagents without sample.

The titration equation was;

$$(NH_4)_2SO_4 + 2NaOH + H_2O \longrightarrow Na_2SO_4 + NH_3 + H_2O$$

Percentage nitrogen was calculated as follow;

$$\%N = \frac{(\text{Titre} - \text{Blank ml}) \times 0.0014 \times N\ HCl \times 100}{\text{Weight of sample (g)}}$$

The protein content was calculated as;

% protein = % total nitrogen x appropriate nitrogen conversion factor (6.25).

Crude fat: Total fat for each of the food samples was determined by using Soxhlet system (HT model 1043-extraction unit AB, Sweden) following the procedures shown in AOAC (2000), official method 4.5.01. Approximately 5g of each of the food samples was measured in a crucible and then transferred into the thimble and covered with a small dried glass wool. The samples were then placed in a Soxhlet system and fat was extracted continuously with petroleum ether (40-60 ºC boiling point range) for eight hours.

The thimbles were then removed from the Soxhlet extractor using tongs and then dried in an oven set at 105ºC for 30 minutes and finally cooled in the desiccator for 15-30 minutes. Fat content was measured by weight loss of sample or weight of fat removed.

Percentage crude fat was calculated as follows;

$$\% \text{ Crude fat} = \frac{\text{Weight of ether extracts (g) (final weight)}}{\text{Weight of the sample (g) (Initial weight)}} \times 100$$

Crude fibre content: For crude fibre analysis, celite materials were first added into the crucibles to facilitate filtration. For each of the food samples, approximately 1 g, was measured and put into the crucibles containing celite materials. Ancom fibre analyser (Model ANCOM 220, USA) was used to determine crude fibre content as outlined by AOAC (2000) in official method 962. 09. The first step was digestion of the sample by using 0.125 M H_2SO_4 for 30 minutes and then washed three times with hot water and the purpose of this step was to remove everything else in the sample except fat. The second step was digestion of the residues with dilute alkali (0. 125 KOH) for 30 minutes and washed by hot water three times with the aim of removing fat. The crucibles containing digested residues were placed in an oven, at 105ºC overnight, cooled in the desiccator and weighed. They were then turned into ash by incinerating them in a muffle furnace at 525ºC for 5 hours. The furnace was switched off, allowed to cool to 180°C and then the crucibles were transferred in a desiccator, cooled for 1 hour and weighed again.

Total fibre content was calculated as follow;

$$\% \text{ Crude fibre} = \frac{\text{Weight of crucible and dry residue (g) - Weight of crucible and ash (g)}}{\text{Weight of the sample taken for analysis (g)}}$$

Dry matter: Determination of dry matter was done by oven drying method (AOAC, 2005) under 925.09 procedures. For each of the food samples, approximately five grams were taken and placed in pre-weighed and labelled crucibles. The samples were then dried in an oven set at 105ºC overnight to a constant weight. The samples were dried in a desiccator and dry matter content was obtained as the difference between pre-dried and post-dried sample weight.

Calculations were done as follow;

$$\% \text{ Dry matter} = \frac{\text{Weight of the crucible and oven-dried sample (g) - Weight of empty crucible(g)}}{\text{Weight of the sample taken for analysis (g)}}$$

Ash content: During ash determination, the crucibles were marked and then heated in a furnace at 500 ºC for 3 hours and then the furnace temperature was lowered to 180ºC and finally the crucibles were transferred desiccator, cooled for 30 min and weighed. Approximately five grams of each of the samples was weighed into the pre-heated and pre-weighed crucibles and then incinerated at 550°C in a muffle furnace using method no. 923.03 (AOAC, 2000) for five hours. The ash content of the samples was calculated as the difference between weight of the sample before and after incineration.

The formula for calculating ash was;

$$\% \text{ Ash} = \frac{\text{Weight of the crucible with ash (g) – Weight of an empty crucible (g)}}{\text{Weight of the sample (g)}} \times 100$$

Moisture content: The crucibles were placed in the drying oven at 105°C for two hours. They were then cooled in the desiccator for about 30 minutes and then weighed. About 5 g of each of the samples was weighed into the pre-weighed crucibles and then placed in the air oven set at 105ºC for 3 hours to a constant weight. The crucibles with the dried samples were then transferred into a desiccator, cooled for 30 min and weighed again. Method number 925.09 of AOAC (2000) was used.

Moisture content was calculated as;

$$\text{Moisture (\%)} = \frac{\text{Sample weight before drying (g) - Sample weight after drying (g)}}{\text{Sample weight before drying (g)}}$$

Carbohydrate content: Both available and total carbohydrate content of all the seven complementary food samples were determined by difference.

The formula for calculating available carbohydrate was;

% Carbohydrate=100 - % (Moisture+ Fat+ Ash+ Crude fibre+ Crude protein)

The formula for calculating total carbohydrate was;

% Carbohydrate = 100% - % (Moisture + Crude protein + Fat+ Ash)

Energy content: Energy values of all the complementary food samples were determined by calculation using Atwater's conversion factors (FAO, 2003). This was done by summing up the values obtained by multiplying the Atwater constants with the laboratory results (values) for carbohydrates, crude fat and crude protein. The conversion factors used were as follows;

- Approximately 4 calories per gram of protein (4.27 kcal/g)
- Approximately 9 calories per gram of fat (8.79 kcal/g)
- Approximately 4 calories per gram of carbohydrate (3.87 kcal/g)

(ii) Vitamins analysis

Vitamin A and C contents for each of the frequently used complementary food and each of the formulated complementary food recipe samples were determined by using the methods of Association of Official Analytical Chemists and the results were presented as an average of the duplicate determinations.

Determination of vitamin A (retinol): Approximately 1 g of the sample was measured in a 22 ml test tube with a tight stopper and then heated in water bath (60ºC) for 20 minutes and finally cooled in cold water. 1 ml of 5% pyrogallol with 1% ascorbic acid was added followed by addition of 2mls of 50% potassium hydroxide solution.

The mixture was vortex mixed for 15 minutes followed by ultrasonic agitation for 60 minutes at 45ºC. After that, 2 ml of distilled water was added followed by addition 2 ml extraction mixture of n-hexane and ethylene acetate (90%:10%). They were vortex mixed again for 15 minutes. The whole of the separated extract (upper layer/organic phase) was transferred into another test tube made of “soft” (sodium) glass and the process of extraction was repeated twice and then washed with 2 ml solution of anhydrous sodium sulphate. The organic extract was then transferred to another test tube, evaporated to dryness and then eluted with 2 ml absolute alcohol. It was then vortex mixed for 15 minutes and then absorbance was measured at 325 nm using X-Ma UV-VIS SPECTROPHOTOMETER, MODEL 3000 (Lietz *et al*., 2000; Rutkowski and Grzegorczyk, 2007; Kandar *et al.*, 2012).

The retinol concentration (mg/l) was calculated as follows;

$$Rc = \frac{A \text{ x } El \text{ x } 10000}{E \text{ x } S}$$

Where,

Rc = Retinol concentration (mg/l)

A = Absorbance as read at 325 nm

El = Elution volume

E = Extinction coefficient of retinol in ethanol (1850)

S = Amount of sample taken for analysis

10000 = conversion factor from % to mg/l

Determination of vitamin A (β-carotene): The first step in β-carotene determination was extraction using the procedures described by Rodriguez-Amaya and Kimura (2004). This was done by weighing approximately 5 g (determined to the nearest 0.001 g) of water bath warmed (40ºC) duplicate samples in a test tube, followed by addition of 50 ml of cold acetone which was then stirred/homogenized on a magnetic stirring plate (Polytron homogenizer) for about 2 minutes and then filtered by using Buchner funnel. The process was repeated until the residue was colourless (3 times). The second step was partitioning in which the 50 ml petroleum ether (boiling point 40-60ºC) was added to the extract followed by addition of distilled water (flowing along the walls of the funnel) to avoid formation of an emulsion (Kumar *et al.,* 2011). The two layers were allowed to separate without agitation for 10 minutes to two layers. The bottom layer was run off into a beaker while the top layer was collected in to a 250 ml conical flask. The bottom layer was transferred in to the funnel and re-extracted with distilled water for three to five times until the extract became fairly yellow. The final extract was measured and poured in to sample bottles to read absorbencies at 450 nm using UV-Visible spectrophotometer. After determination of the maximum wavelength (λ_{max}) of the coloured complex (450 nm) using X-Ma UV- spectrophotometer, the absorbance of all standards was taken to construct a calibration curve by plotting the concentration versus the corresponding absorbance (Appendix 1).

Determination of vitamin C: Vitamin C determination was done following AOAC (2000) procedures using method No. 985.33 by titration. This was done based on the principle that ascorbic acid (vitamin C) reduces the indicator dye 2, 6-dichloroindophenol indophenol to a colourless solution (Rodriguez-Amaya and Kimura, 2004). About 5 grams of the sample was weighed using a food weighing scale in an Erlenmeyer flask. TCA solution was added to the sample to make a total extract volume of 50 ml (sample + TCA solution). The mixture was then filtered using whatman paper No. 1 to obtain a clear extract. The extract was titrated with indophenol solution until rose pink colour (end point). The blank sample was prepared by taking 50 ml of TCA without sample.

Vitamin C content of the food samples was calculated as follow;

$$\text{Vitamin C (mg/100 g)} = \frac{(A-B) \times C \times V_1 \times 100}{S \times V_2}$$

Where A = Volume of standard indophenol solution used for sample

B = Volume of indophenol solution used for sample

C = Concentration of indophenol solution

V_1 = Extraction volume

S = Amount of the sample taken for analysis

V_2 = Analytical volume

(iii) Mineral analysis

Iron, zinc, calcium and iodine contents for each of the frequently used complementary food and each of the formulated complementary food recipe samples were determined using the AOAC (2000) procedures, method no. 985.35 by using atomic absorption spectrophotometer and the results were presented as an average of the duplicate determinations.

Determination of Iodine content: Iodine content of the complementary food samples was determined on the basis of alkaline ashing by the spectrophotometric method according to Sandell-Kolthoff (Błażewicz, 2012). The principle behind the determination is the reduction of Ce^{4+} to Ce^{3+}, in the presence of As^{3+} due to the catalytic effect of iodine (Shakerian, 2014). Approximately 5 g of duplicate sample was weighed into the pre-heated, cooled and weighed crucible. It was ashed at 550º C for 45 minutes and then cooled to 180 º C in an incinerator. The sample was removed from incinerator, cooled to room temperature and then 1ml of 10% zinc sulphate was added and the charred residues were broken using glass rod. After that, the sample was dried at 100º C followed by addition of 15 ml of de-ionized water, which was then boiled in hot plate. The sample was filtered into 125 ml chloroform followed by addition of 5 ml of 20 M H_2SO_4. The filtrate was transferred into 100ml volumetric flask and absorbance was read at 420 nm and then calibration curve was constructed by plotting the concentration versus the corresponding absorbance (Appendix 2).

Standard iodine solutions (0, 0.5, 1.0, 1.5, 3.1, and 6.2 mg/ml) were prepared using serial dilution of 100 mg/L stock solution. Stock solution was prepared by dissolving 13.08mg potassium iodate in 100ml de-ionized double distilled water.

Iodine content in the food samples was calculated using the following formula;

$$I\ (\mu g/100\ g) = \frac{C_0 \times D \times 100}{W \times 1000}$$

Where,

C_0 = Iodine content read from the calibration curve (ng/ml)

D = Dilution factor

W = Weight sample (g)

1000 = Conversion of ng to µg

Determination of Iron, Zinc and Calcium content: Approximately 1 g of each of the samples was weighed using a food weighing scale (in duplicate) in pre-heated, cooled and weighed crucibles. Water was then evaporated from the sample in a steam bath followed by charring the samples over a hot plate. The samples were then incinerated in pre-heated furnace set at 525º C overnight until a whitish or greyish ash was obtained. The temperature of the furnace was then lowered to 180º C for one hour and finally the samples were removed and cooled at room temperature. For each sample, 5 ml of 1N HNO_3 was added to dissolve the ash and then transferred into a 50 ml volumetric flask and filtered using Whatman filter paper No. 541. The samples were diluted to mark and then stored for analysis at the Department of Soil Science Laboratory at Sokoine University of Agriculture.

Spectrophotometric determination of iron and zinc: An aliquot portion of each acidified ash solution was used for the determination of iron, zinc and calcium by the use of flame atomic absorption spectrophotometry. The absorbance was read at 248.3 and 213.9 nm for iron and zinc respectively. Calibration curves with at least 4 concentrations (0, 5, 10, 20 and 40 and 0, 0.5, 1, 2 and 4) of iron and zinc respectively were prepared (Appendix 3 and 4). Concentrations of iron and zinc in test solutions were calculated from the standard curve prepared using the formula obtained from ASEAN Manual of Food Analysis (Prapasri *et al.*, 2011) as follows;

$$\text{Iron/zinc content (mg /100g)} = \frac{C \times V \times D \times 100}{W \times P \times 100}$$

Where,

C = concentration of the sample in (mg/l)

V = Extraction volume (ml)

D = Dilution factor

W = weight of the sample (g)

P = sample solution taken (ml)

1000 = conversion of ml to l

Spectrophotometric determination of calcium: Before reading absorbance for calcium, it was fist diluted by pipetting approximately 1 ml of an aliquot of the test solution into a volumetric flask followed by addition 2 ml of 1% LaCl3 solution and 7 ml of de-ionized water. The absorbance was read at the wavelength of 422.7 nm by using flame atomic absorption spectrophotometer.

Standard calcium solutions (0, 0.4, 0.8, 1.5, 1.6, and 2.0 μg /ml) were prepared by pipetting 0 (reagent blank), 1, 2, 3, 4, and 5 ml of working solution into 50 ml volumetric flasks followed by addition of 1% w/v LaCl3 solution and then diluted to the 1N HNO3. Calibration curve was then prepared (Appendix 5). Concentration of calcium in test solution was calculated using the formula below;

$$\text{Calcium content (mg/100g)} = \frac{\text{C x Total volume (ml) x Dilution x 100}}{\text{Weight of sample (g) x 1000}}$$

Where,

C = Concentration of the sample in mg/l from the calibration curve (mg/L)

1000 = Conversion of ml to l

3.3.4 Gap identification

The second objective of this study was to identify the frequently used complementary foods and their nutrient contents and then identify the nutrients’ gap (excess or less) based on the recommended dietary allowance. This was done through the following steps;

Step 1: 24-h dietary recall

The first step in gap identification was to determine the amount of each complementary food consumed by each child per day based on their age (6-8, 9-11 and 12-23 months). This was achieved by a single interactive 24-hour dietary recall method. It was done by asking mothers/caregivers to recall and list all the foods and fluids their children consumed for the previous 24 hours excluding breastmilk, ingredients and amounts used in meal preparation and quantities of consumed foods/fluids. They were also asked to recall if there was any special event like wedding, religious holiday, special guest in the house, public holiday, the child in question was not sick or if the foods consumed were not within the usual intake of the child and if any of those conditions existed then the interview for that particular mother/caregiver was rescheduled or discontinued.

On the first day of the interview visual aids of fresh foods, home measuring instruments and utensils were used for quantity estimation. On the next day some of the fresh foods, juices and water were prepared as well as home measuring tools such as spoons, plates, bowls, containers of special baby foods, bottles, visual aids and cups were used in the process (after getting a picture of the frequently mentioned foods from the previous day). When a mother/caregiver mentioned a particular food, she was given either a cup, plate or bowl depending on the utensil used by the child and then a food was poured in the utensil and measured by using CAMRY digital kitchen weighing scale (Model: EK3651, Max. 5000g/11 lb capacity 1 g precision, Japan) in grams. At the end of the interview, the interviewer gave summary of all the food items mentioned by the mother/caregiver and asked her if there was any omitted or forgotten food/drink.

The results of all foods and fluids consumed were categorized based on the age (6-8, 9-11 and 12-23 months) of the child, coded by assigning weights (grams) to all portions reported and then entered in to Microsoft Excel. The foods and fluids were summarized based on the age and number of children consumed it as well as the median portion size (expressed in grams per meal). Also, the foods with the highest frequency of consumption (Table 4) were taken and prepared by the selected mothers/caregivers and then taken to the Department of Food Technology, Nutrition and Consumer Studies laboratory at Sokoine University of Agriculture-Morogoro for laboratory analysis.

Step 2: Conversion of laboratory results from unit/100 to unit/amount consumed

The frequently used complementary food samples taken for laboratory test were analysed for proximate composition, vitamin A, vitamin C, iron, zinc, calcium and iodine contents and the results were expressed in grams per 100 grams (dry weight). In order to know the amount of energy, macro and micronutrients consumed by children from each food per day based on their age, the laboratory results (expressed in g/100) were converted to g/median portion size (g). For example, banana porridge with beef (one of the frequently used complementary foods) contained 203µg/100 g RE of Vitamin A and the average amount consumed per day by infants aged 6-8 months was 138.6g (from 24-hour dietary recall). To obtain the amount of vitamin A consumed from that food per day, the following was done;

$$\text{Vitamin A content in banana porridge with beef} = \frac{\text{138.6g consumed x 203µg of vit. A}}{\text{100 g of banana porridge with beef}}$$

This process was repeatedly done for each of the seven frequently used complementary foods, each of the nutrients and for each of the three age groups of children.

Step 3: Finding the difference (gap) between the amount of energy and micronutrients consumed per day and the recommended dietary allowance (RDA)

The estimated energy, macro and micronutrients intake from each of the seven frequently used complementary foods (derived from 24-hour dietary recall interviews) as well as the estimated intake from breast milk (derived from the literature) were summed and then subtracted from the recommended dietary allowance (RDA) and the difference (either excess or less) were defined as the positive or negative nutrient's gap (WHO, 1998; WHO, 2001; Lutter and Dewey, 2003).

3.3.5 Formulation of new recipes by linear programming method

After gap identification, formulation of improved complementary food recipes (based on the previously identified frequently used complementary foods) was done by using linear programming model of Nutri Survey developed by Briend and Erhardt (2004). This was done through the following steps;

Step 1: Generation of the list of locally available foods

A list of locally available foods both processed, unprocessed or semi processed was generated from the questionnaires, market survey and opportunistic observation of what was available in the farms and retail shops as well as the results from 24-hour dietary recall. Ready to eat meals and beverages were not included in the list generated (Parlesak *et al.*, 2016).

Step 2: Price of foods

The price of each food was collected from Tarakea, Kikelelwa and Usseri markets, butcheries, retail shops and from the street vendors. All the village leaders and market managers gave their consent. If some of the foods were sold per item (for example 3 bananas for 200 or 5 fish for 1000), they were weighed on-site and the average weight (kg) was used to calculate the price. For the foods with price range (same product but different prices) based on the market/seller, the lowest price was selected. Also all the processing costs, such as washing, milling, drying, sieving and grinding were included in the ingredient cost.

Step 3: Nutritional composition of the selected foods

Both Tanzania food composition tables and Nutri Survey databases were used to obtain food composition values (MOH, 1992). The values given by nutri-survey during the formulation of recipes were compared with that of Tanzania food composition tables to see if there is a difference in nutrients composition. The values for prepared (cooked, baked, boiled, roasted and simmered) foods were used where appropriate (For example the energy value of raw rice is higher than that of cooked rice) (MOH, 1992).

Step 4: Recipe development

Linear programming method was used to identify the cheapest possible combination of food ingredients that meet a set of nutritional requirements based on the age of the child taking into account safety, amount consumed, cultural acceptability and the sensory attributes (WHO, 2001; Dibari *et al.*, 2012). Seven complementary food recipes were designed by using linear programming module of Nutri Survey (2004) and each food was characterised by its price and its nutrient content taking into account maximum and minimum values. The decision variables were whether a food was selected and at what weight while the objective function was to minimize the total cost of the recipe while improving nutrient contents. The food was considered culturally acceptable and safe if it was within the list generated from market survey and sensory attribute were determined during sensory evaluation of the formulated recipes.

3.3.6 Preparation and sensory evaluation of the formulated complementary food recipes

3.3.6.1 Materials/ ingredients used

After formulation of seven complementary food recipes by linear programming method, the ingredients were purchased from Tarakea market and local retail shops around the market and transported to the Department of Food Technology, Nutrition and Consumer Sciences laboratory at Sokoine University of Agriculture-Morogoro for processing and sensory evaluation process. The ingredients purchased in Tarakea were bananas, pumpkins, salt, cooking oil, pumpkin seeds, sunflower seeds, sesame seeds, yellow maize, amaranth seeds, baobab flour, amaranth seeds, onions, tomatoes, green peppers, carrots, cowpea leaves, rice, milk, lemons, fish, yellow soya bean and eggs.

3.3.6.2 Preparation of the ingredients

In order to reduce anti-nutritional factors and increase digestibility and bioavailability of vitamins, minerals, amino acids and proteins, processes such as boiling, soaking, germination, grinding, milling and peeling were done. Yellow maize (*Zea mays*) were sorted, washed with distilled water and dried in the oven set at 65ºC overnight and then milled into flour. The soya beans (*Glycine max*) were sorted, poured in boiling water and boiled for 45 minutes, peeled, washed, dried in an oven set at 65ºC overnight, roasted and then milled into flour. Pumpkin, sesame, amaranth and sunflower seeds were sorted, washed and soaked overnight for germination and on the next day they were dried in an oven for six hours, roasted to improve the flavour of the gruel, blended/ground to course flour and then sieved to obtain the fine flour. Bananas and pumpkins were peeled, washed and sliced. Onions, tomatoes, green pepper and tomatoes were washed and sliced into small pieces.

3.3.6.3 Formulations

The nutrient composition of the mixes targeted children aged 12-23 months. For infants aged 6-8 and 9-11 months, the proportions and composition of their complementary foods were made by cross multiplication method based on the laboratory results of the formulations and the median portion size (g) consumed by each age group. Table 5 shows ingredients and mixing ratios of the seven formulations optimized by linear programming method.

Table 5: Ingredients and mixing ratios of formulated complementary food recipes

Formulation name	Ingredients and mixing ratios (g)
Banana porridge with beef	60g banana +50g beef+10g oil+10g pumpkin seeds+10g sesame seeds+10g carrots+10 green pepper+5 g onions
Banana porridge with fish	60g banana+ 40g fresh water fish+ 20g sunflower seeds+ 5g carrots+ 5g onion+ 5g green pepper+ 10g lemon juice+ 5g amaranth seeds
Maize porridge	90g yellow maize+ 30 yellow soya beans+ 52g chicken egg + 20g lemon juice
Banana porridge with milk	50g banana+ 40g sour milk+ 20 cowpea leaves' juice +15g carrots+ 20g sunflower seeds+ 5g sesame seeds
Composite flour porridge	90g yellow maize+50g yellow soya bean+ 5g baobab flour
Banana porridge with pumpkins	50g banana+ 30g pumpkins+ 5g cooking oil +10g amaranth seeds+15g green pepper+ 25g sunflower seeds+ 20g carrots
Rice porridge with milk	50g Rice + 50g milk + 10g green pepper +10g carrots + 5g sunflower oil + 15g pumpkin seeds

3.3.6.4 Cooking procedures of the formulated complementary foods

Ready to use ingredients that were used to prepare complementary foods samples for sensory evaluation process are shown in Figure 1. The cooking procedures for each of the formulations were as explained below;

(i) Banana porridge with beef (CF1)

Peeled, washed and chopped bananas were mixed with pre-boiled meat, sunflower oil, iodized salt, pumpkin and sesame seeds' flour, onions, water and carrots and then boiled for 15 minutes followed by addition of chopped sweet pepper and boiled for five more minutes and then stirred while adding beef soup to the desired consistency.

(ii) Banana porridge with fish (CF2)

Peeled, washed and chopped bananas were mixed with pre-washed fresh fish flesh (*Tilapia spp*.), iodized salt, sunflower seeds' flour, onions, water and carrots. These were then boiled for 15 minutes followed by addition of chopped sweet pepper and lemon juice and boiled for five more minutes and stirred while adding boiled water to the desired consistency.

(iii) Maize porridge (CF3)

Mixture of maize and yellow soybeans flour was made into paste and then added to warm water and then boiled for 20 minutes with occasional stirring. Thereafter, whole chicken egg was added, boiled for three more minutes with continuous stirring followed by addition of lemon juice and then served.

(iv) Banana porridge with milk (CF4)

Peeled, washed and chopped bananas were mixed with sesame and sunflower seeds' flour and carrots and then boiled for 15 minutes. This was followed by addition of grinded and hand-squeezed cowpea leaves' juice and then stirred while adding sour milk to the desired consistency.

(v) Composite flour porridge (CF5)

Mixture of maize and yellow soybeans flour was added to warm water and then boiled for 20 minutes with occasional stirring and thereafter baobab flour and sugar were added then served.

(vi) Banana porridge with pumpkins (CF6)

Peeled, washed and chopped bananas were mixed with pre-washed and sliced pumpkins, sunflower seeds' flour, iodized salt, cooking oil and carrots. The mixture was then boiled for 15 minutes followed by addition of green pepper and then stirred while adding boiled water to the desired consistency.

(vii) Rice porridge with milk (CF7)

Sorted and washed rice was mixed with pumpkin seeds' flour, cooking oil and carrots and then boiled for 20 minutes. This was followed by addition of pre-washed and chopped green pepper and then boiled for five more minutes, followed by addition of sour milk and stirred to a desired consistency. The porridges were served in labelled vaccum flasks to maintain the serving temperature of 40ºC.

Figure 2: Different ingredients used in preparation of complementary foods

3.3.6.5 Sensory evaluation

The nine-point hedonic scale (ranging from 1= dislike extremely through 5=neither like nor dislike to 9= like extremely') and five point hedonic scale (5= like extremely, 4 = like moderately, 3 = neither like nor dislike, 2 = dislike moderately and 1 = dislike extremely) developed by Peryam and Pilgrim (1957) were used to analyse and measure consumer's responses to the formulated complementary food recipes. The parameters studied included appearance, odour, texture, taste and general acceptability.

A total of 102 panellists were used in this study: 49 were semi-trained final year undergraduate students of the Department of Food Technology, Nutrition and Consumer Sciences at Sokoine University of Agriculture, Morogoro, Tanzania and 53 were mothers who attended clinic at Tarakea Health Centre, RCH Unit. The use of mothers instead of the target recipients (children) was necessary because of their ability to objectively evaluate the sensory characteristics of the formulations (Muhimbula *et al.*, 2011).

Each panellist was given a white disposable cup labelled with three-digit random number, tissues, spoon and a bottle of Kilimanjaro pure drinking water (500 ml) to rinse their mouth after each tasting to avoid being biased. For each sample new disposable cups and spoon were given to the panellists.

The purpose of the study was explained to the mothers/caregivers and they were also familiarized with method, scorecards/questionnaire and the product being used in the study. They were also asked to voluntarily participate in the process before sensory evaluation process. The nurses at Tarakea RCH Unit voluntarily assisted in the exercise and the doctor in charge gave his consent. Figure 2 shows semi-trained and untrained participants of the sensory evaluation process.

Figure 3: Semi trained and untrained participants of sensory evaluation process

3.3.7 Laboratory analysis of nutrient composition of the formulated complementary food recipes

After sensory evaluation of the formulated complementary food recipes, the samples were taken for laboratory analysis at the Department of Food Technology, Nutrition and Consumer Sciences laboratory at Sokoine University of Agriculture-Morogoro. Proximate composition, vitamins A and C as well as minerals (iron, zinc, and calcium) were determined following the procedures explained in section 3.3.3.2 of this report.

3.4 Data Analysis

Data was cleaned to adjust for inconsistent, conflicting and implausible responses and carefully subjected to the descriptive analyses using the computer software MS Word, Microsoft Office Excel 2007 and Statistical Products and Service Solution software (SPSS) version 20.0. Means were calculated for continuous variables and for categorical variables frequencies and percentages were used. Cross tabulation and chi-square tests were used to determine univariate associations. Binary Logistic Regression Analysis was used to identify socio-demographic factors that were significantly associated with exclusive breastfeeding. This was carried out at two levels, first bivariate logistic regression was performed to each independent variable with the outcome variable (exclusive breastfeeding) and those variables with a p value<0.05 were included in the final model (multivariate analysis).

Results are presented as odds ratios and their respective confidence intervals at 95%. Statistical significance was set at $p<0.05$. For laboratory results of the nutrient contents of old and new recipes, each determination was carried out in duplicate and results were reported as an average value (mean ± standard deviation). Data was entered to excel and then imported to R software (Ri386) version 3.3.1 for windows and then subjected to analysis of variance (ANOVA) where applicable. Turkeys HSD test was used was used for multiple mean comparison tests. Statistical significance was set at $p<0.05$.

For sensory evaluation, data was analysed by the one way analysis of variance (ANOVA) model using R software (Ri386) version 3.3.1 for windows. The means and standard deviations (mean ± standard deviation) were calculated for acceptability of the sensory attributes of the complementary foods. Turkeys HSD test was used to determine the significance of mean differences of scores for all the sensory attributes. The level of statistical significance was set at $p<0.05$.

3.5 Ethical Clearance

The study protocol was approved by the National Institute for Medical Research (NIMRI), Sokoine University of Agriculture and Rombo District Executive Director. Also, written informed consent was obtained from all mothers/caregivers who took part in this study as well as Kikelelwa, Kibaoni and Urauri village leaders. All the participants were ensured of their confidentiality and autonomy and they were assured that the information obtained will not be misused. Whenever necessary, nutritional advice and counselling was given to respondents at the end of data collection process so as to make them benefit both directly and indirectly from the study.

CHAPTER FOUR

4.0 RESULTS

This section is divided into four sub-parts intended to answer the four stated objectives in chapter two. The first sub-section is about child feeding practices, types of complementary foods given to children aged 6-23 months in Rombo district and their preparation methods, sub-sections two and three present results of the proximate, vitamins A and C, iron, zinc, calcium and iodine composition of the frequently used (old recipe) and formulated complementary foods recipes (new recipes) respectively. The last section contains information on sensory evaluation to test the acceptability of the formulated complementary food recipes.

4.1 Infant and Young Child Feeding Practices

This sub-section presents information about social and demographic characteristics of the mothers/caregivers, their children and the households from which they belong, breastfeeding knowledge and practices, complementary feeding knowledge and practices as well as the types of frequently used complementary foods and their preparation methods.

4.1.1 Characteristics of the study subjects

4.1.1.1 Social and demographic characteristics of the study participants

Table 6 shows the socio-demographic characteristics of the 236 mothers/caregivers and their children who met the inclusion criteria and were included in this study. They were from three villages namely Kikelelwa (30.4%), Kibaoni (38.7%) and Urauri (30.9%). Majority of the children (51.4%) were aged between 12-23 months at the time of data collection. Most of the mothers/caregivers (95.65%) were able to at least read and write their names. Majority (62.2%) were aged between 20 and 35 years, 63.9% had completed primary school education and 50.9% were involved in agriculture. About 71.3% of the participants were married (monogamy) and 85.3% were Christians.

Table 6: Socio-demographic characteristics of the study participants

Variable	Number	Percent
Village		
Urauri	71	30.9
Kikelelwa	70	30.4
Kibaoni	89	38.7
Age of children (months)		
6-8		26.1
9-11		22.5
12-23		51.4
Age of mothers (years)		
<20	31	13.5
20-35	143	62.2
> 36	56	24.3
Marital status		
Single	63	27.4
Married	167	72.6
Education level		
Informal	10	4.3
Primary school	147	63.9
Secondary school	67	29.1
Post-secondary school	6	2.6
Occupation		
Housewife	33	14.3
Agriculture	117	50.9
Employed formal	11	4.8
Employed informal	6	2.6
Self employed	63	27.4
Religion		
Christian	196	85.3
Muslim	34	14.8

4.1.1.2 Characteristics of the households from which the participants belong

Shown in Table 7 are the characteristics of the households from which the study participants belonged. Based on the survey for this study, most of the mothers/caregivers (53.5%) reported their households to have 4-6 people and 93.9% had 1-2 children aged zero to five years. About 20.4 and 17.8% of under five children were taken care by their grandparents and siblings, respectively when the mother was away from the house. Different types of crops were reported to be produced in the households but cereals, legumes and bananas were reported to be produced by majority of the respondents. Thirty nine percent of the respondents reported to keep poultry in their households. Other animals that were kept by majority of the respondents were goats (31.3%) and cattle (27.8%).

Table 7: Socio-demographic and economic Characteristics of the study participants' households

Variable	Number	Percent
Average number of people		
1-3	46	20.0
4-6	123	53.5
7-10	48	20.9
>10	13	5.7
Number of under five children		
1-2	93.9	216.0
3-5	5.2	12.0
>5	0.8	2.0
Caretaker when the mother is away		
Mother always carry her child	80	34.8
Grandparents	47	20.4
Siblings	41	17.8
Husband	31	13.5
Neighbours	31	13.5
Food crops produced		
Cereals	146	63.5
Legumes	136	50.5
Bananas	90	39.1
Root crops (potatoes and cassava)	129	56.1
Fruits	23	10.0
Vegetables	30	13.0
Domesticated animals		
Chicken	90	39.1
Cattle	64	27.8
Goats	72	31.3
Pigs	47	20.4
Sheep	23	10.0
Ducks	9	3.9.0

4.1.2 ANC visits and place of delivery

Table 8 summarizes information on antenatal care visits and place of delivery among study participants. During their pregnancy, about 96.1% of the mothers reported to have visited health centres for antenatal care and they were given pre-delivery counselling. About 92.2%, of the children were born at the health centres, with the help of nurses.

Table 8: Antenatal care and breastfeeding initiation

Practice	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Antenatal visit					
Yes	70 (31.7)	83 (37.9)	68 (30.8)	221(96.1)	0.092
No	0 (0)	6 (6.7)	3 (4.2)	9 (3.9)	
Place of delivery					
Health centre	67 (31.6)	77 (36.3)	68 (32.1)	212(92.2)	0.139
Home	3 (1.3)	11 (4.8)	3 (1.3)	17 (7.4)	
On the road	0 (0)	1 (0.4)	0 (0)	1 (0.4)	

4.1.3 Breastfeeding knowledge and practices

4.1.3.1 Breastfeeding initiation and colostrum feeding

Table 9 summarizes information on breastfeeding initiation and colostrum feeding among study participants. Based on this study, 99.6% of these children had at least tested breast milk (have ever been breastfed). Also, 67% of the children were reported to be breastfed within one hour after birth. Almost all of the mothers (96.5%) reported to have given their children the first yellowish milk (colostrum) produced soon after birth.

The reasons given by those who did not give their children colostrum were mostly medical related such as complications related to caesarean delivery, post partum haemorrhage, and pre-eclampsia. There was no significant difference ($p>0.05$) in the rate of antenatal care visits, place of delivery, colostrum feeding and breastfeeding initiation among women from three villages involved in this study.

Table 9: Breastfeeding initiation and colostrum feeding

Practice	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Child ever breastfed					
Yes	69 (30.1)	89 (38.9)	71 (30.0)	229(99.6)	0.317
Don't know	1 (0.4)	0 (0)	0 (0)	1 (0.4)	
Breastfeeding initiation					
≤ 1 hour	45 (19.6)	57 (24.8)	52 (22.6)	154 (67)	0.236
1-3 hours	14 (6.1)	22 (9.6)	16 (7.0)	52 (22.6)	
≥ 3 hours	11 (4.8)	10 (4.3)	3 (1.3)	24 (10.4)	
Colostrums' feeding					
Yes	68 (29.6)	87 (37.8)	67 (29.1)	222(96.5)	0.481
No	2 (0.9)	2 (0.9)	4 (1.7)	8 (3.5)	
Why not colostrums					
Traditionally bad	0 (0.0)	1(0.4)	0 (0.0)	1 (0.4)	0.290
Baby was sick	0 (0.0)	0 (0.0)	2 (0.9)	2 (0.9)	
Mother was sick	1 (0.4)	0 (0.0)	1 (0.0)	2 (0.9)	
Dirty	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	
Caesarean birth	1(0.4)	0 (0.0)	1 (0.0)	2 (0.9)	

4.1.3.2 Pre-lacteal and exclusive breastfeeding practices

Table 10 compares exclusive breastfeeding practices among mothers from three villages involved in this study. Children who were given pre-lacteal feeds such as water, juice, grilled banana, glucose soon after birth were 13.5%. When the mothers/caregivers were asked how long it took for them to give water to their new born babies for the first time, about 64.3% suggested it to be within the first six months. There was a significant difference ($p<0.05$) in the time of introducing water to the newborns between Kikelelwa, Urauri and Kibaoni villages. Only 27.4% of the mothers practiced exclusive breastfeeding for six months.

Slightly more than three quarter (76.5%) agreed that exclusive breastfeeding was good. This was due to the advice they got during antenatal care visits. About 21.7% of those who said EBF was not good as they claimed that the baby was not satisfied with breast milk and when the baby started to cry a lot especially at night it meant she/he needed water and other foods. Even those who agreed that EBF was good, claimed not to practice it because of the pressure from their husbands, in-laws and other community members. Chi-square test showed that perceptions towards exclusive breastfeeding differed significantly among the three villages (p<0.05).

Table 10: Exclusive breastfeeding practices

	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Pre-lacteal foods					
Yes	11 (4.8)	12 (5.2)	8 (3.5)	31 (13.5)	0.533
No	59 (25.7)	77(33.5)	63 (27.4)	199 (86.5	
Types of pre-lacteal foods					
Water (plus glucose)	9 (3.9)	8 (3.5)	3 (1.3)	20 (8.7)	0.444
Infant formula	2 (0.9)	0 (0.0)	1 (0.4)	3 (1.3)	
Grilled banana	0 (0.0)	2 (0.9)	2 (0.9)	4 (1.7)	
Cow's milk	0 (0.0)	2 (0.9)	1 (0.4)	3 (1.3)	
Other women introduce water					
Soon after birth	6 (2.6)	6 (2.6)	4 (1.7)	16 (7.0)	0.026
Within 6 months	35 (15.2)	67(29.1)	43 (18.7)	145 (63)	
At 6 months	13 (5.7)	9 (3.9)	11 (4.8)	33 (14.3)	
After 6 months	16 (6.9)	7 (3.1)	13 (5.6)	36 (15.7)	
Respondents introduce water at;					
Soon after birth	8 (3.5)	6 (2.6)	6 (2.6)	20 (8.7)	0.023
Within 6 months	35 (15.2)	69(30.0)	44(19.1)	148(64.3)	
At 6 months	17(7.4)	10 (4.3)	16 (7.0)	43 (18.7)	
After 6 months	10 (4.3)	4 (1.7)	5 (2.1)	19 (8.2)	
Foods given within the first six months					
Breast milk only	24 (10.4)	20 (8.7)	19 (8.30)	63 (27.4)	0.083
Breastmilk, water and formula	1 (0.4)	1 (0.4)	2 (0.9)	4 (1.7)	
Breastmilk, water and porridge	24 (10.4)	46(20)	28 (12.1)	98 (42.7)	
Water, breast and cow's milk	8 (3.5)	16(6.9)	16 (7.0)	40 (17.4)	
Breastmilk and water only	13 (5.7)	4 (1.7)	5 (2.2)	22 (9.6)	
Perception on EBF					
Good	60 (26.1)	66(28.7)	50 (21.7)	176 (77)	0.080
Not good	10 (4.3)	23(10.0)	21 (9.1)	54 (23.5)	
Why EBF is good?					
Advised by experts	26 (11.3)	42(18.3)	31 (13.5)	99 (43.0)	0.015
Nutritionally adequate	32 (13.9)	20 (8.7)	19 (8.30)	71 (30.9)	
The baby is satisfied	3 (1.3)	5 (2.2)	0 (0.0)	6 (2.6)	

Determinants of exclusive breastfeeding: Table 11 shows unadjusted (crude) and adjusted odds ratios calculated to estimate the effect of independent variables on exclusive breastfeeding. Univariate logistic regression analysis showed that married mothers had higher odds of exclusively breastfeeding than the single mothers (OR=2.867; 95% CI: 1.319-6.234). Other factors such as maternal age, education level, antenatal visit and place of delivery were not significantly (p>0.05) associated with exclusive breastfeeding. Multivariate logistic regression also showed significant increase (p<0.05) in likelihood for exclusive breastfeeding practices among married mothers as compared to unmarried mothers (OR=2.937; 95% CI: 1.255-6.876).

Table 11: Univariate and Multivariate logistic regression analysis of significant determinants related to exclusive breast feeding

Variable	n (%)	n(% Practiced EBF)	Crude OR (95% CI)	Adjusted OR (95% CI)
Age (years)				
<20	31(13.5)	8(12.7)	Reference	-
20-35	143 (62.2)	37 (58.7)	1.0(0.4-2.4)	
> 36	56 (24.3)	18 (28.6)	1.4(0.5-3.60	
Marital status				
Single	63(27.4)	9(14.3)	Reference	
Married	167(72.6)	54(32.3)	2.87(1.3-6.2)*	2.94(1.26-6.88)*
Education level				
Informal	10(4.3)	1(10.0)	Reference	-
Primary	147(63.9)	39(26.5)	3.3(0.4-26.5)	
Secondary	67(29.1)	22(32.8)	4.4(0.5-37.0)	
Post-secondary	6(2.6)	1(16.7)	1.8(0.1-35.4)	
Occupation				
Housewife	33(14.3)	11(33.3)	Reference	-
Agriculture	117(50.9)	32(27.4)	0.8(0.3-0.7)	
Employed formal	11(4.8)	3(27.3)	0.8(0.2-3.4)	
Employed informal	6 (2.6)	4(66.7)	4.0(0.6-25.3)	
Self employed	63(27.4)	13(20.6)	0.5(0.2-1.3)	
Antenatal visit				
No	9 (3.9)	3(33.3)	Reference	-
Yes	221(96.1)	60(27.1)	0.8(0.2-3.1)	
Place of delivery				
Out of hospital	18(7.8)	4(22.2)	Reference	-
Hospital	212(92.2)	59(27.8)	1.4(0.4-4.3)	

*Significant at p<0.05
CI-confidence interval; OR-odds ratio

4.1.3.3 Continued breastfeeding

Table 12 summarizes information about continued breast feeding and breastfeeding on demand among mothers from the study area. About 91.3% (n=210) of the children involved in this study were still breastfeeding regardless of their age. The main reasons given by those who were not breastfeeding included another pregnancy (2.2%), sickness of the mother (0.4%), the baby refused to breastfeed (3%, n=7), the mother travelled (0.9%, n=2) or the mother herself stopped the child from breastfeeding so that she/he could eat other foods (1.3%, n=3). The age at which most of the children stopped breastfeeding was between six to 23 months (7.4%). More than half (86%) of the children were breastfed three or more times per day. Also, about 78.3% of the children involved in this study were still breastfed on demand. There was no significant difference (p>0.05) in breastfeeding on demand among mothers from Urauri, Kikelelwa and Kibaoni villages.

Table 12: Continuation of breastfeeding

	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Is the child still breastfeeding?					
Yes	64 (27.4)	82 (35.6)	64 (27.8)	210(91.3)	0.777
No	6 (2.6)	7 (3.0)	7 (3.0)	20 (8.7)	
If not breastfeeding, why?					
Another pregnancy	1 (0.4)	2 (0.9)	2 (0.9)	5 (2.2)	0.812
Mother is sick	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	
The baby refused	2 (0.9)		2 (0.9)	7 (3.0)	
Mother travelled	0 (0.0)	1 (0.4)	1 (0.4)	2 (0.9)	
The mother stopped the baby	2 (0.9)	0 (0.0)	1 (0.4)	3 (1.33)	
Don’t know	1 (0.4)	0 (0.0)	1 (0.4)	2 (0.9)	
When breastfeeding stopped					
From 6-23 months	5 (2.2)	6 (2.6)	6 (2.6)	17 (7.4)	0.650
Less than 6 months	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	
Breastfeeding frequency/day					
Once	0 (0.0)	0 (0.0)	1 (0.4)	1 (0.4)	0.168
Twice	4 (1.7)	1 (0.4)	7 (3.0)	12 (5.2)	
Three or more times	61 (26.5)	81(35.2)	56 (24.3)	198(86.1)	
Breastfeeding on demand					
Yes	60 (26.1)	71 (30.9)	49 (21.3)	180 78.3)	0.093
No	4 (1.7)	11 (4.8)	15 (6.5)	30 (13.0)	

4.1.4 Complementary feeding practices and knowledge

4.1.4.1 Age of introducing complementary foods

Table 13 summarizes information on the time at which complementary foods were introduced to infants in Rombo district. All the children (100%) involved in this study had already started consuming other foods and fluids in addition to breastmilk. Majority of the mothers/caregivers (56.1%) started giving their children complementary foods between the ages of four to six months. About 8.3 and 35.7% of the mothers/caregivers introduced complementary foods to their children for the first time when they were less than three and more than six months, respectively. When the mothers/caregivers were asked about the time at which other women in their society introduced complementary foods to their children for the first time, majority (55.2%) suggested between four and six months. The time of introducing complementary foods did not differ significantly ($p>0.05$) among mothers from Urauri, Kikelelwa and Kibaoni villages.

Table 13: Age of introducing complementary foods

	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Children already using Complementary foods					
Yes	70 (29.6)	89 (38.7)	71 (30.4)	230 (100)	0.398
No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Community introduce complementary foods at;					
≤ 3 months	2 (0.9)	5 (2.2)	6 (2.6)	13 (5.7)	0.186
4-6 months	33 (14.3)	56 (24.3)	38 (16.5)	127 (55.2)	
> 6 months	31 (13.5)	26 (11.3)	22 (9.6)	79 (34.3)	
Don't know	4 (1.7)	2 (0.9)	5 (2.2)	11 (4.8)	
Respondents introduce complementary foods at;					
≤ 3 months	3 (1.3)	8 (3.5)	8 (3.5)	19 (8.3)	0.162
4-6 months	34 (14.8)	56 (24.3)	39 (17.0)	129 (56.1)	
> 6 months	33 (14.3)	25 (10.9)	24 (10.4)	82 (35.7)	

4.1.4.2 Initial complementary foods and frequency of feeding

Most of the mothers/caregivers (56.1%) reported maize porridge as a first complementary food that was introduced to children. Other reported initial complementary foods were grilled banana (28.7%), infant formula (6.5), banana porridge (4.8%), cow's milk (3.5%) and fresh fruit juice (0.4%). In terms of feeding frequency for children aged 6-8 months, majority were fed three times a day. There was no significant difference (p>0.05) in the types of first complementary foods and feeding frequency among women from the three villages involved in this study (Table 14).

Table 14: First complementary foods and feeding frequency

	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Initial complementary food					
Maize porridge	41 (17.8)	48 (20.9)	40(17.4)	129 (56.1)	0.427
Grilled banana	15 (6.5)	29 (12.6)	22 (9.6)	66 (28.7)	
Fresh fruit juice	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	
Banana porridge	2 (0.9)	6 (2.6)	3 (1.3)	11 (4.8)	
Infant formula	7 (3.0)	5 (2.2)	3 (1.3)	15 (6.5)	
Cow's milk	4 (1.7)	1 (0.4)	3 (1.3)	8 (3.5)	
Feeding frequency per day (6-8 months)					
Less than three times	3 (1.3)	4 (1.7)	6 (2.6)	13 (5.7	0.274
Three times	6 (2.6)	16 (7.0)	6 (2.6)	27 (11.7)	
Four or more times	6 (2.6)	10 (4.3)	4 (1.8)	20 (8.7)	
Feeding frequency/day (9-11 months)					
Less than three times	1 (0.4)	1 (0.4)	0 (0.0)	2 (0.9)	0.373
Three times	8 (3.5)	9 (3.9)	11 (4.8)	28 (12.2)	
Four or more times	6 (2.6)	10 (4.3)	6 (2.6)	22 (9.5)	
Feeding frequency/day (12-23 months)					
Less than three times	0 (0.0)	2 (0.9)	2 (0.9)	4 (1.7)	0.446
Three times	16 (7.0)	17 (7.4)	19 (8.3)	52 (22.6)	
Four or more times	20 (8.7)	19 (6.9)	17 (7.4)	56 (24.3)	

4.1.4.3 Knowledge about frequency of feeding and food groups

When the mothers/caregivers were asked if they knew the number of times a child aged 6-8 months was supposed to be fed per day, more than half (50.4%) of the mothers/caregivers suggested more than three times because they ate very little food at a time. For those infants aged 9-11 months, about 45.2% of the mothers/caregivers suggested that they should be fed more than four times a day. Suggested feeding frequency for children aged 12-23 months was four times a day (36.1%). There was a significant difference in the feeding frequency knowledge for children aged 12-23 months among mothers/caregivers from the three villages ($p<0.05$). The mothers/caregivers who knew about the locally available foods that were good sources protein (body-building foods), carbohydrates (energy-giving foods), vitamins and minerals (protective foods) and iron-rich foods (blood-giving foods) were 34.8, 61.7, 33.9 and 47.8%, respectively. Table 15 summarizes information on the knowledge about locally available nutritious foods and feeding frequency for children aged 6-8, 9-11 and 12-23 months.

Table 15: Knowledge about feeding frequency and locally available food groups

	Kikelelwa (n=70) n (%)	Kibaoni (n=89) n (%)	Urauri (n=71) n (%)	Total (n=230) n (%)	P-value
Feeding frequency/ day (6-8 months)					
Less than three times	4 (1.7)	4 (1.7)	1 (0.4)	9 (3.9)	
Three times	28 (12.2)	34 (14.8)	38(16.5)	100 (43.5)	0.310
Four or more times	38 (16.6)	50 (21.8)	33(14.3)	121 (52.6)	
Feeding frequency/ day (9-11 months)					
Less than three times	11 (4.8)	6 (2.6)	12 (5.20	29 (12.6)	0.151
Three times	20 (8.7)	39 (17.0)	30 (13.0)	89 (38.7)	
Four or more times	39 (16.9)	44 (19.2)	29 (12.6)	112 (48.7)	
Feeding frequency/ day (12-23 months)					
Less than three times	19 (8.3)	19 (8.3)	24 (10.4)	62(27.0)	0.005
Three times	11 (4.8)	39 (17.0)	23 (10.0)	73 (58.7)	
Four or more times	40 (17.4)	31 (13.4)	24 (10.5)	95 (41.3)	
Knowledge on sources of protein					
Knows	26 (11.3)	27 (11.7)	27 (11.7)	80 (34.8)	0.603
Doesn’t know	44 (19.1)	61 (26.5)	44 (19.1)	150 (65.2)	
Knowledge on carbohydrate sources					
Knows	35 (15.2)	59 (25.7)	48 (20.9)	142 (61.7)	0.052
Doesn’t know	35 (15.2)	30 (13.0)	23 (10.1)	88 (38.3)	
Knowledge on vitamin sources					
Knows	26 (11.3)	27 (11.7)	25 (10.9)	78 (33.9)	0.642
Doesn’t know	44 (19.1)	62 (27.0)	46 (20.0)	152 (66.1)	
Knowledge on sources of iron					
Knows	39 (17.0)	38 (16.5)	33 (14.3)	110 (47.8)	0.255
Doesn’t know	31(13.5)	51 (22.2)	38 (16.5)	120 (52.2)	

4.1.4.4 Types and amounts of frequently used complementary foods

Based on the data collected using 24-hour dietary recall, the types of frequently used complementary foods identified are shown in Table 16. Also, average portion size in grams of each food consumed for the previous 24 hours based on the child's age is shown. None of the mothers reported giving vegetables to their children and only few were given fruits.

Table 16: **Types of complementary foods, number and percentage of children consumed that food and the amount consumed in grams (Results of 24-hour dietary recall**)

Type of food	6-8 months (60 infants)		9-11months (52 Infants)		12-23 months (112 children)	
	n (%)	g	n (%)	g	n (%)	G
Banana porridge with beef soup	19(31.7)	97.1	29 (55.8)	177.2	78 (66.1)	165.4
Banana porridge with fish soup	12 (20)	126.8	14 (26.9)	117.2	45 (38.1)	148
Banana porridge milk	18 (30)	88.9	24 (46.2)	126.5	43 (36.4)	150.5
Composite flour porridge	21 (35)	147.8	32 (61.5)	257.1	80 (67.8)	319.2
Maize porridge	34(56.7)	171.2	19 (36.5)	236.2	31 (26.3)	319.3
Rice porridge with milk	5 (8.3)	88.4	4 (7.7)	108	18 (15.3)	140.5
Banana porridge with pumpkin	2 (3.3)	112	*	*	4 (3.4)	155.5
Banana porridge with beans	2 (3.3)	53.5	7 (13.5)	120	5 (4.2)	143.6
Black tea	4 (6.7)	61.75	10 (19.2)	98.3	38 (32.2)	158.1
Ugali with fish stew	1 (1.7)	38	5 (9.6)	50.8	12 (10.2)	110.3
Bread	1 (1.7)	60	*	*	3 (2.5)	48.7
Cow's milk (Fresh milk)	32 (53.3)	141.9	25 (48.1)	200.7	49 (41.5)	233.7
Rice with carrots	*	*	*	*	3 (2.5)	140
Mixed fruits juice	5 (3)	98.6	7 (13.5)	78	14 (11.9)	169.7
Rice with fish soup	1 (1.7)	97	3 (5.8)	71.67	17 (14.4)	119.3
Fruits	3 (5)	143.3	2 (3.8)	41.5	2 (1.7)	53.5
Infant formula	*1 (1.7)*	*40*	*1 (1.9)*	*180*	*	*
Banana with meat	*	*	*	*	2 (1.7)	134.5

n=Number of children consumed the food, %= Percentage of children consumed the food, g = Median portion size consumed based on the child's age, * = None of the children in that age group consumed the food

4.1.4.5 Local preparation methods of the frequently used complementary foods

From the 24-hour dietary recall results shown in Table 16 above, seven frequently used complementary foods were chosen for nutrients analysis and improvement. Ingredients, amount and cooking procedures for each of the selected complementary foods are shown in Table 17. These procedures are the ones that are normally followed during preparation of complementary foods in Rombo district. Addition of sodium bicarbonate has been associated with reduction of cooking time, improving consistency of the foods and reducing flatulence in children.

Table 17: Estimated amount, composition and local cooking procedures of the seven frequently used complementary foods in Rombo district

Name of complementary food	Ingredients and approx. amount used	Cooking procedures
Banana porridge with beef soup (Approx. 60 minutes)	960g Bananas + 500g beef + 20g cooking oil + 5 g salt	Peel, chop and wash bananas and then add sodium bicarbonate, water, salt and cooking oil and boil. When tender add pre-boiled beef soup and stir to a desired consistency
Banana porridge with fish soup (Approx. 20 minutes)	720g Bananas + 120g fish + 20g cooking oil + 5 g salt	Peel, chop and wash bananas and then add sodium bicarbonate water, salt and cooking oil and boil. When tender add pre-boiled fish soup and stir to a desired consistency
Maize porridge (Approx. 15 minutes)	250g maize flour+ 30g sugar + 20g cooking oil	Make a paste of maize flour and cold water and add it to boiling water and stir. Add sugar and cooking oil and then boil while stirring occasionally until ready
Banana porridge with milk (Approximately 20 minutes)	720g Bananas + 500ml milk + 20g cooking oil	Peel, chop and wash bananas and then add sodium bicarbonate, water and cooking oil and boil. When tender stir while adding milk to a desired consistency
Composite flour porridge (Approx. 20 minutes)	300g composite flour+ 30g sugar + 20g cooking oil	Make a paste of maize flour and cold water and add it to boiling water and stir. Add sugar and cooking oil then boil while stirring occasionally until ready
Banana porridge with pumpkins (Approx. 60 minutes)	720g Bananas + 250g pumpkins + 20g cooking oil + 5 g salt	Peel, chop, wash and mix both bananas and pumpkins then add sodium bicarbonate, water, salt and cooking oil and boil. When tender add pre-boiled water and stir to a desired consistency
Rice porridge with milk (Approx. 30 minutes)	250g rice +250g sour milk +20g cooking oil	Sort and wash rice, add water, salt and cooking oil and boil in low heat. When tender stir while adding milk to a desired consistency

4.1.5 Nutrient content of the frequently used complementary foods

4.1.5.1 Proximate composition and energy content

Proximate composition of the seven frequently used complementary foods (banana porridge with beef, fish, milk or pumpkins, composite flour porridge, maize porridge and rice porridge with milk) for children aged 6-23 months in Rombo district on wet basis are shown in Table 18.

Moisture content of the samples ranged from 65.51 to 81.66%. Banana porridge with milk had significantly lower moisture content than the rest of the formulations. The lower moisture content could be attributed to the addition of milk instead of plain water during stirring. Maize porridge had higher moisture content but it was not significantly ($p>0.05$) different from composite flour porridge. Banana porridge with beef, banana porridge with fish, banana porridge with pumpkins and rice porridge were not significantly different ($p>0.05$) in terms of moisture content.

Ash content is an important nutritional indicator of mineral content and a quality parameter that determines contamination with foreign matters. The value of ash content for all the formulations ranged from 1.05 to 3.54%. Composite flour had significantly higher ash content (3.54) ($p < 0.05$). Milk based samples (banana porridge with milk and rice porridge with milk) had non-significant difference ash content values ($p >0.05$). Maize porridge had the lowest ash content followed closely by banana porridge with pumpkins and they were not significantly different from one another ($p > 0.05$).

Maize porridge, rice porridge with milk and banana porridge with pumpkins had non-significantly different lower total fibre content (14.25, 14.61 and 16.52%, respectively) at $p>0.05$. The values of fibre content of all frequently used complementary foods in Rombo district ranged from 14.25 to 27.55%. The highest fibre content was found in composite flour porridge followed closely by banana porridge with beef.

Protein is one of the most important nutrient required in complementary foods and is required for speedy growth and development of a child (Bazaz *et al.*, 2016). Protein content of the frequently used complementary food samples ranged from 8.33 to 25.12%. Banana porridge with pumpkins and rice porridge with milk had non-significantly different higher protein content than the rest of the complementary foods at $p>0.05$. The lowest protein content was found in banana porridge with fish but it was not significantly different from maize porridge, composite flour porridge or banana porridges that contained either beef or milk ($p>0.05$). The reason for lower protein content in banana porridge with beef and banana porridge with fish is because they used only the beef or fish soup in complementary foods preparation and the real beef or fish was used to prepare food for older family members. Porridge made from composite flour as well as banana porridge with milk had significantly higher fat content than other formulations ($p<0.05$). Fat content for all the samples ranged from 1.05 to 20.72 g/100 g (dry weight). Banana porridge with pumpkins had the lowest fat score followed by rice porridge with milk and banana porridge with fish.

Carbohydrates are the main energy sources in the child's diet and are classified as available and unavailable carbohydrates, where the unavailable carbohydrate is considered as dietary fibre (Charrondiere *et al.*, 2004). The results from this study showed that available carbohydrate ranged from 34.34 to 72.61%. Banana porridge with fish had significantly ($p < 0.05$) higher carbohydrate content relative to the rest of the samples. Banana porridge with beef and banana porridge with milk had non-significant ($p > 0.05$) different carbohydrate contents respectively. Also, there was no significant difference ($p > 0.05$) in carbohydrate content between maize porridge, rice porridge with milk and banana porridge with pumpkins. The lowest carbohydrate content was reported in composite flour porridge.

Energy content of the frequently used complementary foods ranged from 317.98 to 379.23 kcal per 100 g (dry weight basis). Composite flour and banana with milk porridges were characterised by the highest levels of energy as compared to the rest of the analysed complementary food samples. The high caloric content of banana porridge with milk could be due to its high carbohydrate and fat (whole milk was used) contents relative to other formulations. Banana porridge with beef had the lowest energy value (317.98 kcal). Energy content of banana porridge with fish, banana porridge with pumpkins and maize porridge were not significantly different ($p > 0.05$) from one another.

Table 18: Proximate composition of frequently used complementary foods (g/100 g dry weight basis)

	Banana porridge with beef	Banana porridge with fish	Maize porridge	Banana porridge with milk	Composite flour porridge	Banana porridge with pumpkin	Rice porridge with milk
Energy	317.98±16.49^{b}	348.14±10.55^{ab}	334.51±12.88^{ab}	373.44±22.34^{a}	379.23±7.51^{a}	333.29±5.31^{ab}	345.79±10.10^{ab}
Protein	9.74±2.48^{c}	8.34±2.57^{c}	13.47±1.07^{c}	8.33±1.48^{c}	13.84±1.58^{bc}	23.65±5.02^{ab}	25.12±1.27^{a}
Fat	3.59±1.08^{c}	2.71±0.25^{c}	6.55±1.93^{bc}	10.66±2.77^{b}	20.72±0.97^{a}	1.05±0.37^{c}	2.36±0.02^{c}
CHO(Available)	61.67±0.76^{ab}	72.61±5.76^{a}	55.41±2.20^{b}	61.05±0.82^{ab}	34.34±2.48^{c}	57.31±4.51^{b}	56.01±3.79^{b}
Moisture	72.36±1.34^{b}	67.72±0.84^{bc}	81.66±1.43^{a}	65.51±1.32^{c}	79.72±0.58^{a}	71.44±2.78^{b}	68.67±1.14^{bc}
Ash	2.71±0.25^{b}	2.10±0.01^{c}	1.05±0.02^{e}	1.68±0.07^{cd}	3.54±0.19^{a}	1.47±0.05^{de}	1.89±0.003^{cd}
Fibre	22.28±3.04^{ab}	14.25±2.93^{c}	23.52±0.83^{ab}	18.28±2.18^{ab}	27.55±2.90^{a}	16.52±0.92^{c}	14.61±2.53^{c}
Dry matter	27.64±1.34^{b}	32.28±0.84^{ab}	18.34±1.43^{c}	34.49±1.32^{a}	20.28±0.58^{c}	28.56±2.78^{b}	31.33±1.14^{ab}

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.5.2 Vitamins A and C composition of the frequently used complementary foods in Rombo district

Shown in Table 19 are values of vitamins A and C of the seven frequently used complementary food samples in Rombo district. A conversion factor of 6 μg of β-carotene equivalent to 1 μg of Retinol Equivalent (RE) was used for the present study. Vitamin A content of the complementary food samples ranged from 195.83 to 971.05 μg/100 g (dry weight) and were significantly ($p < 0.05$) different from each other, except banana porridge with beef, banana porridge pumpkin and rice porridge with milk. Composite flour porridge had significantly ($p<0.05$) higher vitamin A score. The lowest vitamin A content was observed in maize porridge. Food samples with animal products such as meat, fish and milk had relatively higher vitamin A contents.

Vitamin C content of the frequently used complementary foods ranged from 3.48 to 9.56 mg/100 g dry weight. The results revealed significantly ($p<0.05$) higher vitamin C content for composite flour porridge and banana porridge with fish. Banana porridge with beef significantly ($p< 0.05$) lower vitamin C content relative to the rest of the samples. Milk based complementary food samples (banana porridge with milk and rice porridge with milk) as well as maize porridge and banana porridge with pumpkins did not differ significantly from each other ($p>0.05$).

Table 19: Vitamins A and C composition of the frequently used complementary foods in Rombo district (g/100 g dry weight basis)

Complementary foods	B-carotene (µg/100gRE)	Retinol (µg/100g)	Total vitamin A (µg/100g)	Vitamin C(mg/100g)
Banana porridge with beef	170.13±11.45de	582.62±49.22^{a}	752.75±60.67^{bc}	3.48±0.12^{c}
Banana porridge with fish	143.73±0.22de	401.02±9.21^{b}	544.76±8.98^{d}	9.02±0.31^{a}
Maize porridge	195.83±16.77cd	0.00^{c}	195.83±16.77^{f}	5.23±0.52^{b}
Banana porridge with milk	105.30±3.93e	676.01±37.84^{a}	781.32±33.91^{b}	5.62±0.18^{b}
Composite flour porridge	971.05±10.75a	0.00^{c}	971.05±10.75^{a}	9.56±0.23^{b}
Banana porridge with pumpkin	401.49±39.05b	0.00^{c}	401.489±39.05^{e}	6.46±0.58^{b}
Rice porridge with milk	262.66±9.54c	387.51±10.34^{b}	650.17±0.80^{cd}	6.05±0.36^{a}

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly (p<0.05). The sample with 0.00 were from plant sources and therefore retinol was not analysed

4.1.5.3 Mineral element concentration of the frequently used complementary foods in Rombo district

The amount of minerals required from complementary foods depends on the quantity provided by human milk and varies markedly based on bioavailability (Lutter and Dewey, 2003).

Iron content of the frequently used complementary food samples from Rombo district ranged from 2.48 to 22.86 grams per 100 grams of the dry sample as shown in Table 20. There was no significant difference (p>0.05) in iron content between banana porridge with fish and banana porridge with milk. Banana porridge with beef had significantly (p<0.05) higher iron content as compared to the rest of the sample. This could be attributed by the presence of beef in the sample. Banana porridge with pumpkins had lowest (but non-significantly different (p>0.05)) iron content score from rice porridge with milk. The low iron content in rice porridge could be due to the presence of milk which is a poor iron source.

Table 20 shows zinc content of the frequently used complementary foods. All samples taken for analysis had zinc content below the minimum recommended levels for complementary foods with the exception of banana porridge with beef. It ranged from 0.92 to 9.57 mg/100 g (dry weight). Banana porridge with beef had the highest zinc content (9.57) as compared to banana porridge with pumpkin which had less than 1mg/100 g. This could be due to the presence of meat, which was a good source of zinc. Banana porridge with pumpkin had the lowest zinc content but it was not significantly different from composite flour porridge, banana porridge with fish and banana porridge with milk ($p>0.05$).

Findings from this study showed the range of calcium (per 100g dry weight) from 82.73 to 400.58 milligrams as shown in Table 20. Banana porridge with meat/beef had significantly ($p<0.05$) higher calcium content than the rest of the samples. It was followed by milk-contained complementary food samples (banana porridge with milk and rice porridge with milk. The lowest calcium content (73.13 mg/100 g dry weight) was reported in maize porridge but it was not significantly different from that of rice porridge with milk (73.12 mg/100g dry weight) at $p>0.05$.

The iodine content of the frequently used complementary food samples in Rombo district are summarized in Table 20. Composite flour porridge had significantly ($p<0.05$) higher iodine content (200.93µg/100g dry weight) while banana porridge with beef had the lowest score (10.18 µg/100g dry weight). There was no significant difference in iodine content between banana porridge with fish, maize porridge, banana porridge with milk and banana porridge with pumpkins.

Table 20: Mineral composition of frequently used complementary foods for children aged 6-23 months at Rombo district (g/100 g dry weight)

Complementary foods	Iron (mg/100g)	Zinc (mg/100g)	Calcium (mg/100g)	Iodine (µg/100g)
Banana porridge with beef soup	22.86±1.09^{a}	9.57± 0.85^{a}	400.58±40.22^{a}	10.18±4.23^{d}
Banana porridge with fish soup	5.99±0.17^{d}	1.17±0.02^{bc}	82.73±1.47^{d}	40.24±4.54^{cd}
Maize porridge with sugar and oil	9.12±1.24^{b}	2.53±0.15^{b}	149.75±5.11^{bc}	42.04±8.66^{cd}
Banana porridge with milk	4.88±0.39^{cd}	1.38±0.12^{bc}	194.56±6.19^{b}	56.86±9.46^{bc}
Composite flour porridge	9.21±0.53^{b}	1.05±0.12^{c}	111.55±6.84^{cd}	200.93±15.34^{a}
Banana porridge with pumpkin	2.58±0.40^{d}	0.92±0.05^{c}	135.15±11.37^{bcd}	31.73±10.52^{cd}
Rice porridge with milk	2.48±0.24^{d}	1.36±0.35^{bc}	73.13±3.77^{d}	85.12±6.52^{b}

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.6 Nutrient's gap based on the amount of food consumed per day (Recommendations versus intakes)

Complementary feeding interventions are usually targeted at the age range of six to 24 months, which is the time of peak incidence of growth faltering, micronutrient deficiencies and infectious illnesses in developing countries (Dewey and Adu-afarwuah, 2008). However, meeting nutritional needs during this age interval is challenging (Dewey, 2013). Before planning to improve nutrient content of the complementary foods, it is important to identify the gaps first in order to know whether there is a problem or not. The present study considered this by taking the samples to the laboratory for analysis to identify the gap. Based on the amount of complementary foods consumed per day, gaps were observed in fat, vitamin C, iron, zinc, calcium and iodine for most of the samples and in all age groups. The gaps were obtained by finding the difference between recommended amount of nutrients that should be obtained from complementary foods and the actual amount of nutrients consumed based on the median portion size (g) consumed per day (Tables 21, 22 and 23).

For infants aged 6-8 months, energy, protein and vitamin A content of the foods they frequently consumed was enough to meet their recommended dietary allowance. Banana porridge with beef, banana porridge with fish, banana porridge with pumpkins and rice porridge with milk had lower than recommended amount of fat. With the exception of banana porridge with beef, all the other samples had lower than recommended amount of iron and zinc. Calcium was also lower than recommended for all the samples. Only banana porridge with beef had lower than recommended amount of iodine.

This study also revealed that, increase in the amount of complementary foods consumed per day according to the age of child that tended to narrow the nutrients' gaps. The gaps observed in infants aged 6-8 months were the same as the ones observed for the infants aged 9-11 months but the latter was narrower than the previous ones.

Table 21: Nutrients' gap of the frequently used complementary foods for infants aged 6-8 months in Rombo district

	Amount(g)	Energy (Kcal)	Protein (g)	Fat (g)	Vit. A (µg)	Vit. C (mg)	Fe (mg)	Zn (mg)	Ca (mg)	I (µg)
RDA		616	9.1	20.5	350	25	21	5	525	60
BM		414	3.9	15.9	186	15	0.1	2.5	104	41
CF		202	5.2	4.6	164	10	20.9	2.5	421	19
S1	97.1	308.8^{d}	9.46^{bc}	3.49^{cd}	730.92^{b}	3.38^{e}	22.19^{a}	9.29^{a}	388.96^{a}	9.89^{c}
Gap		-106.8^{a}	-4.26^{ab}	1.11^{ab}	-566.92^{d}	6.62^{a}	-1.30^{d}	-6.8^{c}	32.04^{e}	$9.11\ ^{a}$
S2	126.8	441.45^{b}	10.8^{bc}	3.43^{cd}	690.75^{bc}	11.4^{c}	7.60^{c}	1.5^{de}	104.9^{de}	51.02^{bc}
Gap		-239.5^{c}	-5.37^{ab}	1.17^{ab}	-526.8^{cd}	-1.44^{e}	13.30^{b}	1.02^{b}	316.1^{ab}	-32.02^{b}
S3	171.2	572.68^{a}	23.07^{a}	11.2^{b}	335.27^{e}	8.96^{b}	15.62^{b}	4.34^{b}	256.37^{b}	71.97^{b}
Gap		-370.7^{d}	-17.9^{c}	-6.62^{c}	-171.27^{a}	1.04^{d}	5.28^{c}	-1.8^{b}	164.63^{d}	-52.9^{ab}
S4	88.9	331.9^{cd}	7.40^{c}	9.47^{bc}	694.59^{bc}	4.99^{ef}	4.34^{cd}	1.23^{c}	172.96^{c}	50.55^{bc}
Gap		-129.9^{ab}	-2.20^{a}	-4.9^{bc}	-530.6^{cd}	5.01^{ab}	16.6^{ab}	1.27^{b}	248.04^{c}	-31.6^{ab}
S5	147.8	560.51^{a}	20.5^{ab}	30.6^{a}	1435.2^{a}	14.1^{a}	13.61^{b}	1.6^{cd}	164.87^{e}	$296.\ 9^{a}$
Gap		-358.5^{d}	-15.3^{bc}	-26.3^{d}	-1271.2^{e}	-4.13^{f}	7.29^{c}	0.94^{b}	256.1^{bc}	-277.9^{c}
S6	112	373.29^{c}	26.49^{a}	1.17^{d}	449.67^{de}	7.23^{cd}	2.89^{d}	1.0^{cd}	151.4^{cd}	35.53^{bc}
Gap		-171.9^{b}	-21.3^{c}	3.43^{a}	-285.7^{ab}	2.77^{cd}	18.01^{a}	1.47^{b}	269.6^{bc}	-16.5^{ab}
S7	88.4	305.68^{d}	26.49^{a}	2.09^{d}	574.76^{cd}	5.35^{de}	2.19^{d}	1.20^{e}	64.65^{cd}	75.25^{b}
Gap		-103.7^{a}	-17.0^{c}	2.51^{a}	-410.8^{bc}	4.65^{bc}	18.71^{a}	1.30^{b}	356.35^{a}	-56.25^{b}

Negative value (-) = More than recommended amount (no gap), RDA= Recommended dietary allowance, BM= Amount provided by breast milk, CF= Amount needed from complementary foods, Gap= Difference between amount needed from complementary foods and the amount consumed. Values with different superscripts in a column differ significantly ($p<0.05$).

Table 22: Nutrients' gap in the frequently used complementary foods for infants aged 9-11 months in Rombo district

	Amount (g)	Energy (Kcal)	Protein (g)	Fat (g)	Vit. A (µg)	Vit. C (mg)	Fe (mg)	Zn (mg)	Ca (mg)	I (µg)
RDA		686	9.6	22.9	350	25	21	5	525	60
BM		379	0.5	18.3	186	11	0.1	2.4	79	30
CF		307	9.1	4.6	214	14	20.9	2.6	449	30
S1	177.2	563.47^{c}	17.3^{bc}	6.36^{bcd}	1333.9^{b}	6.18^{c}	40.5^{a}	16.9a	709.8a	18.04^{c}
Gap		-256.5^{c}	-8.17^{ab}	-1.76^{ab}	-1119.9^{d}	7.82^{a}	-19.6^{c}	-14.4c	-260.8^{c}	11.9bc
S2	117.2	408.0^{de}	9.77^{c}	3.17^{cd}	638.46^{de}	10.6^{b}	7.03^{c}	1.37c	96.96^{c}	47.16b^{c}
Gap		-101.0^{ab}	-0.67^{a}	1.43^{ab}	-424.7^{ab}	3.43^{b}	13.9^{a}	1.23^{a}	352.04^{a}	-17.2^{ab}
S3	236.3	790.12^{b}	31.83^{a}	15.48^{b}	462.56^{e}	12.4^{b}	21.6^{b}	5.98^{b}	353.70^{b}	99.29^{b}
Gap		-483.1^{d}	-23.2^{c}	-10.9^{c}	-248.56^{a}	1.64^{b}	0.65^{b}	-3.38^{b}	95.29^{b}	-69.30^{b}
S4	126.5	472.4^{cd}	10.53^{c}	13.5^{bc}	988.37^{c}	7.11^{c}	6.18^{c}	1.74^{c}	246.12^{b}	71.93b^{c}
Gap		-165.4^{bc}	-1.43^{a}	-8.88^{bc}	-774.36^{c}	6.89^{a}	14.7^{a}	0.86^{a}	202.88^{b}	41.93a^{b}
S5	257.8	975.01^{a}	35.59^{a}	53.27^{a}	2496.6^{a}	24.6^{a}	23.7^{b}	2.71^{c}	286.80^{b}	516.59^{a}
Gap		-668.0^{e}	-26.5^{c}	-48.7^{d}	-2282.6^{e}	-10.6^{c}	-2.78^{b}	-0.11^{a}	162.19^{b}	-486.6^{c}
S6	0	-	-	-	-	-	-	-	-	-
Gap		-	-	-	-	-	-	-	-	-
S7	108	373.46^{e}	27.1^{ab}	2.55^{d}	702.19^{d}	6.53^{c}	2.68^{c}	1.47^{c}	78.98^{c}	91.93^{bc}
Gap		-66.46^{a}	-18.0^{bc}	2.04^{a}	-488.2^{b}	7.46^{a}	18.2^{a}	1.13^{a}	370.02^{a}	-61.9^{ab}

Negative value (-) = More than recommended amount (no gap), RDA= Recommended dietary allowance, BM= Amount provided by breast milk, CF= Amount needed from complementary foods, Gap= Difference between amount needed from complementary foods and the amount consumed. Values with different superscripts in a column differ significantly ($p<0.05$).

The amount of complementary foods consumed by children aged 12-23 months is higher than that of infants aged 6-11 months. The more the amount of complementary foods consumed per day the narrower the nutrients' gaps (Table 23).

Table 23: Nutrients' gap in the frequently used complementary foods for infants aged 12-23 months in Rombo district

	Amount(g)	Energy (Kcal)	Protein (g)	Fat (g)	Vit. A (μg)	Vit. C (mg)	Fe (mg)	Zn (mg)	Ca (mg)	I (μg)
RDA		894	10.9	22.9	400	30	12	6.5	350	90
BM		346	1.8	18.3	87	7	0.1	3.8	49	39
CF		548	9.1	4.6	313	23	10.9	2.7	301	51
S1	165.4	525.96^{c}	16.12^{b}	5.94^{cd}	1245.1^{b}	1.76^{e}	37.8^{a}	15.8^{a}	662.56^{a}	16.84^{c}
Gap		22.05^{a}	-7.02^{a}	-1.34^{ab}	-932.05^{c}	17.24^{a}	-25.9^{c}	-13.1^{c}	-361.6^{e}	34.16^{a}
S2	148	515.25^{c}	12.34^{b}	4.00^{cd}	806.24^{cd}	13.35^{c}	8.87^{c}	1.73^{c}	122.44^{e}	59.55^{c}
Gap		32.75^{a}	-3.24^{b}	0.59^{ab}	-493.2^{ab}	9.65^{c}	3.03^{a}	0.97^{a}	178.56^{a}	-8.55^{ab}
S3	319.3	1068.1^{b}	43.02^{a}	20.93^{b}	625.30^{d}	16.71^{b}	29.1^{b}	8.09^{b}	478.14^{a}	134.2^{b}
Gap		-520.1^{b}	-33.9^{a}	-16.3^{c}	-312.30^{a}	6.29^{d}	-17.2^{b}	-5.39^{b}	-177.5^{d}	-83.23^{b}
S4	150.5	562.03^{c}	12.53^{b}	16.0^{bc}	1175.9^{b}	8.46^{de}	7.35^{c}	2.08^{c}	292.81c	85.38^{bc}
Gap		-14.03^{a}	-3.43^{a}	-11.4^{bc}	-862.88^{c}	14.5^{ab}	4.55^{a}	0.62^{a}	8.19^{bc}	-34.6^{ab}
S5	319.2	1210.5^{a}	44.18^{a}	66.14^{a}	3099.6^{a}	30.52^{a}	29.4^{b}	3.37^{c}	356.08^{c}	41.37^{a}
Gap		-662.51^{c}	-35.9^{b}	-61.5^{d}	-2787^{d}	-7.52^{e}	-17.5^{b}	-0.67^{a}	-55.08^{c}	-590.4^{c}
S6	155.5	518.27^{c}	36.78^{a}	1.63^{d}	624.33^{d}	10.04^{d}	4.01^{c}	1.43^{c}	210.1^{de}	49.33^{bc}
Gap		29.73^{a}	-27.7^{b}	2.97^{a}	-311.32^{a}	12.96^{b}	7.89^{a}	1.27^{a}	90.85^{ab}	1.67^{ab}
S7	140.5	485.84^{c}	35.29^{a}	3.32^{d}	913.50^{c}	8.50^{de}	3.49^{c}	1.91^{c}	102.75^{e}	119.6^{b}
Gap		61.16^{a}	-26.2^{b}	1.28^{a}	-600.5^{b}	14.6^{ab}	8.41^{a}	0.79^{a}	198.25^{a}	-68.59^{b}

Negative value (-) = More than recommended amount (no gap), RDA= Recommended dietary allowance, BM= Amount provided by breast milk, CF= Amount needed from complementary foods, Gap= Difference between amount needed from complementary foods and the amount consumed. Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.7 Results of recipe formulation by linear programming method

The aim of using linear programming was to reduce nutrients' gap by developing low cost, age appropriate and more nutritious recipes based on local food ingredients and dietary practices that have the potential to improve infant feeding practices. The results were as follow;

Potential ingredients: Selected list of potential ingredients for recipes creation obtained from 24-hour dietary recall and market survey are summarized in Table 24. This list includes both frequently and rarely consumed foods that were selected due to their high nutrient contents. Foods such as carbonated drinks and black tea were frequently mentioned but they were of low nutritive value and for this reason they were excluded from the list. During the interview, most of the mothers reported to give their children beef soup instead of beef (included in the list). The reason given was the absence of teeth and fear of chocking their children because they cannot chew properly. Relevant nutrition information on each food item was obtained from Tanzania Food Composition Table (Lukmanji *et al.*, 2008). The price of each food item (in Tanzanian shillings) is shown in Table 24.

Table 24: Key food list, price and their nutrient contents

Food	**Source of information and nutrient content**				
	Price (Tshs/kg)	**Mentioned in 24-hour recall**	**Available in the market**	**Produced/ kept at home**	**Nutrient content**
Bananas	900	Frequently	Yes	Yes	Energy, Potassium
Meat (beef)	6500	Frequently	Butchers	Yes	Protein, iron, zinc
Fish	6000	Frequently	Market/butchers	No	Protein
Milk	2000	Frequently	Yes	Yes	Protein and calcium
Maize	1400	Frequently	Yes	Yes	Carbohydrates
Groundnuts	2000	Frequently	Yes	Yes (Rarely)	Protein
Rice	1800	Frequently	Yes/shops	No	Carbohydrates
Beans (varieties)	2000	Frequently	Yes	Yes	Protein
Pumpkins	1000	Rarely	Yes (Seasonal)	Yes	Carbohydrates and vitamin A
Wheat	1800	Rarely	Yes/shops	No	Carbohydrates
Carrots	1000	Frequently	Yes	Yes	
Tree tomato	1000	No	Yes (Rarely)	Yes	Vitamin A and C
Cherry tomato	500	No	Yes (Rarely)	Yes	Vitamin A and C
Baobab	3000	No	Yes	No	
Bell peppers	2000	No	Yes	Yes (Rarely)	Vitamin A and C
Onions	1500	Frequently	Yes	Yes	Vitamin C
Sunflower seed	1000	No	Yes	Yes	Energy
Amaranth seed	4000	No	Yes	Yes	Energy
Sesame seeds	4000	No	Yes	Yes (Rarely)	Energy
Cassava	1000	No	Yes	Yes	Carbohydrates
Potatoes	1200	Rarely	Yes	Yes	Carbohydrates
Cooking oil	3000	Frequently	Yes/shops	Yes (Sunflower)	Fat
Coconut	2000	No	Yes	No	Fat
Citrus fruits	1000	Rarely	Yes	Yes	Vitamin C
Eggs	1600	No	Yes/shops	Yes	Proteins
Pork	5500	No	Butchers	Yes	Zinc
Chicken	8000	No	Yes	Yes	Protein

Using Linear Programming Model of NutriSurvey, seven recipes were formulated taking into account the price of the ingredients and nutrition composition (Table 25). Upper and lower acceptable limit of each of the food items were based on the local preparation methods of the frequently used complementary foods as well as estimated portion size (g) from 24-hour recall. Breast milk intake was set between 540 and 550 ml (WHO, 2002) and the price of 100 g for each food was entered. Based on Tanzania food composition tables (Lukmanji *et al.*, 2008), foods with high energy and nutrient content were selected to be added or substituted from the local recipes. Examples of selected ingredients were bananas, beef, fish, sunflower oil, sunflower seeds, sesame seeds, amaranth seeds, pumpkin seeds, carrots, green pepper, onions, tomatoes, baobab flour, pumpkin flesh, soya beans, yellow maize and milk. Built-in linear programming function of NutriSurvey software (2004) optimized the nutrients while minimizing cost.

Despite the addition high energy ingredients (such pumpkin, sunflower, amaranth and sesame seeds) to banana-based complementary foods, it was still difficult to fill the energy gap because the portion size was a limiting factor. All maize based recipes contained adequate energy (894 kcal), whereas banana porridge with milk had the lowest energy content (651.6 kcal (Gap=242.7)). The limiting micronutrients were vitamin A (in banana porridge with fish (gap=47µg), maize porridge (gap=4.1 µg) and composite flour porridge (gap=107.4 µg), iron (in banana porridge with beef (gap=2.5 mg), banana porridge with fish) (gap=2.9 mg), banana porridge with milk (gap=2.1 mg), banana porridge with pumpkin (gap=3.5 mg) and rice porridge with milk (gap=4.6 mg), calcium (banana porridge with beef (gap=131.7 mg), maize porridge (gap=126.3 mg), composite flour porridge (gap=103.3 mg), banana porridge with pumpkin (gap=205.2 mg) and rice porridge with milk (gap=167.1) and zinc (in banana porridge with pumpkin (gap=0.8 mg) and rice porridge with milk (gap=1.6 mg)) (Table 25).

Table 25: Nutrient content of seven formulations optimized through linear programming for children aged 12-23 months (Breast milk was included to meet RDA)

Formulation	RDA	F1	F2	F3	F4	F5	F6	F7
Amount (g)	-	165.4	148	192	140.79	143	155.5	140
Cost (OR)		458.22	182.5	481.08	140.79	319.2	301.53	237.91
Cost (NR)	-	426.4	169	468	125.3	229	131.8	220
Energy(Kcal)	894	756.5	687.2	893.8	651.6	894.1	706.7	727
Protein (g)	10.9	22.5	35	30.5	17.2	31.1	12.9	13.5
Fat (g)	29.8	49.3	36.4	36.2	40.5	34.3	50	39.5
Carbohydrate (g)		63.4	62.4	120.3	64.4	125.7	60.9	84.1
Vitamin A (µg)	400	401.2	353	395.9	511.3	292.6	521	445.3
Vitamin C (mg)	30	51.4	39	33.5	35.2	29.4	43.3	31.9
Iron (mg)	6	3.5	3.1	8.6	3.9	11.1	2.5	1.4
Zinc (mg)	4.1	4.3	4.8	4.3	4.2	4.7	3.3	2.5
Calcium (mg)	400	268.3	867.1	273.7	397.5	296.7	194.8	232.9

Cost (OR) = Cost of the old recipe (frequently used complementary foods in Rombo)
Cost (NR) = Cost of the new recipe (formulated recipes)

4.1.8 Laboratory analysed nutrient content of the formulated complementary food recipes

4.1.8.1 Proximate composition

Tables 26, 27 and 28 depict the nutrient composition present in each of the seven formulations used in this study. The moisture content ranged from 74.79 to 83.02% but did not vary significantly ($p>0.05$) among most of the formulations. The moisture content of the formulated recipes was higher than that of the frequently used complementary foods (65.51-81.11%). Rice porridge with milk had significantly ($p<0.05$) lower moisture content as compared to the rest of the formulations. Addition of water during cooking may help to improve consistency of the complementary porridges.

As shown in Table 26, the ash content of banana porridge with milk was significantly higher than the rest of the formulations at $p<0.05$. The ash content of all the formulations varied from 0.73 to 8.75% on dry weight basis. The lowest value was observed on composite flour although it was not significant different from banana porridge with pumpkin, banana porridge with milk and banana porridge with beef. However, the ash content values for the formulated recipes were higher than that of the frequently used complementary foods in banana porridge with fish (6.65 versus 2.10), banana porridge with milk (8.75 versus 1.68) and rice porridge with milk (5.01 versus 1.89). The increase in ash content of the formulations may be attributed by the addition of dry ingredients such as sesame, pumpkin and sunflower seeds' flour which may potentially increase micronutrient contents of the formulations.

Available Carbohydrate, determined by difference varied from 2.82 to 47.28% (Table 26). These values were generally lower than that of the frequently used complementary foods (34.34-72.61%). This may be due to the fact that, during formulations of the new recipes, much attention was given to micronutrients by reducing amount of bananas and cereals used and increasing micronutrient rich foods such as green pepper, seeds, onions, tomatoes, fish, milk and meat. Also portion size was a limiting factor in optimizing energy content of the recipes.

Protein content was in the range of 31.12 to 66.56% (Table 26). Composite flour porridge and rice porridge with milk had significantly ($p<0.05$) higher and lower protein content respectively. There was no significant difference ($p>0.05$) in protein content between banana porridge with beef, banana porridge with milk and maize porridge. The frequently used complementary foods (old recipes) had lower protein content than the formulated ones (8.33-25.12). This may be due to the addition of protein rich sources such as meat, fish, milk, soya beans, eggs and variety of seeds during the formulation process.

The fat content of the formulated recipes ranged from 10.50 to 21.43%. All of the formulated recipes had higher values of fat relative to their frequently used counterparts (ranging from 1.05 to 20.72%). The high fat values could be accounted for by the addition of oily-seeds such as sunflower and sesame seeds as well as whole milk and addition of cooking oil during the cooking process.

The fibre contents of the optimized recipes (Table 26) were relatively lower than that of the frequently used complementary foods. The values ranged from 4.19 to 15.19% while that of old recipe (frequently used) ranged from 14.25-27.55%. The attempt to reduce anti-nutrients through improved processing methods such as soaking, removing of outer coats of seeds and roasting may have contributed to the reduced fibre content in the formulated recipes.

The caloric values of the formulated recipes ranged from 376.31 to 486.42 kcal. There was an increase in energy content of the formulated recipes when compared to the frequently used recipes. Significantly ($p<0.05$) higher energy values were observed in banana porridge with pumpkins and banana porridge with beef. Banana porridge with milk had the lowest energy value but it was not significantly different from rice porridge with milk.

Table 26: Proximate composition of the formulated complementary food recipes (g/100 g dry weight basis)

	Banana porridge with beef	Banana porridge with fish	Maize porridge	Banana porridge with milk	Composite flour porridge	Banana porridge with pumpkin	Rice porridge with milk
Energy	454.97±14.13^{ab}	421.66±16.57^{bc}	418.41±2.26^{c}	376.31±8.99^{d}	438.75±2.68^{bc}	486.42±0.71^{a}	408.09±1.01^{cd}
Protein	41.74±6.43^{de}	62.35±1.60^{ab}	47.83±1.94^{cd}	50.17±3.82^{bcd}	66.56±2.27^{a}	55.55±1.29^{abc}	31.12±0.53^{e}
Fat	18.17±0.63^{ab}	17.89±3.03^{ab}	15.55±0.81^{bc}	14.42±0.89^{bc}	13.12±0.38^{bc}	21.43±0.22^{a}	10.50±0.49^{c}
Carbohydrate	31.11±8.54^{b}	2.82±1.07^{d}	26.30±2.0^{bc}	11.47±4.05^{cd}	13.48±2.46^{cd}	17.84±1.97^{bcd}	47.28±1.88^{a}
Moisture	80.92±1.23^{a}	82.07±0.82^{a}	82.26±0.62^{a}	80.85±0.001^{a}	82.29±0.16^{a}	83.02±1.01^{a}	74.79±0.18^{b}
Ash	2.68±0.64^{cd}	6.65±1.02^{ab}	1.39±0.07^{d}	8.75±1.76^{a}	0.73±0.53^{d}	0.99±0.8^{d}	5.01±0.80^{bc}
Fibre	6.29±2.10^{c}	10.30±0.67^{b}	10.94±0.38^{b}	15.19±0.63^{a}	6.05±0.33^{c}	4.19±0.20^{c}	6.09±0.06^{c}
Dry matter	19.08±1.23^{b}	17.93±0.82^{b}	17.74±0.62^{b}	19.15±0.001^{b}	17.70±0.16^{b}	16.98±1.01^{b}	25.21±0.18^{a}

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.8.2 Vitamins composition of the formulated complementary foods

The values obtained for the vitamins in the formulated complementary food recipes are shown in Table 27. There was no significant difference between banana porridge with meat, banana porridge with milk and banana porridge with pumpkins. All the samples had vitamin A content ranging from 1122.04 to 3622.65 µg/100 g dry weight. These values are very high when compared to that of the old recipe which ranged from 195.83 to 971.17 µg/100g dry weight. Formulations with animal products such as meat, fish, eggs and milk had higher vitamin A contents relative to plant based complementary foods.

Vitamin C content of the formulations ranged from 65.05 to 124.07 mg/100 g dry weight (Table 27). The values are higher than that of the frequently used complementary food in Rombo district (3.48-9.56 mg/100 g dry weight). The reason could be the addition of vitamin C rich ingredients and changing the cooking method by adding vitamin C contained ingredients at the end of cooking (to shorten the cooking time) and this is because vitamin C is thermo labile. Lower vitamin C value was observed in banana porridge with pumpkins but it was not significant different from the rest of the formulations with the exception of banana porridge with beef ($p>0.05$).

Table 27: Vitamins A and C composition of the formulated recipes (g/100 g dry weight basis)

Complementary foods	B-carotene (μg/100gRE)	Retinol (μg/100g)	Total vitamin A (μg/100g)	Vitamin C(mg/100g)
Banana porridge with beef	2071.49±94.31	1551.16±12.10[a]	3622.65±26.7[a]	75.37±4.86[b]
Banana porridge with fish	1933±17.34	1073.13±9.08[b]	3006.49±16.43[b]	71.11±3.26[b]
Maize porridge	1122.04±7.58	0.00	1122.04±7.58[c]	124.07±23.79[a]
Banana porridge with milk	2316.97±26.49	955.95±92.71[b]	3272.92±18.26[a]	66.43±0.03[b]
Composite flour porridge	1902.42±54.4	0.00	1902.42±54.4[bc]	82.22±0.75[ab]
Banana porridge with pumpkin	2984.03±56.92	0.00	2984.03±56.92[ab]	65.05±9.34[b]
Rice porridge with milk	945.43±12.39	674.47±8.41[c]	1619.89±20.87[c]	66.91±13.98[b]

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$)

4.1.8.3 Minerals composition

Mineral composition of the formulated complementary food recipes are summarized in Table 28. Iron content in the formulated samples (8.08-53.05 mg/100g dry weight) was higher than that of the frequently used complementary foods (2.08- 22.86 mg/100 g dry weight) in Rombo district. Banana porridge with meat had significantly ($p<0.05$) higher iron content as compared to the rest of the formulations. Even before diet optimization, banana porridge with beef had significantly higher iron content. Formulations that contained milk had lower iron content than others. In general, at least half of the formulated recipes were able to provide the recommended amount of iron needed from complementary foods assuming low bioavailability.

Zinc content of the formulated recipes (Table 28) did not vary significantly from sample to sample at $p>0.05$. It ranged from 2.29 to 8.68mg/100 g dry weight. Banana porridge with beef had non-significantly ($p>0.05$) higher zinc content followed closely by banana porridge with fish. The lowest zinc content (2.29 mg/100 g dry weight) was reported in banana porridge with milk. The zinc content of banana porridge with meat before optimization was higher than that of the optimized diet (9.57 versus 6.69 mg/100 of dry sample).

The results (Table 28) showed an increase in calcium content of the formulated complementary foods (333.98-1228.16 mg/100 g dry weight) when compared to that of the frequently used ones (73.13-400.58 mg/100 g dry weight. Banana porridge with beef had higher calcium content before and after optimization. There was also an increase in iodine content (Table 28) in the formulated recipes. The values varied from 126.81-792.78 µg/100 g dry weigh. Maize porridge had higher iodine content that the other formulations.

Table 28: Mineral composition of the formulated complementary food recipes (g/100 g dry weight basis)

Complementary foods	Iron (mg/100g)	Zinc (mg/100g)	Calcium (mg/100g)	Iodine (µg/100g)
Banana porridge with beef soup	53.05±1.88[a]	6.69±1.79a	1228.16±7.03[a]	184.18±63.38[c]
Banana porridge with fish soup	24.38±2.51[b]	8.68±7.65[a]	383.50±7.42[cd]	602.12±1.18[ab]
Maize porridge with sugar and oil	18.08±4.38[bc]	7.40±2.54[a]	863.79±34.06[b]	792.78±15.66[a]
Banana porridge with milk	15.17±1.58[cd]	2.92±0.45[a]	749.87±7.79[d]	642.97±0.03[ab]
Composite flour porridge	24.7±0.22[b]	4.09±0.27[a]	544.47±16.55[b]	643.02±23.33[ab]
Banana porridge with pumpkin	14.26±1.69[cd]	2.83±0.87[a]	342.23±27.33[c]	126.81±7.00[c]
Rice porridge with milk	8.08±1.68[d]	2.29±0.21[a]	333.98±4.97[d]	528.84±19.54[b]

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.9 Comparison of frequently used and formulated complementary food recipes

Energy and micronutrients content of the linear programming optimized complementary food recipes were compared with the frequently used complementary foods in Rombo district and the results are shown in Table 29. Generally, all the formulated recipes had higher energy and micronutrient content relative to the frequently used complementary foods.

With the exception of banana porridge with milk, all the other formulated complementary food recipes had significantly ($p<0.05$) higher energy content as compared to the frequently used ones. This increase may have been attributed to the addition of high energy seeds such as that of sunflower, pumpkin, sesame and amaranth as well as yellow soybeans.

There was also a significant increase in protein content for all the formulated recipes at $p<0.05$. Addition of animal products such as beef, fish and milk may have contributed to the increase in protein content of the formulated recipes. This is because, only the soups (for meat and fish) were used to prepare complementary foods because most mothers/caregivers feared that the steak might chock the baby since they can not chew properly but in the formulated recipes minced/grinded meat and fish were used. Also, addition of seed varieties and soybeans may have contributed to improved protein content of the formulated recipes.

There was a significant increase in fat content for all the formulated recipes with the exception of banana porridge with milk and composite flour porridge ($p<0.05$). Fat content of the frequently used banana porridge with milk was not significantly different ($p>0.05$) from the formulated one. The reason may be due to the addition of the same amount of milk and substitution of the added oil with sunflower and sesame seeds. Also there was a significant decrease in fat content of the formulated composite flour porridge when compared to the frequently used one at $p<0.05$. This may be due to the removal of groundnuts that are known to have high fat content.

There was a significant decrease ($p<0.05$) in carbohydrate content for most of the formulated complementary food recipes with the exception of banana porridge with rice porridge with milk. For most of the formulated recipes, protein-rich ingredients such as meat, fish, milk, seeds and soybeans may have occupied the place for carbohydrates and also the observed changes may be due to the effects of processing.

Vitamin A and C content of all the formulated recipes were significantly higher than that of the frequently used ones at $p<0.05$. Addition of animal sources, seeds and vegetables such as carrots, green pepper, amaranth leaves' juice and onions may have contributed to the increase in vitamin contents of the formulated recipes. Also, modification of the cooking methods such as reduction of cooking time for vitamin C rich sources may have contributed to the increase.

In terms of minerals, there was a significant ($p<0.05$) increase in iron, calcium and iodine content of the formulated recipes when compared to the frequently used ones (Table 29). Addition of seed varieties, soybeans and animal sources may have been the reason for the increase. Zinc content for most of the formulated complementary food recipes was not significantly different from that of the frequently used ones ($p>0.05$). Only formulated banana porridge with milk had significantly ($p<0.05$) higher zinc content than the frequently used one (Table 29).

Table 29: Mean scores of frequently used (old) complementary foods at Rombo district as compared to the linear programming formulated/ optimized (new) recipes of the same complementary foods

	S1		S2		S3		S4		S5		S6		S7	
	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New
Energy	317.98^{b}	454.97^{a}	348.14^{b}	421.66^{a}	334.51^{b}	418.41^{a}	373.44^{a}	376.31^{a}	379.23^{b}	438.75^{a}	333.29^{b}	486.42^{a}	345.7^{b}	408.09^{a}
Prot.	9.74^{b}	41.74^{a}	8.34^{b}	62.35^{a}	13.47^{b}	47.83^{a}	8.33^{b}	50.17^{a}	13.84^{b}	66.56^{a}	23.65^{b}	55.55^{a}	25.12^{a}	31.12^{a}
Fat	3.59^{b}	18.17^{a}	2.71^{b}	17.89^{a}	6.55^{b}	15.55^{a}	10.66^{a}	14.42^{a}	20.72^{a}	13.12^{b}	1.05^{b}	21.43^{a}	2.36^{b}	10.50^{a}
Carb.	61.67^{a}	31.11^{b}	72.61^{a}	2.82^{b}	55.41^{a}	26.30^{b}	61.05^{a}	11.47^{a}	34.34^{a}	13.48^{b}	57.31^{a}	17.84^{b}	56.01^{a}	47.28^{a}
Vit. A	752.75^{b}	3622.7^{a}	544.76^{b}	3006.5^{a}	195.83^{b}	1122.0^{a}	781.32^{b}	3272.9^{a}	971.05^{b}	1902.4^{a}	401.49^{b}	2984.03^{a}	650.1^{b}	1619.9^{a}
Vit. C	3.48^{b}	75.37^{a}	9.02^{b}	71.11^{a}	5.23^{b}	124.07^{a}	5.62^{b}	66.43^{a}	9.56^{b}	82.22^{a}	6.46^{b}	65.05^{a}	6.05^{b}	66.91^{a}
Fe	22.86^{b}	53.05^{a}	5.99^{b}	24.38^{a}	9.12^{a}	18.08^{a}	4.88^{b}	15.17^{a}	9.21^{b}	24.7^{a}	2.58^{b}	14.26^{a}	2.48^{b}	8.08^{a}
Zn	9.6^{a}	6.7^{a}	1.2^{a}	8.6^{a}	2.5^{a}	7.4^{a}	1.4^{b}	2.9^{a}	1.1^{b}	4.1^{a}	0.9^{a}	2.8^{a}	1^{a}	2.3^{a}
Ca	400.6^{b}	1228.2^{a}	82.73^{b}	383.50^{a}	149.75^{b}	863.79^{a}	194.56^{b}	749.87^{a}	111.55^{b}	544.47^{a}	135.15^{b}	342.23^{a}	73.13^{b}	333.98^{a}
I	10.18^{b}	184.18^{a}	40.24^{b}	602.12^{a}	42.04^{b}	792.78^{a}	56.86^{b}	642.97^{a}	200.93^{b}	643.02^{a}	31.73^{b}	126.81^{a}	85.12^{b}	528.84^{a}

Values with different superscripts in a column differ significantly ($p<0.05$).

4.1.10 Sensory evaluation of the formulated recipes

The results of demographic characteristics and sensory evaluation by semi-trained (Food Science students) and untrained panellists (Mothers/caregivers) are presented in Tables 30, 31 and 32, respectively. All formulated complementary food recipes were evaluated for acceptance testing by a total of 102 panellists of whom 40 and 53 were semi-trained and untrained, respectively (Table 30). Majority of panellists in both groups were aged between 20-35 years. For semi-trained panellists, the nine point likert scale was used and the mean scores for the attributes evaluated ranged from 5.78-7.73, 5.29-7.51, 5.53-7.57, 5.80-7.69, 5.73-7.57 and 5.65-7.51 in terms of appearance, taste, aroma, colour, texture and general acceptability, respectively. Five point likert scale was used for untrained panellists and the range of scores were; appearance (4.32 to 4.94), taste (4.17 to 4.89), aroma (4.28 to 4.96), colour (4.62 to 4.98), texture (4.53-4.83) and general acceptability (4.45 to 4.98).

Table 30: Demographic characteristics of the panellists

Characteristic	**Number of panellists**		**Percentage of panellists**	
	Semi-trained (n=49)	Untrained (n=53)	Semi-trained (n=49)	Untrained (n=53)
Sex				
Male	29	0	59.2	0
Female	20	53	40.8	100
Age (Years)				
< 20	1	8	2.0	15.1
20-35	47	30	95.9	56.6
>35	1	15	2.0	28.3

4.1.10.1 Appearance

In terms of appearance, the highest mean score was given for maize porridge (F3) and banana porridge with beef (F1) by semi-trained and untrained panellists respectively and the lowest mean score was given for rice porridge with milk (F7) by both groups. There was no significant difference between banana porridge with beef (F1) and banana porridge with pumpkins (F6) in terms of appearance for both groups. Formulation F7 (rice porridge with milk) was rated significantly lower than the rest of the formulations ($p<0.05$) by both semi-trained and untrained panellists.

4.1.10.2 Taste

This study (Tables 31 and 32) also revealed moderate likeness of the formulated recipes regarding taste ranging from 5.29 to 7.51 and 4.17 to 4.89 for semi-trained and untrained panellists, respectively. Banana porridge with beef (F1) had the highest rating, closely followed by banana porridge with pumpkins (F6) while milk-based formulations (F4 and F7) had the least ratings for taste.

The rating for formulations F3 (Maize porridge), F5 (Composite flour porridge) and F7 (Rice porridge with milk) were not significantly different at $P>0.05$ for trained panellists. All the formulations rated by untrained panellists were not significantly different in terms of taste with the exception of F4 (Banana porridge with milk) and F7 (Rice porridge with milk) at $p>0.05$. Most of the panellists suggested that, salt or lemon should be added to rice porridge with milk (F7) in order to improve flavour.

4.1.10.3 Aroma

Aroma an important attribute in sensory evaluation because it influences the choice of foods to eat. Ratings for all the formulations in terms of smell/aroma were within acceptable range of 5-9 and 3-5 for nine and five point likert scales, respectively (Tables 31 and 32). Banana porridge with beef (F1) and banana porridge with pumpkins (F6) had flavour ratings significantly higher than the rest of the formulated diets at $p<0.05$, while the least rated were milk-based formulations (F4 and F7). For trained panellists, banana porridge with fish (F2) and rice porridge with milk (F7) as well as maize porridge (F3) and composite flour porridge (F5) were not significantly different at $p>0.05$. For untrained panellists, formulations F1 (banana porridge with beef), F3 maize porridge), F5 (composite flour porridge) and F6 (banana porridge with pumpkins) were not significantly different at $p>0.05$.

4.1.10.4 Colour

The mean score of colour for all the formulated complementary food recipes ranged from 5.8 to 7.69 and 4.62 to 4.98 for semi-trained and untrained panellists, respectively (Tables 31 and 32). Banana-based foods (F1 and F6) were not significantly different at $p>0.05$ for trained panellists. For untrained panellists, formulations F2 (banana porridge with fish), F3 (maize porridge), F5 (composite flour porridge) and F6 (banana porridge with pumpkins) were not significantly different from each other but were different from other formulations in terms of colour at $p>0.05$.

4.1.10.5 Texture

The texture of complementary foods is an important attribute that drives child's acceptance depending on his/her developmental stage and therefore it was important for it to be included in sensory evaluation. Based on the present study (Table 30), both panellist groups showed significantly higher preference ($p< 0.05$) for formulation F1 (banana porridge with beef) followed closely by F3 (maize porridge) in terms of texture. Rice porridge with milk (F7) was the least preferred formulation although it was not significantly different from banana porridge with milk (F4) for both groups at $p> 0.05$. All the formulations scored within the acceptable range for both groups.

4.1.10.6 General acceptability

In general, banana porridge with beef (F1) was highly acceptable for both groups (Tables 31 and 32). However, the general acceptability score was not significantly different from F2 (banana porridge with fish), F3 (maize porridge), F5 (Composite flour porridge) and F6 (banana porridge with pumpkins) for both panellist groups at p>0.05. For trained panellists, banana porridge with milk (F4) had the least score in terms of general acceptability but it was not significantly different (p>0.05) with rice porridge with milk (F7). Untrained panellists rated rice porridge with milk (F7) as the least generally acceptable formulation as compared to the rest of other formulated complementary foods although it was not significantly different (p>0.05) from banana porridge with milk (F4).

Table 31: Mean scores of sensory evaluation of the formulated complementary food recipes as tested by semi- trained panellists

	Appearance	Taste	Aroma	Colour	Texture	General acceptability
F1	7.27±1.30[ab]	7.51±1.43[a]	7.57±1.38[a]	7.12±1.69[ab]	7.57±1.21[a]	7.51±1.45a
F2	6.88±1.63[ab]	6.69±2.11[ab]	6.86±1.61[ab]	6.80±1.66[abc]	7.14±1.14[ab]	6.92±1.69[ab]
F3	7.73±0.97 [a]	6.22±1.52[bc]	6.29±1.15[bc]	7.69±1.39[a]	7.51±1.32[a]	7.20±1.29a
F4	5.94±1.81[cd]	5.29±2.18[c]	5.53±2.08[c]	5.80±2.08[c]	6.00±2.13[c]	5.65±2.06[c]
F5	6.69±1.57[bc]	6.27±1.83[bc]	6.12±1.54[bc]	6.57±1.51[bc]	6.47±1.57[bc]	6.80±1.61[ab]
F6	7.12±1.25[ab]	7.27±1.79[ab]	7.33±1.52[a]	7.24±1.46[ab]	7.16±1.59[ab]	7.37±1.67a
F7	5.78±1.95[d]	6.22±1.87[bc]	6.78±1.77[ab]	6.59±1.94[bc]	5.73±1.99[c]	6.12±2.02[bc]

Means bearing different superscripts on the same column are significantly different (p<0.05). F1 to F7 are the complementary foods formulation names as detailed in Table 4.

Table 32: Mean scores of sensory evaluation of the formulated complementary food recipes as tested by un-trained panellists

	Appearance	Taste	Aroma	Colour	Texture	General acceptability
F1	4.94±0.23[a]	4.87±0.39[a]	4.96±0.19[a]	4.98±0.14a	4.98±0.14[a]	4.98±0.14 [a]
F2	4.74±0.49[bc]	4.72±0.53[a]	4.64±0.71[ab]	4.72±0.69[ab]	4.74±0.59[abc]	4.85±0.50[a]
F3	4.85±0.36[a]	4.89±0.32 [a]	4.85±0.46 [a]	4.85±0.41[ab]	4.87±0.52[ab]	4.92±0.33[a]
F4	4.42±0.93[bc]	4.34±0.85[b]	4.36±0.88[bc]	4.62±0.69[b]	4.60±0.66[bc]	4.72±0.60[ab]
F5	4.91±0.30[a]	4.87±0.42 [a]	4.91±0.35 [a]	4.87±0.48[ab]	4.91±0.35[ab]	4.85±0.53[a]
F6	4.85±0.41[a]	4.75±0.68 [a]	4.87±0.32 [a]	4.83±0.51[ab]	4.83±0.43[abc]	4.81±0.48[a]
F7	4.32±0.92[c]	4.17±1.01 [b]	4.28±0.93[c]	4.62±0.66[b]	4.53±0.95[c]	4.45±0.91[b]

Means bearing different superscripts on the same column are significantly different (p<0.05). F1 to F7 are the complementary foods formulation names as detailed in Table 4.

4.1.11 'Problem nutrient(s)'

The newly formulated complementary food recipes were expected to bridge the gaps in energy and micronutrients between recommended dietary allowance and the amount consumed through breastfeeding for infants and children aged 6-23 months in Rombo district. However, when the mean score all the formulated recipes were compared with the recommended dietary allowance there was still gaps in zinc. This may be due high amount of plant-based ingredients (known to have low bioavailable zinc) relative to animal-based ingredients. Also, processing techniques such as soaking, roasting, fermentation and dehulling (aiming at reducing the effects of anti-nutritional factors) may have reduced the amount of zinc in the ingredients.

CHAPTER FIVE

5.0 DISCUSSION

This section presents discussion based on the results of infant and young child feeding practices, nutrients content of the frequently used complementary foods, nutrient's gap identification based on the amount of food consumed by a child per day, formulation of complementary food recipes using low cost, locally available ingredients by linear programming method, testing the nutrients content and sensory evaluation of the formulated recipes.

5.1 ANC and Infant and Young Child Feeding (IYCF) Practices

5.1.1 Antenatal care visits and place of delivery

WHO (2016) recommends that a normal pregnant woman without complications should have at least four antenatal visits and the first visit should occur during the first trimester of pregnancy (NBS and IFC Macro, 2016; WHO, 2016). Attending clinics for antenatal care is very important because it helps in identification and management of obstetric complications such as preeclampsia, tetanus toxoid immunisation, intermittent preventive treatment for malaria, identification and management of infections including HIV, syphilis and other sexually transmitted infections (STIs) as well as educating mothers on the importance of hospital delivery, preparations needed before delivery, early initiation of breastfeeding, exclusive breastfeeding as well as planning for optimal pregnancy spacing (WHO, 2016).

The findings from this study have shown high rate of antenatal care visits with 96.1% of the mothers having attended clinic at least once during their pregnancy. This compares well with the findings from NBS and ICF macro (2016), in which the percentage of women aged between 15-49 years who received antenatal care (ANC) during their pregnancy was 96% and 98% in 2010 and 2016 respectively (NBS and ICF Macro, 2016). Hashim *et al.* (2017) came up with the same results in Moshi urban. This shows good adherence to the focused antenatal care campaign (Kearns *et al.,* 2014). Secondary education of the mothers was independently associated with increased odds for attending clinics for antenatal care which is the same as what has been reported by Gupta *et al.*, (2015).

Other studies conducted in different areas of Tanzania (Mpembeni *et al*., 2007; Gross *et al*., 2010; Nyamtema *et al*., 2012) reported relatively lower rates of antenatal care visits. The factors reported by these studies as the contributors to poor ANC visits included poor infrastructure, long distance to the health facility with ANC services, ignorance among pregnant women (Nyamtema *et al.,* 2012), substandard ANC services (Conrad *et al*., 2012), substandard ANC resources (Gross *et al*., 2011) as well as occupation of the mother (Care, 2016). These factors were not a problem in the study area because according to Rombo District Profile (2013), each village has at least one health centre; the major roads were in good condition (tarmac), majority of the participants (63.9%) had at least primary education and the presence of posters educating mothers on the importance of attending clinic at the RCH unit of each health centre.

Also, this study supports what have been reported by NBS and ICF Macro (2016) regarding high rates of hospital delivery in Kilimanjaro region with 92.2% participants in the study area delivering their babies at the health centres. A significant positive association was found between hospital delivery and maternal education. The study conducted by Armstrong *et al.* (2016), reported the same association. Hospital delivery can help to manage several complications that may occur during and after delivery such as pre-mature birth, still births, postpartum haemorrhage and preeclampsia (UNICEF/WHO/UNFPA, 2006; Straneo *et al.*, 2014; Aboubaker *et al*., 2014).

5.1.2 Breastfeeding practices

It is recommended that breastfeeding should be initiated soon after giving birth preferably within one hour (WHO, 2001; UNICEF/WHO, 2009). Early breastfeeding initiation has been associated with reduced risk of infant and neonatal morbidity and mortality (Debes *et al*.,2013). Of the total 230 children studied, 67% were put on breast within 1 hour of birth. In Kilimanjaro region, about 73.7% of the new born babies start to breastfeed within one hour after birth and this value is relatively higher to what has been reported by this study (NBS and ICF Macro, 2016). There was no significant association between maternal age, education, occupation and marital status with breastfeeding initiation ($p<0.05$). Despite the fact that more than half of the mothers initiated breastfeeding within one hour, still 33% delayed and the reasons given were mostly medical-related such a caesarean section, postpartum haemorrhage and pre-term birth.

Colostrum, the yellowish milk produced by the mother during the first few days after delivery, provides essential nutrients as well as antibodies to boost the baby's immune system, thus reducing the likelihood of death in the neonatal period and therefore it should not be discarded (UNICEF, 2013; Aggarwal, 2015; Tiwari *et al.*, 2016). About 96.5% of the infants in the study area enjoyed all these benefits of colostrums which is the same as what has been reported by Safari *et al.* (2013) and Patil *et al.* (2015). The reasons by those who didn't give colostrum to their infants were post-delivery complications resulted from caesarean section, the baby being too sick to breastfeed while some of them considered it dirty and traditionally unacceptable and hence it was discarded.

Any food provided to a new born before the initiation of mother's breastfeeding is considered to be a pre-lacteal food (Asim *et al*., 2015). It deprives the child valuable nutrients from the colostrum thus, causing a reduction of the priming of the gastrointestinal tract, exposing the new born to the risks of infection, increased chances of chocking and all of these may lead to increased risks of infant morbidity and mortality (Meetze *et al*., 1992, Agho *et al*., 2013; Bekele *et al*., 2014). While waiting for breastfeeding initiation, about 13.5% of the mothers in the study area gave their children pre-lacteal foods. This value is higher than what was reported by NBS and ICF Macro (2016) where the percentage of infants who were given pre-lacteal foods in Kilimanjaro region was 4%. This difference can be explained by the fact that this study included three villages only whereas NBS and ICF Macro (2016) involved the whole region. Water (including glucose water), infant formula, grilled banana and cow's milk were the common pre-lacteal foods. Agnarsson *et al.* (2001) also reported glucose and water as common pre-lacteal foods in Igunga Tanzania. Honey, sugar-salt-water solution, fruit juice, tea and fresh butter were also reported as a pre-lacteal food in Pakistan and Ethiopia (Bekele *et al*., 2014; Asim *et al.* 2015).

World Health Organization (2001) recommends exclusive breastfeeding for six months, with introduction of complementary foods and continued breastfeeding thereafter. The importance of exclusive breastfeeding for the first six months of a child's life have been documented (WHO/UNICEF, 2003; Lutter and Dewey, 2003; Patil *et al*., 2015). Based on the results from this study, 64.3% of the mothers introduce water to their infants within the first six months and only 27.4% practices exclusive breastfeeding as recommended. This value is lower than that of the national level (59%) but higher than that of Kilimanjaro region (14.6%) (NBS and ICF Macro, 2016). These differences can possibly be due to the coverage of the study where NBS and ICF Macro (2016) involved both urban and rural women but this study involved rural women only. Shirima *et al*. (2000) reported longer exclusive breastfeeding to urban women as compared to their rural counterparts. Also, NBS and ICF Macro (2016) used 24 hour recall method while this study used recall since birth method. Several authors (Piwoz *et al*., 1994; Engebretsen *et al.,* 2007; Agampodi *et al.*, 2009) have questioned the validity of 24 hour recall method as it tends to overestimate the prevalence of EBF. Married women were 2.89 times more likely breastfeed exclusively as compared unmarried and widowed women (AOR = 2.89, 95% CI: 1.24 – 6.74). Other studies found education level of the mother, age of the child, and breastfeeding advice as the determinants of exclusive breastfeeding (Laddunuri, 2012; Safari *et al.*, 2013; Victor *et al.*, 2013; Mgongo *et al.*, 2014; Mogre *et al*., 2016).

This study has also revealed that, more than three-quarter of the mothers (76.5%) perceived exclusive breastfeeding to be good for a child. This perception was influenced by the advice the mothers get from medical experts, nutritional adequacy of the breast milk and child's satisfaction. The main reason given by those who thought exclusive breastfeeding was not good for a child was because the child is not satisfied by the breast milk and when he/she cries a lot they start to give him/her water and then thin porridge in addition to breast milk. The same reasons were given by mothers of Muheza, Tanga through an in-depth interview (Maonga *et al*., 2016). HIV positive mothers in Malawi, felt that exclusive breastfeeding may lead to maternal ill-health and accelerate HIV to full blown AIDS (Kafulafula *et al.,* 2014).

Children are breastfed for a long time in Tanzania (Hussein, 2005). The median duration of breastfeeding among children in Tanzania is 20 months (NBS and ICF Macro, 2016). Based on this study, about 91.3% of the mothers were still breastfeeding same as what was reported by Mgongo *et al.* (2014). The reasons given by those who were not breastfeeding were another pregnancy, the mother stopped the baby so that she/he can eat other foods, the baby refused, the mother travelled or the mother was sick. Related reasons for not breastfeeding are shown by Wanjohi *et al.* (2017).

Determinants of exclusive breastfeeding: Married mothers were found to be three times more likely to practice exclusive breastfeeding than the single mothers. Marital status of the mothers has been reported to be one of the determinants of exclusive breastfeeding in other studies (Tampah-naah and Kumi-kyereme, 2013). Support from the husband/partner increases the likelihood for exclusive breastfeeding (Tewabe *et al.*, 2017). Other factors that have been associated with increased chances for exclusive breastfeeding included pre-delivery counselling on exclusive breastfeeding *(Mgongo et al.*, 2014), age of the mother (Victor *et al,* 2013), age of the child (Mogre *et al.*, 2016), occupation (Safari *et al.,* 2013), maternal knowledge on the importance and duration of exclusive breastfeeding (Maonga *et al.*, 2015) as well as delivery at the health facility (Laddunuri, 2012).

5.1.3 Complementary feeding

All the children involved in this study had already started using complementary foods and majority started at the age of 4-6 months. The common initial complementary foods were maize-based porridges (56.1%) and banana-based porridges (28.7%). Other studies have also reported maize-based porridges as common complementary foods in Tanzania (Kimanya *et al.*, 2009: 2010; Muhimbula *et al.*, 2011; Kulwa *et al*., 2015; Vitta *et al.* 2016). The reason for banana-based porridges to be one of the frequently used-complementary foods is because banana is a staple food to people in Kilimanjaro region. Other foods used as first complementary feeds were non-breast milks, infant formula and fruit juice.

In order to estimate the number of meals per day, it is important to consider energy and nutrient content of the foods as well as the usual amounts consumed at each feeding. If the number of meals is high, energy needs can be satisfied with foods of lower energy density (Benbouzid *et al.*, 1999). World Health Organization (2001) recommends an average healthy breastfed infant aged 6-8 and 9-23 months to be fed 2-3 and 3-4 times per day respectively with additional nutritious snacks. Majority of the mothers involved in this study fed their children three times a day regardless of their age groups. This practice have also been reported elsewhere (UN, 1990; UNICEF, 2010; Altare *et al*., 2016).

Knowledge of mothers regarding the frequency of feeding is generally good. Most of the mothers suggested that a child aged 6-8, 9-11 and 12-23 months should be fed three or more times, four or more times and three times per day, respectively. The reason given by those who suggested that a child aged 12-23 months should be fed three times per day was because the child is grown and he/she can follow family timetable with breast milk and water in between the meals.

World Health Organization (1998; 2001) encourages mothers/caregivers to give their children variety of foods prepared from safe, nutritious, culturally acceptable and locally available ingredients. However, more than half of the mothers in this study did not know the locally available sources of protein, vitamins and minerals. Poor knowledge on food groups among mothers was also reported in India (Lodha and Bharti, 2013). Due to poor knowledge of locally available food sources based on their groups, majority of locally formulated complementary foods, as well as some commercial complementary foods used in Tanzania does not meet the quality attributes especially in terms of energy and micronutrient density (Muhimbula *et al*., 2011). This in turn leads to low intake of nutrients which may result into poor nutritional status of the children.

5.1.4 Types, amount and local preparation methods of frequently used complementary foods in Rombo district

Most of the studies (Mamiro *et al*., 2004; Nyaruhucha *et al*., 2006; Kimanya *et al.*, 2009: 2010; Muhimbula *et al*., 2010; Kulwa *et al*., 2015) have continuously reporting cereal-based foods as the frequently used complementary foods in Tanzania. Findings from this study have revealed banana-based foods as the frequently used complementary foods in Rombo district followed closely by cereal based foods. This is due to the fact that, the main staple food in Kilimanjaro region is banana and about 15,950 hectares are used for banana production in Rombo district with an estimated yields of 10 tonnes per hector (Rombo DC profile, 2013). However, Tanzania Food Composition Tables (Lukmanji *et al.*, 2008) shows low energy and nutrient contents of banana-based foods relative to cereal-based foods. This means that, there is a need to alternate the two food types in order to improve nutritional status of children in the area by encouraging mothers to diversify foods for their children.

It is recommended that, the amount of complementary foods consumed per day for infants and young children aged 6-8, 9-11 and 12-23 months should range from 137-187, 206-281 and 378-515 g/day, respectively (WHO/PAHO, 2003). Overall average amount of foods consumed by each age group was lower than the recommended amount because infants and young children aged 6-8, 9-11 and 12-23 months in this study consumed 100.27±39.32, 143.84±77.15 and 174.27±91.39 g/day of complementary foods respectively. Lower than recommended median portion sizes of complementary foods per day were also reported in Dodoma-Tanzania (Kulwa *et al*., 2015). These values are even lower than the documented gastric capacity of 249 and 285 g/meal for 6–8 and 9 –11 months infants, respectively (Monte and Giugliani, 2004; Dewey, 2013). Lower feeding frequencies in combination with inadequate amount of complementary foods consumed by children aged 6-23 months may likely lead to inadequate energy and micronutrients intake.

During preparation of complementary foods, there is no specific measurement of ingredients and no one cares about the nutrient composition of the foods, they only think about the child's satiety. Also, sodium bicarbonate is added to the foods to shorten cooking time, increase palatability and consistency of the foods. Addition of sodium bicarbonate may result in a large destruction of proteins, thiamine, riboflavin as well as of vitamin C and therefore it should be discouraged (Johnston *et al.*, 1943). Also, the grains are rarely washed prior to milling and the main processing method is milling for grains and peeling for bananas and potatoes. Therefore processing, preparation and handling of complementary foods was generally poor. However, several traditional food processing methods that are beneficial to a child's health have been proposed by Hotz and Gibson (2007).

5.2 Nutrient Content of Frequently Used Complementary Foods

The availability and use of nutrient-rich complementary foods is still a major problem in Tanzania and other developing countries. After exclusive breastfeeding period, the gap between nutritional requirement and amount obtained from breast milk increases with age. The gaps are mostly attributed to either poor dietary quality or poor feeding practices, if not both (Abeshu *et al.*, 2016). The moisture content of the porridges was similar to the findings of Anigo *et al*. (2010) and Kulwa *et al.* (2015). A complementary food that is more energy and micronutrient-dilute needs a larger volume to cover the gap

(WHO, 2009). High moisture content in food products have also been associated with increased growth of microorganisms, which in turns causes spoilage and low nutritional qualities of the food products (Steve and Babatunde, 2013).

The ash content reported in the present study was lower than what was reported by Tiencheu *et al*. (2016) but similar to that of Steve and Babatunde (2013) and Parvin *et al*. (2014). The lower values of ash content in the samples used in this study may probably indicate lower mineral contents. Composite flour porridge had higher ash content relative to other foods due to the presence of variety of ingredients such as maize, rice, soya beans, groundnuts and finger millet that may have more minerals (particularly iron, zinc and calcium) relative to other samples.

The findings from this study revealed that most of the complementary foods in Rombo district meet the recommended amount of protein needed from complementary foods (WHO, 1998).Even the foods that could not meet WHO recommendations (banana porridge with fish and banana porridge with milk), they were still able to provide at least 50% of the amount of protein needed from complementary foods. The higher protein content in rice porridge may be contributed by the addition of milk which is a good source of protein. Pumpkin seeds (usually discarded or given to pigs in Rombo district) have been reported to have more protein than the flesh (Usha *et al.*, 2010; Karanja *et al.*, 2013).

In order to meet amount of energy, essential fatty acids and uptake of fat soluble vitamins by lipids, fat from complementary foods should provide approximately 30 to 45% of the total energy required by infants and young children based on their age and development stage (Monte and Giugliani, 2004). Composite flour porridge had significantly higher

($p<0.05$) fat content relative to the rest of the complementary food samples. The high fat content in composite flour may be due to the inclusion of oily seeds such as groundnuts, soya beans and whole grains as well as addition of vegetable oil during cooking. Also addition of whole milk in banana porridge may have contributed to the high fat content of the sample. Fat content of the complementary food samples ranged from 1.05 to 20.72 g/100 g (dry weight) which is higher than the results reported in study conducted on quality protein maize (QPM) (Desalegn *et al.,* 2015).

The carbohydrate (excluding fibre) contents of complementary food sample in this study were in the range of 34.34 to 72.61%. These values are higher than what was reported by Kulwa *et al*. (2015)on maize-based complementary foods but lower than that of Martin *et al*. (2010) on banana based complementary foods.

The recommended energy intake from complementary foods varies according to the age of child, amount of breast milk consumed, fat content in breast milk and the frequency of feeding (WHO, 2003). A review conducted by Muhimbula and Issa-Zacharia (2010) revealed that, most of the complementary foods in Tanzania are bulky but with lower energy and micronutrient concentrations. The findings from this study support this review because the energy content of all the samples of the frequently used complementary food were below the recommended amount of energy need from complementary foods for children aged 12-23 months but for the younger ones (6-11 months), the energy content was satisfactory. The energy content of the samples ranged from 317.6 to 379.23 kcal/100 g (dry weight) and banana porridge with beef had the lowest score. These values are similar to that of Bassey *et al.* (2013).

In this study, total vitamin A content of all the samples were higher than the range reported by Isingoma *et al.* (2015), with the exception of maize porridge. Samples that contained animal products such as meat, milk and fish had higher vitamin A which is supported by Englberger *et al*. (2003). Maize porridge had the lowest vitamin A content which in agreement with what was reported by Jemberu *et al.* (2016). The observed lower than recommended vitamin A content in the in maize porridge which is one of the frequently used complementary food in Tanzania, encourages the formulation complementary foods using more nutritious ingredients such as orange-fleshed sweet potatoes (Jemberu *et al.*, 2016), carrots, legumes (Abebe *et. al.*, 2006) and seeds (Stodolak *et al*., 2009) as well as using improved traditional processing methods such as fermentation, soaking, germination/malting and de-hulling (Hotz and Gibson, 2007).

Studies have shown that most homemade complementary in Ethiopia have low vitamin C content (Abeshu *et al.*, 2016). This is not different from what has been reported by this study whereby vitamin C content of the frequently used complementary foods in Rombo district ranged from 3.48 to 9.56 mg/100g of dry sample. Composite flour porridge and banana porridge with fish had the highest vitamin C content relative to the rest of the complementary food samples. This may be due to the addition of fish at the end of cooking which reduced the cooking time of fish since ascorbic acid is heat labile. World Health Organization (2003), recommended addition of vitamin C rich ingredients such as citrus fruits, tomatoes, green, yellow and red peppers as well as green leafy vegetables to home-made complementary foods.

Iron, zinc, and calcium have always been reported as limiting nutrients in unfortified plant-based complementary foods commonly used in developing countries (Gibson *et al*., 2010; Abeshu *et al.*, 2016). Similarly, most of locally used complementary foods in

Tanzania are poor in iron, zinc and calcium because they are mainly plant-based with little or no addition of animal products. The findings from this study have also shown lower than recommended amount of iron, zinc and calcium in the frequently used complementary foods in the study area.

Banana porridge with beef was the only sample that was able to provide more than the amount of iron needed from complementary foods assuming moderate bioavailability. With the exception of banana porridge with milk, banana porridge with pumpkin and rice porridge with milk; all the other samples were able to provide at least half of the recommended iron intake from complementary foods. Several studies have suggested addition of animal products, the use of commercial infant formulas (Steve and Babatunde, 2013) as well as micronutrient powders (WHO, 2011) to improve iron status of infants and young children in developing countries. In order to increase iron content and reduce anti-nutrients such as phytates, some studies suggested soaking and germination of cereals and legumes prior to processing (Mihafu *et al.,* 2017).

According to FAO/WHO (2001) complementary foods should provide 86-100% of zinc based on the age and breastfeeding status of the child. With the exception of banana porridge with beef, all the other samples of frequently used complementary foods in Rombo district had less than 3 mg/100g of zinc. These values are higher than the findings of Jani *et al.* (2009) in Pakistan and Kulwa *et al.* (2015) in Tanzania.

The recommended amount of calcium (196-353 mg/d) needed from complementary foods for children aged 6-23 months cannot be met by plant-based complementary foods in Rombo district. Only banana porridge with beef had the calcium value above the recommended range. Even the milk containing foods such as rice porridge and banana porridge with milk had lower calcium values relative to beef-containing foods. Another study conducted by Pereira *et al.,* (2009) have also reported lower than recommended amount of calcium in complementary foods.

The lowest iodine concentration was found in banana porridge with beef (10.18 µg/100 g dry weight) and the highest was found in composite flour porridge (200.93 µg/100g dry weight). With the exception of banana porridge with beef, iodine content of all other samples were above the recommended intake of 19, 30 and 51 µg/d from complementary foods for infants and young children aged 6-8, 9-11 and 12-23 months respectively (WHO, 1998). The reason for low iodine concentration in banana porridge with beef might be the use of poorly stored and expired salt.

Nutrient gap of the frequently used complementary foods: Lower than recommended energy content of frequently used complementary foods in Tanzania have been documented (Muhimbula and Issa-Zakaria, 2010). There were energy gaps in almost all the samples of complementary foods taken for laboratory analysis. Despite the larger amount of foods consumed by children aged 12-23 months compared to their younger counterparts, it was still difficult to bridge the energy gaps. Several studies have identified "problem nutrients" during the complementary feeding period (Dewey and Vitta, 2013). Calcium, iron and zinc are the main nutrients that are always difficult to meet with plant-based complementary foods (Darmon, *et al.,* 2002; Kulwa, *et al.,* 2015). However, this study revealed that, apart from iron, zinc and calcium, vitamin C is also lacking in most complementary foods as it is known to enhance absorption of non-heme iron (Bowman and Russell, 2001).

5.3 Formulation of Complementary Foods by Linear Programming Method

5.3.1 Nutrient content of formulated complementary foods based on linear programming outputs

The present study shows that low cost, nutritious, age appropriate and culturally acceptable complementary food recipes which are consistent with the local preparation methods and feeding practices can be developed using linear programming method. Slightly improving nutrient content of the existing complementary foods without much interference to their normal cooking methods may likely enhance their acceptability and long-term sustainability (Ferguson *et al.*, 2006). This was best achieved by including locally available foods (frequently used and underused) that contain high levels of macro and micro nutrients as suggested by Ferguson *et al,* (2004), Kuyper *et al.* (2013) and Parlesak *et al.*(2016).

Animal products which offered highest overall amount of micronutrients such as meat were also the most expensive. Conversely, addition of nutritious seeds, fruits and vegetables may have helped to lower the cost while increasing the nutrients. This is similar to what have been done in other studies (Maillot *et al.*, 2007).

It was possible to achieve optimal complementary foods that meet energy needs in cereal-based complementary foods. However, reformulation of banana-based complementary foods was unable to meet recommended energy needs despite the addition of high energy seeds such as pumpkins, sunflower and sesame seeds. Addition of vitamin C sources such as tamarind, baobab flour or lemon juice have been able to meet the recommended amounts. In this study, the nutrients that were likely to remain low in most formulations were energy, vitamin A, iron, calcium and zinc similar to other studies (Santika *et al*., 2009; Suri *e. al.*, 2014; Stuart *et al.*, 2015)..

5.3.2 Nutrient content of the formulated complementary food recipes based on laboratory results

Several studies have successfully improved nutrient content of complementary foods (modifying the existing ones or formulating new recipes) by using linear programming methods (Darmon *et al.*, 2002; Dibari *et al.*, 2012; Ryan *et al.*, 2014). This research confirms that linear programming tools in combination with Tanzania food composition tables are reliable for formulating and predicting the nutrient content of complementary foods which are age specific, locally available, culturally acceptable and of low cost in Tanzania.

In the present study, laboratory analysis confirmed that the energy, protein, lipid and micronutrients values of the formulated were within the pre-established cut-offs because most of the values calculated by the linear programming tool differed by 10% from results produced by laboratory analyses as suggested by other researchers (Ryan *et al.*, 2014)**.** The values obtained for the proximate composition of the formulated complementary foods were higher than what was reported in other studies (Begum *et al.*, 2016).

The ratio of moisture to dry matter was approximately 80:20 respectively in most of the formulations. Despite the higher moisture content, their nutrient contents were mostly able to meet the recommended amount needed from complementary foods (WHO, 1998). This can help to reduce the reported problem of too much dilution of complementary foods in Tanzania which tends to decrease the energy and macronutrient values (Muhimbula and Issa-Zacharia, 2010).

Carbohydrates are the main sources of energy to cells in the body especially the brain. In the present study, carbohydrate content of the formulated complementary foods were lower than what was reported by Amegovu *et al.* (2013). Lower carbohydrate content in most of the formulations may be caused by addition of soya beans to maize-based and pumpkins, meat, fish, milk and seeds to banana-based formulations that may have lowered the carbohydrate values and increased protein content (Martin *et al.*, 2010).

For most of the formulations, protein contents were within the recommended amount needed from complementary foods (WHO, 2004). The values are in agreement with the earlier studies (Begum *et al.*, 2016; Barber *et al.*, 2017; Fasuan *et al.*, 2017). The protein is needed for tissue replacement, deposition of lean body mass and growth (Akinola *et al.*, 2014). The observed increase in the level of protein was attributed to the addition of meat, fish, soya beans as well as sesame flours which is in agreement with other studies (Fasuan *et al*., 2017).

Addition of oil seeds such as sunflower and sesame seeds attributed to the increase in fat content of the optimized complementary foods. This is important because adequate oil content in complementary foods is important for transporting fat soluble vitamins and may contribute to increased energy density (Allen *et al.*, 2006).

The formulated complementary foods were found to contain energy in the range of 376.31 to 486.42 kcal. These values are within the linear programming predicted values. The increment in energy contents of the formulated recipes could be attributed by the addition of soya beans and eggs which are known high amount of protein and oily seeds which may add calories fat content of the foods. Similar finding was observed by Desalegn *et al.* (2015).

5.4 Sensory Evaluation

Sensory analysis is an important tool in food science and is becoming accepted as a necessary part of food quality experiments. It is easy in its principle but its implementation in the field is often complicated because of low literacy among untrained panellists (Muhimbula *et al.,* 2010). Likert scale which (a psychometric response scale) is primarily used to obtain consumer's preferences or degree of agreement of a product during sensory analysis process (Bertram, 2010). Based on the level of understanding among the two panellist groups, this study used both nine-point and five-point likert scales.

The findings from this study showed that, different attributes of most of the formulations were equally accepted by both panellist groups (semi-trained and untrained). Muhimbula *et al.* (2010) also found no difference between semi-trained and untrained panellists. The overall acceptability of milk contained formulations (banana and rice porridges with milk) was relatively lower than the rest of the formulations. For semi-trained panellists, the score for banana porridge with milk ranged from 'neither like nor dislike like slightly' and 'like moderately to like extremely' for untrained panellists. This is due to the fact that, banana porridge with milk (mixture of cooked bananas, milk and cooking oil only) is one of the traditional foods that defines Chagga people and not widely consumed by people from other tribes and therefore it was totally new to most of the semi-trained panellists and they suggested that salt should be added to improve flavour. During the formulation of this recipe, ingredients to improve flavour such as lemon, carrots and roasted sunflower and sesame seeds' flour were added but still the taste was not improved to the extent of being liked very much. For rice porridge with milk, most of the panellists in both groups suggested the use of fresh milk instead of sour milk with addition of salt to improve taste and general acceptability of this formulation.

The roasted seeds (pumpkins, sunflower, sesame, amaranth and soybeans) had an important impact in flavour improvement for most of the formulations (Singh-Ackbarali and Maharaj, 2014). Addition of lemon, baobab flour or roasted seeds' flour to maize based formulations (F3 and F5) contributed not only to the improved flavour, appearance, aroma, texture, colour and general acceptability of the foods but also to increased energy and nutrient density of the foods (Stodolak *et al*., 2009). Also the introduction of roasted bean flavour (soya beans) to maize based formulations (F3 and F5) did not affect the flavour of the products instead the consumers liked it even more. This supports what has been reported by Maseta *et al.* (2016).

General acceptability of all banana-based formulations (with the exception of banana porridge with milk) in all attributes was high. This is because banana based porridge (Known as *mtori* in Swahili) is widely consumed in Tanzania and therefore it wasn't new even to semi-trained panellists. The addition of salt increased general acceptability of salted formulations as compared to non-salted ones (Milk versus non-milk based formulations) which is the same as the findings of Mugula and Lyimo (2000). Therefore this study has shown that addition of potentially more nutrient dense ingredients of low cost to the frequently used complementary foods doesn't affect the sensory quality of those foods.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the study, it was observed that exclusive breastfeeding practices for the first six months as recommended by World Health Organization was done by less than 50% of the mothers. In terms of complementary feeding practises, most of the mothers introduced complementary foods to their infants between four and six months which is not recommended by WHO. Maize porridge has been reported as a frequently used complementary food in the study area and most infants are fed three times a day.

Also, most of the frequently used complementary foods were found to be contain lower than recommended amount of energy, protein, vitamin C, iron, zinc, calcium and iodine. The formulated food recipes were potentially suitable to fill or narrow the nutrient gaps between the actual intake and the recommended amount to be provided by complementary foods. Linear programming was found to be a useful method to formulate the recipes using low cost, locally available and culturally acceptable ingredients.

Sensory evaluation done on all the recipes revealed that addition of vitamin C rich ingredients such as lemon and baobab flour to the recipes significantly improved their organoleptic quality and contributed to their high acceptance. Since these recipes were cheaper than the frequently used ones, locally available and yet more nutritious, this may be a potentially effective method in solving some of the nutrition related-problems facing infants and young children in Rombo district other areas of Tanzania which consume the same foods.

6.2 Recommendations

i. This study provides a benchmark for educating mothers on the benefits of early breastfeeding initiation, breastfeeding exclusively for six months and on demand for two years and beyond and they should be assured that breast milk satisfies all the nutritional needs of an infant for the first six months of life as recommended. Also, the mothers/caregivers should be educated on the importance of including nutrient-dense ingredients and proper preparation methods for complementary foods as well as adequate portion sizes based on child's age. There is also a need to educate mothers/caregivers on the importance of feeding their children less diluted complementary foods.

ii. Since being single was reported as a determinant for exclusive breastfeeding, this study call for more attention and provision of education, social and financial support to single mothers so that they can practice exclusive breastfeeding which is cheaper than bottle feeding.

iii. It is also a call for public health nutritionists and food technologists in Tanzania to use linear programming methods to design dietary guidelines that are more cost-effective in preventing energy and micronutrient deficiencies and this will help to capture even the poorest segment of the population.

iv. If the developed recipes in this research are adopted, they may save a lot of foreign exchange used on supplements and contribute in the efforts to combat malnutrition in Tanzania because the ingredients and the recipes are of low cost, locally available and the preparation methods are not new to the consumers.

v. This study also suggests that education on the nutritional benefits and preparation methods (demonstration) for the formulated complementary food recipes may help improve adoption and sustainability of the recipes.

vi. Also this study was conducted in October and November, which was the time for land preparation and planting. This may have affected what was available in the market and therefore another study is recommended in the harvest season to see if there is a variation in the range of foods available in the market and if the cost of the complementary foods can be minimized even further.

vii. It was not possible to meet the recommended dietary allowance for zinc by using plant based formulations and therefore inclusion zinc-rich animal sources such as liver is recommended.

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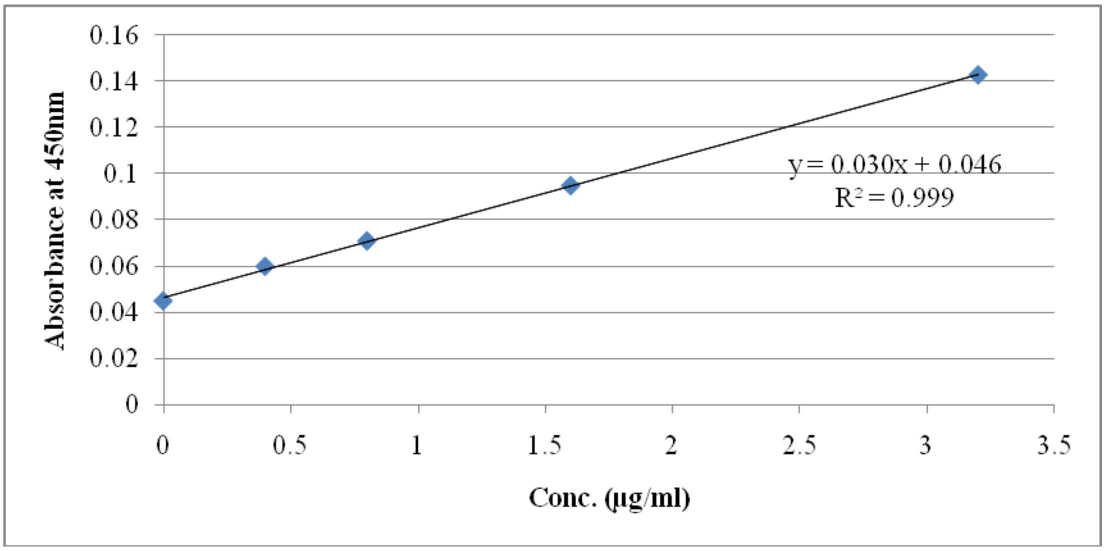
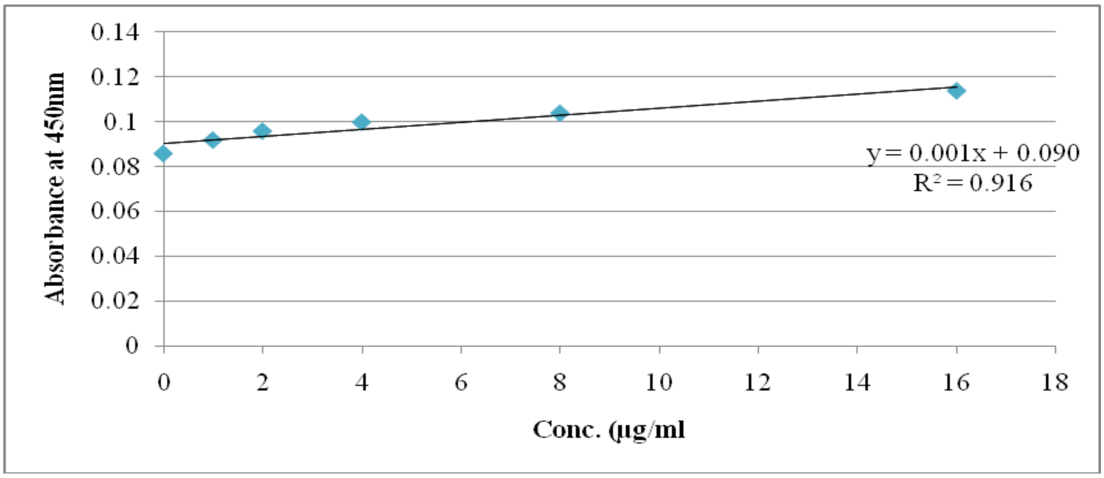
APPENDICES

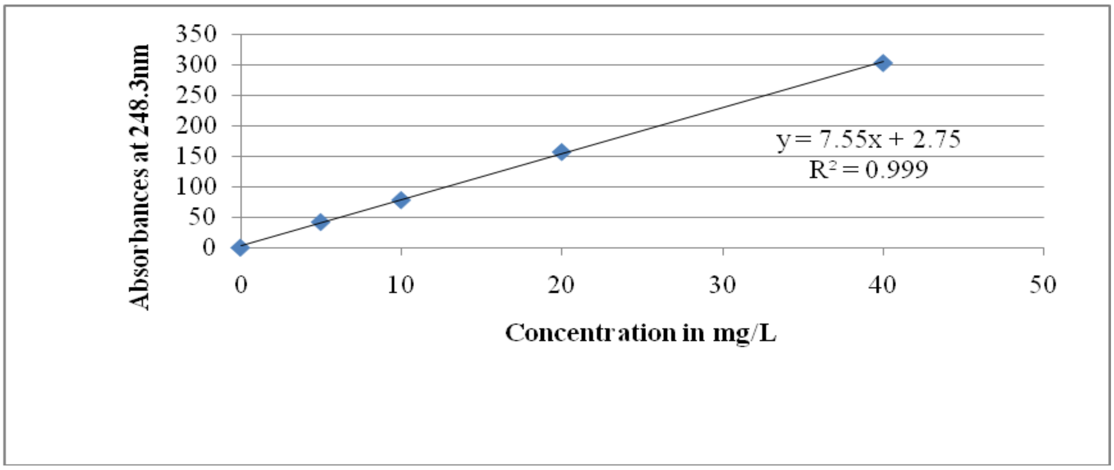
Appendix 1: β-Carotene standard plot



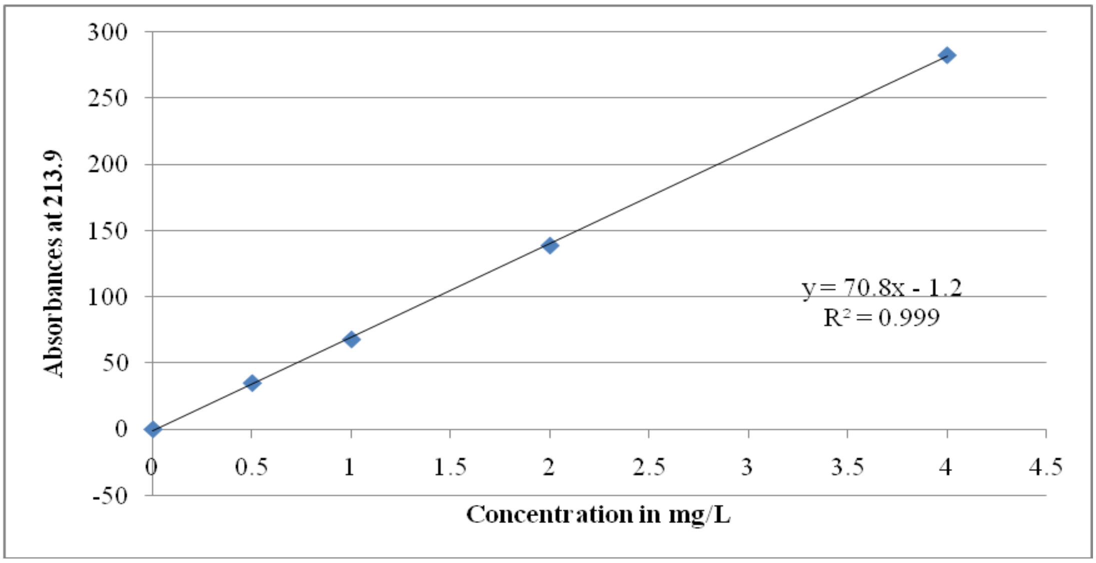
Appendix 2: Iodine standard plot



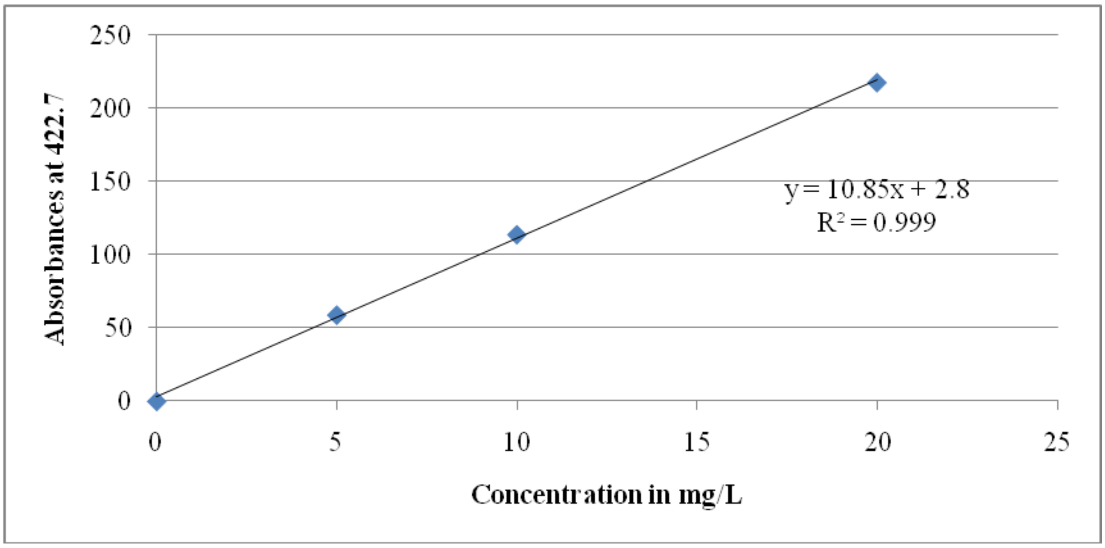
Appendix 3: Iron standard plot at 248.3



Appendix 4: Zinc standard plot at 213.9



Appendix 5: Calcium standard plot at 422.7



Appendix 6: Questionnaire

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Questionnaire

Note to Enumerator: Explanation to interviewer

INTRODUCTION AND CONSENT

My name is………….. from Sokoine University of Agriculture. We are working on a research on how to improve nutrient contents of complementary foods for children aged 6-23 months at Rombo district. You have been selected to participate in this study. I would like to ask you some questions about child care and feeding practices as well the types of foods you give your child and their preparation methods. The interview will take about 30 minutes. All the information we obtain will remain strictly confidential and your answers and name will never be revealed. Also, you are not obliged to answer any question you do not want to, and you may stop the interview at any time. The information will be used by the district authorities, other government officials and researchers to initiate efforts to improve nutritional status of children aged 6-23 months old in this district.

Identification (To be filled by the enumerator)

Questionnaire number	…………………………………………………	
Enumerator’s name and code	…………………………………………………	
Date of visit		Dd/ month/year …../……../……..
Questionnaire results	01 = Complete(all sections of the form have been filled out) 02 = Incomplete	☐

A. Information about the child (tick/fill where appropriate)

Child's name	……………………………………………………………	
Child's sex	01 = Male 02 = Female	☐
Child's age (See RTH card to confirm)	day/month/year	_ _ / _ _ /_ _ _ _
	Age in completed months	………………..

A. Social and demographic characteristics of the mother or caregiver (tick/fill where appropriate)

Interviewer's name	…………………………………………………………..	
Contacts/Mobile number	…………………………………………………………..	
Which village are you from?	01 = Kikelelwa 02 = Kibaoni 03 = Urauri	☐
Are you the primary caregiver of the child?	01 = Yes 02 = No	☐
What is your relationship with the child?	01 = Mother 02 = Grandmother 03 = Other (specify)	☐
How old are you?	day/month/year (if possible)	__ / __ /____
	Age in completed years	
Can you read and write?	01 = Yes 02 = No	☐
What is your level of education?	01 = Never been to school 02 = Primary school 03 = Secondary school 04 = Higher education(college/university)	☐
	Highest grade/form/year you completed at that level?	
What do you for a living (Occupation)?	01 = Housewife 02 = Farmer(cultivation/animal keeping) 03 = Employed in formal sector 04 = Employed in an informal sector 05 = Self employed 06 = Others (specify)	☐
If you are a farmer, what crops do you grow?	01 = Maize 02= Beans 03 = Potatoes 04 = Green Vegetables 05 = Fruits 06= All of the above	☐

	07 = Other crops (Mention)	
If you are a livestock keeper, what animals do you keep?	01= Cattle 02 =Goat(s) 03 = Sheep 04 = Chicken 05 = All of the above 06 = Other animals (Mention)	☐
Marital status	01 = Currently married (monogamous) 02 = Currently married (polygamous) 03 = Widowed 04 = Divorced 05 = Single 06 = Others (specify)	☐
Religion	01 = Muslim 02 = Christian 03 = Traditional religion 04 = Others (Mention)	☐
Number of household members	Including the children	☐
Number of children per household	Under five aged children	☐
When you are out of the house, who takes care of the child?	01 = Husband 02 = Child's siblings 03 = Grandparents 04 = Others (specify)	☐

B. ANC, Breastfeeding and complementary feeding knowledge and practices (tick/fill where appropriate)

ANC and exclusive breastfeeding knowledge and practices		
During the pregnancy with this child, did you visit any health care center for a prenatal visit?	01= Yes 02= No 03 = Don't know	☐
Where was this child born?	01 = In the hospital 02 = At home 03 = others (Specify)	☐
Was this child ever breastfed?	01= Yes 02= No 03 = Don't know	☐
If yes, how many hours after birth was this child breastfed for the first time?	01 = Within 1 hour after birth 02 = From 1 to 3 hours after birth 02 = More than 3 hours after birth 04 = Does not know	☐
Did you feed colostrum (the	01 = Yes	

first yellowish breast milk) to your child?	02 = No	
If no, why?	01 = Discarded 02 = Was not safe for baby 03 = Cultural restriction 04 = Child was sick 05 = Other (specify)	☐
During the first 3 days after birth, was the child given anything other than breast milk?	01= Yes 02= No 03 = Don't know	☐
If yes, was she/he given?	01 = Tea 02 = Water (including sugar water) 03 = Infant formula 04 = Grilled banana 05 = Other non-breastmilk milks 05 = Others (specify)	☐
When do people in this community give water to their children for the first time?	01 = Soon after birth 02 = Within the first 6 months 03 = At 6 months 04 = After 6 months 05 = Other (Specify) 06 = Don't know	☐
When did you give water to your child for the first time?	01 = Soon after birth 02 = Within the first 6 months 03 = At 6 months 04 = After 6 months 05 = Other (Specify) 06 = Don't know	☐
What foods did you give to the child within the first six months?	01 = Breastmilk only 02 = Breastmilk and infant formula 03 = Breastmilk and porridge 04 =Porridge only 05 = Cow's milk and breastmilk 06 = Cow's milk only 07 = Others (Specify)	☐
Do you think it is good to give only breastmilk for the first six months?	01= Yes 02= No	☐
If yes, why?	01 = That is what is recommended 02 = It contains all the nutrients needed 03 = Other reasons (Specify) 03 = I don't know	☐
If no, why?	01 = Not allowed traditionally 02 = The baby will not be satisfied	☐

	03 = Other reasons (Specify) 04 = I don't know	
Is this child still breastfeeding?	01= Yes 02= No	☐
If no, why?	01 = The baby was sick 02 = Pregnancy 03 = The mother was sick 04 = The baby refused to breastfeed 05 = Mother travelled 06 = Mother died 07 = Other reasons (Specify)	☐
If no, at what age did you stop to breastfeed the child?	01 = Soon after birth 02 = Within the first 6 months 03 = At 6 months 04 = After 6 months 05 = Other (Specify)	☐
How many times do you normally breastfeed the child per day?	01= Once 02= Twice 03 = More than 3 times	☐
For how long do you breastfeed the child on one breast before shift to another breast?	01=Until the child is satisfied 02=Until there is no more milk from the breast 03 =Any other answer	☐
Breasfeeding practices for the previous 24 hours		
Was this child breastfed since yesterday?	01= Yes 02= No 03 = Don't know	☐
If yes, how many times?	01= Once 02= Twice 03 = More than 3 times	☐
Since yesterday, was the breastfed whenever he/she wanted or on a fixed schedule?	01 = Whenever the child wanted 02 = On a fixed schedule 03 = Does not know	☐
If breastfed on a fixed schedule, why?	01 = The baby is sick 02 = The mother was away from the 03 = The mother is sick/using medi 04 = Other reasons (Specify)	☐
Complementary feeding knowledge and practices		
Does the child consume any food other than breast milk?	01 = Yes 02 = No	☐
When do people in this community start giving other foods to their children in addition to breastmilk?	01 = At less than 3 months of age 02 = Between 4 and 6 months 03 = 6 months and above 04 = Does not know	☐

At what age was the child fed his/her first solid/semi-solid food?	01 = At less than 3 months of age 02 = Between 4 and 6 months 03 = 6 months and above 04 = I don't remember	☐
What was the first food you gave your child	01 = Maize porridge 02 = Grilled banana 03 = Juice 04 = Banana porridge "*Mtori*" 05 = Other foods (Specify)	☐
How often do you feed your child in a day in addition to breastmilk?	01 = Two times a day 02 = Three times a day 03 = Four times a day 04 = Five times a day 05 = Others (Specify)	☐
How often should you feed a child at age …...? [Mention age ranges below] • At 6 months • 6-9 months • 9-12 months • 12-24 months	At 6 months 01 = 2 times 02 = More than 2 times	☐
	6-9 months 01 = 3 times 02 = More than 3 times	☐
	9-12 months 01 = 4 times 02 = More than four times	☐
	12-23 months 01 = 4 times 02 = More than four times	☐
Is it important to give foods in addition to breast milk to your baby?	01 = Yes 02 = No	☐
If yes, why do you think it is important?	01 = Breastmilk is not enough 02 = because others are giving their children other foods 03 = Any other reason	☐
To feed their children, many mothers give them maize porridge or cassava porridge. Please tell me which foods or types of food can be added to the porridge to make it more nutritious. (Probe)	01 = Animal-source foods (meat, poultry, fish, liver/organ meat, eggs, etc.) 02 = Pulses and nuts: flours of groundnut and other legumes (peas, beans, lentils, etc.), sunflower seed, peanuts, soybeans 03 = Vitamin-A-rich fruits and vegetables (carrot, orange-fleshed sweet potato, yellow pumpkin,	☐

	mango, papaya, etc.) 01 = Green leafy vegetables (e.g. spinach) 02 = Energy-rich foods (e.g. oil, butter/ghee) 03 Don't know	
Which local foods would you describe as? ***[Mention the food groups below. Probe for more responses.]*** • Body-building foods • Energy-giving foods • Protective foods • Blood-giving foods ***Circle "1" for mentioned and "2" for not mentioned.***	Mentioned=1, Not Mentioned=2	
	Body-building foods__________________ Meat (beef, pork, lamb, goat, chicken) Fresh or dried fish, shellfish Eggs Groundnuts, cashew nuts, beans, peas Milk and milk products	☐
	Energy-giving foods__________________ Bread, rice, maize, wheat, millet, sorghum Yam, cassava, cocoyam, potato Plantain Coconut oil, groundnut oil Margarine, butter,	☐
	Protective foods______________________ Ripe mangoes, oranges, apples Pineapples, bananas, avocado, pears, watermelons Tomatoes,	☐
	Blood-giving foods___________________ Fish, liver, meat Egg, green vegetables	☐

C. Types of frequently used complementary foods and their preparation methods

What kind of food you frequently (almost every day) give your child? (list them in order of importance)	(a)……………………………………………………..…. (b)…………………………………...……………… (c)...

	(d)...			
Where do you get the raw materials that you use to prepare food for your child?	01 = Market/shops 02 = Produce yourself (cultivate/animal keeping) 03 = Both (1 and 2)			☐
What ingredients do you use in preparing your child's food? **Let responder freely mention the foods, then prompt for items in the list that are not mentioned.** **For each food item and for each age interval, write:** **"1" for daily;** **"2" for 1-2 times per week and** **"3" for 3 times or more per week.**	**Type of foods**	**6-9 months How often**	**9-12 months How of**	**12-24 months How often**
	a. Dark green, leafy vegetables			
	b. Yellow- or orange-colored vegetables (e.g., carrots)			
	c. Yellow- or orange-colored fruits (e.g., mango)			
	d. Other vegetables			
	e. Orange-fleshed potatoes			
	f. Meat (beef, chicken)			
	g. Eggs			
	h. Fish			
	i. Liver			
	j. oil			
	k. other food items			
How the child's porridge consistency should be?	01= Thick 02= Thin and watery porridges 03= Does not know			☐
How do you prepare your child's food?	01 = Prepared specially for child 02 = Same as what the rest of the family is eating 03 = Same as what the rest of the family is eating, but modified to suit child's age 04 = Other(specify)			☐

A 24 Hour dietary recall (to be answered by a mother/caregiver responsible for feeding the child)

Note to Enumerator: Explanation to interviewee: Please describe everything that your child ate and drank yesterday during the day or night, whether at home or outside the home. Record the amount on the 24-hour recall sheet using household equipment. Be sure to probe until the respondent says nothing else. If the respondent mentions mixed dishes like porridge, sauce or stew, probe what ingredients were in that mixed dish.				
Was the reference day :1= normal day(usual intake) 2= special day (festival, funeral)				
Please list all the foods you gave to your child in the last 24 hours (from yesterday morning to this morning) **READ OUT THE LIST. Circle "1" for yes and "2" for no**		**Yes = 1 No = 2**	Amount served (household measure) and weight in grams	Amount consumed (household measure) and weight in grams
	B. Water			
	C. Infant formula			
	D. Fortified, commercially available infant and young child food			
	E. Porridge			
	F. Tinned, powdered, or fresh animal milk			
	G .Fruit juice			
	H. Other liquids (sugar water, coffee, tea, soft drinks)			
	I. Bread, rice, noodles, or other foods made from			

	grains			
	J Potatoes, yams, cassava, cocoyam, or any other foods made from roots 1 2	☐		
	K. Carrots or sweet potatoes that are yellow or orange inside	☐		
	L. Any dark green, leafy vegetable	☐		
	M. Ripe mango, pawpaw (include other vit-A rich foods available)	☐		
	N. Any other fruits or vegetables	☐		
	O. Liver, kidney, heart, or other organ meats	☐		
	P. Any meat such as beef, pork, lamb, goat, chicken, or duck	☐		
	Q. Eggs	☐		
	R. Fresh or dried fish or shellfish	☐		
	S. Any foods made from beans, peas, lentils, or nuts	☐		
	T. Cheese or yogurt	☐		
	U. Any oils, fats, or butter, or foods made with any of these	☐		
	V. Any sugary foods such as chocolates, sweets, candies, pastries, biscuits, cakes 1 2	☐		
	W. Any other solid or semi-solid food 1 2	☐		

Preparation method of the frequently used complementary foods

Can you please elaborate to me on how you prepare one of the foods that that you giv child almost every day?		
Name of the food		
Ingredients	Preparation Of Ingredients	Amount Estimated
Example: Bananas	*Peeling*	*2 raw bananas*

THANK YOU FOR YOUR TIME