NUTRIENT COMPOSITION OF COMPLEMENTARY FOODS FOR CHILDREN IN TEMEKE DISTRICT

BY

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ABSTRACT

The provision of nutrient-dense complementary foods is essential to ensure an infant's nutrient requirements are met. Yet often, relative to recommendations, traditional complementary foods have low levels of nutrients, suggesting a need, for improvement to ensure dietary adequacy. In this study, nutrient composition of locally available dishes used as complementary foods for children aged 6-24 months was determined so as to provide suitable recommendations that will ensure sustainable improvement of the overall nutritional adequacy of complementary foods and well being of children in Tanzania. Data were collected from 100 interviewed caregivers using structured questionnaires and through laboratory analysis of 100 different complementary foods. Standard AOAC methods were used to determine nutrient composition. The findings show that, maize porridge (71%), composite flour porridge (55%) and mashed potatoes/mashed bananas (41%) are the main complementary foods prepared for young children in the study area. The proximate composition data showed that maize porridge provided energy of 282.59±59.54 Kcal/100g, composite flour porridge provided 319.13±61.31 Kcal/100g and mashed potato provided 243.50±53.56 Kcal/100g dry matter. The micronutrient composition data showed that the phosphorous, copper, iron and zinc content in mg/100g dry matter were 183.09±74.52, 0.37±0.12, 5.14±2.24, and 0.51±0.22 g for composite flour porridge, and 164.00±106.25, 0.32±0.13, 4.15±1.68 and 0.42±0.17 for mashed potato/mashed banana; whereas 59.33±42.21, 0.28±0.19, 2.65±1.56 and 0.27±0.16 were contained in maize flour porridge. A comparison on what the foods could provide and what is the recommended daily dietary requirements show that the

amount of food consumed are inadequate to meet daily body needs. This is due to bulkness of the complementary foods. Furthermore, the nutrient composition data suggest that ensuring a nutritionally adequate complementary feeding diet based on traditional foods alone is difficult. It could therefore be inferred that mothers need a guidance to improve traditional foods through combinations with other foods available to them locally.

DECLARATION

I, Julius Ntwenya, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work and has not been submitted for a higher degree award in any other University.

23/10/2009

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DEDICATION

This work is dedicated to all the people who have dedicated their lives in advocating proper growth, development and good health of the young children.

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LIST OF ABBREVIATIONS

AOAC	-	Association of Official Analytical Chemists
ANHMRC	-	Australia National Health and Medical Research Council
DRI	-	Dietary Reference Intake
ER	-	Equivalent retinol
FAO	-	Food and Agriculture Organization
g	-	Grams
ICDS	-	Integrated child management services
NBS	-	National Bureau of Statistics
PAHO	-	Pan American Health Organization
PHDR	-	Poverty and Human Development Report
PRA	-	Participatory Rural Appraisal
TBS	-	Tanzania Bureau of Standards
TDHS	-	Tanzania Demographic and Health Survey
TRCHS	-	Tanzania Reproductive and Child Health Survey
UNICEF	-	United Nations International Children's Emergency Fund.
UNSCN	-	United Nations Subcommittee on Nutrition
URT	-	United Republic of Tanzania
WHO	-	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Adequate nutrition during infancy and early childhood is fundamental to the development of each child's full human potential (WHO, 2005). Despite global efforts for improving maternal and child health and specific efforts like maternal and child care clinics and integrated child management services (ICDS), malnutrition among children remains a significant problem worldwide (Kumar *et al.*, 2006). Nearly one-third of children in the developing world are either underweight or stunted (World Bank, 2006). Inappropriate feeding practices are a major cause of the onset of malnutrition in young children (WHO, 1998).

From six months onwards, when breast milk alone is no longer sufficient to meet all nutritional requirements, infants enter a particularly vulnerable period of complementary feeding during which they make a gradual transition to eating family foods (WHO, 2001). Complementary foods are often of lesser nutritional quality than breast milk; in addition, they are often given in insufficient amounts (WHO, 1998). During the period of complementary feeding, a child needs frequent feeding at least four times daily, depending on the number of times a child is breastfed and other factors and requires meals that are both dense in energy and nutrients and easy to digest. Because of the rapid rate of growth and development during the first two years of life, nutrient needs per unit body weight of infants and young children are very high (PAHO and WHO, 2001). The incidence of malnutrition rises sharply during this period in most countries, and the deficits acquired at this age are difficult to compensate for later in childhood. The effects of poor nutrition and stunting continue over the child's life contributing to poor school performance, reduced productivity, and other measures of impaired intellectual and social development (Whaley *et al.*, 2003).

The foods, a family normally eats will have to be adapted to the needs of small children, and time must be made available for preparing the meals and feeding children (UNICEF, 1998). In view of this, appropriate processing and blending of locally available food commodities have to be carried out and researched into by the scientific community since cereal grains will continue to be the major basic diets of infants and adults in developing countries. This approach would require knowledge about the nutritive values of local food commodities, indigenous to the affected communities (Solomon, 2005). This study therefore focused at assessing the nutrient content of locally available dishes used as complementary foods for the infants aged 6-24 months in Temeke District so as to provide suitable recommendations that will ensure sustainable improvement of the overall nutritional adequacy of complementary foods and well being of children in Tanzania.

1.2 Problem Statement

Malnutrition remains an urgent global public health concern (World Bank, 2007). TDHS (2005) reveals that there is a need to improve nutritional status for the under fives in Tanzania. Stunting, though on decline, continues to affect a sizeable proportion of children in the country. It declined from 47 percent in 1991/1992 to 44 percent in 1999 (URT, 1999) and 38 percent in 2004. During year 1991 and 1999 underweight in children increased from 29 percent to 30 percent, while wasting decreased from 7 percent in 1991 to 5 percent in 1999 and further declined to 3 percent in 2004 (TDHS, 2005). Other nutrition aspects indicate that up to two thirds of children are anaemic, the disparity between Mainland Tanzania and Zanzibar is alarming whereby about 42 percent and 63 percent are anaemic respectively (TDHS, 2005). On the other hand, the nutrition status is much better in urban compared to rural areas (World Bank, 2007).

In their first two years of life, infants and young children have particularly high energy and nutrient requirements (Kumar *et al.*, 2006). Thus, they require special foods of adequate nutrient and energy density, consistency, and texture, and they need to be fed more often than adults (Ruel *et al.*, 2004). Kikafunda *et al.* (1997) found that in most developing countries, the high cost of fortified nutritious proprietary complementary foods is always, if not prohibitive, beyond the reach of most families. Numerous studies demonstrate that inappropriate complementary feeding practices including premature or late introduction of foods other than breast milk, inadequate amounts of nutritionally adequate and safe foods, and early cessation of breastfeeding are a major contributing factor to malnutrition, morbidity and mortality of infants and young children in developing countries (WHO, 1999). Inappropriate feeding practices and their consequences are major obstacles to sustainable socioeconomic development and poverty reduction. Governments will be unsuccessful in their efforts to accelerate economic development in any significant long-term sense until optimal child growth and development, especially through appropriate feeding practices, are ensured (WHO, 2003).

The findings of this study will provide knowledge about the nutrient content of locally available dishes used to feed children in Temeke District. The information is essential for advicing on appropriate processing and blending of locally available food commodities in order to improve nutrient density of complementary foods found within the local communities and improved nutrient intake, which results in prevention of malnutrition problems. Moreover the findings of this study will influence national policies and priorities in repositioning nutrition in national development plans.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to assess the nutrient composition of complementary foods commonly used for children aged 6-24 months in Temeke District.

1.3.2 Specific objectives

The specific objectives of the study were:

i. To identify common complementary dishes for children aged 6-24 months and their methods of preparation

ii. To determine nutrient content of the identified complementary foods

iii. To provide recommendations on improvement of nutrient content of complementary foods in Temeke District.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

In this chapter, a review of what is known about complementary foods is discussed as to orient and locate the research by defining its breadth and limitation. The chapter begins by an overview of infant and young child feeding, complementary feeding, importance of complementary feeding for child health, complementary foods and nutrient composition of various foods. Details are also given on the combinations of foods, complementary foods preparation, storage and handling, cooking fuel and cooking practices, traditional food processing, energy and nutrient required from complementary foods and the use of energy and nutrient dense complementary foods. The last section presents a summary of the reviewed literature.

2 .2 Infant and Young Child Feeding

2.2.1 Overview

World Health Organization (WHO) has emphasized that there should be an effort to ensure positive perceptions of and attitudes towards breastfeeding within the general population (WHO, 2002). Breastfeeding should be continued from six to twenty four months and beyond. Babies should receive nutritionally appropriate, safe and adequate complementary foods from six months. Children need to be fed four to six times daily, increasing the number of child's feeds per day with meals that are both dense in energy, nutrients and easy to digest are important aspects for child basal metabolism, physical activity and growth (WHO, 1998). However, the complementary foods are very often watery-thin gruels, soups or broths and efforts are under way to better understand the extent of the problem. Exclusive breastfeeding has the potential to avert 13 per cent of all under-five deaths in developing countries, making it the most effective preventive practice to save children's lives (WHO, 2002). Nearly 40 per cent of all infants aged 0 to 6 months in the developing world are exclusively breastfed; the proportion has been increasing, particularly in sub-Saharan Africa, where it rose by more than one third over the 1996–2006 periods (Moon, 2007). There is ample evidence of a positive influence of breastfeeding, especially exclusive breastfeeding on the survival of the infants. There is some evidence that motor development is enhanced by practicing exclusive breastfeeding for the first six months of life, but more research is needed to confirm this (Dewey *et al.*, 2001).

2.2.2 Complementary feeding

Complementary feeding is defined as the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk (Dewey, 2001). Appropriate complementary feeding promotes growth and prevents stunting among children 6–24 months (WHO, 2000). Rates of malnutrition usually peak at this time with consequences that persist throughout life. More research work and promotion are proposed in order to identify and improve the acceptability of complementary foods (Bowman and Russell, 2001).

2.2.3 Importance of complementary feeding for child health

It is well recognized that the period of complementary feeding is one of the most critical times for preventing malnutrition (World Bank, 2005). Growth faltering is most evident during this time period particularly during first phase of complementary feeding (6-12 months) when foods of low nutrient density begin to replace breast milk and rates of diarrheal illness caused by food contamination are at their highest (Shrimpton *et al.*, 2001). After about two years of age, it is very difficult to reverse stunting that occurred at earlier ages suggesting a critical window for prevention of growth faltering. Numerous studies also show that, the response to improved feeding is greatest during 6-24 months and point to the period of breast-feeding and complementary feeding as a critical window of opportunity to improve postnatal growth (Lutter *et al.*, 1990).

Micronutrient deficiencies are also highly prevalent among infants and young children because of their high nutrient needs relative to energy intake and effects of frequent infections (Gibson and Ferguson, 1998). In Africa, about 24 percent of children are underweight and 35 percent are stunted whereby between 35 million and 50 million children under age five are affected (World Bank, 2006). Dietary inadequacies of Vitamin A, iron, zinc and iodine are the most widespread nutritional deficiencies globally and they affect women and young children disproportionately (World Bank, 2007). Between 78 and 254 million people, including an estimated 127 million children are vitamin A deficient (UNSCN, 2004 and West, 2002). The estimated prevalence of iron deficiency among children under five years of age in 80 developing countries in 2004 was 54 percent, as compared to an estimated 34 percent who are vitamin A deficient (World Bank, 2007). Again, the range in prevalence between countries is wide. An estimated 20 to 35 percent of children below five years of age are anemic in Latin America and Southeast Asia, compared to an estimated 75 to 85 percent in many African countries (Adamson, 2004). In young children iron deficiency may impair growth, cognitive development and immune function and in school-aged children, it can affect school performance, and in adults it may lower work capacity (UNSCN, 2004).

2.3 Complementary Foods

In many developing countries, complementary foods as well as foods for adults are based on local staple diets made from cereals, roots and tubers of cassava and potatoes. A list of various foods which are commonly consumed and their composition per 100 g of raw edible portion is shown in Table 1. These foods are usually prepared as thick porridges for adults or as liquid gruels for infants. To be suitable for feeding of young children, these cereals are prepared in liquid form by dilution with a large quantity of water, thereby resulting in more volume but with a low energy and nutrient density (Sanni *et al*., 1999). Svanberg (1988) found that this dilution could bring flour concentration as far as 5 percent which could give only 0.2 Kcal per gram of the gruel. Kwaku *et al*. (1998) found that complementary foods in developing countries can have energy densities as low as 25–30 Kcal/100 g. Too large volume per meal or too large number would be needed to satisfy child's energy requirements. In this way the improvement of the complementary foods is of paramount importance.

Table 1: Nutrient composition of foods

Energy and nutrient	Name of the food										
	Carrot	Spinach	Banana	Onion	Irish potato	Rice	Maize	Soybean	Tomato	Sweeetpotato	Wheat
Energy (Kcal)	43	22	92	38	79	360	86	416	21	105	331
Protein (g)	1.03	2.86	1.03	1.16	2.07	6.61	3.22	36.5	0.85	1.65	10.4
Carbohydrate (g)	7.14	0.8	21	6.83	16.4	79.3	16.3	20.9	3.54	21.3	12.5
Fibre (g)	3	2.7	2.4	1.8	1.6	_	2.7	9.3	1.1	3	_
Vitamin A (µg ER)	2 813	672	8	_	_	_	28	2	62	2 006	0.39
Vitamin B1(mg)	0.09	0.08	0.05	0.04	0.09	0.07	0.2	0.87	0.06	0.07	0.09
Vitamin B2 (mg)	0.06	0.19	0.1	0.02	0.04	0.05	0.06	0.87	0.05	0.15	4.8
Niacin (mg)	1.11	1.37	0.74	0.43	2.02	2.88	2.08	10.5	0.73	1.1	0.27
Vitamin B6 (mg)	0.15	0.19	0.58	0.12	0.26	0.15	0.06	0.38	0.08	0.26	41
Folate (µg)	14	194	19.1	19	12.8	9	45.8	375	15	13.8	_
Vitamin C (mg)	9.3	28.1	9.1	6.4	19.7	_	6.8	6	19.1	22.7	_
Vitamin E (mg)	0.46	1.89	0.27	0.13	0.06	_	0.09	1.95	0.38	0.28	1.44
Calcium (mg)	27	99	6	20	7.00	9	2	277	5	22	27
Phosphorous (mg)	44	49	20	33	46.0	108	89	704	24	28	493
Magnesium (mg)	15	79	29	10	21	35	37	280	11	10	126
Iron (mg)	0.5	2.71	0.31	0.22	0.76	0.8	0.52	15.7	0.45	0.59	3.21
Potassium (mg)	323	558	396	157	543	86	270	1 797	222	204	397
Zinc (mg)	0.2	0.53	0.16	0.19	0.39	1.16	0.45	4.89	0.09	0.28	2.63
Total fat (g)	0.19	0.35	0.48	0.16	0.1	0.58	1.18	19.9	0.33	0.3	1.56
Saturated fat (g)	0.03	0.06	0.19	0.03	0.026	0.16	0.18	2.88	0.05	0.06	0.29
Sodium (mg)	35	79	1	3	6	1	15	2	9	13	2

Source:Pamplona-Roger (2007).

2.3.1 Combinations of foods

Combinations of different foods increase palatability and are nutritionally beneficial to children (WHO, 1998). Martinez *et al.* (1998) found that the incorporation of bone increases the calcium and phosphorous contents in fish-based complementary foods. Obatolu *et al.* (2000) showed that incorporating malted maize into complementary food mixtures improved the nutritional quality of the blends thus serving as a good quality complementary food for children in terms of protein and energy adequacy.

Abebe *et al.* (2006) showed that the addition of kidney beans enhanced the protein content of corn and kocho based complementary foods from 8.8 g/100 g and 1.5 g/100 g (dry weight) to 14.1 g/100 g and 13.8 g/100 g, respectively. The pumpkin in corn:kidney bean:pumpkin and kocho:kidney bean:pumpkin provided 54 μg ER per 100 kcal, increasing the Vitamin A value of the mixes by 25 and 180 fold, respectively. Other crops such as kale, yellow sweet potatoes, avocado and papaya grown in those areas were also recommended as alternative carotenoid sources. A similar study on assessment of locally available complementary dishes in Nigeria based on cereals and legumes revealed that the crude protein, lipid, fibre, ash, moisture, energy and carbohydrate contents were either comparable or higher than values in the proprietary formula (Solomon, 2005). Faber (2004) reported that the nutrient density of complementary foods consumed by 6-12 months old rural infants in South Africa was less than half the desired density for calcium, iron and zinc, however energy intake and protein density were adequate.

In the evaluation of the nutritional quality and acceptability of sorghum-based tempe as potential complementary food in Tanzania, Mugula and Lyimo (2000) observed that the developed tempe had protein quality and energy recommended for complementary foods thus giving more opportunities for utilizing sorghum cereal as the locally available resource in developing both nutrient and energy dense complementary foods. Traditional cereal porridges made from maize, millet and sorghum flours form an important part of complementary diets of young children in many parts of Africa (Steve and Sola, 2006). The energy density of the porridges significantly increases by increasing concentration and addition of milk and/or groundnut (Kikafunda *et al.*, 1997). Mosha *et al.* (2000) reported that many of the home made and commercial complementary foods consumed in Tanzania were low in fat, iron, calcium, zinc and phosphorous but high in crude fibre, carbohydrate and magnesium. However calcium, iron and zinc in the home made complementary foods were the most deficient nutrients (Table 2).

Table 2: Proximate composition (g/100g) and energy content (kcal/100g) of the various homemade and commercial complementary foods

Food	Energy	Protein	Fat	Ash	Fibre	Carbohydrate
Maize gruel	457.09±1.21^{c}	13.34±0.49^{f}	13.13±0.02^{d}	2.14±0.02^{d}	7.67±0.3^{c}	71.39±0.70b
Cassava gruel	389.30±0.93^{e}	6.00±0.02^{g}	2.22±0.06^{g}	5.44±0.06^{b}	16.00±0.60^{a}	86.33±0.90a
Millet	419.40±1.6^{d}	32.84±0.90^{c}	5.20±0.60^{f}	1.64±0.01^{d}	3.39±0.10^{e}	60.31±1.00c
Plantain	382.34±1.99^{e}	57.50±0.98^{a}	8.74±0.90e	8.37±0.10^{a}	12.24±0.98^{b}	18.42±0.92f
Millet-composite[3]	564.26±1.01^{b}	45.80±0.48^{b}	33.54±0.59^{b}	0.83±0.00^{e}	3.34±0.70^{e}	19.80±0.48f
Sorghum	408.61±1.62^{d}	14.60±0.85^{e}	3.32±0.06^{g}	2.00±0.00^{d}	4.20±0.90^{d}	80.08±0.76^{a}
Cerelac-1[4]	419.24±0.92^{d}	15.90±0.40^{e}	8.72±0.36^{e}	2.36±0.06^{d}	1.54±0.06^{fg}	69.29±0.68^{b}
Cerelac-2[5]	426.96±1.30^{d}	15.90±0.86^{e}	8.92±0.52^{e}	2.97±0.08^{d}	1.03±0.00^{g}	70.77±0.56^{b}
Lactogen-1[6]	509.91±0.70^{b}	16.60±0.66^{e}	24.95±0.46^{c}	3.71±0.10^{c}	1.00±0.00^{g}	54.74±0.97^{d}
Lactogen-2[7]	478.16±0.80^{c}	12.27±0.72^{d}	19.59±0.33^{c}	4.95±0.07^{b}	1.30±0.00^{g}	53.19±0.89^{d}

Source: Mosha *et al.* (2000).

1 Means ± standard errors, all values based on dry weight basis
2 Means within a column with different superscripts are significantly different using Duncan's Multiple Range Test $p<0.05$
3 Millet-sardine-peanut (2:1:1) composite flour porridge
4 Wheat-milk blend, recommended for children above 9 months
5 Rice milk blend, recommended for infants 4-9 months old
6 Milk based, recommended for children under one year old
7 Milk based, recommended for children above 6 months old

2.3.2 Preparation, storage and handling

Combinations of various complementary foods may typically involve addition of microbiologically sensitive ingredients such as soybean powder and dry ground crayfish. The Ingredients can be processed at home or bought ready to use from market vendors. Purchasing ingredients from vendors in markets is an important critical control point if the ingredient is added to foods and served to children without heat treatment. During cooking, complementary foods need to attain temperatures capable of destroying vegetative forms of food-borne pathogens (Ehiri *et al.*, 2001). The hygienic quality of prepared food can be assured if basic food safety principles are observed.

Incidence data identify the home as an important location for acquiring food-borne diseses. The domestic kitchen can be used for a variety of purposes and is often contaminated with potentially harmful micro-organisms such as Campylobacter and Salmonella. Due to the reduced immune response of infants, the activities associated with the preparation of infant formula and associated bottles and equipment are of particular concern (Redmond and Griffith, 2009).

2.3.3 Cooking fuel and cooking practices

Cooking fuel and cooking practices are important in food hygiene since cooking and reheating temperatures are often critical control points in the preparation of complementary foods. In situations where fuel for cooking is in short supply, households may, in a bid to save energy, prepare large quantities of food in advance and then store it until needed. In the absence of facilities for monitoring food temperature and for properly storing leftover foods, storage and reheating become important critical control points. The potential for contamination and growth of pathogens increase when microbiologically sensitive ingredients are added to stored food and consumed without adequate reheating (WHO, 1998).

2.3.4 Traditional food processing

Traditional food processing treatments such as soaking, cooking, germination, and fermentation have great influence on food composition, flavor, palatability and nutrient availability that may be brought about by the biochemical changes that occur (FAO, 2004). These treatments can degrade anti-nutritional factors such as phytate and polyphenols and result in a greater availability of minerals. The high content of anti-nutritional factors and poor bioavailability of minerals in plant-based foods as well as losses during processing play a vital role in micronutrient deficiency (Temple *et al.*, 1996).

Degradation of phytate compounds in cereal and legume foods by processing is well elucidated (Hurrel *et al.,* 2003 and Svanberg *et al.*, 1993), and this process includes activation of endogenous enzyme (phytase) and/or the use of exogenous commercial phytase during processing. The high amount of polyphenolic compounds, i.e. tannins, in high-tannin food grain products accounts for poor minerals availability.
Sanni *et al.* (1999) reported an increase in the crude protein, vitamins and amino acid content and a decrease in crude fibre and phytate phosphorous in fermented blends of cereal and soy bean based complementary foods. Studies in Tanzania on the effect of food processing on iron availability of African pearl millet complementary foods

showed that despite a high content of iron, its availability in roasted pearl millet was quite low (Cisse *et al.*, 1998). The results proved that the iron availability in pearl millet could not meet the iron requirements for infants whatever methods of processing was used, emphasizing the need for supplementation. Alain *et al.* (2007) found that treatment of cowpea and Bambara bean flours with 60% ethanol improves nutritional quality of complementary foods by eliminating anti-nutrients and concentrating most essential nutrients.

2.3.5 Nutrient requirements during the first 2 years of life

Access to nutrient dense foods during the complementary feeding period along with appropriate feeding practices and continued breast-feeding is needed to ensure optimal growth and development. Strategies to improve the availability of and accessibility to low cost complementary foods can play an important role in behavioral changes necessary to improve the nutritional status of infants and young children (Ruel, 2000). The availability of low cost, high quality and easy to prepare complementary foods in the commercial market could potentially address inadequacies in the macro and micronutrient content of typical complementary food diets. However data shows that the proportion of expenditure devoted to food has declined, there has also been a decline in the proportion of food that is home produced, as dependence on subsistence has declined (TDHS, 2005).

2.3.5.1 Energy, protein and lipids

Total daily average energy requirements for healthy breast fed children are 413 kcal/day at 6-8 months, 379 kcal/day at 9-11 months and 346 kcal/day at 12-23 months of age (PAHO and WHO, 2001). In developing countries the average expected energy intake from complementary foods is approximately 200 kcal at 6-8 months, 300 kcal at 9-11 months and 550 kcal to 12-23 months (PAHO and WHO, 2001). These values represent 33%, 45% and 61% of total energy needs respectively. Achieving these energy intakes requires that both feeding frequency and energy density of complementary foods be adequate. Assumed functional gastric capacity (30 g/Kg reference body weight is 249g/feeding at 6-8 month, 285 g/feeding at 9-11 month, and 345/feeding at 12-23 month (PAHO and WHO, 2001). The amount of protein needed from complementary foods increases from about 2 g per day at 6-8 months to 5-6 g per day at 12-23 months, with percentage from complementary foods increasing from 21% to 50%. However the fat content of complementary foods becomes more important as breast milk intake declines. To achieve at least 30% of energy from fat in the total diet, the amount of fat needed from complementary foods (assuming average breast milk intake) is zero at 6-8 months, approximately 3 g per day at 9-11 months and 9-13 g per day at 12-23 months, or 0%, 5-8% and 15-20% of energy from complementary foods (PAHO and WHO, 2001).

2.3.5.2 Micronutrients

Micronutrient needs are high during the first 2 years of life to support the rapid rate of growth and development during this period. The percentage of the recommended nutrient intake needed from complementary foods varies widely, depending on the concentration of each nutrient in breast milk. The nutrients that are most problematic for which at least 75% must come from complementary foods are iron (87-97%), zinc (80-87%) and vitamin B6 (80-90%) (WHO, 1998). Thus, complementary food diets needs to contain foods rich in these nutrients or fortified in some way. Table 3 shows recommended nutrient requirements during first 2 years of life.

Table 3: Recommended nutrient requirements during first 2 years of life

Nutrient	Age category in months		
	6-8	9-11	12-23
Calcium (mg/day)	525	525	350
Copper (mg/day)	0.3	0.3	0.4
Iron(mg/day)	11	11	6
Phosphorous(mg/d)	400	400	270
Zinc (mg/day)	5	5	6.5
Potassium (mg/day)	700	700	800
Magnesium (mg/day)	75	80	85
Sodium (mg/day)	320	350	500
Fat(g/day)	30	*ND	*ND
Protein(g/day)	9.1	9.6	10.9
Energy (Kcal/day)	413	379	346

Source: WHO (1998).

***ND=Not determined**

2.4 The Use of Energy and Nutrient Dense Complementary Foods

Fortification of complementary foods at home with sprinkles (SP), a crushable tablet (such as the Foodlet), or a lipid-based nutrient supplement (a more concentrated version of Ready-to-Use Therapeutic Food) has several advantages. It does not require major changes in dietary practices, allows the child to obtain a full dose of micronutrients when mixed with a small quantity of food, is better accepted than medicinal iron drops taken between meals, and is less expensive than centrally processed, fortified complementary foods (Zlotkin *et al.*, 2004). Evidence in support of the efficacy of home fortification is building. In Ghana, home fortification of complementary foods has indicated to be effective for reducing the prevalence of iron deficiency. The prevalence of iron deficiency anemia was 31% in the nonintervention control group compared with10% in the intervention groups combined (Adu-Afarwuah *et al.*, 2008). Similar results were found for Foodlet when added to complementary foods for infants in Malawi, undernourished infants 6–17 mo of age consuming modified Ready-to-Use Therapeutic Food had a significantly greater hemoglobin concentration than did those who received no supplement (Kuusipalo *et al.*, 2006).

2.5 Summary of the Literature Reviewed

Childhood malnutrition remains a common problem in much of the developing world, Tanzania inclusive. A recent comprehensive report on repositioning nutrition as central to development, which was prepared by the World bank in the year 2006 indicate that complementary feeding period is one of the most critical moment for preventing malnutrition (World Bank, 2006). Growth faltering is most evident during this time period particularly during 6-12 months. In developing countries the average expected energy intake from complementary foods is approximately 200 kcal at 6-8 months, 300 kcal at 9-11 months and 550 kcal to 12-23 months and on the other hand the nutrients that are most problematic for which at least 75% must come from complementary foods are iron (87-97%), zinc (80-87%) and vitamin B6 (80-90%) (WHO, 1998).

Most of the reviewed literatures suggest that the traditional complementary foods are deficient in nutrient content. Kwaku *et al.* (1998) found that complementary foods have energy densities as low as 25-30 Kcal/100g. Findings by Faber (2004) reports complementary foods consumed by 6-12 months old infants in South Africa to be less than half the desired density for calcium, iron and zinc. Combinations of foods have been reported to increase palatability and are nutritionally beneficial to children (WHO, 1998). Fortification of complementary foods at home with sprinkles (SP), has several advantages. In Ghana, home fortification of complementary foods was effective for reducing the prevalence of iron deficiency (Adu-Afarwuah *et al.*, 2008). Strategies to improve the availability of and accessibility to low cost complementary foods have been reported to improve the nutritional status of infants and young children (Ruel, 2000).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Overview

This chapter presents the methods used to collect and analyse data. The chapter is divided into five sections. Section one presents the approach, section two presents the identification and collection of commonly consumed complementary foods, and section three presents laboratory analyses. Section four presents ethical considerations and the last section presents limitations of the study.

3.2 Approach

The study was subdivided into two stages. The first stage involved identification of complementary foods that were commonly fed to infants while the second stage involved determination of nutrient composition in these foods. Protein, carbohydrate, fat, energy, fibre, ash, moisture content, iron, zinc, calcium, magnesium, potassium, phosphorous, manganese, sodium and copper composition of the complementary foods were determined. The nutrients composition analyses were done at Sokoine University of Agriculture.

3.3 Identification of Complementary Foods

The population from which the sample for this study was drawn consisted of households with children aged 6-24 months. The sampling unit comprised of households where a child was residing. The choice of the household as a unit of analysis was based on the fact that it is where the complementary feeding takes place.

3.3.1 Sampling

The sample size was one hundred households. This was not only found to be convenient since statistical computations are meaningful but also due to time and financial resources convenience. The study employed a combination of purposive and simple random sampling techniques. Four wards (Keko, Temeke, Mbagala kuu and Tua Ngoma) were selected out of twenty four wards. Twenty five respondents were selected in each ward. Twenty mitaa were selected at random out of ninety four mitaa by listing all the names of the mitaa in small pieces of paper and eventually by picking the piece of paper. From each ward five mitaa were selected. At the mtaa level, all households having a child aged 6-24 months were identified and listed by the help of a mtaa leader in which five households were selected from each mtaa to give a total of 100 households. Furthermore, simple random sampling technique was used to select a child at the household where there was more than one child aged 6-24 months within the same household. Therefore from the twenty mitaa a total of one hundred households were selected for interviews and for the collection of food samples.

3.3.2 Identification of commonly used complementary foods

Identification of commonly used complementary foods was done by using a single 24 hour dietary recall interview in the selected households and Participatory Rapid Appraisal (PRA) using key informant's interviews. Data on background information was collected with the help of a pre-tested questionnaire. The questionnaire (Appendix I) was prepared in Kiswahili the national language in Tanzania for convenience in data collection. The questionnaire was used to elicit the information on demographic and socio-economic factors that influence child feeding practices. At each visit, a caregiver (a person who prepares the food and feeds a child) was asked to give information on the types of foods other than breast milk that were fed to the infants using the 24 hour dietary recall technique. Respondents were asked if the food consumed in the previous twenty four hours was typical or not. Time, quantity eaten and details of food or drink preparations were also documented (Appendix II). The researcher and one trained assistant administered the questionnaires. The researcher went through each completed questionnaire to check the consistency and accuracy of responses.

3.3.3 Collection of complementary food samples

Appropriate representative samples of complementary foods (dishes) used to feed the 6-24 month infants in 100 selected households were collected asceptically after cooking. The samples were put in plastic sterile containers with tight-fitting lids. Hot food samples from households were cooled immediately in an insulated plastic box containing ice blocks and were kept there until transported to the laboratory at Sokoine University of Agriculture. Approximate 500g of each sample was collected. Each food or dish sample collected was recorded in the field datasheet and labeled at the point of collection using a permanent ink marking pen. A total of one hundred complementary food samples were collected from one hundred different households.

3.4 Laboratory analyses for determination of the nutrient contents

Standard procedures of Association of Official Analytical Chemist (AOAC; 1990 and 1995) were used to determine the moisture content, crude fat, crude protein, crude ash, and crude fiber content. Energy value was calculated using the Atwater's conversion factors. Minerals (iron, zinc, calcium, magnesium, copper, and manganese) were determined by Atomic Absorption Spectrophotometer model number 919, phosphorous by ultra violet visible spectrometer model number 5625, whereas sodium and potassium were analyzed by digital flame analyzer model number 2655-00. Details of analyses of each are given in Appendix III.

3.5 Ethical Considerations

Verbal consent to participate in the study was obtained from mothers. The Health Department of Temeke Municipal Council reviewed the protocol and gave approval for the study.

3.6 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 12.0 and SAS were used for data analysis. Descriptive statistics such as mean, frequencies and percentages of variables were determined. General linear model (GLM) was done to test for statistical significance using SAS statistical package.

3.7 Limitations of the Study

Few of the identified households could not supply the food samples for laboratory analysis to determine their nutrient composition due to shortage of food at home and in some of the households the people responsible for preparation of complementary foods were not available at home. In such circumstances the households were excluded from the study, to maintain the sample size; an extra equal number of households were added from the nearby households having similar socio-economic characteristics to the excluded ones.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

In this chapter, the results of the study are presented and discussed in line with the study objectives. The results are divided into three major sections; the first section presents the socio-demographic profile of the study population. The second section presents the dishes that are commonly fed to infants (6-24 months old) in Temeke District plus the procedures employed in cooking them. The third section presents the calculated energy and nutrient contents of selected complementary foods per.

4.2 Demographic and Socio-economic Profile of the Study Households

Table 4 shows demographic and socio-economic characteristics of the respondents involved in the study. The demographic characteristics included age and sex while socio-economic characteristics involved in the study were employment status, level of education and main sources of food and water for household use. Out of 100 respondents, all were females of which 73% are having a primary school education, which is also regarded as basic education in Tanzania. Evidence shows that female education is associated with greater knowledge, better child-feeding, child-care, and hygiene practices, and more effective management of resources (Cleland *et al.*, 1988 and Reed *et al.*, 1996). Education provides people with the knowledge and skills that can lead them to a better quality of life. The Tanzania Demographic and Health Survey reveal that education is correlated with the health of mothers and their children, and with reproductive behavior (TDHS, 2005).

Results further showed that the respondents were highly dependent on cash to buy food as well as to pay for all their basic needs including water. A total of 99% of the households reported buying food for household consumption. In Accra, Ghana, more than 90% of the food consumed was purchased, and the rest came from intra-or inter-family transfers and gifts (Ruel, 2000). This high dependence on the market for basic needs means that urban people have to work to generate income and usually both men and women work. Most employment opportunities are outside the home, and this is likely to have a great impact on mother's ability to take care of their children and other family members. Evidence also suggest that the higher proportion of female headed households and smaller household sizes in urban areas reduce the household supply of alternative caregivers and result in harsher trade-offs for women between time spent in income generation (their productive role) and time spent in their reproductive, maternal and caring roles (Ruel, 2000).

Table 4: Demographic and socio-economic profile of the study households (N=100)

Variables	Variable type	Frequency (n)	Percentage (%)
Level of education of mother	Illiterate	8	8
	Primary education	73	73
	Secondary education	16	16
	Post secondary education	3	3
Level of education of father	Illiterate	10	10
	Primary education	56	56
	Secondary education	30	30
	Post secondary education	41	4
Employment status of the mother	Housewife	71	71
	Employed	8	8
	Self employed	20	20
	Casual laborer	1	1
Employment status of the father	Employed	25	25
	Self employed	54	54
	Not employed	5	5
	Casual laborer	16	16
Main sources of water for household use	Community tap water system	60	60
	Wells	23	23
	Vendors	17	17
Main sources of food for household	Own grown	1	1
	Purchasing	99	99

4.2.1 Age and sex of surveyed children

Table 5 shows demographic information (age and sex) of surveyed children under the study. Results indicate that 49% of the sampled children were boys and 51% were girls. All the children were divided into three age groups. The age groups were 6-8 months, 9-11 and 12-24 months. Age categorization allowed estimating the amount of energy and nutrients as well as the dietary intake that would be needed to meet the recommended food intake, energy and other nutrient requirements (WHO, 1998). The minimum age reported was 6 and the maximum age was 24 months. The mean age was 13 months. The results indicate that 20%, 35% and 45% of the surveyed children belonged to 6-8 month, 9-11 month and 12-24 month age categories, respectively.

Table 5: Age and sex of surveyed children

Variables	Categories	Frequency (n)	Percentage (%)
Age (months)	6-8	20	20
	9-11	35	35
	12-24	45	45
Sex	Males	49	49
	Females	51	51

4.3 Commonly Used Complementary Foods

Table 6 presents results on complementary foods reported for 24-hour recall period listed in descending order according to the number of children (or households). The results show that Ugali (78%), Maize porridge (*Uji*) (71%), composite flour porridge (55%), rice (19%), tea (16%) and cassava porridge (1%) were the common dishes reported. Out of one hundred interviewed caregivers, the only foods reported as being prepared especially for the young child, though not exclusively for the young child were home prepared maize porridges (*uji*) which was the most commonly used complementary food, followed by composite flour porridge and mashed potato/mashed banana.

The findings of this study are similar to the findings by Faber (2004) and that of Gardner (2002) who reported infants to be most fed by maize porridge. Faber (2004) reported more than half of the infants in South Africa to be fed with maize porridge whereas Gardner (2002) and Kamudoni *et al.* (2007) reported 80% and 79% of children was fed maize porridge in Jamaica and Malawi, respectively. In Kenya, of the actual foods selected, cereal-based gruel was consumed daily by over 90% of children throughout the study (Onyango *et al.*, 2002). In addition 16% of the caregivers reported that they gave tea to their children. Provision of tea to infants and young children is not recommended as it may decrease their appetite and further hamper their nutritional status (Suba *et al.*, 2007). Milk formula was consumed by 3% of the infants on the day of recall. Due to high prices of the ready-to-eat canned baby foods their consumption is questionable among the lower-socio-economic sector. Mothers should be encouraged to use home-prepared food instead of ready to eat-canned-foods as this will serve money without compromising nutrients.

Table 6: Complementary foods consumed by children during the 24 hour recall period

Dish	Children (N=100)		Portion size (g)		
	N	%	Average	Minimum	Maximum
Ugali (Maize)	78	78	92	42	236
Maize porridge	71	71	121	65	230
Composite flour porridge	55	55	124	68	227
Mashed potato/banana	41	41	72	48	206
Rice	19	19	45	10	160
Tea	16	16	130	80	175
Cassava porridge	1	1	83	57	180
Milk formula	3	3	40	28	79

4.4 Preparation of complementary foods

Porridges were prepared by stirring a predetermined flour mass with cold water into slurry. The most common practice was to add the flour into cold water and mix to a paste, and then to add the paste to boiling water, stirring all the time and then to bring the mixture back to boil taking into consideration the required final solid concentration. The slurry was cooked by stirring over low heat for 10-15 min. from the point when the mixture had started to boil. About 33% of the respondents reported holding the cooked foods, and serving later to their children after reheating, partly due to time constrains and in some cases due to financial constrains which necessitated them to cook in bulky to do away with several cookings. In the absence of facilities for monitoring food temperature and for properly storing leftover foods, there is a high potential for contamination and growth of pathogens especially when microbiologically sensitive ingredients are added to stored food and consumed without adequate reheating (Ehiri *et al.*, 2001). From the questionnaire survey results, only 5% of caregivers reported to have ever soaked millet used in porridges. This is in contrast with the WHO and PAHO complementary feeding guidelines in which household technologies such as fermentation, soaking, roasting and malting are highly recommended as they contribute to improving safety and quality of complementary foods (PAHO and WHO, 2001).

4.4.1 Maize flour porridge

Maize flour porridge was prepared mainly from maize flour. Various energy-rich food items were usually added to the porridge namely sugar, cooking oil, cow's milk and margarine. Salt was also added to porridge by 8% of the caregivers whereby enhancement of flavor (taste) and lack of income were reported to be major reasons for adding salt to the porridge. Only one respondent out of one hundred respondents reported the need for iodine as a major reason for adding salt in maize porridge. Some of the caregivers did not introduce energy and nutrient dense ingredients such as margarine, butter and sugar because they did not want their children to get used to the tastes which they feared that they could not sustain.

4.4.2 Composite flour porridge

Composite flour porridge was the third most fed complementary food. About 55% of the caregivers reported feeding their children with composite flour porridge (Table 6). The composite flour was prepared from a mixture of millet, rice, maize, groundnuts, sugar, water, soybean, sorghum, margarine, wheat, beans and milk. On the basis of these ingredients several mixtures existed. Millet, maize, groundnuts, soybean, rice, wheat, beans and sorghum were dominant ingredients used to prepare the composite flour. In addition, cows' milk, sugar and margarine were added to boost up the energy and nutrient level of porridge. Most of the respondents showed interest in feeding their children with this porridge but low purchasing power appeared to be a problem.

4.4.3 Mashed potato/banana

Mashed banana/mashed potato was the fourth most fed complementary food (Table 6). About 41% of the caregivers reported feeding their children with mashed potatoes/mashed bananas. The mashed potato and mashed banana were prepared from a mixture of banana, potatoes, cooking oil, onion, green pepper, tomatoes, salt, water, carrot, fish soup, cow's milk, meat soup and green leafy vegetables. Banana and potatoes were the dominant ingredients and in case where banana was added, potatoes were not added. The mashed potato and mashed banana were mixed with either meat soup or fish soup.

4.5 Frequency of Feeding Complementary Foods

Table 7 shows the frequency of feeding complementary foods. The findings show that the frequency of feeding complementary foods ranged from 2 to 5 meals per day. Out of 100 caregivers, 79% reported giving complementary foods 2 to 3 times a day, 17%, 3-4 times a day and 4% fed 4 to 5 times per day. The mean frequencies of feeding were 3.0, 3.17 and 3.31 for children aged 6-8, 9-11 and 12-24 months respectively. The results are in line with Subba *et al.* (2007) who reported a mean feeding frequency of 3 times a day. The feeding frequency ranged from 2-4, 2-4, and 2-5 meals in the 6-8, 9-11 and 12-24 months age categories. None of them reported to be feeding more than five times a day. Preparing and feeding five meals per day requires a considerable amount of time and effort by caregivers. This may prompt the care-givers to hold prepared food over from one meal to the next, thereby potentially increasing the risk of microbial contamination (PAHO and WHO, 2001). On the other hand, none of the respondents in this study reported to feed babies only 1-2 times a day, which is inadequate according to PAHO and WHO (2001) recommendations. The recommendation is that complementary foods should be provided 2-3 times per day at 6-8 months of age for average healthy breastfed infants and 3-4 times per day at 9-11 and 12-24 months of age. In addition, nutritious snacks such as fruits, bread or chapatti with nut paste can also be offered 1-2 times per day, as desired. However, results show that 62% of children in the 9-11 and 12-24 months age categories belonging to all the four education categories were fed few numbers of meals according to their age (Table 7).

Table 7: Child's age category, mother's educations level and feeding frequency

Child's age category in months	Education level category of the mother	Frequency of feeding			Mean feeding frequency
		2-3	3-4	>4	
6-8	Illiterate	1	-	3	3
	Primary education	13	-	24	
	Secondary education	2	3	1	
	Post secondary education	1	-	-	
9-11	Illiterate	3	1	-	3.7
	Primary education	24	3	-	
	Secondary education	1	2	-	
	Post secondary education	-	1	-	
12-24	Illiterate	2	1	-	3.31
	Primary education	25	5	3	
	Secondary education	7	-	1	
	Post secondary education	-	1	-	

4.6 Nutrient Contents of the Complementary Foods

Proximate and minerals composition results of the identified and selected complementary foods are presented in this section. The section also looks at the amounts of food required to meet the child's daily nutrient requirements (Table 8).

Table 8: Proximate composition (g per 100g on dry matter basis) of selected complementary foods

Proximate composition	Name of the complementary food			P- value
	Composite flour Porridge	Mashed potato/mashed banana	Maize porridge	
Dry matter	12.43 ± 2.18^{ba}	14.06 ± 3.71^{a}	11.68 ± 3.96^{b}	0.02
Moisture	87.57 ± 2.18^{ba}	85.94 ± 3.71^{b}	88.32 ± 3.96^{a}	0.02
Ash	2.59 ± 1.91^{b}	5.96 ± 2.43^{a}	3.18 ± 1.58^{b}	<0.00
Crude protein	7.14 ± 2.22^{a}	6.22 ± 2.42^{ba}	5.40 ± 2.36^{b}	0.01
Fibre	4.09 ± 2.05^{a}	4.51 ± 1.83^{a}	4.29 ± 2.16^{a}	0.71
Fat	3.96 ± 2.71^{a}	2.87 ± 2.17^{ba}	2.55 ± 2.10^{b}	0.04
Carbohydrate	63.75 ± 15.82^{a}	48.19 ± 13.50^{b}	59.52 ± 13.72^{a}	0.00
Energy (Kcal/100g)	319.13 ± 61.31^{a}	243.50 ± 53.56^{c}	282.60 ± 59.54^{b}	<0.00

Values superscripted with the same letter along the same row are not significantly different at $p<0.05$

4.6.1 Proximate composition

The proximate analysis was reported on dry matter, moisture content, ash, protein, fibre, fat, carbohydrate and energy contents

(a) Dry matter content

Table 8 shows dry matter contents of the three complementary foods examined. The multiple mean separation by Least Significant Difference (LSD) showed the mashed potato/mashed banana had highest mean score of 14.06±3.71 g/100g and differed significantly from maize porridge which had lowest mean score of 11.68±3.96 g/100g. The composite flour porridge did not differ significantly from the two complementary foods ($p<0.05$). High dry matter content in banana has been reported by Onyeka and Dibia (2002). The content of dry matter in the identified selected complementary foods falls within ranges of the reported data by Gibson *et al.* (1998); who reported complementary foods made from a mixture of unrefined maize flour, soya flour and water to contain 10% dry matter and that from a mixture of rice, kidney, beans, roasted sesame, sugar, and water contained 13% dry matter.

(b) Moisture content

Table 8 shows moisture contents of the three complementary foods examined. The multiple mean separation by Least Significant Difference (LSD) showed maize porridge had highest mean score of 88.32±3.96 g/100g and differed significantly from mashed potato/mashed banana which had lowest mean score of 85.94±3.71 g/100g. The composite flour porridge which had scored mean of 87.57±2.18 g/100g did not differ significantly from the two complementary foods ($p<0.05$). Higher moisture content values are associated with low dry matter proportion as well as low energy and nutrient values (Onyeka and Dibia, 2002). The high moisture content of the three complementary dishes indicates that they are highly perishable. In the nutrition evaluation of the malted weaning foods made from maize, soybean, groundnuts and cooking banana, the moisture content at the range of 40.2 to 41.2 g/100g have been reported to be suitable for storage (Onyeka and Dibia, 2002).

The high moisture contents in foods are not suitable for storage, since growth of spoilage micro-organisms is favoured at such levels. This is an important consideration in local feeding methods in Tanzania. Most mothers often prepare large quantities of infant food and keep it in containers to avoid frequent cooking in order to have spare time and energy for other domestic activities.

(c) Ash content

Table 8 present results on ash content of the examined complementary foods. Ash content ranged between 2.59g in composite flour porridge to 5.96g/100g dry matter in mashed potato/mashed banana. The ash content differed significantly ($P<0.05$) between composite flour porridge and mashed potato/banana. Significant difference ($P<0.05$) in ash content was also observed between mashed potato/banana and maize porridge. However, no significant difference was observed between composite flour porridge and maize porridge. Ash content is an important nutritional indicator of mineral content (Fennema, 1996). The ash content values obtained in this study are consistent with published reports of 2.0±0.00 to 8.37±0.1 g/100g for home made complementary foods (Mosha *et al.*, 2000).

(d) Protein content

Table 8 shows crude protein contents of the three complementary foods examined. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge had highest mean score of 7.14±2.22 g/100g and differed significantly from maize flour porridge which had lowest mean score of 5.40±2.36 g/100g. The mashed potato/banana which had scored a mean of 6.22±2.42 g/100g did not differ significantly from the two complementary foods ($p<0.05$). The highest crude protein content observed in the composite flour porridge samples than in mashed potato/bananas and/or maize porridge was expected. The protein content of the major ingredients used in composite flour preparation has been reported to be high. Nkama and Filli (2006) found that grain legumes like soybean contribute significantly towards protein content when added to complementary foods. Ayo *et al.* (2007) observed a similar trend when soybean was added to composite flour. In the present study, the composite flour porridge consisted of millet, rice, maize, groundnuts, sugar, soybean, sorghum, margarine, wheat, beans and milk.

(e) Fibre content

Table 8 shows fibre contents of the three complementary foods examined. The results show no significant difference in fibre content among the three complementary foods under the study at $p<0.05$. The findings of this study compare well with most of the earlier studies that have reported a higher fibre content value for complementary foods in developing countries. Mosha *et al.* (2000) reported fibre content ranging from 3.39±0.10 to 16.00±0.6 g/100g for home made complementary foods while Gibson *et al.* (1998) reported fibre content ranging from 0.1-4 g/100g.

The observed low fibre content would have been contributed by grain processing practices such as milling and cooking procedures such as boiling. Pedersen et al. (1989) found that refining of flour significantly removes dietary fibre and reduces the level of mineral concentration. Possible undesirable aspects of high fibre levels in weaning foods include increased bulk and lower caloric density, irritation of the gut mucosa, and adverse effects on the efficiency of absorption of various nutrients of significance in diets with marginal nutrient content. A maximum level of 5% of fibre for infants and young children is set by FAO/WHO Codex standards (FAO and WHO, 1998). The current study has recorded values of about 4% for all the three tested complementary foods.

(f) Fat content

Table 8 shows fat contents of the three complementary foods examined. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 3.96±2.71 g and differed significantly from maize flour porridge which had lowest mean score of 2.55±2.10 g/100g. The mashed potato/banana which had scored mean of 2.87±2.17 g/100g did not differ significantly from the two complementary foods ($p<0.05$). Total fat contents found in commonly used complementary foods in developing countries have been reported to be low, varying between 0.1-0.3 g/100g in porridges; although addition of soya milk or peanuts increased the fat content to 1.2-1.9 g/100g (Hudson *et al.*, 1980). The addition of groundnuts, soybeans, margarine, wheat and cow's milk to composite flour porridges could account for its observed higher level of fat as compared to maize flour porridge and mashed potato/mashed banana. Groundnuts paste has been reported to contain high quantity of fat of 24-36% (Ayo *et al.*, 2008). Fat is important in the diets of infants and young children because it provides essential fatty acids, facilitates absorption of fat soluble vitamins, and enhances dietary energy density and sensory qualities (Dewey *et al*, 2001).

(g) Carbohydrate content

Table 8 presents results on carbohydrate content of the three complementary foods. The highest and lowest carbohydrate contents were recorded for composite flour porridge and mashed potato/mashed banana, respectively. There was no significant statistical difference in carbohydrate content between composite flour porridge and maize porridge. However significant statistical differences were observed between composite flour porridge and mashed potato/banana. The observed higher levels of carbohydrate content in composite flour porridge could be due to the ingredients such as maize, sorghum and millet. A range of carbohydrate values of 70 and 92% of dry weight have been reported for traditional complementary foods in West Africa (Onofiok and Nnanyelugo, 1998). The range noted in the present study is slightly lower than the reported range. Carbohydrate containing foods are important vehicles for proteins, vitamins, minerals and other food components such as phytochemicals and antioxidants (Bowman and Russel, 2001).

(h) Energy content

Table 8 shows energy contents of the three complementary foods examined. The results show significant difference in energy content among the three complementary foods under the study at $p<0.05$. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge had the highest mean score of

319.13±61.31 kcal/100g and differed significantly from mashed potato/banana which had the lowest mean score of 243.50±53.56 kcal/100g. The maize porridge which had scored a mean of 282.60±59.54 kcal/100g also differed significantly from the two complementary foods ($p<0.05$). The results indicated that complementary foods are low in calorie content and their energy value varied according the type of dish.

In all the complementary foods, the energy content of the dishes was low than the minimum energy (483.9 Kcal) recommended in the Codex Alimentarius Standards for complementary foods (FAO and WHO, 1998). Results from this study show that the complementary foods had an average energy content of 281.8 Kcal/100g on dry matter basis. Ayo *et al.* (2008) observed a similar pattern in Nigeria. The energy value reported for porridges in this study were slightly higher than 40.6-174 kcal/100g reported in the study done in Jamaica (Gardner *et al.*, 2002). The observed energy level pattern could partly be due to addition of energy rich ingredients such as soybeans, groundnuts, margarine, cow's milk and cooking oil in composite flour porridge. The results are in line with the findings by Kikafunda *et al.* (1997) who urged that the energy density of porridges significantly increases by addition of groundnuts to porridges. Similarly, WHO (1998) recommends addition of one teaspoon of vegetable oil to 100 g of a typical maize pap to increase the energy density from 0.28 to 0.73 kcal/g.

4.6.2 Food intakes to meet nutrient requirements

Traditional complementary foods given to children were found to be low in nutrient content. Considering the daily energy requirements, data shows that a child aged 6-8, 9-11 and 12-24 months consuming composite flour porridge would need 1041.31, 955.58 and 872.38 g of food a day respectively (Table 9). Whereas a child aged 6-8, 9-11 and 12-24 months consuming mashed potatoes/mashed banana would need 1206.66, 1107.33 and 1010.91 g of food respectively (Table 9). Functional gastric capacity is 249 g/feed at 6-8 month, 285 g/feed at 9-11 month and 345 g/feed at 12-23 month (PAHO and WHO, 2001). This show clearly that, owing to the low energy density of foods, it means that the child will need to feed extra amount of food to be able to meet their body needs which is not practical owing to the small sizes of the stomachs. The use of foods of high nutrient density and frequent feeding schedule can help provide adequate food for growth and activity (Onofiok and Nnanyelugo, 1998).

Table 9: Amount of food in grams to be consumed to meet the daily recommended nutrient requirements according to age

Nutrient/Age	Composite flour porridge			Mashed potatoes			Maize porridge		
Age in months	6-8	9-11	12-23	6-8	9-11	12-23	6-8	9-11	12-23
Protein	1025.80	1082.17	1228.71	1040.85	1098.04	1246.74	1443.19	1522.48	1728.65
Energy	1041.31	955.58	872.38	1206.66	1107.33	1010.91	1251.34	1148.32	1048.34

4.6.3 Minerals composition

The results for minerals composition are presented in Table 10. The minerals analysed in the three complementary foods were phosphorous (P), iron (Fe), zinc (Zn), manganese (Mn), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and copper (Cu).

(a) Phosphorous content

Table 10 shows phosphorous contents of the three complementary foods examined. Phosphorous contents in the three complementary foods ranged from 59.33 mg in maize porridge to 183.09 mg in composite flour porridge mg/100g dry weight The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 183.09±74.52 mg/100g and differed significantly from maize flour porridge which had lowest mean score of 59.33±42.22 mg/100g. The mashed potato/banana which had scored a mean of 164.00±106.25 mg/100g also differed significantly from maize flour porridge ($p<0.05$). Composite flour porridge and mashed potato/mashed banana were not statistically different ($P<0.05$) in phosphorous content. The results further showed that in order to supply 400 mg/day of phosphorous as recommended by WHO (1998) a child would need to take approximately 3896.45-5772.52 g of maize porridge, these values are higher than what a child could manage (Table 11). And for composite flour porridge approximately 1186.56-1757.87 g of composite flour porridge were required on a daily basis. Mashed potatoes/mashed banana required between 1171.25-1735.19 g of food to meet the child's recommended dietary intake/requirements. Where the complementary food is the sole source of nutrients other than human milk, phosphorus should be included in the diets of most weaning children because it is a necessary component for bone and tissue growth (Abrams and Atkinson, 2003).

(b) Copper content

Table 10 shows copper content of the three complementary foods examined. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 0.369±0.121 and differed significantly from maize porridge which had lowest mean score of 0.279±0.193 mg/100g. The mashed potato/banana which had scored a mean of 0.322±0.125 mg/100g did not differ significantly from the two complementary foods ($p<0.05$). The observed concentrations of copper in the present study are comparable with previously reported copper analysis values varying from 0.04 to 0.3 mg per 100g in the traditional complementary foods (Gibson *et al.*, 1998 and Mosha *et al.*, 2000). A child feeding on maize porridge required approximately 920.686-1227.581 g of maize porridge to be able to supply 0.3 mg/day recommended dietary allowance of copper per a day (Table 11). This amount of food is again somewhat higher than the recommended amount of 249 g/meal, 285 g/meal and 345 g/meal for a child aged 6-8, 9-11 and 12-23 month, respectively (PAHO and WHO, 2001). Although little amounts are required by the body, copper deficiency may cause growth impairing, bone demineralization and anaemia (Grodner *et al.*, 2000).

Table 10: Mineral contents (mg per 100g on dry matter basis) of selected complementary foods

Mineral	Name of the complementary food			P-value
	Composite flour porridge	Mashed potato/mashed banana	Maize porridge	
P	183.09 ± 74.52^{a}	164.00 ± 106.25^{a}	59.33 ± 42.22^{b}	<0.00
Cu	0.37 ± 0.12^{a}	0.32 ± 0.13^{ba}	0.28 ± 0.19^{b}	0.06
Fe	5.14 ± 2.24^{a}	4.15 ± 1.68^{b}	2.65 ± 1.57^{c}	<0.00
Zn	0.51 ± 0.22^{a}	0.42 ± 0.17^{b}	0.27 ± 0.16^{c}	<0.00
Mn	1.87 ± 1.11^{a}	1.21 ± 0.68^{b}	0.28 ± 0.66^{c}	<0.00
Ca	156.09 ± 129.88^{a}	81.16 ± 130.34^{b}	52.91 ± 45.73^{b}	0.00
Mg	104.92 ± 41.86^{a}	110.08 ± 37.91^{a}	49.33 ± 28.99^{b}	<0.00
K	229.88 ± 135.94^{a}	627.48 ± 291.57^{b}	140.50 ± 297.96^{b}	<0.00
Na	161.26 ± 193.08^{a}	1331.00 ± 500.01^{b}	474.50 ± 510.90^{c}	<0.00

Values superscripted with the same letter along the same row are not significantly different at $P \leq 0.05$

(c) Iron content

Table 10 shows iron contents of the three complementary foods examined. The results show significant differences in iron contents among the three complementary foods under the study at $p<0.05$. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge had highest mean score of 5.14±2.24 mg/100g and differed significantly from maize porridge which had lowest mean score of 2.65±1.57 mg/100g and mashed potato/banana which scored a mean of 4.15±1.67 mg/100g also significant at $p<0.05$. These findings compare well with the report by Mamiro *et al.* (2005) in which cereal porridge was reported to supply 4.5 mg of iron per day. Tanzania bureau of standards recommends cereal-based weaning foods to contain 10.87 mg/100g of iron (TBS, 1983). On the basis of the Tanzania standard for cereal-based weaning foods, all the foods contained lower amount of iron as compared to the 10.87 mg/100g) specified value of iron. The results further showed that in order to meet daily iron body needs which is 11 mg/day according to WHO (1998) for a child aged 6-8 and 9-11 month and 6 mg/day for a child aged 12-23 month approximately 939.99-1723.32 g of composite flour porridge were required (Table 11). The quantities of food that would be needed to meet estimated iron needs were generally much higher than the current observed maximum intakes which are 249 g/feed, 285 g/feed and 345 g/feed for a child aged 6-8, 9-11 and 12-23 month, respectively (PAHO and WHO, 2001). It appears to be practically impossible to supply enough iron from unfortified complementary foods to meet the iron requirements of infants. The findings of this study compare favorably with that of Faber (2004) who has reported low level of iron in the infant's complementary foods in South Africa.

(d) Zinc content

Table 10 shows zinc contents of the three complementary foods examined. The results show significant difference in zinc content among the three complementary foods under the study at $p<0.05$. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 0.51±0.22 mg/100g and differed significantly from maize porridge which had the lowest mean score of 0.27±0.16 mg/100g and mashed potato/banana which had scored mean of 0.42±0.17 mg/100g. It has been suggested that complementary foods need to provide 90% of the recommended intake of 3 mg/d zinc for 9-11 month old infants (WHO, 1998). Hence, one criterion for the selection of complementary foods is that they be rich sources of zinc, as well as of iron. In this regard, composite flour porridge would be worth selecting owing to its relative high zinc content. The results further showed that a child aged 6-8 and 9-11 would need 7827.19 g and the one aged 12-24 months would need 10175.34 g of composite porridge per day (Table 11) to meet the recommended daily intake of zinc. Again these values are much higher than 249 g/feed, 285 g/feed and 345 g/feed which are possible for a child aged 6-8, 9-11 and 12-23 month, respectively (PAHO and WHO, 2001).

(e) Manganese content

Table 10 shows manganese contents of the three complementary foods examined. The results show significant difference in manganese content among the three complementary foods under the study at $p<0.05$. The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 1.87±1.11 mg/100g and differed significantly from maize porridge which had lowest mean score of 0.28±0.66 mg/100g and mashed potato/banana which had scored a mean of 1.21±0.68 mg/100g also differed significantly from the two complementary foods ($p<0.05$). Manganese is a constituent of several enzymes involved in metabolism and important in bone formation (Roth and Townsend, 2003).

(f) Sodium content

Table 10 present results on sodium content of the three complementary foods examined. The results show significant difference in sodium content among the three complementary foods under the study at $p<0.05$. The multiple mean separation by Least Significant Difference (LSD) showed the mashed potato/banana to have the highest mean score of 1331.00±500.01 mg/100g and differed significantly from composite flour porridge which had lowest mean score of 161.26±193.08 mg/100g. The maize porridge which had scored mean of 474.50±510.90 mg/100g also differed significantly from the two complementary foods ($p<0.05$).

Table 11: Amount of food in grams to be consumed to meet the daily nutrient intakes according to age categories in months

Nutrient/Age Age in months	Composite flour porridge			Mashed potatoes			Maize porridge		
	6-8	9-11	12-23	6-8	9-11	12-23	6-8	9-11	12-23
P	1757.87	1757.87	1186.56	1735.19	1735.19	1171.25	5772.52	5772.52	3896.45
Cu	654.18	654.18	872.23	662.83	662.83	883.78	920.69	920.69	1227.58
Fe	1723.32	1723.32	939.99	1885.29	1885.29	1028.34	3555.54	3555.54	1939.38
Zn	7827.19	7827.19	10175.34	8571.57	8571.57	11143.04	16155.43	16155.43	21002.06
Ca	2706.31	2706.31	1804.21	4602.21	4602.21	3068.14	8495.55	8495.55	5663.70
Mg	575.20	613.55	651.89	484.72	517.04	549.35	1301.91	1388.70	1475.49
K	2450.15	2450.15	2800.17	793.66	793.66	907.04	4266.07	4266.07	4875.51
Na	1596.70	1746.39	2494.84	187.05	187.08	267.26	577.45	631.58	902.26

(g) Calcium content

Calcium content in the complementary foods ranged from 52.19mg in maize flour porridge to 156.09mg in composite flour porridge per 100g dry weight (Table 10). The multiple mean separation by Least Significant Difference (LSD) showed the composite flour porridge to have the highest mean score of 156.09±129.88 mg/100g and differed significantly from both maize porridge and mashed potato/banana which had mean scores of 52.91±45.73 mg/100g and 81.16±130.34 mg/100g respectively ($p<0.05$). Calcium contents were far below the estimated needs which are 350 mg/day at 12-23 and 525 mg/day at 6-8 month and 9-11 month. However the findings are in the same range with that of Mosha *et al.* (2000) who reported homemade complementary foods to contain 18.47-319.79 mg of calcium per 100g of food on dry matter basis. Composite flour porridge was rated the first potential source of calcium. A child aged between 6-11 months and 12-24 months would need 2706.31 and 1804.21 grams of composite flour porridge to meet the daily body needs (Table 11). Owing to the small size of their stomach these values are much higher as compared to what a child could consume which is 249 g/feed, 285 g/feed and 345 g/feed recommended for a child aged 6-8, 9-11 and 12-23 months, respectively (PAHO and WHO, 2001). Adequate calcium intake may increase the rate of bone growth and bone mineral density in children (Balch, 2000).

(h) Magnesium content

The magnesium content of the three complementary foods ranged between 49.33 to 110.08 mg/100g. The multiple mean separation by Least Significant Difference (LSD) showed the maize flour porridge to have the lowest mean score of

49.33±28.99 mg/100g and differed significantly from both composite flour porridge and mashed potato/banana which had mean scores of 104.92±41.86 mg/100g and 110.08±37.91 mg/100g respectively ($p<0.05$). In South Africa a study by Faber (2004) showed that complementary foods provided 75 mg of magnesium per 100g. Mashed potato/banana reported to contain highest magnesium content (Table 10). In comparison to age-based recommendations (PAHO and WHO, 2001), magnesium intakes from composite flour porridge and mashed potato/mashed banana appear to be fair sources (Table 11). Magnesium has been identified as a problem nutrient from six to twenty four months and must be supplemented by addition to complementary foods (Brown *et al.*, 1998). Although magnesium intakes may be slightly below optimal values, a severe deficiency in young children is uncommon.

(i) Potassium content

In terms of potassium content the results varied between 140.496 and 627.481 mg/100g dry weight. Mashed potato/mashed banana rated the highest in terms of potassium content. Composite flour porridge differed significantly ($p<0.05$) with maize flour porridge and mashed potato/mashed banana. However, potassium content did not differ statistically ($p<0.05$) between mashed banana and maize porridge. Leafy green vegetables, fruit such as tomatoes, cucumbers, zucchini, bananas, eggplant and pumpkin, and root vegetables are particularly good sources of potassium (ANHMRC, 2006). The observed higher potassium content in mashed potato/mashed banana could be due to presence of banana, leafy vegetables and tomatoes.

(j) Summing up on mineral contents

With regards to mineral content, the local complementary dishes contained low amounts of the minerals such as Fe, Mn, Mg, Cu, P, Ca, K, Na and Zn. Similar inadequacies of some minerals have been observed in various home-made complementary foods in developing countries (Mosha *et al.*, 2000, Gibson, 1998, Hotz and Gibson, 2001 and PAHO and WHO, 2001). In this regard, supplementation of household complementary foods with mineral-rich foodstuff and possibilities for use of nutrient-rich fortified complementary foods needs to be explored. Importantly too, it is not enough to have sufficient amounts of minerals in complementary foods, it is more important to have them in a form in which they are easily digestible and available to the body. This is an especially pertinent issue in a country such as Tanzania where most of the diets are of plant sources. Minerals are essential for normal growth and development, utilization of macronutrients, maintenance of an adequate defense against infectious diseases, and for many other metabolic and physiological functions.

It is worth noting that most of the complementary foods in developing world, Tanzania being one of them are deficient in minerals. In this regard, it is recommend that feeding with the prepared energy and nutrient rich complementary foods be more frequent and the period of breast feeding be extended to at least two years.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study shows that the local complementary foods do not meet the recommended nutrient requirements of infants and children. Therefore, supplementation with appropriate micronutrients or micronutrient-dense foodstuffs is necessary. All the three complementary foods (maize flour porridge, composite flour porridge and mashed potatoes/mashed bananas) were found to supply less than half the daily recommended nutrient requirements given the feeding capacity of the child. On the other hand, the supply of the micronutrients iron, zinc, copper, calcium and manganese were substantially low. Composite flour porridge provided the best avenue for the improvement of complementary foods owing to its contribution to daily energy and nutrients intake. The study further reveals that only a few varieties of complementary foods are prepared for young children.

It was also found that to be able to meet the daily recommended nutrient requirements, the child would need to eat a large amount of food more than what a child could consume. The extra amount of food to be consumed was practically impossible owing to the small size of the child's stomach.

5.2 Recommendations

Findings of this study clearly manifest the contribution of complementary foods to infants and young children's well being. Thus there is an urgent need in ensuring that locally made complementary foods are improved because of their overwhelming importance for optimal growth, development, and well-being of the 6-24 month old children. Thus this study recommends the following:

- Mothers need guidance on how to improve traditional foods through combinations with other foods available to them locally such as groundnuts, cowpea and soya bean.
- Possibilities for adding industrially manufactured energy and nutrient dense supplements such as plumpynuts to the traditional complementary foods should be explored so as to improve energy and nutrient density of the traditional complementary foods.
- Issues on child nutrition especially in complementary foods should be given priority at the District level developmental plans.
- Further studies to explore on the vitamin level of the locally made complementary foods and the evaluation of the effects of cooking preparation procedures on the vitamin and mineral content of the complementary foods is especially relevant.

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APPENDICES

Appendix 1: A Survey Questionnaire for a Study on Nutrient Composition of Complementary Foods for 6-24 Months Children in Temeke District

Questionnaire

Number..

Date of interview...

Ward/Village..

Background information on the household

Qn.No	Question	Response
1	Age of the caregiver (Years)	
2	What is the highest educational level of the caregiver (Years of schooling)?	
3	What is the highest educational level of the mother?	
4	What is the highest educational level of the father?	
5	How old is the child (months)?	
6	What is the employment status of the mother?	
7	What is the employment status of the father?	
8	What is the major source of water for the household use?	
9	What is the major source of food for the household?	

Information on the most fed complementary food, reason (s) for preference and number of meals fed per day

QN.NO	QUESTION	RESPONSE
10	Which food do you feed your child with most of the time?	
11	Explain reason(s) for feeding/using this food most of the time referred to question 10	
12	How often do you feed your child in a day from morning till bed time?	

13. Twenty-four hour dietary recall information

Name/code Ward Street Date Day of the week Is this typical day?						
Food description	Time	Ingredients used	Amount of ingredients (Container used)	Amount of ingredients (grams/mls)	Amount of food consumed (container used)	Amount of food consumed (grams/mls)

Thank you for your cooperation

Appendix 2: Sample collection form

Mainquestionnaire

number...

Sample number...

Information on the collected food sample:

Name of the dish	Ingredients used	Quantity of each ingredient (container used)	Quantity of each ingredient (grams/mls))
Details of preparation			

Appendix 3: Laboratory analyses

Moisture content determination

The determination of moisture content was done according to standard oven drying method explained by AOAC (1995). Food samples were weighed and the weight recorded as (W_1) and then placed in a pre-weighed crucible (W_2) and then dried in an oven set at 105°C for 24 hours. After 24 hours the crucible with content was then cooled in desiccators and re-weighed again and then recorded as (W_3) until it attained a constant weight. The amount of moisture in percentage was calculated as follows:

$$Moisture\ content = \frac{W1 - (W3 - W2)X100}{W1}$$

Crude ash content determination

Ash content was determined using a muffle furnace as described in standard method (AOAC, 1995). 2 g of the collected sample was weighed in a pre-weighed crucible and then placed in a furnace that was set at 550^{0}C for 3 hours until it attained a constant weight. The ash was then weighed and expressed as percentage of the original sample weight on dry weight basis.

Percentage ash was calculated using relationship:

$$\%\ Ash = \frac{Weight\ of\ the\ ash\ (g) \times 100}{Weight\ of\ the\ dry\ sample}$$

Crude protein content determination

The determination of Crude protein was done by using Kjeldah nitrogen measurement according to AOAC method 920.87 (AOAC, 1995). 2g of sample was placed in Kjeldah flask to which 25ml concentrated sulphuric acid was added. One Kjeldah tablet was added in the flask and the content boiled into a micro Kjeldah set up until a clear solution was obtained. The content was cooled to room temperature and connected to the distillation unit containing 100ml of 50% v/w NaOH. The condenser was dipped into a flask containing 100 ml of 0.5 N Sulphuric acid. Distillation was allowed to proceed until 150ml was collected. The collected solution was then titrated with 0.5 N using methyl red indicator. The percentage of protein nitrogen was determined and the value obtained was multiplied by factor (6.25) to get the percentage of crude protein.

$$\% \, Nitrogen = \frac{0.01401 \times (Titre\,(mls) - blank\,(mls)) \times concentration\ of\ acids\ in\ molarity}{Sample\ weight}$$

$$\% \, Crude\ protein = \% \, N \times Factor$$

Fat content determination

The fat content was determined by solvent extraction method (AOAC, 1995) whereby the samples were mixed up with Ethyl ether, the aqueous phase was allowed to separate. Decantation was done to collect the aqueous phase, and the concentration of lipid in the solvent was determined by evaporation of the solvent and measuring the mass of lipid remaining

$$\% \text{ Lipid} = \frac{\text{Weight of lipid}}{\text{Weight of the sample}} \times 100$$

Crude fiber content determination

Crude fiber was determined by ANKOM technology-9/99 using AOAC (1995). The reagents used included sulphuric acid solution, sodium hydroxide and acetone. The analysis involved digestion of the sample in acid followed by alkali and acetone. The residue was then filtered and dried at 105°C for 2-3 Hours. It was then ashed in a pre weighed crucible for 2 hours at 550°C

$$\text{Crude fiber content} = \frac{((C - B) - (E - D))X100}{A}$$

Where;

A = weight of sample (g)

B = Bag weight (g)

C = Bag + dry residue (g)

D = Crucible weight (g)

E = Crucible + ash (g)

Carbohydrate determination

The carbohydrate content of the collected samples was calculated as the percentage difference (AOAC, 1995). The following formula was used:

$$\% \, CHO = 100 - (\% \text{ Crude protein} - \% \text{ Crude fibre} - \% \text{ Crude fat} - \% \text{ ash})$$

Energy values

Energy value was calculated using the Atwater's conversion factors. Energy values for collected samples were calculated by multiplying percentage fat, percentage protein, percentage carbohydrates by the Atwater factors of 9, 4, and 4 respectively (AOAC, 1990).

$$Energy = (9 \times \%\, Crude\ fat) + (4 \times \%\, Crude\ protein) + (4 \times \%\, Carbohydarte)$$

Mineral (iron, magnesium, zinc, phosphorous, copper, potassium, sodium, manganese and calcium) content determination

The ash content was used for analysis of the minerals according to the AOAC (1990) procedures. The ash was dissolved in 20 ml of 1 N HCL, and heated for 5 minutes at 80-90°C. The solute was then transferred quantitatively to a 100ml volumetric flask and made to level with distilled water. Zinc, magnesium, phosphorous, calcium, copper, manganese, potassium, sodium and Fe, was determined.

$$Mineral\ content\ (mg/100) = \frac{R \times DF \times 100}{S \times 1000}$$

Where R= Reading value, DF = Dilution factor, S = Sample weight