IMPROVING SAFETY AND QUALITY OF COMPLEMENTARY FOODS FOR CHILDREN AGED 6-23 MONTHS IN RURAL AREAS OF MALAWI THROUGH THE HAZARD ANALYSIS AND CRITICAL CONTROL POINT STRATEGY

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A thesis submitted to the Graduate School in partial fulfilment for the requirements of the Doctor of Philosophy degree in Nutritional Sciences of Egerton University

EGERTON UNIVERSITY

APRIL 2019

DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been presented in this or any other University for any degree.

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DEDICATION

This work is dedicated to my wife Victoria and my daughter Thandiwe

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ABSTRACT

The prevalence of stunting is very high in Africa (33.9%) despite global decline from 32.6 to 22.2% between 2000 and 2017; and over 33% of all stunted children live in Sub Saharan Africa. In Malawi, 37.1% of under-five children are stunted, 12% are underweight and 3% are wasted. Dedza district has very high prevalence of stunting (43%) despite various interventions to improve child nutrition. The most mothers do not follow standard practices of ensuring food safety, hygiene and dietary diversity when preparing food. Lack of hygiene may lead to microbial contamination of food. This study targeted mothers, caregivers and children aged 6-23 months with the aim of determining child feeding practices, child nutritional status, prevalence of microbes and aflatoxins in complementary foods and developing a strategy to prevent microbial contamination and growth of moulds in food using the Hazard Analysis and Critical Control Point (HACCP) approach. A cross sectional nutrition survey was conducted to determine child-feeding practices and to assess nutritional status among 303 caregivers and 306 children respectively. Samples of maize flour from 40 households were analysed for moulds, yeasts and coliform presence using culturing laboratory methods. Aflatoxin was analyzed using High performance Liquid Chromatography (HPLC). Focus group discussions were conducted to identify critical control points and sources of food contamination among mothers and caregivers. A training intervention was developed using the HACCP approach and 40 mothers and caregivers randomly selected from the original sample of 303 were trained and evaluated after six months. Data were analysed using Microsoft Excel, SPSS and WHO Anthro to generate descriptive statistics and z scores for anthropometry indices. Results showed that the majority of mothers (82%) were not following recommended child feeding practices. A total of 47.1% of the children were stunted, 15.5% were underweight and 2.3% were wasted. About 86% flour samples were contaminated with moulds (2.04±0.75 $\log_{10}$ CFU/g), yeast (1.38±1.11 $\log_{10}$CFU/g) and coliforms (1.40±1.06 $\log_{10}$CFU/g). Aflatoxin B1 (0.37±0.86 ppb) was detected in 60.6% of the flour samples. After training, more mothers and care givers (82.5%) adopted recommended hygiene practices than at baseline (37.5%) and diarrhea prevalence declined from 28.7% to 8.5% among children. From the results, it can be concluded that child feeding practices are unsatisfactory in rural areas of Malawi and that training of mothers and caregivers may improve food hygiene practices. It is therefore recommended that the role of hygiene in food preparation practices should be integrated into the infant and young child feeding policy in Malawi.

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LIST OF SYMBOLS AND ABBREVIATIONS

AFB_1	Aflatoxin B1
AFM_1	Aflatoxin M_1
ANOVA	Analysis of variance
ARI	Acute Respiratory Infection
Aw	Water Activity
BMI	Body Mass Index
CAC	Codex Alimentarius Committee
CABMACC	Capacity Building for the Management of Climate Change
CCP	Critical Control Point
CFU	Colony Forming Units
CI	Confidence Interval
CIYCF	Community Infant and Young Child Feeding
COHA	Cost of Hunger
COMESA	Common Market for Eastern and Southern Africa
DAES	Department of Agriculture Extension Services
DCCMS	Department of Climate Change and Meteorological Services
DHS	Demographic and Health Survey
DEFF	Design Effect
DNA	Deoxyribonucleic Acid
EPA	Extension Planning Area
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
FGD	Focus Group Discussion
FGR	Foetal Growth Restriction
GDP	Gross Domestic Product
HACCP	Hazard Analysis and Critical Control Point
HAZ	Height for Age Z scores
HPLC	High Performance Liquid Chromatography
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy and Research Institute
IgA	Immune globulin A
IITA	International Institute for Tropical Agriculture

IUGR	Intrauterine Growth Retardation
IYCN	Infant and Young Child Nutrition
LUANAR	Lilongwe University of Agriculture and Natural Resources
MAPAC	Malawi Programme for Aflatoxin Control
MBS	Malawi Bureau of Standard
MDD	Minimum Dietary Diversity
MG	Malawi Government
MOAFS	Ministry of Agriculture and Food Security
MOH	Ministry of Health
MPN	Most Probable Number
MUAC	Mid Upper Arm Circumference
MWK	Malawi Kwacha
NASFAM	National Association of Smallholder Farmers in Malawi
NECS	Nutrition Education and Communication Strategy
NEPAD	New Partnership for African Development
NFS	National Foundation of Sanitation
NHSRC	National Health Sciences Research Committee
NMS	National Micronutrient Survey
NRR	Non Response Rate
NSO	National Statistical Office
PACA	Partnership for Aflatoxin Control
PATH	Program for Appropriate Technology in Health
PEM	Protein Energy Malnutrition
PhD	Doctor of Philosophy
SD	Standard Deviation
SGA	Small for Gestational Age
SMART	Standardized Monitoring and Assessment of Relief and Transitions
SPSS	Statistical Package for Social Sciences
TIPS	Trials of Improved Practices
TVC	Total Viable Count
UNESCO	United Nations Education and Scientific Commission
UNICEF	United Nations Children’s Fund
USAID	United States Aid for International Development

USD	United States Dollar
WAZ	Weight for Age Z scores
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WHZ	Weight for height Z scores

OPERATIONAL DEFINITIONS OF KEY TERMS AND CONCEPTS

:Thanzi ORS":	Name given to home-made fluid for managing diarrhoea in Malawi. It is composed of four parts sugar, one part salt in 1000 milliliters of water (1 L) and is given to the child to hydrate the body and replenish electrolytes in the body.
"Likuni Phala":	This is a local name of a commercially processed complementary food in Malawi. It is made of a blend of maize and soybeans in the ratio of 4:1. The complementary food is fortified with micronutrients such as vitamin A and is sold through commercial channels.
Caregiver:	Any adult person that is responsible for the day to day care of a child
Colony forming units (cfu):	This is a mould or yeast or bacteria that are capable of living and reproducing to form a group of the same moulds, yeast or bacteria. The cfu is used to describ the number of active, live organisms in a laboratory sample
Complementary food:	This is the food which is introduced to an infant at the age of 6 months to complement breastfeeding. At this age, the breast milk does not supply adequate energy and nutrients to the infant. So, complementary food provides energy and nutrients to fill the deficit
Critical control points:	These are the points in the production process where an action can be taken to prevent, eliminate, or reduce a food safety hazard to an acceptable level.
Critical limit:	This is a limit at which a hazard is acceptable without compromising food safety.
Food Security:	Condition which exists when all people at all the time have nutritionally adequate, safe and culturally acceptable food for an active health life
Hazard control:	The measures that can be taken or activities that can be done to prevent or control the hazard.
Hazard:	Any factor that can cause a food product to be unsafe for consumption
Locally processed complementary food	This is complementary food that is locally produced and prepared by the mother at household level.

Nutritional status This is the condition of the body resulting from the balance of nutrient intake and energy expenditure. When energy expenditure is higher than intake, one becomes undernourished and when energy intake is higher than expenditure, one becomes over nourished.

Stunting: This is a condition where a child fails to attain its potential height in relation to its age.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The problem of malnutrition, especially undernutrition is widespread throughout the world. Malnutrition is the condition that develops when an individual's energy and dietary intake is below or above recommended intakes. Malnutrition can be defined as undernutrition when an individual's energy and nutrient intake does not meet the individual's needs, it may also result from inadequate care and infectious diseases. Malnutrition may also be overnutrition, when energy and nutrient intake are supplied above the individual's needs (Veneman, 2009). In addition to biomedical and clinical indicators of malnutrition, other indicators of malnutrition which include stunting, underweight and wasting, which are indices used to measure growth in children (Gibson, 1990). Stunting is an indication that the child is too short for its height. It is indicated by height for age (HAZ) below minus two standard deviations from the median height for age of the standard reference population. Wasting indicates that the child is too thin for its height and the indicator used is weight for height (WHZ) below minus two standard deviations from the median weight for height of the standard reference population. On the other hand, underweight is measured by weight for age (WAZ) below minus two standard deviations from the median weight for age of the reference population which indicates nutrition deficit defined as low weight-for-age (Badham and Sweet, 2010).

The prevalence of undernutrition is high in Malawi with stunting affecting 37.1% of underfive children and 30.9% of children aged 6-23 months while underweight affects 12% of underfive children and 9.9% of children age 6-23 months. Wasting affects 3% of underfive children and 3.6% of children 6-23 months old (National Statistical Office {NSO} and ICF International, 2017). A high proportion of children are also affected by micronutrient deficiencies. The 2009 National Micronutrient Survey (NMS) of Malawi showed that over half of underfive children (51.7%) had anaemia and 53.9% suffered from Vitamin A deficiency (NSO, 2009). However, 2015-2016 Demographic and Health Survey (DHS) results showed that the proportion of underfive children suffering from anaemia increased from 51.7% in 2009 to 63% while those suffering from Vitamin A deficiency declined from 53.9% in 2009 to 3.6% in 2016 (NSO and ICF, 2017a). These statistics suggest that there must be other factors that contribute to high prevalence of undernutrition among children.

The common locally processed complementary food in rural areas of Malawi is usually thin porridge made of 7% maize flour (97% extraction maize). This porridge is low in energy and usually provides 105KJ of energy instead of 151KJ per 100g (Hotz and Gibson, 2001). The consistency (thickness) of the porridge is increased as the child's age increases to about 9 months. Sometimes groundnut flour is added to the porridge to increase its energy content. The challenge is that foods such as maize, sorghum and groundnuts are susceptible to fungal contamination which produces mycotoxins in foods. Examples of species of moulds that produce mycotoxins include *Aspergillus, Fusarium, Trichoderma,* and *Stachybotrys (*Etzel, 2002). Examples of mycotoxins are Aflatoxins, Fumonisin, Cyclopiazonic acid, Deoxynivalenol and ochratoxin.

It has been found that feeding children with complementary foods that are contaminated with pathogenic microbes such as bacteria, coliforms, fungi and exposure to aflatoxin contributes to infections and undernutrition in young children (Khlangwiset and Wu, 2010). Prevention of microbial and fungal contamination of complementary foods may therefore contribute to reduction of exposure of children to aflatoxin which may eventually contribute to reduction in stunting and underweight. However, a few studies on the safety of complementary foods have been conducted in Malawi and information on contamination of complementary food with coliforms and aflatoxin is not readily available. This study therefore contributes to scientific knowledge and literature on strategies that can ensure safety of complementary foods in rural areas of Malawi.

1.2 Statement of the problem

There is high prevalence of undernutrition in Malawi which may be attributed to inadequate energy and nutrient intake by the children due to lack of dietary diversity and low meal frequency. In addition, the complementary foods are mainly prepared from maize flour which is sometimes mixed with legumes such as groundnuts. Maize and groundnuts are susceptible to mould infestation and aflatoxin contamination. Aflatoxin causes growth failure in children and leads to weakening of the immune system which makes children vulnerable to different infections. The majority of mothers and caregivers do not use standardized recipes and recommended hygiene practices when handling and processing foods. Grains are not sorted or washed before processing into flour for complementary foods. These processes may lead to incorporation of grains that are infested and contaminated with pathogenic microbes including moulds which may produce aflatoxin that is detrimental to the health of the children. Foods are stored in environments where temperature and moisture are not controlled and the storage conditions are not standardized. Such environments provide favourable conditions for the growth of microbes such as moulds and production of aflatoxin. The majority of mothers and caregivers do not wash hands and cooking utensils with detergents such as soap before handling and preparing complementary foods. This may result in food contamination with bacteria and other microbes which cause diarrhoea and other foodborne illnesses.

1.3 Objectives of the study

1.3.1 Overall objective

The overall objective of this research was to determine microbial and aflatoxin contamination in infant and young child feeding and to develop a strategy to control the occurrence of pathogenic microbes and mycotoxins in complementary food of children 6-23 months old.

1.3.2 Specific objectives

i. To determine the infant and young child feeding practices among mothers and caregivers of children aged 6-23 months in Mayani Extension Planning Area (EPA), in Dedza district.
ii. To assess the nutritional status of children aged 6-23 months in Mayani EPA, in Dedza district.
iii. To determine the presence of aflatoxins and to enumerate the occurrence of moulds and coliforms in locally processed complementary foods in the study area.
iv. To determine the sanitation and hygiene protocols used by mothers and caregivers and to develop a HACCP intervention for training.

1.4 Hypotheses

There is no significant difference between the proportion of mothers who adhere and those who do not adhere to the recommended infant and young child feeding practices in Mayani EPA of Dedza district.

There is no contamination of locally processed complementary food with moulds, yeast, coliforms and aflatoxin among rural households in Mayani EPA in Dedza district.

1.5 Justification and significance of the study

Lack of standard protocols for storage of complementary foods and poor hygiene practices expose complementary foods to microbial and mycotoxin contamination in rural areas of Malawi. If not prevented or controlled, these microbes and mycotoxins may result in foodborne infections and diseases which may lead to poor health and undernutrition in children. This study was therefore conducted to develop an intervention using the HACCP approach to prevent microbial contamination of complementary foods and to reduce aflatoxin levels in complementary foods to make them safe for child feeding. The study has identified and recommended practices that should be followed to prevent microbial and aflatoxin contamination of locally processed complementary foods in Malawi. The study is therefore beneficial to the communities because it will improve food safety and child feeding practices among mothers and caregivers.

CHAPTER TWO
LITERATURE REVIEW

2.1 The problem of malnutrition at global level

The joint estimates of child malnutrition by United Nations Children's Fund (UNICEF)-World Health Organization (WHO) and the World Bank (WB) (2018) show that prevalence of stunting has been declining globally since the year 2000, from 32.6 percent to 22.2 percent and the number of children affected dropped from 198 million to 151 million by 2017. However, prevalence of stunting remains very high in West and Central Africa (33.7%), Eastern and Southern Africa (34.1%) and South Asia (35%). On average, over one third of all stunted children live in Sub Saharan Africa. The World Health Organization estimated that globally, about 6.3 million children under five years of age died in 2013 and that 45% of the deaths were attributed to undernutrition.

The major contributing factors to undernutrition, illnesses and deaths in children include contaminated water and foods, inadequate infant and young child feeding practices and micronutrient deficiencies. A qualitative study conducted in Bangladesh by Rasheed, Haider, Hassan, Pachon, Islam, Jalal and Sanghvi (2011) using trials of improved practices (TIPS) showed that nutrition of the children deteriorated rapidly due to lack of understanding of the child's nutrition needs and insufficient time for feeding children by mothers. Environmental factors and foetal growth restriction (FGR) and preterm births have also been identified globally as risk factors for stunting (Danael, Andrews, Sudfeld, Fink, Mc Coy, Peet, et al., 2016). Mothers who conceive while undernourished do not gain optimum weight during pregnancy resulting in delivery of babies that may be small for gestational age (SGA) or they are delivered before full term (preterm). Environmental factors such as poor sanitation may result in children suffering from frequent episodes of diarrhoeal diseases due to contamination of complementary foods that may also lead to wasting and stunting among the children if not prevented or controlled.

The negative consequences of undernutrition on national socioeconomic development are enormous and it is imperative that governments should allocate adequate resources to improve nutrition and reduce undernutrition among communities. The results of a study on the cost of hunger (COHA) in Africa, conducted by the African Union, supported by the New Partnership for African Development (NEPAD) and the World Food Programme (WFP) with financial support from the United Nations Economic Commission for Africa (UNECA) revealed that African countries are experiencing huge economic losses through failure to address malnutrition (Malawi Government {MG}, 2015a). Results of the Cost of Hunger in Malawi released in 2015 showed the Social and Economic Cost of Child Undernutrition on health, education and on productivity.

The study revealed that estimated data from the 2010 DHS (NSO, 2010), showed that there were 862,477 clinical episodes in 2012, and out of these, 176,748 were episodes of diarrhoea, fever, respiratory infections and anemia which are associated with the higher risk of children being underweight. There were further 685,728 cases of underweight children and this generated a total cost of MWK 11.4 billion with only 42.5 percent of the episodes receiving proper health attention. The study further showed that between 2008 and 2012, the deaths of 23% of all the children who died were associated with undernutrition in Malawi. The study also showed that 59.9% of the working-population in Malawi had suffered from growth retardation before the age of five years. On education, the study showed that stunted children had an incremental risk of 5.3 percent to repeat a class compared to those not stunted and that overall, 18% of those who repeated a class in 2012, were stunted and this cost MWK3.4 Billion of which 65.3% was borne by the families. The low education attainment among stunted children is likely going to have impact on the level of income one would earn in adult life.

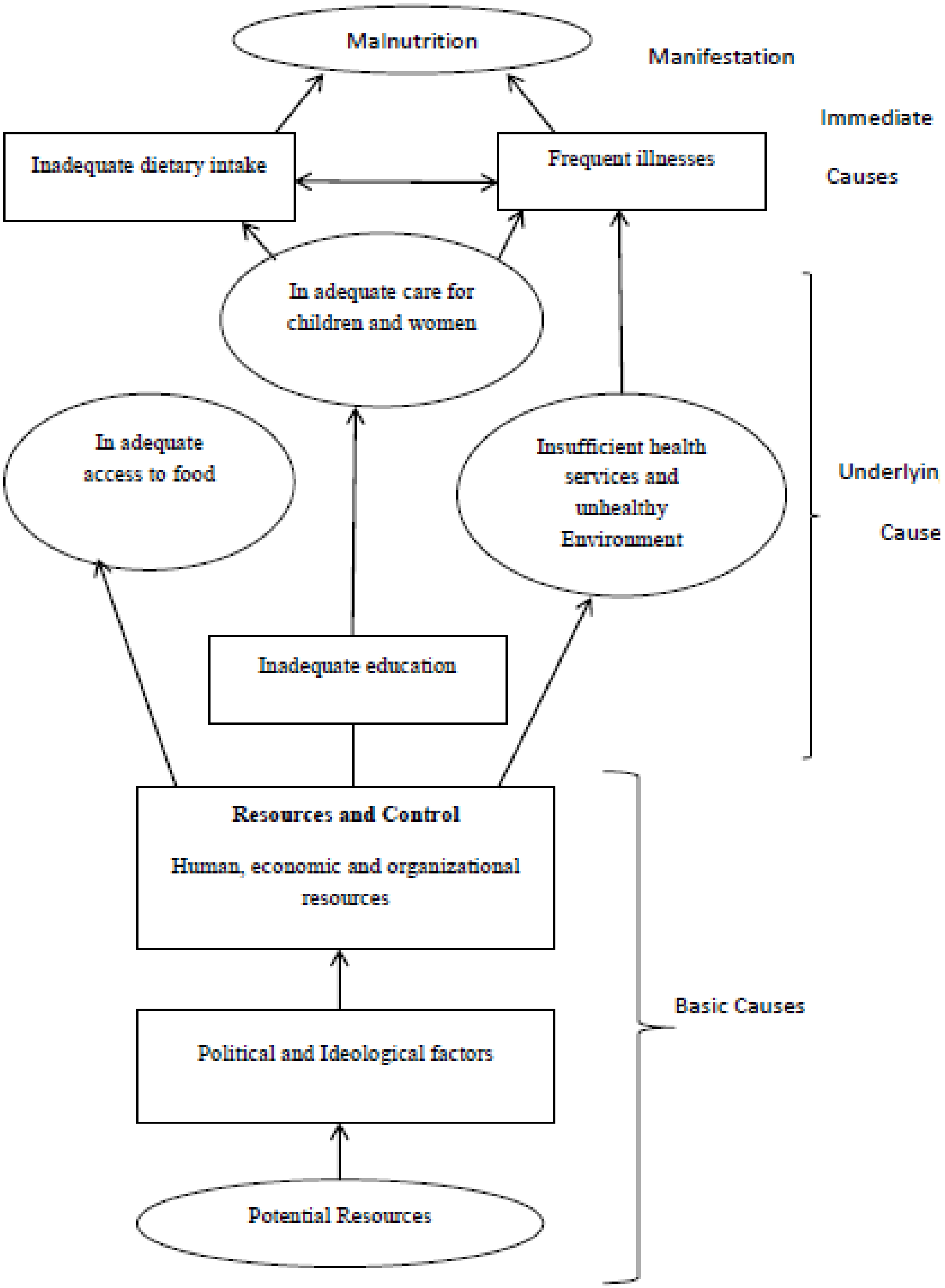
On Productivity, the study showed that out of the estimated 5 million people who work in manual activities, 65.6 percent were stunted as children and that this represented an annual loss in potential income due to lower productivity that is over 6.7 Million United States Dollars (USD), about 1.15% of Malawi's Gross Domestic Product (GDP). Overall, the study showed that an estimate of USD597 Million (10.3% GDP) was lost in 2012 because of undernutrition. These statistics underline the significance of reducing undernutrition among pregnant women and infants and young children so as to realize economic growth and productivity at national level. There is therefore need to implement high impact nutrition sensitive interventions on maternal and child nutrition and increasing awareness among policy makers and the general populace about the negative consequences of hunger and malnutrition.

2.2 Factors associated with undernutrition

The causes of undernutrition that include stunting, underweight, wasting and micronutrient deficiencies are complex and different factors are involved in the etiology of malnutrition. The Conceptual framework of causes of malnutrition developed by UNICEF is presented in **Figure 1**. This framework demonstrates the hierarchical nature of the causes of malnutrition and clearly demonstrates that not one strategy can be used to successfully eliminate malnutrition (UNICEF, 1997). The causes of malnutrition are categorized as basic, underlying and immediate causes. The basic causes of malnutrition include policy issues that affect the formal and informal infrastructure, political ideologies and distribution and utilization of resources of a country. This implies that a country needs to have well laid down infrastructure for delivery of efficient and effective health systems that will support the health and nutritional status of its citizens.

The underlying causes include household food insecurity, illiteracy, insufficient health services and unhealthy environment. These factors deal with the way communities and household manage their lives. Allocation and equitable distribution of adequate food to household members and support for education and good health seeking behaviours may assist to reduce the underlying causes of malnutrition. The immediate causes of malnutrition are inadequate food intake and frequent illnesses. Inadequate dietary intake may be a reflection of unavailability of food at household level or failure by individual household members to get adequate food while frequent illnesses may prevent the child from eating and utilizing food due to lack of appetite or other complication leading to undernutrition. Understanding this complex nature of the causes of malnutrition is the key to the development of interventions that may reduce prevalence of malnutrition including stunting, underweight and wasting among young children.

This study conducted in Dedza district in Malawi contributes to improvement and reduction of the underlying causes of malnutrition. This study implemented an education intervention that contributed to improvement in hygiene practices among mothers when handling and processing complementary foods and improving the sanitation and hygiene of the environment where food was kept and also where children were being raised. Improvement in the knowledge of mothers on child care practices which may also contribute towards reduction of the underlying causes of malnutrition. Equipping mothers with knowledge and skills improves maternal child care and health seeking behaviours.



Source: UN ACC/SCN (1997)

Figure 1: Conceptual Framework of causes of Malnutrition

2.2.1 Maternal characteristics

2.2.1.1 Maternal nutrition and health

Maternal nutrition and health greatly influence a child's nutritional status. Women who are underweight or anaemic before and during pregnancy can give birth to babies that have low birth weight (weight < 2.5 kg). Undernutrition during pregnancy affects fetal growth and determines both stunting of linear growth in the first two years of life and subsequent obesity and non-communicable diseases in adult life (Black et al., 2013). At the same time, maternal overweight and obesity are associated with maternal morbidity, preterm birth and increased infant mortality. Undernutrition increases the risk of maternal death during childbirth (UNICEF, 2009). The problem of stunting starts during the mother's period of pregnancy. The woman is expected to gain an average weight of 12.5kg for her to give birth to a normal healthy infant (Schutz and Garrow, 2000). Low energy and nutrient intake during pregnancy therefore results in low birth weight which persists into the first two years of life. Studies conducted in rural areas of Southern Malawi have shown that Malawian children fall short of 10cm in height from the WHO median by the age of 3 years (Thakwalakwa, Phuka, Flax, Maleta and Ashorn, 2009). Figure 2 illustrates the cumulative deficit in height of Malawian children compared to the WHO median.

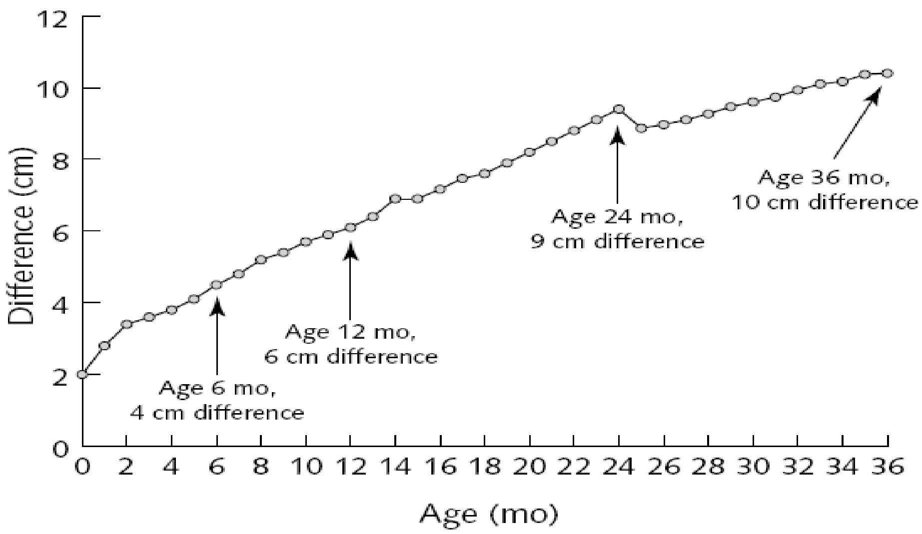


Figure 2: Cumulative difference in stature of children

Source: Maleta et al (2003)

Figure 2 shows that of the total 10 cm deficit in height in 3 years, 20% is already present at birth, 20% occurs between 0-6 months, 50% occurs between 6 and 24 months while 10% occurs between 24 and 36 months. A study conducted in Chikwawa district by Kalanda (2006) demonstrated that maternal anthropometry before and during pregnancy predict the health of the newborn babies. Low body mass index (BMI) was associated with intrauterine growth retardation while low maternal mid upper arm circumference (MUC) was associated with low birth weight (<2500kg). In the Lancet of January 2008, Black et al., (2008) indicated that maternal undernutrition is associated with intrauterine growth retardation (IUGR) and short maternal height (<154 cm) is associated with obstetric complications and neonatal deaths. On the other hand, maternal overweight and obesity during pregnancy increases the risk of child obesity that may continue into adult life (Black et al., 2013). Children that are born with low birth weight are susceptible to increased mortality, retarded growth, long term consequences on mental and physical development, learning difficulties and poor school performance.

Maternal dietary practices have also been identified as motivators for appropriate child feeding. Results of studies conducted in Cambodia, Haiti and Ghana (PATH, 2012) showed that mothers that ate diversified diets were also feeding their children with diversified complementary foods which resulted in improved nutritional status of the children. Availability of diversified and adequate food at household level may therefore have significant effect on maternal and child nutrition. Improving household food security should therefore be part of the effort to improve maternal health and nutrition (FAO, 2010).

2.2.1.2 Maternal education and cultural beliefs

Maternal education is associated with reduction in the prevalence of undernutrition in underfive children. Studies from Malawi, Tanzania and Zimbabwe show that the prevalence of undernutrition in children decreases with an increase in maternal education (Makokha, (2013). In a study that analyzed data from 2010 DHS for Malawi, 2009-2010 DHS for Tanzania and the 2005-2006 DHS for Zimbabwe, results showed strong association between prevalence of undernutrition and maternal education. The study showed that the threshold of maternal education above which it significantly improves child stunting and underweight was 9 years of schooling in Malawi and 11 years of schooling in Tanzania and Zimbabwe. In another study conducted by Kalanda (2006) in Chikwawa district in southern Malawi to determine morbidity incidence and growth pattern in Malawian infants in relation to time of introduction of complementary foods, maternal illiteracy was significantly associated poor complementary feeding practices. Improved maternal knowledge also translates into better child care practices (Thuita et al., 2002). A study conducted in Mangochi district in southern Malawi, found a positive association between education of the mother and prolonged breastfeeding (Vaahtera et al., 2001).

Other researchers have reported that education makes a woman conscious about the wellbeing of herself and her family and it gives the basic ideas about the path to wellbeing and also equips and encourages the mother to increase her knowledge on healthy living.

These studies implicitly show that improving maternal socioeconomic characteristics may lead to improvement in the nutritional status of the child.

However, results of a study on nutritional and health challenges of pastoralist populations in Kenya by Wayua (2017) showed that 13% of the mothers gave birth to low birth weight (<2.5 kg) babies and that pregnant women consumed restricted diets with the belief that they would have easy delivery. Cultural beliefs in this case resulted in intrauterine foetal growth restriction which resulted in low birth weight. The consequences of low birth weight include increased risk of neonatal death and undernutrition that may lead to reduced body size, impaired body composition and reduced muscle strength of the child. A study conducted by Chiutsi, Heil, Kalimbira, Masangano, Mtimuni, Krawinkel, and Jordan (2017) in Kasungu and Mzimba districts of Malawi in which mothers were trained in child feeding and hygiene practices using a training cascade model revealed that before the training, lack of community support to mothers led to poor child feeding and care practices. Preparation of porridge enriched with legumes was despised by grandmothers and spouses because it was out of the norm. The study further showed that after mothers were trained together with grandmothers and husbands, adoption of culturally accepted messages and use of recipes of locally available foods increased among the mothers. These findings show that community support to mothers may be instrumental in improving child nutrition and health since they may demystify some strongly held cultural beliefs about food.

2.2.1.3 Maternal occupation

Malnutrition is linked to poverty and low socioeconomic status. Studies show that that stunting tends to be low among children from families with higher socioeconomic status (Vitoro et al, 2008). Households with low socioeconomic status are resource constrained and may not provide adequate care to their children in terms of adequate nutrition and access to health services. Such households are also at risk of food and nutrition insecurity because of inability to acquire adequate and safe food and also difficulties in storing foods in proper environments.

Studies have further shown that children whose mothers work as business women and farmers are more likely to be stunted than children whose mothers worked as house wives (Fikadu, Assegid and Dube, 2014). High prevalence of stunting among children whose mothers work away from home may be attributed to the decreased contact time between the mother and the child which results in reduced duration of exclusive breast feeding resulting in early cessation of breast feeding and increased exposure to bottle feeding and improper complementary feeding. Similar findings were reported in a study conducted in India (Mittal et al, 2007) which showed increased chances of children being underweight if the mother was employed (46.15%) than when the mother was unemployed (37.8%). All these may have significant effects on the growth of the children.

2.2.2 Child characteristics

Child characteristics that are associated with the risk of being stunted include low birth weight (<2.5kg) birth order of the child. Children that are born to mothers with low body mass index tend to be born with low birth weight and other congenital malformations (Badham and Sweet, 2010). Low birth weight babies are vulnerable to frequent illnesses which further deplete nutrients from the body and cause growth failure (Mamiro et al., 2005). The birth order of the child also influences the onset of stunting among infants. Studies conducted in Ethiopia by Fikadu, et al., (2014), showed that children born and living with three underfive children were more likely to be stunted than children living in households with one underfive child. A meta-analysis of the Demographic and Health Survey data by in Egypt showed that high birth order and short birth interval significantly increased the odds of stunting among children (Zottarelli, 2007).

2.2.3 Environmental factors

Child nutritional status may also be affected by environmental factors that may include inadequate sanitation and water supply, in appropriate household food allocation and contaminated food and poor hygiene practices and unsafe storage and preparation of food. Water and sanitation plays an important role in complementary feeding practices. In appropriate disposal of wastes and use of contaminated water may contaminate complementary foods and lead to children suffering from diarrhoea which depletes nutrients from the body. Unhygienic practices during food preparation may also lead to food contamination and infections to the children. Food that is poorly stored may also be contaminated and become hazardous to the children. Children that are frequently ill will end up being stunted.

2.3 Recommended infant and young child complementary feeding practices

Feeding practices are important in the first 2 years of a child’s life. This period is a critical window for the promotion of optimal growth, health, and development in children (Black, 2008). Breast milk is the natural food for the human baby and supplies adequate nutrients for the first six months of life. The mother is expected to give the infant breast milk alone, and not even any water or liquid for the period up to the age of six months (World Health Organization, 2010). When an infant reaches the age of about six months, the milk alone is no longer sufficient in meeting nutrient requirements and other food (s) should be given in addition to the milk.

Figure 3 presents information on energy gaps that develop when a child reaches the age of six months which may not be met by breast milk alone.

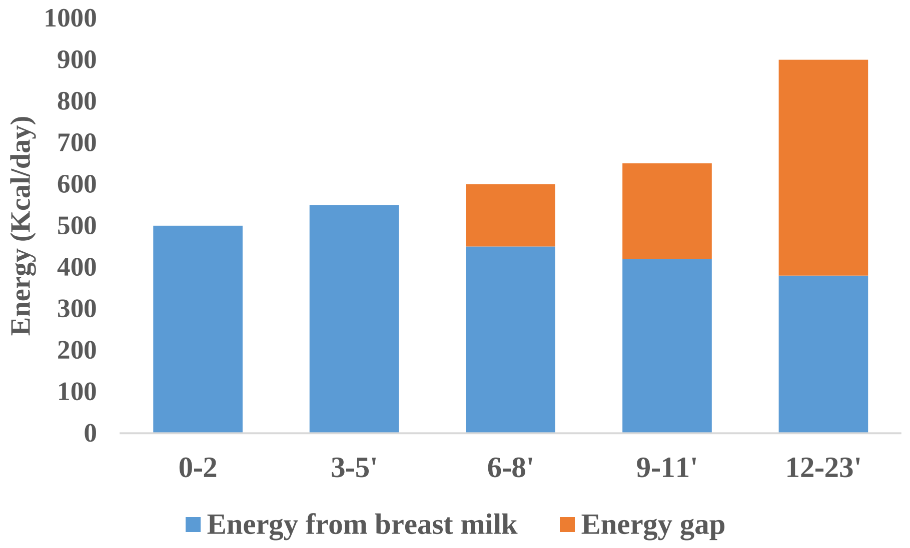


Figure 3: Energy required by age and the amount supplied from breast milk

Source: Malawi Govt. (2007)

Figure 3 shows that by the age of 6 months, breast milk alone may provide about 467 Kcal/day of energy but the infant may need about 650 kcal/day. The gap in energy requirement should therefore be filled by providing other foods in addition to breast milk. At six months of age, the infant is also old enough to eat other foods in addition to breast milk. Complementary feeding is the timely introduction of safe and nutritionally rich foods in addition to breastfeeding at 6 months of age and its duration is 6-23 months (Bhutta et al., 2013).

It is recommended that complementary feeding should be adequate in terms of the energy and nutrient needs of the child; it should be introduced at the appropriate age and not replace but rather augment intake from breast milk; should be safe from environmental and biological contamination and should be provided in a manner and style which is consistent with the child’s appetite and that feeding frequency and feeding methods should be appropriate for the age of the child (WHO, 2010). Appropriate complementary feeding practices have been reported to be significantly associated with child nutritional status (height-for-age z –scores {HAZ}) (Arimond and Ruel, 2004).

To promote appropriate Infant and Young Child Feeding (CIYCF), UNICEF in partnership with governments have developed country specific counseling packages which recommends that a mother should introduce other foods to the baby gently at six months of age in addition to breastfeeding (UNICEF, 2012). When giving complementary foods to the baby, the mother should consider the frequency of feeding the child, amount of food to give, the density of the food and how the food is utilized. The mother or caregiver should also observe good hygiene to avoid diarrhoea and other illnesses.

Further, it is recommended that practices for feeding young children aged 6-24 months should among others include increasing the feeding frequency as the child age increases. Providing complementary food at the recommended meal frequency ensures adequate supply of energy and nutrients to the children. Studies have shown that minimum meal frequency is associated with lower risk of underweight among children (Marriot, White, Hadden, Davies and Wallingford, 2012). The recommended meal frequencies for children of different age categories are three times a day for 6-9 months old, four times per day for 9-12 months and five times per day for children aged 12-24 months (WHO, 2010). It is further recommended that children aged 9-12 months and 12-24 months should be given one and two snacks per day respectively.

In addition to meal frequency, mothers and caregivers should also gradually increase food consistency and variety as the child age increases. Food that can easily be swallowed by the child at six months of age such as mashed foods should be provided. The foods should be energy dense and mothers should introduce finger foods (snacks that can be eaten by children alone) to children beginning around 8 months of age. Provision of foods from the family diet should start at about 12 months of age.

Complementary foods should prepared from a variety of foods that may supply different nutrients to the child. Foods such as vitamin A rich fruits and vegetables should be given to the child daily. To increase nutrient density in complementary foods, fortified foods and foods from animal sources should be included. Some studies have shown that increased dietary diversity is positively associated with increase in height-for-age (Bhutta et al.,2013) and that consumption of diversified and minimum acceptable diets in low income countries reduces the risk of stunting and underweight among children (Marriott, et al., 2012). Apart from ensuring diversity and nutrient density mothers and caregivers should create a favourable environment for feeding the children. Mothers should be aware of the cues that children give when they are hungry. Mothers should therefore feed the infants directly, help the infants to eat, offer favourite foods and talk or sing to the child while eating. Children should not be forced to eat but should be persuaded to eat. During illness, increase fluid intake by breastfeeding the child frequently. After the illness, give breast milk and food more often.

Good hygiene practices by mothers and caregivers are important elements in complementary feeding which ensures that children are provided with food that is safe and free from disease causing microorganisms. Personal hygiene should include washing hands with clean running water and detergents or soap before preparing food and feeding the child. Hygiene also includes use of clean utensils and storing food in safe and clean facilities.

It is important to follow recommended child feeding practices especially in the first 2 years of a child's life because it is a critical window for the promotion of optimal growth, health, and development in children UNICEF, 2011). Breast milk is the natural food for the human baby and supplies adequate nutrients for the first six months of life and at six months, the milk alone is no longer sufficient in meeting nutrient requirements. This is why complementary foods should be introduced to add onto the energy and nutrients supplied by breast milk. At such an age, children are well developed and matured enough to digest other foods in addition to milk. If not provided with complementary foods at that age, children may be undernourished and might start showing signs of energy and protein deficiency (UNICEF, 2011).

The World Health Organization (WHO) indicates that the greatest decline in nutritional status of children is seen between the ages of six months and two years. This is a critical nutritional window for children at which feeding should change from exclusive breastfeeding to receiving complementary foods in addition to continued adequate intake of breast milk (WHO, 2010). The recommended practices of complementary feeding require that complementary feeding should be adequate to meet the energy and nutrient needs of the child. The food should be introduced at the appropriate age of the child and should not replace but complement nutrient intake from breast milk. It is also recommended that the food should be safe from environmental and biological contamination and should be provided in a manner and style which is consistent with the child's appetite. The feeding frequency and feeding methods should be appropriate for the age of the child (WHO, 2010).

2.4 The magnitude of nutritional problems in Malawi

In Malawi, there has been a decline in prevalence of underweight and wasting among underfive children over the past decade. Prevalence of underweight has declined from 31% in 2001 to 13% in 2010 and prevalence of wasting has gone down from 5.5% to about 3.5% (NSO and ORC Macro, 2001; NSO, 2010). The Ministry of Health (MoH) indicated in the 2011-2016 Malawi Health Sector Strategic Plan that prevalence of Acute Respiratory infections (ARI) decreased from 19% in 2004 to 8.5% in 2006 and access to health services for treatment of ARI among underfive children increased from 19.6% in 2006 to 65.7% in 2010. The coverage of vaccination against measles and Polio III increased from 59% and 72% in 2004 to 93% and 85.6% respectively in 2010 (MG, 2011).

Prevalence of anaemia among underfive children declined from 80% in 2001 (NSO, 2009) to 54.8% in 2009 (NSO, 2009). However, the 2015-2016 DHS showed that prevalence of anaemia among underfive children had increased from 54.8% to 63% (NSO and ICF, 2017). Among women of child bearing age (15-49 years) prevalence of anaemia decreased from 47% in 2001 to 32% in 2009 (NSO, 2009). However, the prevalence of anaemia has increased to 33% between 2009 and 2016 (NSO and ICF, 2017). These statistics reflect deeply rooted health and nutrition problems among children under the age of five years and women of child bearing age in Malawi.

Local studies conducted in different districts of Malawi have reported high coverage of vitamin A supplementation (Above 85%) among underfive children (Care Malawi, 2013, Mtimun, Katundu, Nkhoma and Geresomo, 2008; Picado and Mtimuni, 2010). The United Nations Children's Fund (UNICEF) indicated that Vitamin A supplementation coverage rate increased from 57% in 2004 to 96% as of 2011 (UNICEF, 2011). The Malawi Government also formulated policies and strategies to promote good nutrition and health among its population. These included the National Food Security Policy (Ministry of Agriculture and Food Security [MG], 2005), Infant and Young Child Nutrition Policy (MG, 2007a), National Nutrition Policy and Strategic Plan (MG, 2007b), Nutrition Education and Communication Strategy (NECS) (MG, 2010).

Despite these interventions and progress made on reducing prevalence of underweight and wasting, prevalence of stunting among underfive children has remained high and no significant reduction has been achieved. The persistent high prevalence of stunting might also emanates from underlying causes of under-nutrition that include low household and family socioeconomic status that lead to low household incomes, poor child feeding and care practices, inadequate maternal education and lack of knowledge in appropriate food processing and utilization (MG, 2013). The trend of prevalence of stunting over the past three decades has been high with well close to half of all the children under five years of age being stunted. Results from the Malawi Demographic and Health Surveys (DHS) conducted over a period of thirty years show that prevalence of stunting has remained consistently high. The prevalence of stunting was 56% in 1992; 49% in 2000; 47.8% in 2004, 47.1% in 2010 and 37.1% in 2016 (NSO, 1992, NSO & ORC Macro, 2000; NSO & ORC Macro, 2004; NSO, 2010 and NSO & ICF, 2017). A survey conducted in Ntchisi district in Central Region of Malawi by the World Fish Center in 2009 to determine the contribution of fish to household dietary diversity and complementary foods showed that 49% of underfive children were stunted and 17.6% were underweight (Mtimuni et al, 2010).

In nutrition surveys conducted in Dowa district by Care International in 2012 and 2013 to assess the contribution of a nutrition project to child feeding and nutritional status, the results showed that respectively, 48.9% and 45.7% of underfive children were stunted while 13.1% and 18.4% were underweight (Care Malawi, 2012; 2013). Thakwalakwa et al., (2008) reported prevalence rates of stunting of 70% in a study of children aged 0-35 months in Mangochi district in Southern Malawi. Other studies have shown that about 5% of children in Malawi are born with low birth weight (<2500g) and that the majority (92%) of pregnant women do not gain ideal body weight (average weight gain <12.5kg) during pregnancy (Mulenga and Geresomo, 2011). Low weight gain during pregnancy is normally associated with poor maternal nutritional status which leads to constrained foetal growth in utero and low birth weight. There has been a general decline in the prevalence of underweight (31.1% in 2001, 22% in 2004, 14% in 2009 and 12% in 2016) and wasting (4.7% in 2001, 5.2% in 2004, 3.5% in 2005, 1.3% in 2009 and 3% in 2016) have declined over the years but the margin of reduction has been small (NSO and ICF, 2017). The World Health Organization puts the average rate of stunting in Sub-Saharan Africa at 40%. Despite the gradual decline in prevalence of stunting and other forms of undernutrition (underweight and wasting) Malawi is therefore one of the countries with the highest rates of stunting in Africa.

At the national level the prevalence of stunting varies from one region of the country to another with the highest prevalence in the Central Region (38.2%) followed by the Southern Region (36.6%) and the Northern Region (35.1%). Variations also exist in the prevalence of stunting between districts. In the Central Region, Mchinji district has the highest prevalence of stunting (44.0%) followed by Dedza (42.8%), Ntcheu (41.6%), Ntchisi (39.5%) and Dowa (39%) whose prevalence are way above the national prevalence (NSO and ICF 2017).

2.5 Consequences of malnutrition

The consequences of undernutrition especially stunting manifest throughout adult life (Victora et al., 2010). Stunting occurs in the first one thousand days of life (from conception to two years after birth). Studies have shown that the period between preconception and two years after birth provides a window of opportunity when adequate nutrition can have measurable and lasting impact on the growth, development, incidence of disabilities and susceptibility to disease or infection (Badham and Sweet, 2010). Targeting children that are younger than two years old with nutrition and care interventions will therefore provide them favourable conditions to attain their potential growth and development. Stunting is undesirable because once a child is stunted, the condition cannot be reversed. Stunted children enrol in school late because they look small for their age. Such children have low cognitive test scores and are more likely to fail and repeat classes than children who are not stunted (Martorell et al., 2010). Repeating classes results in poor learning and school performance and high dropout rate (Malawi Government, 2006). In turn, school underperformance leads to reduced productivity and low income earning capacity in adult life.

A study to evaluate a programme in Latin America that provided good quality complementary food to infant and young boys showed that in adulthood, the wages of those who were given good quality complementary food increased by 46 per cent compared to those who did not participate in the programme (Veneman, 2009). Stunted female children grow up into women at risk of obstetric complications because of small pelvic size and anaemia which impact on their risk of maternal mortality (Martorell et al., 2010). Studies have also shown that underfive children born to shortest mothers (height<145 cm) have a 40% increase in risk of mortality and poor birth outcomes (Ozaltin and Subramanian, 2010). Short women have higher maternal mortality rates and are more likely to have small and underweight babies than women with normal heights. Children that are undernourished grow up into adults who are more likely to suffer from non-communicable diseases such as diabetes, high blood pressure, heart disease, kidney disease and obesity than those who are not undernourished (Black et al., 2008).

To prevent stunting and its negative consequences, children should be provided with safe and adequate complementary food starting from the age of six months. The complementary food should be adequate in terms of the energy and nutrient needs of the child and free from environmental and biological contamination (WHO, 2010).Complementary food should be nutrient dense and balanced and this can be achieved by incorporating foods from different food groups. It is recommended that children should be fed complementary foods prepared from at least four food groups or more every day (Veneman, 2009). Studies have shown that the relationship between undernutrition and poor health is complex because poor health leads to undernutrition and a child who is undernourished has increased susceptibility to disease (Katona and Katona, 2008). Severe cases of undernutrition therefore result in death of the child.

2.6 Complementary feeding practices in Malawi

In Malawi, the local complementary foods are prepared by mothers or caregivers from the locally produced foods. These are different from the commercial complementary foods that are sold on the commercial market under different brand names such as Nestle Nestum, Nestle Cerellac, Baby mash and milk and other infant formulas. Traditional local complementary foods are commonly made from starchy staples such as maize, rice, sorghum, millet and cassava. Results from a nutrition survey conducted in Dowa and Kasungu districts by Care International in 2012 showed that the majority of young children (96% in Dowa and 97% % in Kasungu) consumed complementary foods prepared from maize only (Care Malawi, 2012). Results from a formative research conducted by PATH in 2010 to determine barriers and facilitators of optimal infant and young child feeding in Malawi using the trials of improved practices (TIPs) methodology showed that the majority of mothers believed that thin watery foods were best for young children aged below 10 months (Picado and Mtimuni, 2010). Mothers further believed that children who had not yet grown teeth could not eat thick porridge.

Complementary foods made of maize flour only are often bulky because they are watery and do not contain other ingredients such as legumes and animal source foods that may add energy dense nutrients such as fats and minerals and vitamins. The thin porridge is usually made of 7% maize flour (97% extraction maize) which is rarely enriched (Hotz and Gibson, (2001) indicated that this type of porridge usually provides 105KJ of energy instead of 151KJ per 100g. In addition to provision of complementary foods of low nutrient density, some mothers introduce complementary foods to their children too early (<6 months) or too late (>6 months). When introduced early, children may not be able to digest such foods and may end up with bloating or diarrhoea due to microbial contamination during preparation. When introduced later than six months, the children may not get adequate energy and nutrients from the breast milk. This may result in underfeeding and undernutrition.

A study conducted by Kalanda and others in rural areas of Chikwawa district of Southern Malawi in 2005 found that over 40% of the children aged 0-6 months had received complementary food by the age of two months and 65% by the age of three months (Kalanda et al., 2006). The study further showed that early introduction of complementary foods was strongly associated with increased risk of acute respiratory infections ($P<0.05$) and lower weight for age at 3 and 6 months. Mtimuni et al (2008), in a baseline survey conducted in Ntchisi district in 2007 found that 44.6% of children were introduced to complementary foods before the age of six months and 3.4% were introduced after six months. These findings demonstrate that in Malawi, the majority of mothers do not follow the recommended complementary feeding practices.

The government of Malawi and other organizations are promoting the use of maize-soy blend complementary food, locally called *Likuni Phala* among mothers and caregivers. *Likuni Phala* is composed of maize and soy beans in the ratio of 4:1. Soybean (*Glycin max*) is one of the widely promoted legumes as an important source of protein. Soybean has protein content of 40% which is higher and cheaper than that of beef (18%), chicken (20%), fish (18%) and groundnut (23%) (Institute for International Agriculture {IITA}, 2014). A portion of 100g of *Likuni Phala* provides 396kcal energy, 16g protein and 7.7g fat (MG, 1992). This nutrient composition is more than that provided by the ordinary porridge made from maize flour which is commonly used for infant porridges in Malawi. *Likuni Phala* is also produced commercially and sold through the commercial market and its price is out of reach of most rural households. Preparation of maize-soy blend flour in the home requires more time and most mothers find using maize flour an easier and quicker option (Maleta, 2006).

There are efforts to encourage mothers to add other ingredients to the porridge to make it tasty and nutrient dense. Some of the ingredients incorporated include orange fresh sweet potatoes to improve vitamin A content, cooking oil to increase energy content, groundnut flour and mashed vegetables. In some cases, flours from germinated or fermented cereals are used in some communities to increase energy density and to reduce the bulkiness of the complementary foods (Tatala, 2007). Porridge from germinated cereals contains more energy and nutrients in a smaller volume because less water is used. Germinating cereals facilitate better absorption of iron and easy digestion and flours from germinated cereals are safe because germs cannot grow easily in fermented porridge. Some studies have been conducted to improve protein values of complementary foods in Malawi such as incorporating meat and fish powders into complementary foods (Chitowe, 2013). However, due to lack of money for purchasing ingredients and lack of appropriate technologies to process and prepare such types of foods, many communities do not follow these techniques (Aworh, 2008). This therefore makes it imperative that simple and cheap technologies or methods of food preparation should be tested with mothers and caregivers to improve the quality and safety of complementary foods.

2.7 Aflatoxin and complementary foods

The challenge of using legumes such as groundnuts and soybeans to enrich the complementary foods in Malawi is that this practice competes with the marketing of the legumes. Legumes fetch more money on the market and most households prefer selling the legumes to adding to complementary foods. In cases where groundnuts are processed and added to complementary foods, the inferior grains such as the shriveled, damaged, discoloured and insect infested which are susceptible to mould and aflatoxin contamination are used (Soko, Matumba, Gokah and Kauma, 2011). This may provide a window of opportunity for aflatoxins to go into complementary foods and affect the nutritional status and the health of the children. The other problem is that food safety and hygiene aspects have not been incorporated in most child feeding programmes in Malawi. Dietary staple foods such as maize, sorghum and groundnuts are susceptible to fungal contamination (Gong et al, 2003).

Storage of cereals under unregulated temperatures and humidity and failure to sort and select clean grains of cereals and legumes may also lead to contamination of complementary foods with moulds (Matumba, Chamango and Munthali, 2012). The moulds may produce mycotoxins such as aflatoxin that may cause growth retardation in children resulting into stunting. Examples of species of moulds that produce mycotoxins include *Fusarium, Trichoderma,* and *Stachybotrys (*Etzel, 2002). The common mycotoxins that affect human health include Aflatoxin which is common in maize, groundnuts, figs, tree nuts (AFB1) and milk and milk products (AFM1). Aflatoxin is produced by *Aspergillus flavus and Aspergillus* *parasiticus* and is the most potent mycotoxin that may affect the human health. *Aspergillus* species grow at temperature ranging from 13°C to 37°C and relative humidity of 85% (FAO, 1998). Aflatoxin is stable to heat and may be destroyed at temperatures ranging from 268 to 269°C and thrives at water activity (Aw) of 0.82 (Lusweti, 2014). Aflatoxin mostly affects the liver and may cause cance**r** *(carcinogenic) (*Etzel, 2006). Prolonged exposure to low dose of aflatoxin is associated with impaired growth in children (Baumgartner, 2005). Another common mycotoxin that contaminates maize is *Fumonisin* which is produced by *Fusarium moniliforme. S*tudies have shown that consumption of contaminated maize and maize products may lead to neuro-tube defects in new born babies (Gelineau-van et al, 2009). Neuro-tube defects are normally associated with folic acid deficiency in pregnant women. This may imply that consumption of mycotoxins may also interfere with folic acid metabolism during pregnancy.

Other mycotoxins of health importance include Cyclopiazonic acid, Deoxynivalenol and *Ochratoxin.* Cyclopiazonic acid is produced by *the* fungi *Aspergillus flavus, Penicillium and aurantiogriseum* which contaminate cheese, groundnuts, millet and maize (Adams et al, 1999). Cyclopiazonic acid causes convulsions when consumed in food. *Deoxynivalenol is* produced by *Fusarium* and *graminearum* in contaminated cereals. Deoxynivalenol causes vomiting and the affected person may refuse to eat (Adams et al, 1999). *Ochratoxin is produced* by *Penicillium verrucosum and Aspergillus* ochraceus and is common in maize, other cereals and coffee beans. Aflatoxin is the most common contaminant of groundnuts and cereals in the Tropical Sub-Saharan Africa and the most widely studied potent mycotoxin to animals and humans (Kaaya and Warren, 2005).

A study conducted by ICRISAT in Malawi in 2008 and 2009 showed that most soils are highly contaminated with *aflatoxin* which also contaminates the food crops grown in such soils (Monyo, 2012). The McKnight Foundation in collaboration with ICRISAT and the National Smallholder Farmers Association of Malawi (NASFAM) in 2009 conducted a study to map the occurrence, significance and distribution of Aflatoxin in major groundnut producing districts of Malawi. The study collected samples of groundnuts and maize from farmers' households, local markets, shops and supermarkets (Monyo, 2010). Results showed that the prevalence of Aflatoxin in groundnut and maize samples from farmers' households ranged from 0 to 3871 parts per billion (ppb) and 0ppb to 1335 ppb respectively. Aflatoxin levels of above 100ppb were detected in 25% of groundnut samples from market places.

From super markets, shops, local markets and warehouses, 60%, 58%, 49% and 41% of the samples respectively had Aflatoxin prevalence of above 4ppb. The problem of Aflatoxin in Malawi has only been considered in the context of trade barriers with other countries. The effects of aflatoxin exposure on the domestic market and the public health in Malawi have not been given attention in spite of the negative health effects that are known (Jiang et al, 2008).

The European regulations prohibit imports of legume and grain commodities with Aflatoxin levels of above 4ppb. The Common Market for Eastern and Southern Africa (COMESA) region, to which Malawi is a member, has set legal limits for total aflatoxin in cereals and legumes at 10ppb. Globally, the recommended limits for total aflatoxins in foods range from 4–20 ppb and Codex Committee proposed a level of 10 ppb (Matumba, et al 2012). The US Food and Drug Administration (FDA) administration action guideline put the limit at 20 ppb total aflatoxins for all products intended for feed or food. However, the World Health Organization (WHO) recommends 0 ppb for children, 20 ppb for adults (Manary, 2005). This therefore makes it imperative for complementary foods in Malawi to conform to the recommended legal limits for aflatoxin levels.

Various studies that have been conducted to assess contamination of complementary foods have suggested the use of the Hazard Analysis Critical Control Point (HACCP) Strategy (Ehiri et al, 2001 and Toure, 2009). The HACCP is a strategy that identifies hazards associated with different stages of food preparation and handling, assesses the relative risks, and identifies points where control measures would be effective. A critical point is therefore a point, step or procedure at which a significant hazard occurs in food preparation and handling and at which control can be applied to prevent, eliminate or reduce the hazard to an acceptable level. This research will therefore use the HACCP strategy to determine aflatoxin contamination of complementary food in rural areas of Malawi and suggest techniques that should be adopted to prevent aflatoxin in complementary foods at specific points of handling the food.

2.8 The occurrence and distribution of aflatoxin in food in developing countries

Aflatoxin is a common contaminant of foods in staple diets of many developing countries (Williams, et al, 2004). The Food and Agriculture Organization of the United Nations estimated that up to 25% of the world's food crops are significantly contaminated with mycotoxins (Wagacha and Muthomi, 2008). Aflatoxin exists in different forms which include aflatoxin B1, B2, G1 and G2 in addition to other types. The common type of aflatoxin in food is aflatoxin B_1 (AFB_1) and aflatoxin M_1 (AFM_1) in milk and milk products. Aflatoxin is produced by the moulds- *Aspergillus flavus* and *Aspergillus parasiticus* and is the most potent mycotoxin. *Aspergillus flavus* and *Aspergillus parasiticus* grow at temperatures ranging from 13°C to 37°C, relative humidity of 85% and above and water activity (a_w) of 0.82 and above (FAO, 1998).

Aflatoxin is stable to heat and may only be destroyed at temperatures above 268°C which are higher than most of the cooking temperatures (Lusweti, 2014). This mycotoxin is widely spread in Africa and the Asian region (Williams et al, 2008) mostly due to the high temperatures and humid conditions that exist in most of the countries in Africa and Asia.

The high prevalence of aflatoxin implies that a large proportion of the population in Africa and Asia is chronically exposed to aflatoxin through the diets that are made from the contaminated foods. Aflatoxin exposure is also a common problem in low-income populations in the tropical regions where people consume relatively large quantities of staples, particularly cereals such as maize, millet, sorghum and legumes such as groundnuts (Khlangwiset and Wu, 2010). Epidemiological studies have shown that exposure to aflatoxin leads to harmful effects on the health of animals and people of all ages.

Studies conducted in Sub Saharan Africa have demonstrated the association between exposure to aflatoxin and health outcomes in humans. A cross sectional study conducted in Benin and Togo (Gong et al., 2003) showed that aflatoxin exposure was widespread among the children and that stunting was associated with high blood aflatoxin-albumin adducts (AF-alb adducts) which is a measure of recent past exposure. The study showed that 99% of the children had aflatoxin albumin adducts in their blood and had 22% reduction in their height. A report from the same study by Egal et al (2005) showed that consumption of maize was an important source of aflatoxin exposure to the study population. High presence of AF-alb adducts in blood was strongly correlated with higher *A. flavus* (CFU) in maize ($p=0.006$), higher aflatoxin levels (ppb) in maize ($p<0.0001$) and higher consumption frequencies of maize ($p=0.053$).

Another study conducted in Kisumu District in Kenya by Okoth and Ohingo in 2004 showed that 29% of the samples of maize flour used for preparing complementary food were contaminated with aflatoxin at concentrations ranging 2-82 mg/kg. The number of children who were wasted and were being fed on the contaminated flour was significantly high

(P=0.002) (Okoth and Ohingo, 2004). Exposure of pregnant women to aflatoxin has also been associated with low birth weight in children. In a cohort study conducted in Gambia by Turner in 2007, infants aged 0-12 months had their weights and heights measured for one year and their blood measured for aflatoxin exposure. The results showed that the infants had 8.7 ppb aflatoxin-albumin adducts in blood. A study reported by Jolly (2010) in Ghana also showed that mothers who had aflatoxin in their blood adducts had low birth weight and small for gestational age babies. These studies therefore demonstrate the significance of exposure of children and mothers to aflatoxin on nutritional status and health.

2.9 Prevalence of aflatoxin in food crops in Malawi

In Malawi, three crops: maize, cassava and groundnuts which are all susceptible to aflatoxin contamination, make up nearly 60-65 percent of the daily calorie intake of Malawians and maize alone represents more than 50 percent (FAO, 2009). Maize supplies about 48 percent of protein consumption of Malawians, and about 45 percent of total food quantity. Malawians' daily consumption of maize has been calculated to be between 353 to 382 grams and is one of the highest in Africa (Rios et al 2013). If these foods are not well handled, Malawians are therefore at risk of exposure to high levels of aflatoxin.

The problem of aflatoxin in Malawi has often been considered primarily within the international trade barrier. A study conducted in 1994 on the impact of Aflatoxin contamination on groundnut export in Malawi showed that at the present value, during 1985/86 season, Malawi lost an equivalent of USD 845,000.00 (MWK380, 250, 000.00) and in 1988 the loss was USD57,000.00 (MWK25, 650, 000.00) (Babu, Subrahmanyam, Chiyembekeza and Ng'ong'ola, 1994). The average loss in exports due to Aflatoxin contamination between 1985 and 1988 was USD586, 000.00 (MWK263, 700,000.00). This was despite the fact that between 1961 and 2006, the amount of land under groundnut cultivation in Malawi increased from 159,000 hectares to about 267,000 hectares, with an average annual growth rate of 3.4%. However, Malawi's groundnut export collapsed from 30 tons to zero in 1989, due to detection of high aflatoxin levels when groundnuts were landed in the United Kingdom. After 1990, there were variations in groundnut exports. In 2004 export of groundnuts increased to 8.6 tons and fell to 2.4 tons in 2005 and rose to 3.8 tons in 2006. In 2007 the export increased to 16.9 tons, but decreased to 14.3 tons in 2008 and increased to 19.9 tons in 2009. Due to these variations, Malawi government paid more attention to the international trade than to the domestic market, and the associated public health effects of aflatoxin exposure through diets.

There is evidence that aflatoxin is a problem in Malawi and that the soils and crops such as maize and groundnuts are contaminated with aflatoxin. A study conducted by ICRISAT showed that 46% and 23% of groundnut samples in 2008 and 2009 respectively had AFB_1 contamination levels greater than 4ppb. Over one fifth (21%) of the groundnuts samples collected in 2008 and 8% of samples collected in 2009 had aflatoxin contamination levels greater than 20ppb respectively. Studies have also shown high *Aspergillus flavus* and *Aspergillus parasiticus* contamination of the soils across the country with between 11% and 28% of the soil samples collected from the warm low to mid altitude ecologies having contamination levels of up to 16108 cfu/g and low contamination in 2-10% of samples in the mid to high altitude ecologies with 828 cfu/g of soil (Monyo, et al, 2012). High levels of aflatoxin in maize (0-3871ppb) and groundnuts (0-1335 ppb) have also been reported (Monyo et al, 2010). Other studies in Malawi have also shown high levels of aflatoxin (90±95µg/kg) in maize based locally brewed beer in Lilongwe and Dowa districts of Central Region (Matumba et al, 2012). In the Southern Region of Malawi, high aflatoxin levels were detected in sorghum malt (408±68µg/kg) and in opaque beer (22.32µg/l) made from sorghum malt (Matumba et al, 2010). These levels of aflatoxin are higher than the maximum allowable level of 10µg/kg in ready to eat foods as set by the Codex Alimentarius Commission.

In another study, the McKnight Foundation in collaboration with ICRISAT and the National Smallholder Farmers Association of Malawi (NASFAM) in 2009 conducted a study to map the occurrence, significance and distribution of Aflatoxin in major groundnut producing districts of Malawi. The study collected samples of groundnuts and maize from farmers' households, local markets, shops and supermarkets (McKnight Foundation, 2010). Results showed that the prevalence of Aflatoxin in groundnut and maize samples from farmers' households ranged from 0 to 3871 parts per billion (ppb) and 0 ppb to 1335 ppb respectively. Aflatoxin levels of above 100ppb were detected in 25% of groundnut samples from market places. From super markets, shops, local markets and warehouses, 60%, 58%, 49% and 41% of the samples respectively had Aflatoxin prevalence of above 4ppb. These findings indicate that aflatoxin contamination is high in maize and groundnuts in Malawi. This may have negative effects on human health if aflatoxin levels are not controlled in diets.

A study conducted by Matumba et al., (2010) to determine Aflatoxins in sorghum, sorghum malt and traditional opaque beer in Southern Malawi showed that 15% of samples of malt (*thobwa*) and 43% of beer samples were contaminated with aflatoxins. The sorghum malt for beer brewing had higher total aflatoxin content (average 408±68 µg/kg) than any other type of sample. The average aflatoxin content in the beer was 22.32 µg/l. This content is higher than the permissible maximum level in ready to eat foods set by the Codex Alimentarius Commission (10µg/kg). This study shows that consumption of opaque sorghum-based beer puts consumers at risk of aflatoxin exposure. The malt (*thobwa*) is also commonly used as weaning foods in Malawi which may also put infants at risk of exposure to aflatoxin.

In another related study conducted by Matumba et al (2012) in 2012, total of 9 traditional maize based opaque beers were randomly collected from tribal (*Chewa*) ceremonies and commercial village brewers from Lilongwe and Dowa districts of Malawi. The samples were evaluated for mycotoxins using a multi-mycotoxin method based on liquid chromatography-tandem mass spectrometry. Samples were analyzed for aflatoxins B1 (AFB1), AFB2, AFG1, AFG2, Fumonisin B1 (FB1), FB2, FB3, and other mycotoxins. Results showed that all samples were positive for Fumonisin with FB1+FB2 and FB1+FB2+FB3 content of 1745±1294µg/kg and 1898±1405µg/kg respectively. All beer samples except one contained aflatoxins at a mean concentration of 90±95µg/kg. The researchers observed that consumption of 1.0–6.0L of the traditional beer from this study translates to daily FB1+FB2 exposure of 29–174µg/kg body weight per day which is far above the provisional maximum tolerable daily intake of 2µg/kg body weight per day set by the Joint FAO/WHO Expert Committee on Food Additives. The study therefore demonstrated that consumers of traditional beer in Malawi are at risk of exposure to Fumonisin and aflatoxins.

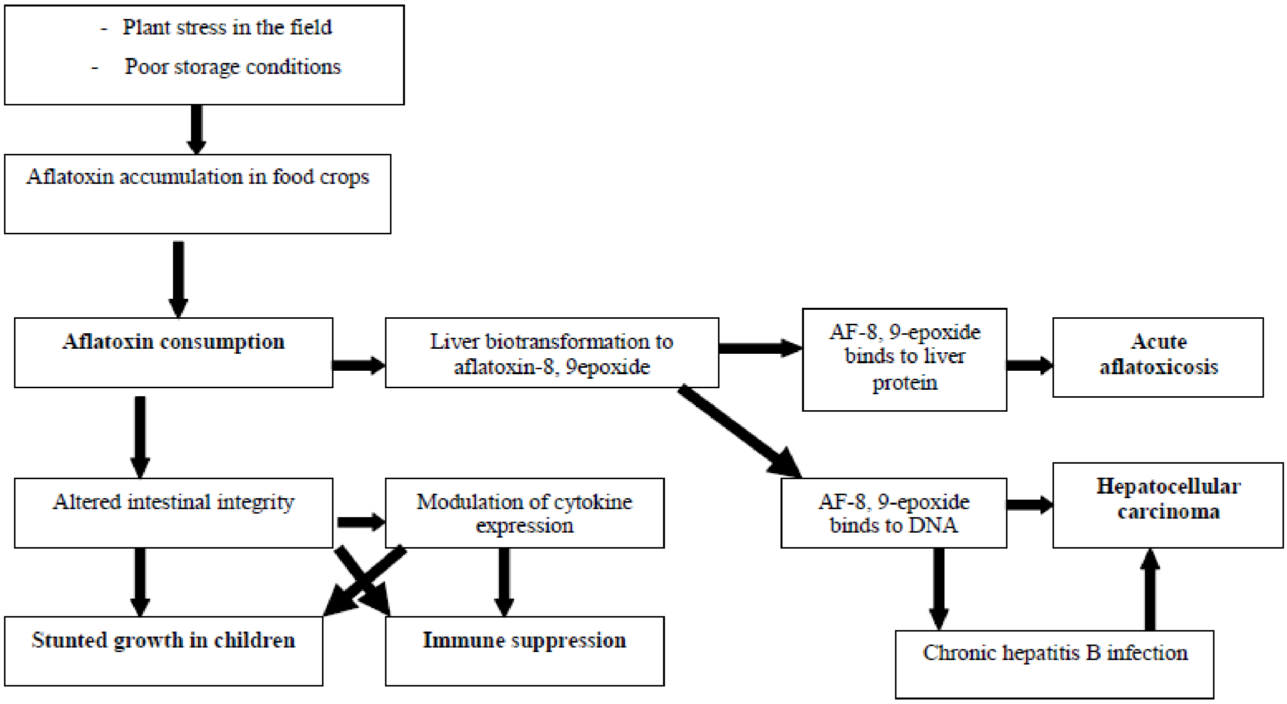
The problem of mycotoxins in Malawi was also reviewed by the Malawi Programme on Aflatoxin Control (MAPAC) (Rios, Gokah, Kauma et al, 2013). The review indicates that aflatoxin contamination in stored maize in Malawi ranges from 0-1335 ppb and that maize flour prepared by soaking maize in water to preferment the flour (which is a common practice in Malawi) has the highest aflatoxin contamination of up to 1335ppb followed by whole maize flour up to 805ppb. Grain from farmers and vendors has 0-800ppb of aflatoxin. Rosa et al (2013) however, indicated that studies done at Chitedze Research Station of Ministry of Agriculture showed that traditional processing methods of maize that involve soaking, drying, de-hulling and sun drying the flour can reduce Aflatoxin B1 contamination. The review further describes a link between aflatoxin contamination and agriculture and food security; in that if large amounts of grain is rejected from the market due to unsafe aflatoxin levels then the grain will end up being consumed domestically especially during periods of food scarcity. Unregulated marketing may also result in increase of contaminated grain being sold on the market.

The districts with the highest grain contamination in Malawi have been identified as Chikwawa, Salima, Mzimba, Kasungu, Ntcheu and Mulanje. The districts with the highest soil contamination are Chikwawa, Lilongwe, Salima, Ntcheu, and Kasungu. Chikwawa, Salima, Ntcheu and Kasungu districts have high *A. flavus* loads and are exposed to drought-induced pre-harvest contamination. Mzimba and Mulanje districts have low *A. flavus* loads, but are predisposed to late-season rains, which create conditions for post-harvest contamination. The high levels of maize and groundnuts contamination with aflatoxin and wide consumption of these grains and high levels of malnutrition among underfive may suggest high levels of exposure. However, there are no conclusive studies that have been conducted in Malawi to directly link aflatoxin exposure to chronic malnutrition.

In a study conducted in two districts of Malawi, Mzimba and Balaka by Seetha, Tsusaka, Munthali, Musukwa, Mwangwela, Kalumikiza, Manani, Kachulu, Kumwenda, Musoke and Okori (2017) to examine the impact of training on nutrition, hygiene and food safety, where mothers of children aged 6-23 months were trained using the Positive Deviance/ Hearth model on appropriate complementary feeding, water, sanitation and hygiene (WASH) and aflatoxin contamination in food, the results of aflatoxin assay analysis of children's urine showed that over half of the sampled children were contaminated with aflatoxin. The researchers pointed out that though the aflatoxin-albumin biomarker is the most appropriate measure for chronic exposure of some moths, the urine aflatoxin biomarker was used to indicate exposure over 24 hours. It is therefore demonstrated that infants and young children (6-23 months) are exposed to aflatoxin and that complementary foods could be one of the pathways. The studies in Malawi show that aflatoxin contaminates a wide range of foods especially those prepared from cereals.

2.10 Mechanisms by which aflatoxin affects human health

Aflatoxin exists in different chemical structures and may be named Aflatoxin B_1, Aflatoxin B_2, Aflatoxin G_1, and Aflatoxin G_2. Among these different types, Aflatoxin B_1 is the most prevalent and the most potent of the aflatoxins (Williams et al., 2004). Figure 4 illustrates the pathways through which aflatoxin affects human health.



Source: Wu (2010)

Figure 4: Mechanism of Aflatoxin Effects on Human Health

Figure 4 illustrates the relationships between aflatoxin exposure through consumption of contaminated food and the health effects that it may have on the consumer. Aflatoxin exposure may result in alteration of the intestinal integrity (Gong et al., 2004). This may lead to the weakening of the intestinal tight junctions, which may in turn be easily disrupted and invaded by bacteria. Because of the weakening of intestinal integrity, inflammation may occur which may also result in malabsorption of nutrients and food intolerance. Nutrient malabsorption and food intolerance lead to nutrient deficiencies and malnutrition. Studies conducted by Gong et al., (2003) in Benin and Togo among children aged 9-59 months, showed that 99% of the fully weaned children had high aflatoxin albumin levels in their blood and this was associated with 22% reduction in height of the children. In Ghana, a study on exposure of pregnant women to aflatoxin showed that exposure to aflatoxin resulted in the birth of low birth weight or small for gestational age babies (Jolly, 2002). Aflatoxin is therefore associated with intrauterine growth retardation of infants in addition to the other negative effects on human health.

Aflatoxin may be transformed by P450 enzymes to its DNA-reactive form; aflatoxin-8,9-epoxide (Khlangwiset and Wu, 2010). The molecule may bind to liver proteins and lead to liver failure and result in acute aflatoxicosis. Aflatoxicosis is the poisoning that results from ingesting aflatoxin (Williams, et al., 2004). The symptoms of severe aflatoxicosis include hemorrhagic necrosis of the liver, swelling of the bile ducts, oedema of the legs, vomiting and abdominal pain (Wagacha et al., 2008). Metabolic activation of Aflatoxin B1 (and G1) may also produce AFB1 epoxide adducts that may attach to DNA and protein. Aflatoxin B1 adducts interrupt protein synthesis and may result in growth retardation in children. Aflatoxin adducts may also lead to development of liver cancer and chronic hepatitis B (Kiessling, 1986). Aflatoxin B1 has also been found to inhibit the biosynthesis/translocation of secretory protein, prolactin in rats (Singh et al 2006). Figure 5 illustrates the mechanisms of formation of 8, 9-epoxide.

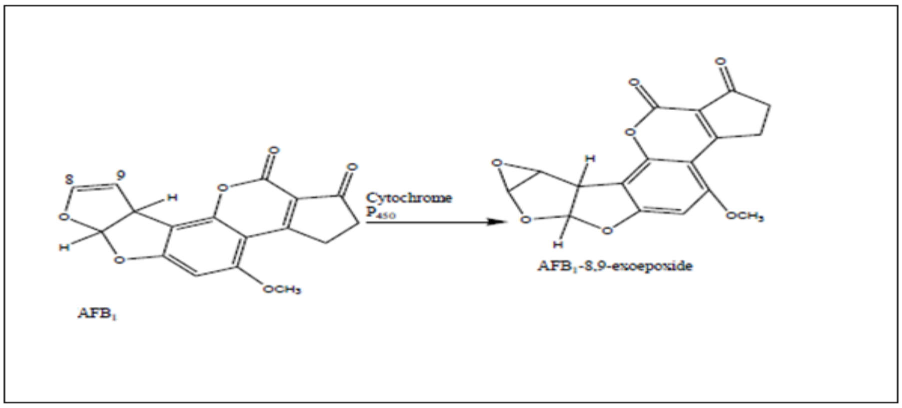


Figure 5: Formation of 8-9-epoxide in the liver

Aflatoxin binds and interferes with enzymes and substrates that are needed in the initiation,

transcription and translation processes involved in protein synthesis. Aflatoxin interacts with purines and purine nucleosides and impair the process of protein synthesis by forming adducts with DNA, RNA and proteins (Bbosa et al, 2013). Aflatoxin also inhibits RNA synthesis by interacting with the DNA-dependent RNA polymerase activity and causes degranulation of endoplasmic reticulum. Aflatoxin also causes liver and kidney necrosis which results in the reduction in protein content in body tissues such as skeletal muscle, heart and liver.

Aflatoxin consumption reduces protein synthesis and modulates the expression of cytokines, and results into stunted growth and immune suppression in children. Studies conducted in poultry, pigs and rats have shown that exposure to aflatoxin in contaminated food results in suppression of the cell mediated immune responses (Williams et al, 2004). Aflatoxin also impairs the functions of macrophages in animal species (Moon, et al., 1999). Aflatoxin has also been shown in vitro to inhibit phagocytic cell function in normal human peripheral blood monocytes. Turner et al., (2013) reported changes in immunity as a function of aflatoxin-albumin adducts detected in 93% of children in a study conducted in Gambia. In the same study, exposure to aflatoxin resulted in reduced secretory immunoglobulin A (IgA) and a weak antibody response to pneumococcal infection.

A study conducted by Okoth and Ohingo (2004) in Kisumu District, Kenya on Dietary aflatoxin exposure and impaired growth in young children showed a strong correlation between wasting and consumption of flour contaminated with aflatoxin (P=0.002). The study further showed that 29% of flour samples from 242 households contained aflatoxin in the ranges of 2-82 mg/kg. Studies have further shown that the adverse growth effects of exposure to aflatoxin correlate strongly with change from breastfeeding to solid foods, including maize which is used widely as a weaning food (Wagacha and Muthomi, 2008). Therefore, if not prevented or controlled, aflatoxin in complementary foods may have harmful effects on the health and development of young children.

2.11 Options to make food safe from aflatoxins

2.11.1 Creating awareness among consumers and adopting preventive methods

Due to its versatility to thrive in areas of different temperature and water conditions, aflatoxin is not biodegradable. Studies have suggested that aflatoxin may be destroyed at temperatures ranging from 268 to 269^{o}C which are higher than the cooking temperature of the complementary foods (Lusweti, 2014). Most methods suggested by researchers are therefore preventive in nature. The strategies include raising awareness among communities of the dangers of consuming contaminated and unsafe food. Training communities on appropriate methods of drying, sorting, and storing food has also been suggested as an effective preventive strategy. Researchers have also pointed out the need for conducting research to develop innovative market mechanisms to take aflatoxins out of human food chains (International Food Policy and Research Institute {IFPRI}, 2013).

2.11.2 Adopting and scaling up effective traditional food processing methods

Some studies have also shown that certain food processing methods reduce mycotoxins in foods including AFB1. Traditional fermentation of cereals (maize) in West Africa for preparing complementary food *(ogi)* has been found to reduce aflatoxin levels in the food and improves flavour and texture of the food (Aworh, 2008). The fermentation process creates an environment that does not allow the growth of aflatoxin producing moulds (*Aspergillus*). A study conducted in Tanzania by Nyamete, Bennink and Mugula (2016) determined the effectiveness of lactic acid fermentation in aflatoxin B1 reduction in maize based gruel. The study investigated use of lacto bacteria, natural fermentation and back-slopping (adding a sample of fermented gruel to freshly prepared gruel) to reduce aflatoxin B1. The results showed that lacto bacteria cultures reduced 45%-55% of aflatoxin B1 while natural fermentation and back-slopping removed 56% and 68% of aflatoxin B1 respectively. Fermentation has also been reported to reduce microbial load in locally processed cereal-legume-oilseed flour (Ibeanu, Ene-Obong, Peter-Ogba and Onyechi, 2015). These studies show that fermentation and use of lacto bacteria can increase safety of complementary food made of maize gruels. However, in Malawi, mothers and caregivers rarely use fermentation in preparing maize flour based complementary foods.

Another study conducted in Kenya by Mutungi (2006) showed that dehulling maize grains reduce levels of aflatoxin in naturally contaminated maize by 46.6%. The study further showed that soaking the dehulled grain in chemicals such as locally filtered ash solution, ammonium persulphate and sodium hypochloride reduced aflatoxin levels by 49.7%, 73.2% and 72.2% respectively during overnight soaking in 1% concentration. A review on the link between Infant malnutrition and chronic aflatoxicosis in Southern Africa by Katerere, Shephard and Faber (2008) showed that food habits and poor hygiene and storage of foods are major contributing factors to dietary exposure to mycotoxins.

Traditional methods of processing maize such as soaking and drying, dehulling and sun drying can also reduce Aflatoxin B1 contamination in the final flour (Rios, Gokah, Kauma et al, 2013). Drying maize to 15.5% moisture content within 24-48 hours would reduce the risk of fungal growth and aflatoxin production (Bankole and Adebanjo, 2003). Processes such as cleaning the cereal or legume by sorting, washing the food before processing and dehulling grain mechanically have also been found to reduce aflatoxin levels.

Studies have also shown that dietary interventions may help to reduce exposure to aflatoxin. Some researchers recommend consumption of relatively lower quantities of maize and groundnuts by replacing them with other foods that are not commonly contaminated by aflatoxin (Bandyopadhyay et al., 2007). Some foods contain compounds that inhibit formation of epoxides; for example, broccoli sprouts and green tea. There are also dietary additives that reduce the risks of exposure to aflatoxin. Such substances include enterosorbents that bind aflatoxin in the gastrointestinal tract and facilitate elimination (Phillips et al., 2008). The enterosorbents can be mixed with the food or can be taken separately during mealtimes to bind aflatoxin in digestive system and reduce aflatoxin bioavailability in the body. An example of the enterosorbents is calcium montmorillonite called Nova Sil clay on the market (Khlangwiset and Wu, 2010). However, it may be expensive to use Nova Sil clay as a mitigation factor against aflatoxin exposure because regular supply may be needed to meet the daily needs.

2.11.3 The Hazard Analysis and Critical Control Point (HACCP) Strategy

The HACCP strategy has been applied to the study of complementary foods by several researchers to find critical control points for control of diarrhoea among young children (Ehiri et al 2001; Toure, 2009). It is important to understand that each HACCP strategy is specific to particular types of foods and for specific types of hazards (Ehiri, et al., 2001). In this study, the HACCP strategy was identified and would be used to prevent contamination of local complementary foods with moulds, coliforms and aflatoxin in rural areas in Malawi. During the study, mothers and caregivers were trained on how to follow the strategy to prepare complementary foods that are free from aflatoxin and safe to the health of the children.

The advantage of using the HACCP strategy is that it identifies potential food hazards and faulty practices at an early stage in food preparation and handling and therefore prevents and reduces risks to children. The HACCP strategy determines the points in the food preparation/handling and serving process quickly and relatively cheaply (Ehiri et al, 2001). This strategy is also important in situations of extreme poverty and where adequate surveillance of food-borne diseases may be lacking. The Codex Alimentarius Commission in 1993 (FAO, 1993), endorsed the HACCP system as the most cost effective approach for ensuring the safety of food. In this research, the HACCP strategy has the potential to make a significant contribution in preventing and controlling fungal, coliform and aflatoxin contamination of complementary foods in rural areas of Malawi.

2.11.3.1 Five preliminary steps before HACCP

These steps include i) assembling of the HACCP team, ii) describing the product, iii) identifying intended use of the product, iv) constructing a flow diagram and v) onsite confirmation of the flow diagram. These steps should be put in place before the HACCP process can be implemented.

2.11.3.2 The process of implementing the HACCP strategy

The implementation of the HACCP strategy uses seven steps that one needs to observe to identify the critical control points in food handling. The seven steps include the following:

i. Conducting the HACCP analysis

This step is aimed at identifying the hazards, assessing their severity and any risks that are associated with the hazards. The process assesses the food handling processes to identify any significant risks related to the food product. This step serves as the basis for the rest of the HACCP activities (NFS, 2006)

ii. Identifying the critical control points (CCP)

Critical control points (CCP) are operations at which control must be exercised over one or more factors to eliminate and prevent or minimize a hazard, (Bryan, 1992).

iii. Establishing critical limits

A critical limit is a measurement or observation that separates what is acceptable from what is not acceptable such as temperature at which food should be kept for a specific period of time. The critical limit cannot be violated if the hazard has to be controlled at that CCP. Critical limits must be effective at keeping the hazard under control. Critical limits can be quantitative (numerical) or qualitative (descriptive).

iv. Monitoring

Monitoring involves systematic observation, measurement and recording of the significant factors for control of the hazard. The process must permit action to be taken before the food is made available to the consumer.

v. Establishing corrective actions

Corrective actions are activities that should be implemented when monitoring shows that the criteria set for safety and quality at a particular critical control point are not met (Bryan, 1992).

vi. Verification

This is the application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with the HACCP plan. It involves collection of information and tests to ensure that the system is working as planned (Bryan, 1992).

vii. Record keeping

This involves compiling of all information related to the process of developing the HACCP plan.

Therefore, as part of the effort to reduce prevalence of stunting among young children in Malawi, the HACCP strategy was used to study aflatoxin contamination of complementary foods in rural areas of Malawi and critical control points were identified.

2.12 Conceptual framework

Literature from various studies and other publications show that there is need for research and interventions to prevent and control microbial and aflatoxin contamination of human foods and their associated health risks (Matumba et al, 2012). Studies conducted in Malawi have shown high levels of microbial contamination of food (moulds and coliforms) due to inappropriate sanitation and hygiene practices. Moulds, which produce aflatoxin such as *Aspergillus flavus* and *Aspergillus parasiticus* have been detected in soils from agricultural lands and contamination of crops, especially maize and groundnuts which are important ingredients for complementary foods (Monyo et al., 2010). With high prevalence of stunting among underfive children and high dependency on locally produced foods for complementary feeding, this research used the conceptual framework shown in Figure 6 to assess different processes followed during handling and preparation of complementary foods and identified a suitable HACCP based strategy to prevent and reduce microbial contamination and aflatoxin presence in complementary foods.

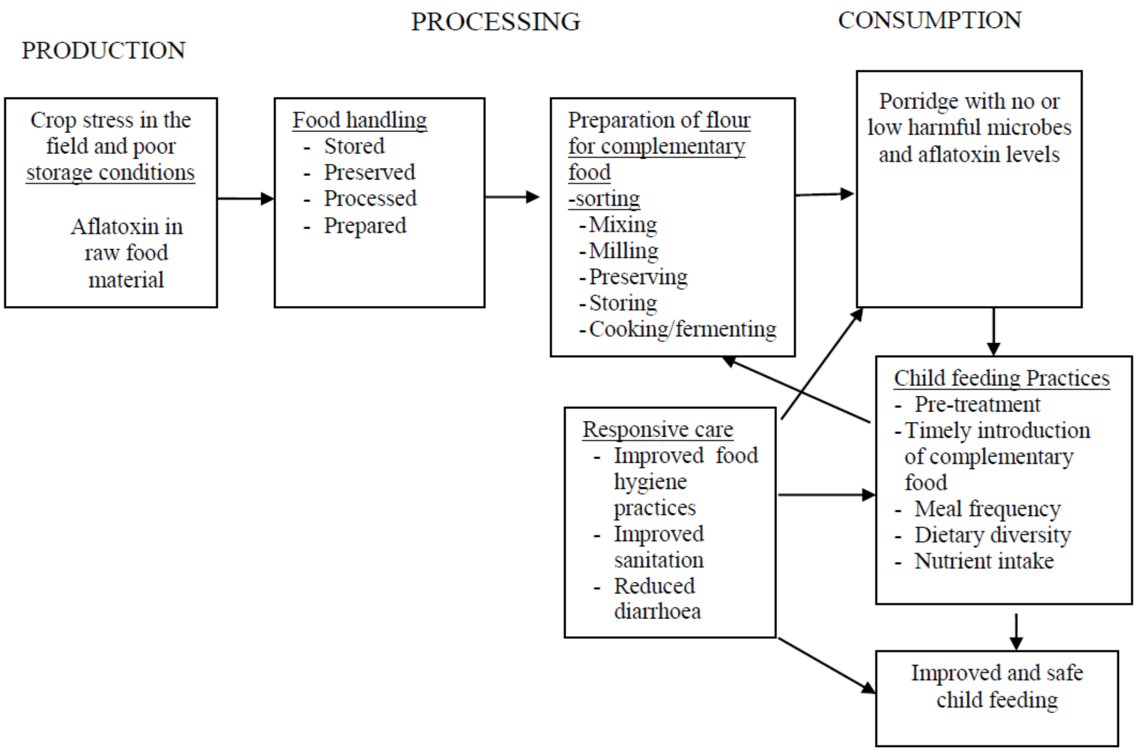


Figure 6 Conceptual Framework

2.13 Scope and limitations of the study

2.13.1 Scope of the study

This research was conducted in Dedza district in Malawi and covered 12 villages in Mayani Extension Planning Area (EPA) in Traditional Authority Tambala. Dedza district was selected because it is one of the districts with high levels of stunting (43%) among underfive children (NSO and ICF, 2017). The district was one of the targeted districts for implementation of a project called Capacity Building for Management of Climate Change (CABMACC) by Lilongwe University of Agriculture and Natural Resources (LUANAR) which also sponsored this research. As a condition for funding the research, it was a requirement to conduct this study in Dedza district.

2.13.2 Limitations of the Study

The Limitations of this research are that though it is well established that moulds and aflatoxin contaminate food crops in the field before harvesting (Khlangwiset and Wu, 2010), only raw food materials (maize flour) from households were used. Also, the study did not use porridge to analyze microbes and aflatoxin based on the understanding that most pathogenic microbes can be destroyed by cooking and also on the fact that once aflatoxin is detected in maize flour, the porridge will also be contaminated and end up in the body of the child after eating the porridge. This is because aflatoxin cannot be destroyed by cooking. Therefore the presence of aflatoxin in maize flour would reflect exposure of the children to aflatoxin.

The other limitation was that it was assumed that once the maize flour was used for preparing the porridge, the porridge would be fed to the child soon after cooking leaving no room for recontamination and mould growth on the porridge. However, if the porridge was stored for some time before feeding the child, other microbes would grow on it and affect the health of the child.

CHAPTER THREE
MATERIALS AND METHODS

3.1 Research area

This research was conducted in Mayani Extension Planning Area (EPA) in Traditional Authority Tambala in Dedza district in the Central Region of Malawi. Malawi is an upland country in South East Africa bordered by Tanzania to the North, Zambia to the West and Mozambique to the South and East. The country covers an area of 118,484 square kilometre and one third of the area is covered by Lake Malawi (580 km long). The population of Malawi is about 17.6 Million people (Malawi Government, 2018), most (85%) of whom live in rural areas and 45.8% are children under 14 years of age.

The economy of Malawi is predominantly agriculture and tobacco is the lead export crop followed by tea, sugar and cotton (NSO, 2017b). The majority of the population of Malawi in rural areas produces and stores their own food for domestic consumption, supplemented by food obtained through procurement from the market. Due to climatic changes and dependence on rain-fed agriculture for food, some parts of the country experience frequent food insecurity due to frequent floods, inadequate rainfall (MG, 2019) and land degradation which result in decreased crop yields. In the rural areas, postharvest losses of food account for about 30% of the total harvest and most of the losses are due to poor conditions and insect damage in storage (Matumba et al 2012).

Dedza district is one of the major production areas for maize and groundnuts which are commonly used as staple foods by communities and also for preparing complementary foods for infants and young children. The district has a population of 830,512 people (NSO, 2018) and the majority of the communities are engaged in farming with maize as the common staple food. Other crops produced include potatoes, groundnuts and beans. Mayani EPA is also susceptible to droughts and frequent floods that affect agricultural production and therefore food availability.

The district has the second highest prevalence (43%) of stunting among under-five children in the Central Region. Dedza is also one of the districts where Lilongwe University of Agriculture and Natural Resources (LUANAR) was implementing the project called "Capacity Building for the Management of Climate Change (CABMACC)". This research was funded with finances from the CABMACC project and was conducted in the CABMACC project area as one of the conditions for getting the scholarship for the doctorate degree. Figure 7 presents the map of Dedza district showing Mayani EPA where the research was conducted.

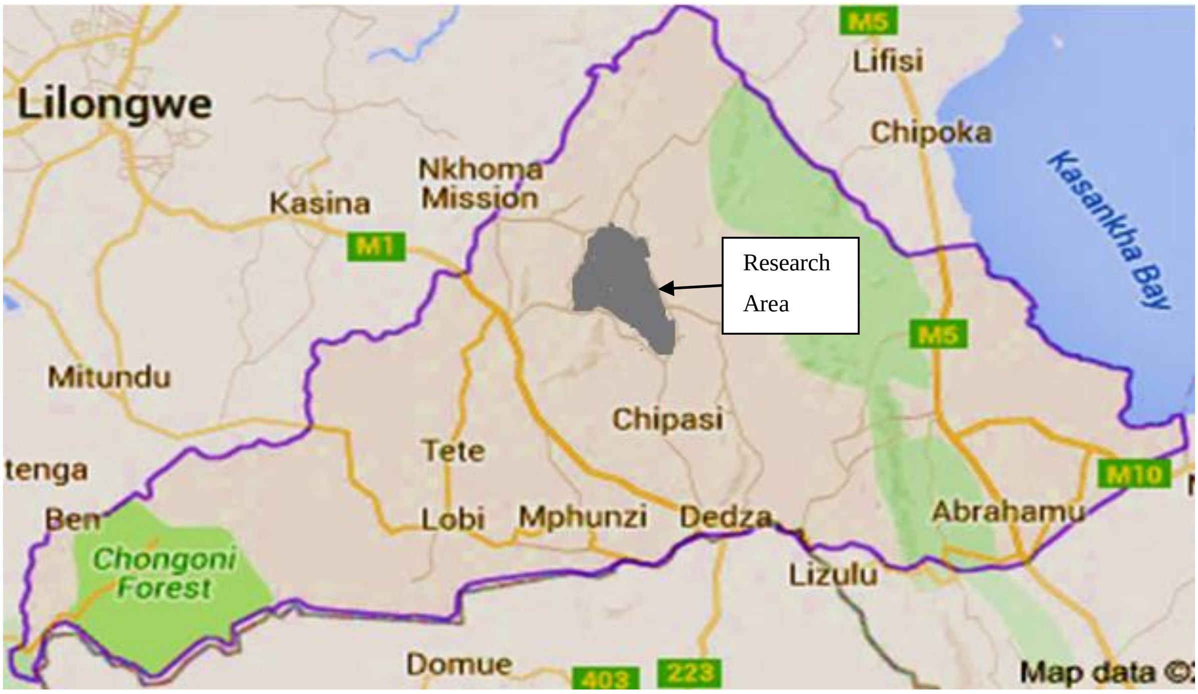


Figure 7 Map of Dedza District showing research area shaded grey

3.2 Research design

The research was implemented following two designs which are described in the sections that follow:

3.2.1 Cross-sectional design

This was a baseline nutrition survey that was conducted among 306 sampled households to assess nutritional status of children aged 6-23 months, and to determine child care and feeding practices and among 303 mothers and caregivers. The baseline nutrition survey was aimed at establishing the existing child care and feeding practices among mothers and caregivers. The survey was conducted between July and August 2015. This is a post-harvest period in Malawi when the majority of households have food in store. This assisted to ensure that households were not constrained in terms of food availability and the survey collected data on the usual child feeding practices among the sampled households. During the post-harvest period the majority of mothers and caregivers have enough time to care and feed their children. This is in contrast with the rainy season when the majority of mothers and caregivers spend most of the time working in the fields; therefore not observing the recommended meal frequencies.

3.2.2 Experimental design

The experimental design was used to collect and analyze data from a nested sample of 40 households where mothers or caregivers were assessed on how they handled and processed complementary foods to identify critical points where contamination could take place. A quasi experimental design following a single-case intervention (AB) was used to implement a training intervention using a smaller sample of mothers and caregivers which was selected from the initial sample of 303 mothers and caregivers who participated in the baseline nutrition survey. Figure 8 illustrates the theory of the experimental design that was used.

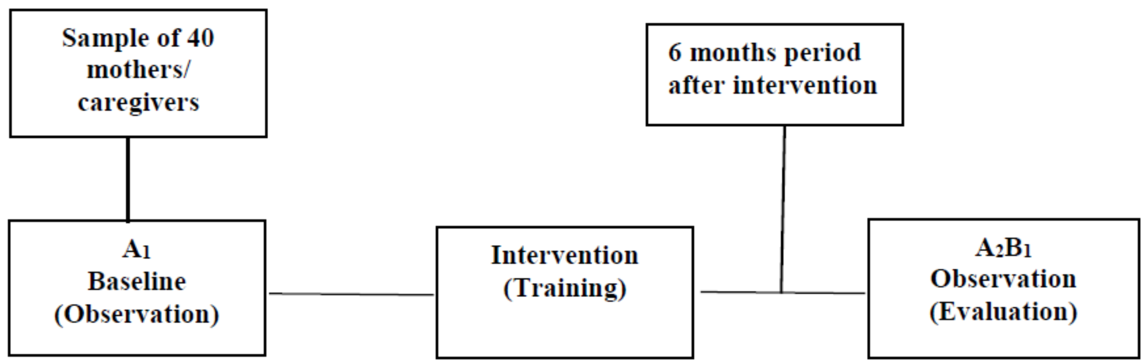


Figure 8 Theoretical framework of the single-case design

The theoretical concept of the design is that at baseline (A_1), the mothers and caregivers participated in the development of the HACCP strategy through focus group discussions. Information was collected from mothers and caregivers on the common foods used as complementary foods and how the foods were handled. Porridge prepared with maize flour (7% solids) was identified as the common complementary food given to children. Mothers and caregivers further described the procedures for handling and processing maize flour, how they stored the flour and how they prepared the porridge. Samples of maize flour were collected from the households and analysed for total viable counts (TVC), coliforms, yeast, moulds and aflatoxin.

The baseline information assisted to expose the existing hygiene and child feeding practices that needed modification or change. After identifying the areas that needed change, training modules were developed for training the mothers and care givers to bring behaviour change in hygiene and food processing. The mothers and caregivers were later trained for four days on practices that would mitigate and reduce contamination of complementary foods. After the training, the mothers were observed for Six months. After the six months, the mothers and caregivers were assessed for knowledge and practices that would mitigate and reduce microbial contamination of the complementary food based on the information provided during the training sessions. The single-case intervention design has advantages in that it does not require a control group. Data are collected from the same participant at different time periods and this allows comparison to be made on the same participant in terms of behaviour change or change in skills. (Lobo, Moeyaert and Babik, 2018).

3.3 Sampling methods

3.3.1 Study population

This study was conducted among farming households in Mayani EPA, Traditional Authority Tambala in Dedza district. Mothers and caregivers of children aged 6 to 23 months living in the study area were targeted as participants for the study. The study also targeted children aged 6-23 months whose mothers were selected for the study for assessment of nutritional status and feeding practices. The participants were sampled randomly from a sampling frame of 62 villages and 1099 households. A systematic random sampling technique was used to select 12 villages from the 62 villages and the participating households were selected based on the availability of children within the eligible age limits (6-23 months). Since randomization was done at village level and not household level, every child in the targeted age category (6-23 months) was eligible to participate in the study.

3.3.2 Sample size determination

The sample size for the cross sectional nutrition survey was determined based on the following formula recommended for calculating sample size for cross sectional surveys (Golden, Seaman and Erhardt et al., 2011):

$$n = \left\{ z^2 * \frac{p(1-p)}{d^2} \right\} * \frac{DEFF}{1 - NRR}$$

Where n = sample size, z = the risk of error (95% CI) set at 1.96; p = expected prevalence set at 29 %
d^2 = relative desired precision set at 5%; NRR=non response rate set at 10%; and DEFF = Design Effect set at 1.

In this calculation, the risk of error (z) is the z value corresponding to the confidence level at 95% which is 1.96, p is the expected prevalence of the variable of interest. In this study, the variable of interest was prevalence of stunting among children. According to the 2010 DHS report, about 29% of children aged 6-23 months were stunted in Dedza district (NSO and ORC Macro, 2011). The value of p used was therefore 29%. The relative desired precision (d) for the survey was set at 5% and the design effect (DEFF) of 1 was used in the calculation. With most community based surveys, there are some participants who decide not to provide responses by means of dropping out of the survey or by not wanting to answer certain questions. In this study, non response rate (NRR) was estimated at 10%.

The calculated sample size for children to be included in the study was 316. Given that the avarage number of children 6-23 months old per household in Dedza was 1.02 (NSO and ICF Macro, 2011), the total number of households was calculated by dividing the number of children in the sample (316) by the average number of children per household (1.02). This translated into the household sample size of 310 households. The non response rate of 10% included in the calculation of sample size provided a cover for any attrition of the sample during the study. It was therefore envisaged that non participation of 10% would not affect the design of the study.

3.3.3 Inclusion and exclusion criteria

All households with children aged 6-23 months in the sampled villages were eligible to participate in the study. All children aged 6-23 months in the selected households were also eligible to have their nutritional status assessed. All households with no children within the age range of 6-23 months were excluded from participating in the research. Households with children 6-23 months old who were visitors and not permanent residents in the research area were also excluded from the study. During anthropometry measurements any child who was seriously sick on the day of the study or sick for the previous two days was not measured or weighed. Mothers or caregivers who would not give consent to participate in the study would also not be included in the research. However, in this research, no mother or caregiver refused to give consent.

3.3.4 Sampling procedures

To sample the desired number of households for the cross-sectional survey, villages in the study area were listed with the help of the Agricultural Extension Development Coordinator (AEDC) for Mayani EPA. A total of 12 villages were selected from a list of 62 villages in the study area using systematic random sampling method. To sample the 12 villages, the total number of villages in the study area (N=62) was established. After establishing the total number of villages, the number of villages was divided by the desired sample size (n=12) of villages to come up with a sampling interval (k=5). So in this case, the first village was sampled randomly and followed by selecting every 5th village from the listed villages until a total of 12 villages were obtained.

All households in the 12 sampled villages were listed by research assistants to identify households with children aged 6-23 months. (A household was defined as a group of people who live together and shares food from the same pot (FAO, 2007]). In polygamous homes, where all members share the same pot, the household was identified as one. However, where members do not share the same pot; the households were treated as separate. Each household was given an identification number for easy reference and to ensure confidentiality. In each village, households with eligible children were recruited into the study until the required sample was obtained. In the case where a mother or caregiver had left the village, a replacement household was identified randomly to fill the gap. Before conducting interviews, mothers or caregivers were requested to give informed consent to participate in the study. Only mothers or caregivers who gave consent were interviewed.

For the experimental design of the study, a nested sample of 40 households from the original 303 households was randomly selected from two communities (*Kamgunda* and *Mtawanga villages*) using simple random sampling method. The names of the villages were written on pieces of paper and mixed in a tin. One Research Assistant was asked to pick one paper randomly from the tin. The remaining papers were mixed up again and another Research Assistant was asked to pick the second paper randomly again. The nested sample is a useful approach to collect, interpret or verify data in detail from a smaller sample (Onwuegbuzie and Leech, 2007) that represents the original bigger household sample size; in this case the 303 households. In this study, a nested sample of 40 mothers and caregivers and 40 children (6-23 months) was considered large enough to achieve data saturation (Flick, 1998), it is suitable for within-case analyses that involve analyzing, interpreting and legitimizing data in a context that makes up a single case for a small group or a community.

Nested sampling strategies also facilitate credible comparisons of members of the same subgroup where one or more members of the sub-group represent a sub-sample of the full sample (Onwuegbuzie et al., 2007).

The nested sample was used for detailed study for collecting flour samples for laboratory tests for microbes and aflatoxin. The nested sample was also used for focus group discussions (FGD) that generated information for developing the HACCP strategy for identifying the critical control points by considering child feeding practices and their challenges in the study area. The HACCP strategy also considered the hygiene and sanitation practices among mothers and caregivers as part of the value chain for complementary feeding. These findings were triangulated with quantitative data from the household interviews to get a clear understanding of the status of child feeding practices in the study area. Samples (40) of maize flour (300g) used for preparing complementary foods were collected. To ensure that the flour samples were representative, small samples (50g) were collected from different parts of the container in which the flour was stored. The flour was then mixed thoroughly in batches of 300g and stored in zip-lock material in a cooler box for transfer to the laboratories at LUANAR, Bunda Campus.

The flour samples were collected in the month of October because this is the hot dry season in Malawi, with temperatures varying between 25 and 37 degrees Celsius and humidity around 50% (Department of Climate Change and Meteorological Services [DCCMS], 2014). The month of October is also the beginning of the lean period as far as food availability is concerned in rural areas of Malawi. This implies that the food might have stayed longer in storage after being harvested in the month of May. It was therefore important to assess different sources of food and fungal and aflatoxin contamination levels so as to establish control measures that could be put in place to improve the safety of the complementary foods.

3.4 Data collection for the cross sectional nutrition survey

In the baseline nutrition survey, several tools and instruments were used to collect data from the sampled households. Data were collected on child feeding practices and assessment of nutritional status of the children. Details of procedures and types of data collected are described in the sections that follow.

3.4.1 Data collection instruments and tools

In this research, different instruments were used to collect information on different variables. The tools that were used for collecting data included the following:

3.4.1.1 Household questionnaire

A semi structured questionnaire (Appendix 2) was used to collect information on socio-demographic characteristics of mothers or care givers, household heads and the children. Information on socio-demographic characteristics for mothers, caregivers and household heads included age, marital status, highest level of education, ability to read or write and household composition (number of people in the household and their ages and sex). Information was also collected on child feeding practices such as age of introducing complementary foods, frequency of feeding children of different ages, the most common complementary food provided and diversity of foods given to children. Mothers and caregivers were further asked to explain how they stored, processed and prepared complementary foods. Information was further collected on child morbidity over a period of two days and two weeks before the date of the interviews as this has a direct effect on food intake and child nutritional status.

3.4.1.2 Pretesting of the questionnaire

The questionnaire was translated by the researcher into the common local language (*Chichewa*) used by the communities in the study area. After translation, the questionnaire was pretested in one of the communities in Lilongwe district next to Lilongwe University of Agriculture and Natural Resources. The pretesting was done for several reasons. Firstly the pretesting was done as part of training of the Research Assistants to acquaint them with skills and techniques of conducting an interview. The pretesting also provided an opportunity to the research team to identify questions which were easily and correctly understood by respondents, to identify questions that were not clear to respondents and also to get input from respondents on the correct words and terms to use in the questions. The pretesting exercise was also used for standardizing the questionnaires. Standardization of the questionnaire included back translation from English to *Chichewa* and back to English by an independent translator to ensure that the original meaning of the questions was not lost.

3.4.1.3 Anthropometry measurements

Anthropometry measurements such as body weight and recumbent length of the children were taken using SECA 881U mother-infant digital scales and length boards designed and manufactured under the specifications by UNICEF. The standard procedures for measuring height or length in children entail that children that are below the age of 24 months should always be measured while lying down on the length board (Gibson, 2005). This is because such children are too young to stand upright on the length board and this may lead to increased measurement errors. In such a case, recumbent length is measured and recorded. On the other hand, the recommendation is that for children aged 24 months and above, the measurements should be taken while the children are standing. Since all the children in our research were below the age of 24 months, recumbent length was measured using specifically designed length boards for children capable of measuring length up to 120cm (UNICEF, 2013).

3.4.2 Training of research assistants

In this research, seven Research Assistants were recruited and trained on the protocols to collect and record information during the study. All the Research Assistants had at least a Bachelor of Science degree in Nutrition and Food Science and four of them were completing Master of Science degree programmes in Human Nutrition and Food Science at LUANAR. The training package included going through the study design and the types of data to be collected. Research Assistants were briefed on how to conduct a household interview, how to facilitate focus group discussions and how to take notes during focus FGD.

Research Assistants were also taken through the procedures of measuring children using anthropometry equipment. The equipment used was digital scales (SECA 881U) and specifically designed length boards for children capable of measuring length up to 120cm (UNICEF, 2013). During the training, demonstrations were made on how to take care of the anthropometry equipment, how to calibrate the scales using objects of known weight, how to weigh children, how to reset the scale and how to measure recumbent length of the child using the length boards. Recumbent length was measured because all the children were under the age of 24 months. It is recommended that children under the age of two years should be measured while lying down because at that age they cannot stand upright on a height board (Gibson, 1990). The Research Assistants were also guided through the questionnaire to familiarize them with each and every question before going for field work.

3.4.3 Data collection procedures

Data were collected with the assistance of Research Assistants who were recruited and trained before the survey. The survey tools such as questionnaires, FGD check lists, anthropometry equipment and food sampling tools were used.

3.4.3.1 Assessment of sociodemographic characteristics of household members

Social and demographic characteristics of the household members form the environment in which children grow. Understanding of the household characteristics may help one to know some of the factors that influence child feeding practices among mothers and caregivers. In this study, mothers and caregivers were the respondents during the household interviews. Information was collected on age, sex and marital status of the household head, mother or caregiver and their level of education. Information on marital status of the head of household and that of the mother or caregiver were also determined and recorded. Where the husband had more than one wife, the marital status was recorded as married-polygamous and where there was one husband and one wife, the information was recorded as married-monogamous. Other criteria for marital status included single, referring to a woman who has never married before, divorced and widowed. Categories for highest level of education attained included no education, Primary standard 1 to 4, primary standard 5 to 8, secondary form 1 to 2, secondary form 3 to 4 and tertiary education which was the level after secondary school.

3.4.3.2 Child feeding practices by mothers and caregivers

The indicators for child feeding practices which were assessed included age of the child when complementary foods were introduced, dietary diversity of complementary foods and minimum meal frequency as recommended by WHO (2010).

3.4.3.2.1 Assessment of introduction of complementary food

Mothers and caregivers were asked to recall the age of their youngest child when the first complementary food was provided. Mothers and caregivers were probed to indicate the exact age of the child when any food or liquid was provided as the first food apart from breast milk. Mothers and caregivers were also asked to indicate the most common type of complementary that they provide to their child. The proportion of children aged 6-8months who received complementary food the previous day were divided by the total number of children aged 6-8 months.

3.4.3.2.2 Determination of dietary diversity for the children.

To determine the dietary diversity of children, a dietary diversity questionnaire was used to collect information from the mother or caregiver on the dietary history of the index child based on the 24- hour dietary recall. Information was obtained on food groups from food intake by the children (WHO, 2010). The respondents were asked to recall the foods given to the child in the previous 24 hours before the interviews. A scale of 7 food groups as recommended by the World Health Organization (2010) was used in assessing the dietary diversity of the children as shown in Table 1

Table 1 Categories of food groups for children

Food Groups	Points
1. Grains, roots and tubers	1
2. Legumes and nuts	1
3. Dairy Products (milk, yoghurt and cheese)	1
4. Flesh foods (meat, fish, poultry and liver/organ meats)	1
5. Eggs	1
6. Vitamin A rich fruits and vegetables	1
7 Other fruits and vegetables	1
Total	7

Key: If the answer is "YES" then award 1 point; if the answer is "NO" award 0 point

For each of the seven food groups, a point was added if any food in the group was consumed over the reference period giving a maximum sum total diversity score of 7 points for each individual child when the responses were positive to all food groups. From the seven food groups, two mutually exclusive dietary diversity categories were derived into No dietary diversity (NDD) (1-3 food groups consumed) and Minimum dietary diversity (MDD) (≥4 food groups consumed). The indicator was therefore calculated by dividing the total number of infants 6-23 months old who received foods from ≥4 food groups during the previous day by the total number of children aged 6-23 months in the study.

Mothers and caregivers also provided information on various challenges they faced during complementary feeding. Detailed discussions were held in focus groups and the findings were included in the analysis of feeding practices to triangulate with information from household interviews.

3.4.3.3 Assessment of nutritional status of children

Nutritional status of all the targeted children was assessed using anthropometrict measurements. All children that were not eligible were excluded from the assessment.

3.4.3.3.1 Child anthropometry measurements

Two types of anthropometric measurements were taken; body weight and recumbent length as specified by Gibson (1990), WHO (1983) and Jelliffe (1966). Since all the children were under the age of two years, recumbent length instead of height was measured. Children in the age ranges of 6-23 months may not stand upright and steady without support. Therefore taking their length while they are lying on the measuring board provides room for minimizing measurement errors. All the measurements were taken twice for each child and the average was recorded as the final reading. Children were also checked for bilateral oedema and there was no child identified with oedema. Records of children with oedema are normally excluded from data analysis for anthropometry because oedema confounds the weight measurements and such children are already classified as suffering from severe acute malnutrition (Gibson, 1990).

Information to establish the age of the children was obtained from the children's records in their health passports from the underfive clinics. The information collected from the card was the date and year of birth of the child and the age was determined by calculation during data entry and analysis. Where health passports were not available, age of the child was estimated using calendar of events and ages of other children who were born within the same period with the child being assessed. The sex of each child was also recorded because it is an important variable when analyzing anthropometry data when comparison of nutritional status between male and female children is required.

Weight of the child: Digital electronic scales (SECA 881U) were used to measure the weights of the children. The scales were checked everyday using the same object with a known and constant weight to ensure that accurate measurements were taken and recorded. The scale was placed on a flat hard surface and two people assisted each other to measure the weight of the child. Children who could stand on their own were put on the scale by one of the research assistants while the researcher was taking the readings and recording them. Children who could not stand on the scale were weighed together with their mothers. Mothers were requested to stand on the scale first, their weights were cancelled (zeroed) using the reset button of the scales and then while standing on the scale, they were given the child to hold. The scale therefore displayed the weight of the child and this was recorded by the researcher. The children were weighed with no shoes and in minimum clothing (underwear) to minimize measurement errors. The researcher was responsible for taking and recording all the measurements. Two readings were taken for body weight and the average was recorded as the final reading. All the weights were recorded to the nearest 0.1kg.

Recumbent Length: Recumbent length was measured using wooden length boards for children. The children were measured without shoes. The length board was placed on a flat hard surface and the child was placed on the length board, face upwards, with the head on the fixed end and the body parallel to the long axis of the board. The shoulder blades were resting against the surface of the length board, the crown of the head of the child touching the fixed head board so that the Frankfurt plane was vertical. The researcher held the child's feet, toes pointing directly upward, and keeping the child's knees straight, the researcher then rolled the foot piece of the length board until it touched the child's feet at a right angle. The reading was recorded to the nearest 0.1 cm.

Oedema: This is a clinical measure of acute undernutrition and because of accumulation of body fluids in the affected child, the weight of the child may increase and therefore confounding the nutritional status of the child. Children with oedema are normally excluded from the analysis the nutritional status. Children with bilateral oedema already have severe acute malnutrition and are normally excluded from anthropometry measurements (Gibson, 1990). Thumb pressure was applied on the top part of both feet of the child. Any thumb pit or dent that would remain after release of thumb on both feet of the child would imply that the child had nutritional oedema. In this research there was no child found with oedema. In addition to anthropometry measurements, the sex and age of the child was recorded and used during analysis of the nutritional status.

Child morbidity: Information was collected from mothers on symptoms and signs of prevalence of different types of illnesses among the children in the previous two weeks or two days before the interviews. Focus was mainly on illnesses that have direct effect on the nutritional status of the children such as diarrhoea, fever with chills (malaria), and fever with difficult breathing (pneumonia). Mothers were also asked to describe what actions they took when their child had diarrhoea.

3.5 Data collection for the experimental design of the study

3.5.1 Data collection instruments and tools

Different tools were used for collecting data on the 40 sampled households to get detailed information on various aspects of child feeding and hygiene practices. The researcher and research assistants collected information through focus group discussions and observations through home visits. Food samples were also collected from the households to be analysed for microbes and aflatoxin contamination. Some of the data collection tools are discussed in the sections that follow.

3.5.2 Focus group discussion guide

Focus group discussions were conducted to collect information on the common child care and feeding practices in the communities. A focus group discussion guide with an outline of topics was used during the discussions. The topics included types of foods used locally by mothers and caregivers as complementary foods, ingredients used in preparing complementary foods, the form in which the food was given to children, methods used in preparing complementary foods, steps followed when handling the grains during processing; such as sorting or grading, cleaning or washing, and soaking or roasting. Information was also collected on storage of food, facilities used for storage of food, and hygiene of utensils used for preparing food. The different sources of food available to the households and other factors that influenced the choice of food given to children as complementary food were also identified and recorded.

Four focus group discussions were conducted in each village comprising of 10, 10, 10 and 9 participants taking part respectively giving a total of 39 participants instead of 40 because one of the participants was sick and had gone to a clinic for medical attention. The discussions were held in an open and relaxed environment because the participants were familiar with each other. The discussions were conducted in the local language spoken in the area (*Chichewa*) to make sure that all participants were following the discussions. Two Research Assistants recorded the proceedings of the FGD in notebooks while the researcher was facilitating the discussions. Data were also collected from the households on sanitation, hygiene practices, water sources and storage, and prevalence of diarrhoea among young children. Diagrams were drawn to identify critical control points for preventing contamination of complementary food. The notes were later transcribed and translated into English by the researcher. After the FGDs were completed, the researcher and two research assistants had round table- discussions to synthesize and analyze emerging themes from the transcripts.

3.5.3 Observation form and schedule

Research assistants to record different practices by mothers and caregivers used observation forms during home visits. Observations were made and recorded on food storage facilities, cleanliness of utensils storage and cooking of food and water utensils, utensils for serving food, source of drinking water, utensils for drawing and storing water and facilities for disposal of refuse around homesteads. Observations were also made during food preparation, child feeding, storing of already prepared complementary food, storage and mixing of ingredients for preparing complementary foods. The forms were used during the period before mothers and caregivers were trained on the HACCP based strategy and during the final evaluation after the training. In addition to use of the observation form, the food storage environment was assess by recording temperature and relative humidity with a hand held Hygro-Thermometer PCE-555. These observations were important because they reflected the levels of adherence to the recommended practices by the mothers and caregivers and revealed areas that needed more effort to change.

3.5.4 Tools for collecting food samples

Food samples were collected using a cup, a portable kitchen scale, zip-lock bag material and cooler boxes. Dry ingredients (flour) were weighed using the kitchen scale in the room where the flour was stored. The flour was then collected in sterilized zip lock bag materials which were kept in insulated cooler boxes to protect the food samples from contamination after collecting from households. The samples were then transported to the food microbiology laboratory at Lilongwe University of Agriculture and natural Resources. Deep freezers were used to keep the samples before analysis for mould and aflatoxin contamination.

3.5.5 Apparatus for mould count and determination of aflatoxin in food

Appropriate laboratory apparatus and protocols for culturing and identification of moulds were used as recommended by Benson (2001) and the Association of Official Analytical Chemists, (1990). The general equipment included incubators, water baths, autoclave, refrigerators, microscope, pipette tubes of different calibrations, petri dishes, beakers and test tubes.

3.5.6 Determination of aflatoxins and enumeration of moulds, yeast and coliforms in maize flour

3.5.6.1 Preparation of media for culturing samples

Media for culturing microbes were prepared following the conventional acceptable procedures as recommended by the International Organization for Standardization (ISO) 1999 and ISO 7954 General guidance for enumeration of yeasts and moulds. The media which included peptone water (OXOID CM 0509), Potato Dextrose Agar (BIOLAB art #HG00C100.500), Malt Extract Agar (BIOLAB art # HG000C10.500) and CZAPEK DOX Agar Modified (OXOID code CM97) were prepared separately following the manufacturer's instructions as described in the sections that follow.

A total of 20 g of peptone water was added to 1 litre of distilled water. The mixture was distributed into tubes and sterilized by autoclaving at 121^0C for 15minutes. A total of 39g of Potato Dextrose Agar were suspended in 1 litre of demineralized water and boiled until completely dissolved. The mixture was autoclaved at 121^0C for 15 minutes and cooled to 45 ^{0}C. The mixture was then poured into petri dishes and left to set. Malt Extract Agar was prepared by suspending 50g in 1 litre of demineralized water and the mixture was boiled until completely dissolved. The mixture was autoclaved at 115^0C for 10 minutes and cooled to 45 ^{0}C before pour plating in petri-dishes. CZAPEK DOX Agar Modified (OXOID code CM97) was prepared by suspending 45.4g in 1 litre of distilled water and boiling to dissolve. The mixture was then sterilized by autoclaving at 115 ^{0}C for 20 minutes and cooling to 45^0 C before pouring in petri dishes.

3.5.6.2 Isolation of fungi using serial dilution technique

A flour sample weighing five grams was suspended in 45 ml of sterilized buffered Peptone Water Agar to obtain a 10^{-1} dilution (stock solution). From the stock solution, a series of 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5} dilutions were prepared by adding 1mL of solution to 9 ml of peptone water media respectively. After making the dilution series, one mL suspension was obtained from the 10^{-1}, 10^{-3} and 10^{-5} dilutions respectively and transferred into sterile petri dishes. Using the pour plate method, 15 ml of Molten PDA media at 45 ^{0}C were poured into petri dishes in duplicates and left to solidify in the Biosafety Cabinet. After the media had solidified, the plates were covered with aluminum foil and incubated at room temperature

(25 ^{0}C) for 7 to 15 days with the flat plate upside down to allow for the production of sclerotia and ascospores.

3.5.6.3 Enumeration of total viable counts, moulds and yeast

The total number of colonies was counted and recorded on each petri dish. Mould and yeast colonies were identified, counted and recorded as colony forming units (CFU) from each sample plate after 7 days of incubation. Plates with counts between 10 CFU - 150 CFU were selected and yeasts, moulds and other microbes were counted respectively according to their appearance. If the colonies of same microbes covered the whole plate, the counts were recorded as too numerous to count. The colony counts were adopted using average plate counts of two duplicate plates.

3.5.6.4 Isolation of pure cultures

The streak plate method was used to isolate moulds from yeasts and other microorganisms from the samples. The four way or quadrant streak method was used to inoculate pure colonies of moulds on differential media Czapek Dox Agar (CZA) and Malt Extract Agar (MEA) as recommended by Benson (2001). The petri dishes were covered with aluminum foil and incubated for 7 days in duplicates. Macroscopic characteristics such as colony diameter, exudates, colony reverse and microscopic characteristics including conidiophore and conidia were observed after staining the slides with lacto phenol cotton blue. Examination of the colonies on a microscope with a low power (x10 objective) and medium power (x40 objectives) were done for determining detailed structures.

3.5.6.5 Morphological characteristics of Aspergillus flavus

The characteristics looked for when identifying the moulds included macroscopic characteristics such as the colony shape and colour. On CZA media, the colony colours and shapes expected included yellow to green or dark green, reverse hyaline, sclerotia white to wood brown, globose-sub globose in shape and exudates transparent to red brown droplets in heavily sclerotial strain. On MEA, the expected colour was dark green and reverse hyline shape. An electronic microscope (Olympus CX 20) was used to confirm the identification of the specific types of moulds using microscopic characteristics at total magnification of x400 (X40 objective lens and x10 eyepiece lens) of wet slide preparations on the microscope to confirm the presence of *Aspergillus flavus* from a pure culture isolate. Plate 1 shows petri dishes with mould colonies after streak plating in a laboratory.

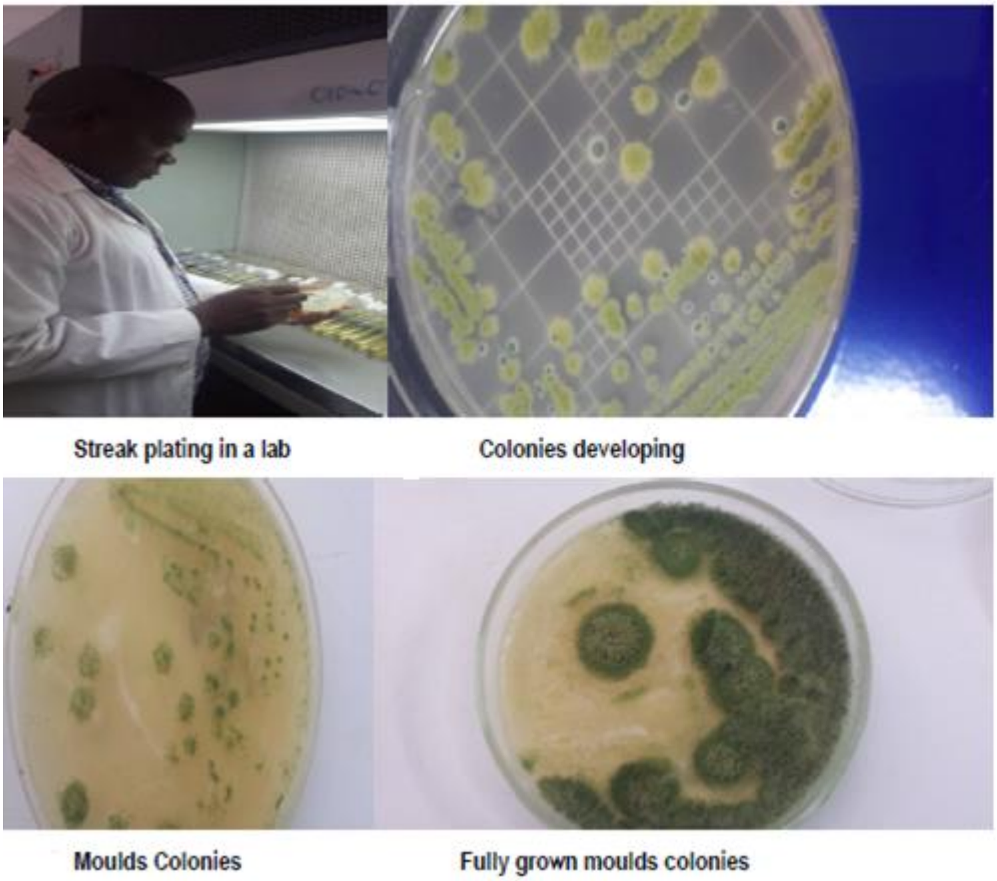


Plate 1 Isolation of moulds colonies in a laboratory

3.5.6.6 Determination of coliforms

To determine coliforms, the Most Probable Number (MPN) method was used. An amount of 1.0 ml of the dilute sample was inoculated into three separate tubes of 9.0 ml lauryl sulphate broth (M 080 Himedia, India) with inverted Durham tubes. The samples in the tubes were incubated at 37^{o}C for 24-48 hours. After 24 hours, the tubes showing gas production were recorded as positive and a loop-full from each gas positive tube was transferred to a separate tube containing Mac Conkey’s broth (X 4230 Oxoid, England) with Durham tubes and incubated at 44.5^{o}C for 48 to 72 hours. Tubes showing gas production were noted and confirmed as positive for coliforms. The MPN Table was used to calculate the number of coliforms per ml (Wanjala, et al., 2017).

3.5.6.7 Determination of aflatoxin in food samples

Aflatoxin levels in food samples were analysed using the High performance Liquid Chromatography-FLD (HPLC-FLD) according to recommendations by Pitt et al (1983) and method used by Matumba et al., (2010). The flour samples were analysed at the Partnership for Aflatoxin Control in African (PACA) Laboratory at Chitedze Agriculture Research Station in Lilongwe. The samples were analysed in duplicates and the average values were recorded as the final measurement for the sample.

3.5.6.8 Sample extraction

A Mixture of 50g of flour sample and five grams of salt (Nacl) was placed into a blender jar, 100 mL methanol: water (80:20) was added and blended in the blender jar at high speed for one minute. The extract was poured into fluted filter paper Number 41 and the filtrate was collected in clean conical flasks.

3.5.6.9 Extract dilution

A total of 10mL of the filtrate was poured into clean glass cylinder and diluted with 40 mL of distilled water. The dilute was then filtered into a glass microfiber filter into a clean vessel.

3.5.6.10 Column chromatography

The filtered diluted extract (10 mL) was passed completely through AflaTest-P affinity column at a rate of about 1-2 drops per second until water came through the column. Then 10 mL of distilled water was passed through the column at a rate of about 2 drops per second. This step was repeated until air came out of the column. Glass cuvettes (VICAM Part #34000) were placed under AflaTest-P Column and 1.0 mL HPLC grade methanol was placed into a glass syringe barrel. The AflaTest-P column was then eluted at a rate of 1 drop per second by passing the methanol through the column and collecting all the sample eluate (1.0 mL) in a glass cuvette and 1.0 mL of distilled water was added to the glass cuvettes. About 20-100 microliters (μL) of the eluate was injected onto HPLC for detection of aflatoxin (Plate 2).

Blending Samples Filtering Samples Cleaning samples

Samples in vials ready for HPLC Determining aflatoxin in HPLC

Plate 2 Sample preparation for analysis of aflatoxin with HPLC

3.5.7 Determination of the sanitation and hygiene protocols used by mothers and Caregivers

3.5.7.1 Identification of the critical control points

Using focus group discussions, a HACCP strategy was used to conduct a hazard Analysis to identify critical control points. The research team together with the mothers and caregivers identified risk factors which could lead to contamination of the complementary foods. Flow diagrams were constructed with the mothers and caregivers to show the flow of activities during handling and processing of maize flour for complementary feeding. Using the flow diagrams constructed during the focus group discussions, suspect critical control points and associated hazards for complementary food preparation were identified. Four identified critical control points included handling techniques of the grain before milling into flour such as sorting, mixing and winnowing, the second critical point was during drying and sieving of the flour, the third point was the storage conditions of the maize flour where temperature and relative humidity were not regulated and the fourth one was the way the food is cooked. These critical points would expose the food to microbial contamination which would also lead to production of mycotoxins by fungi into the maize flour.

During handling of maize grain, the use of contaminated ingredients such as rotten and discoloured or damaged maize grains would introduce moulds and aflatoxin into the complementary food. Such grains may be contaminated with aflatoxins which may find their way into the complementary food. The same applies to drying of the flour. If the water content of flour is above 15%, microbial growth may be enhanced leading to spoilage and multiplication of pathological microbes (**Figure 9**).

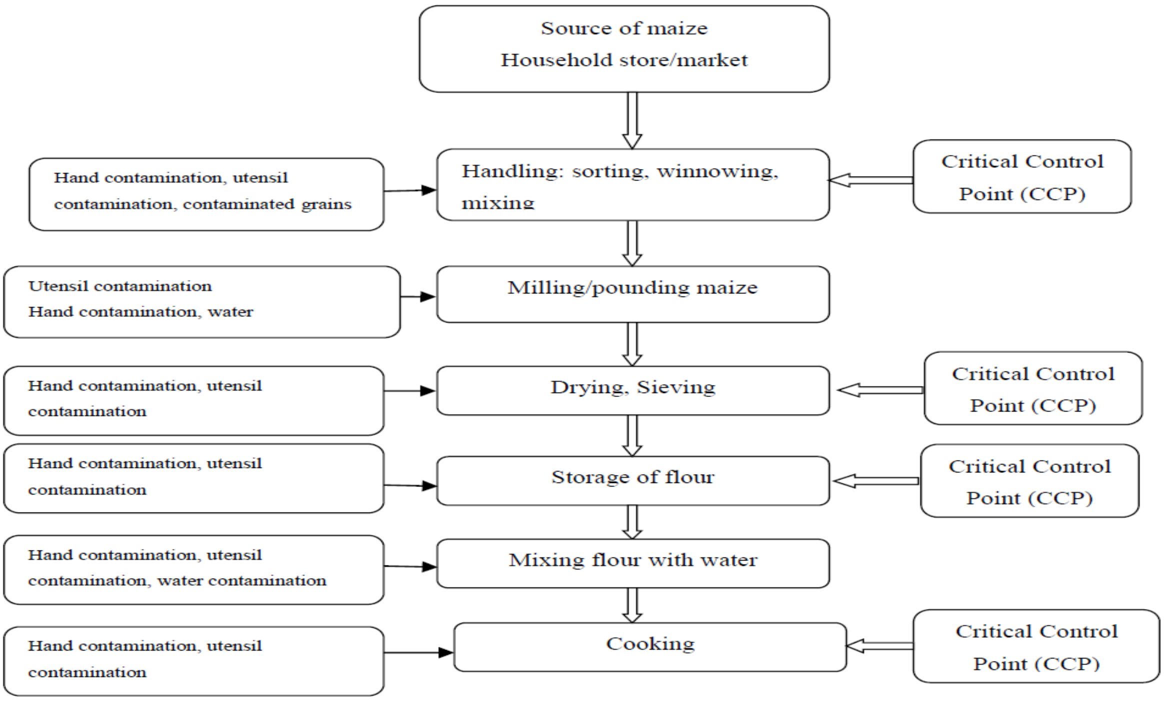


Figure 9 Stages of handling maize flour and critical control points

After identification of the critical control points, samples of flour were collected from the households. The storage temperature and relative humidity of the ingredients were measured using the Hygro Thermometer PCE 555 and recorded. The samples were transferred to the laboratory for enumeration of moulds and determination of aflatoxin levels.

3.5.7.2 Observations on sampled households

The research team visited mothers and caregivers in their homes to observe sanitation of the surroundings and how caregivers ensured hygiene during cooking of complementary food, storage of water for drinking, serving of food and the actual feeding of the children. Before the visit, caregivers were not informed on the type of information that was going to be collected to prevent them from being biased when responding to questions. Checklists for hygiene practices were used to score caregivers hygiene practices during the visit.

The criteria for hygiene during food preparation included cleaning of the kitchen or cooking place before cooking, washing cooking utensils, use of water from clean and covered containers, use of clean utensils for carrying cooking ingredients, covering of food during cooking, covering of food after cooking and serving food on clean plates or in clean cups. Personal hygiene was assessed by checking the cleanliness of the clothes, covering of hair during cooking, short finger nails and body cleanliness and washing of hands before and during cooking of food.

These attributes were scored as “Yes=1” representing correct practice and “No=0” representing incorrect practices. The duration of cooking the food and consistency was also assessed using standard recipes for preparing complementary foods. The data collected during household observations formed the baseline for the hygiene practices by mothers and caregivers. After observations, researchers identified and recorded all the practices that were perceived as inappropriate and unhygienic among caregivers. Messages were developed and demonstrations were also planned for training mothers and caregivers to improve the practices and to bring positive behaviour change.

3.6 Implementation of the training intervention

3.6.1 Training of mothers and caregivers

Using the developed messages, mothers and caregivers were trained on how to process and prepare hygienic and safe complementary foods. The training was delivered in two components which included teaching mothers using key messages on importance of hygiene during food preparation, how to ensure that water is drawn from safe sources and stored in utensils that are clean and safe from contamination and ensuring personal hygiene before handling food. The other component involved demonstrations on various aspects such as how to sort, grade and clean maize grains before milling into flour for preparing complementary food. Demonstrations were also conducted on hand washing with soap and running water, cleaning of utensils with detergents, and storage of food in clean, dry and cool environment. Mothers were also trained on importance of hygiene when handling complementary food. Sanitation of the cooking place such as sweeping the surroundings, prevention of dust and covering cooking utensils during cooking and storing of food were also covered during the training sessions.

Mothers and caregivers were also taught on the importance of keeping livestock in confinement or away from areas where food was being prepared and kept. Emphasis was made on the risks of food contamination with animal droppings which may contain bacteria (*E.coli*) which may lead to diarrhoea in children. A module with information that could be translated into a total of 12 key messages were taught to the mothers and caregivers (Appendix 3). Training was done in the community where the mothers lived to ensure that they were trained in familiar environment. Mothers were observed as they handled food through the critical control points. The duration of the training was three days per one group for component one of training and two days per group for the practical demonstrations. These trainings were repeated after a month.

3.6.2 Evaluation of mothers and caregivers

Six months after the training, mothers and caregivers were interviewed and observed in their homes to determine hygiene and sanitation practices. The same checklists that were used during the baseline data collection were used during the final evaluation (Appendix 4). A hygiene scale was developed using the 12 key practices on which mothers and caregivers were trained. The data were assessed and analyzed. A household that scored between 9 and 12 was recorded as observing acceptable hygienic practices and any household that scored below 9 was recorded as not observing sanitation and hygiene practices. The data were entered into SPSS version 20.0 for analysis using cross tabulation and Chi-square test to determine differences between proportions of mothers and caregivers who were following the recommended practices and those who were not.

3.7 Reliability and validity

Reliability is a measure of the degree to which research instruments yield consistent results after repeated trials (Mugenda and Mugenda, 2003). Validity expresses the degree to which an instrument or research tool measures what it purports to measure.

In this study, reliability of the questionnaires was ensured by pretesting the questionnaires on a sample of about 20 respondents to find out whether the questions were capturing the intended information consistently from one respondent to another. The questions were tested and with inputs from the local communities discussions were held to assess whether the language used and the format of the questions was easily understood by the communities. Necessary changes were made and the tools were pretested by collecting data from the communities before the survey was implemented. The data for pretesting were analysed and the results were consistent among the respondents without wide variations.

The weighing scales were standardized on a daily basis by using an object of known weight to test the scales. Only scales that provided correct readings were used in the study. Internal reliability within the research team members was ensured by allowing team members to take measurements on the same subjects and compare the readings until there were no errors in measurements.

To ensure validity of the study tools, the research tools such as the household questionnaires and observation checklists were validated in two stages. Firstly, the tools were submitted to supervisors and other nutrition experts to read through the questions to evaluate whether the questions effectively captured the topics under investigation. The questionnaire and checklists were also translated back to back from English to local language (*Chichewa*) and from *Chichewa* back to English to ensure that the questions did not lose their original meaning. The translation into the local language ensured that the questions were clearly understood by the respondents. This assisted to ensure face validity as well as content validity of the tools (Bolarinwa, 2015)

3.8 Ethical review and approval

An application was made to the National Health Sciences Committee (NHSC) of Ministry of Health in Malawi and an approval was obtained to conduct the study under protocol: NHSRC#15/4/1432. Written approval was also obtained from the Director of Agricultural Extension Services (DAES) in Ministry of Agriculture, Irrigation and Water Development to allow the research team to enter the communities through Mayani Extension Planning Area office in Dedza district. The ethical approval was obtained based on the criteria as stated in the sections that follow.

3.9 Informed consent

The study participants were informed of the objectives of the research to ensure that they fully understood the nature of the survey, the reasons the survey was conducted, the possible benefits to individuals and their communities and any possible risk they might suffer. In this study, there were actually no risks expected. A written or thumb print consent was obtained from the head of the household, the mother or the primary caregiver for the child. Informed consent was obtained before household interviews. Respondents were free to discontinue with the study at any point when they felt so and this would not result in any harm or punishment to the respondent. However, in this study no responded refused to participate or withdrew during interviews.

3.10 Data transformation

Before performing statistical analysis, the data on TVC, mould counts, yeast counts and coliforms were converted to decimal logarithmic values (log_{10}) to reduce the variations in the recorded values.

3.10.1 Anthropometry data

Anthropometry measurements were converted into z-scores by WHO Anthro software. The z-scores are important in building up nutritional status indices such as weight-for age (WAZ), Height-for-age (HAZ) and Weight-for height (WHZ) for measuring prevalence of underweight, stunting and wasting respectively.

3.10.2 Total viable counts (TVC), moulds, yeast and coliforms

Total viable counts, mould, yeast and coliform counts were converted into logs of 10 to reduce the variance in the measurements before generating descriptive statistics such as means, frequencies and standard deviations.

3.10.3 Hygiene practices among mothers and caregivers

A hygiene scale of 1 to 12 scores was constructed for assessing hygiene practices during the HACCP intervention. Mothers and caregivers who scored from 9 to 12 on the hygiene scale were determined to be following hygiene practices and those who scored less than 9 scores were classified as not following hygiene practices.

3.11 Data analysis

Data were analyzed according to the specific objectives of the study. Different data analysis technics were used and different statistical tests were employed to determine the statistical significance of descriptive variables of interest.

3.11.1Analysis of anthropometry data

Anthropometry data were analyzed using the 2005 WHO Anthro software for analysis of nutritional status. Three indices were calculated namely: weight for height, weight for age and height for age. Nutritional status for 306 children was assessed. All children whose height for age was below minus two standard deviations (or z-scores) from the reference mean for height-for-age (HAZ) were classified as stunted. Children whose weight-for-height was below minus two standard deviations (or z-scores) from the reference mean for weight-for-height (WHZ) were classified as wasted while children with weight-for- age (WAZ) z-scores below minus two of the reference mean were classified as underweight (WHO, 2006).

The indices are expressed as standard deviation units from the median for the reference group. Children who fall below minus two standard deviations (-2 SD) and minus three standard deviations (-3SD) from the median of the reference population are regarded as moderately malnourished, while those who fall below minus three standard deviations (-3 SD) from the median of the reference population are considered severely malnourished (WHO, 2006). These cut off points for interpreting nutritional status are presented in Table 2.

Table 2 Cut off points of z scores for Nutritional status of children

Index	Interpretation of Nutritional Status ±2 z-score	<-2 z-score to -3 z-score	<-3 z-score
Weight for Age (WAZ)	Normal	Moderate underweight	Severe underweight
Height for Age (HAZ)	Normal	Moderate stunting	Severe stunting
Weight for Height (WHZ)	Normal	Moderate Wasting	Severe wasting

After analyzing the nutritional indices, the dataset was exported to SPSS and merged with data from the household survey for further analysis. Data were first analyzed using cross tabulation and Chi-square test was used to find associations among categorical variables. Variables that were statistically significant were further subjected to binary logistic regression analysis to find associations between prevalence of different forms of malnutrition (stunting, underweight, wasting) as dependent variables and household socio-demographic characteristics, child meal frequency, child dietary diversity, hygiene practices and mould count and aflatoxin levels in flour used for preparing complementary foods as independent variables. The results are presented in tables and graphs. The summary of the details of methods and tests used to analyze data are presented in Table 3.

Table 3 Summary of Data Analysis for the study

Objective	Variables of interest	Methods of Analysis	Statistical Tests used
1. To determine child feeding practices among mothers and caregivers	Age of introducing complementary food to the child, dietary diversity, minimum meal frequency	Descriptive statistics to show frequencies and percentages of occurrence	Pearson Chi-Square Test to establish associations between household demographic characteristics and feeding practices
2. To assess nutritional status of children in the study area	- Height (cm) and Weight (kg) - Age (months) and Sex (M/F) - Height for age z-scores - Weight for age z-scores -Weight for height z-scores	- Descriptive Analysis (frequencies, means, range, standard deviations)	- Pearson Chi-square test to establish relationships between nutritional status and child's age and sex - Student t-test to establish differences between means of anthropometry variables among the children

Table 3: Summary of data Analysis for the Study (continued)

Objective	Variables of interest	Method of Analysis	- Statistical tests used
3. To enumerate microbial and aflatoxin contamination of maize flour	- Total viable counts, mould counts (log_{10}, cfu/g) yeast counts (log_{10}cfu/g), coliforms (MPN), aflatoxin levels (ppb)	- Descriptive statistical analysis (frequencies, Means and Standard deviations),	
4. To determine the sanitation and hygiene protocols used by mothers and Caregivers	- Critical control points, - Personal hygiene of food handlers, - Food preparation - Behaviour change of mothers and caregivers	- Flow diagrams, - Descriptive statistics using cross tabulations	- Chi-square Test to establish differences in proportions of mothers or caregivers who adopted recommended hygiene practices - T-test to show differences in the means of hygiene scores before and after training

CHAPTER FOUR

RESULTS

4.1 Demographic characteristics, feeding practices and nutritional status of children

The descriptive characteristics of the sampled households and children are presented in Table 4. A total of 303 (97.7%) out of the calculated sample of 310 households and 306 (96.8%) children participated in the survey. About 95.7% of respondents were biological mothers of the children and the rest were caregivers.

Table 4 Descriptive characteristics of sampled mothers, caregivers and children

Characteristics	n	%
Number of households (mothers and caregivers) who participated in the study	303	97.7
Number of children who were assessed in the study	306	96.8
Number of biological mothers	290	95.7
Number of non-biological mothers (caregivers)	13	4.3
Number of children still breastfeeding	288	94.1
Number of children not breastfeeding	18	5.9

Table 4 shows that 94.0% of the children were still breastfeeding while 6% had completely stopped breastfeeding and were eating complementary food only. The response rates of the sampled mothers and children were within the statistical estimate of the sample size for the study.

4.1.1 Household demographic and socioeconomic characteristics

Of the sampled households, 89.1% were headed by males with the mean age of 32.3±10.6 years for the household heads. All the mothers and caregivers interviewed were of the reproductive age (15-49 years) group with a mean age of 26.5±7.0 years and the youngest being 16 years old. Table 5 presents demographic characteristics of sampled households.

Table 5 Socio-demographic characteristics of sampled households

Characteristics	Value	
Mean age of mother or caregiver	26.5±7.0	
Mean age of household head	32.3±10.6	
Mean household size	5.0±1.8	
Sex of Household head	**n**	**%**
Male	270	89.1
Female	33	10.9
Marital status of mother or caregiver		
Married (monogamy)	214	70.6
Married (polygamy)	58	19.1
Widowed	5	1.7
Single	3	1.0

Table 5 shows that the mean household size was 5.0 which was larger than the national average of 4.0 people per household (NSO, 2018). The majority of households were headed by males. Poly gamy was also common in the study area (19%). Maternal literacy is important in promoting recommended child feeding practices. Table 6 presents information on the highest level of education attained by mothers and caregivers.

Table 6 Highest level of education for mother or caregiver

Education level	n	%
Tertiary education	1	0.4
Secondary school (Form 3-4)	10	3.7
Secondary school (Form 1-2)	14	5.2
Primary school (standard 5-8)	89	33.0
Primary school (standard 1-4)	103	38.1
Adult literacy	3	1.1
No education at all	50	18.5
Proportion of mothers and caregivers who could read or write		

Table 6 shows low levels of education attainment and literacy among mothers or caregivers. The majority of mothers and caregivers attempted only primary education and 18.5% did not have to any formal education at all.

4.2 Child feeding practices by mothers and caregivers

4.2.1 Introduction of complementary food

The majority of mothers (80.0%) introduced complementary foods to their children at the right age of six months though 9.3% introduced complementary foods earlier than six months. The reported minimum age when complementary foods were started was one month; and over one tenth (10.2%) of mothers and caregivers introduced complementary foods later than the age of six months. Food groups consumed by children of different age categories and associations between types of foods consumed and proportions of children in different age categories are presented in Table 7.

Table 7 Food groups consumed by children of different age categories

Age category of children in months						
Food group	**6 – 9**	**9-12**	**12-23**	**(Total)**	***Chi-square***	**P-value**
Grains, roots and tubers (N=280)	88.6	97.0	92.8	92.7	3.6	0.17
Legumes and nuts (N=157)	42.9	53.0	55.1	51.8	3.0	0.22
Dairy products (N=79)	20.0	30.3	26.9	26.9	2.1	0.36
Flesh foods (N=33)	4.3	12.1	13.2	10.9	4.2	0.13
Eggs (N=16)	0.0	6.1	7.2	5.3	5.2	0.07
Vitamin A rich vegetables (N=75)	11.4	24.2	30.5	24.8	9.7	**0.01***
Other fruits and vegetables (N=118)	11.4	39.4	50.3	38.9	31.4	**0.01***

***significant at p<0.05**

Table 7 shows that the common food groups consumed by children were grains, roots and tubers. Consumption of other foods such as Vitamin A rich vegetables and other fruits and vegetables differed significantly (p=0.01 and p<0.01 respectively) across the age categories of the children.

4.2.2 Meal frequency and dietary diversity of children

Meal frequency is an important component of complementary feeding and information on number of times children were fed a day before the survey and proportions of children who met the requirement for minimum or more meal frequency are presented in Table 8.

Table 8 Meal frequency among the children

			Meal frequency		
Age of Child (months)	Once (%)	Twice (%)	Three times (%)	Four Times	Minimum or more
6-9	38.7	38.7	22.6*	0	57.1**
9-12	18.8	34.4	42.2	4.7	17.2
12-23	16.0	31.4	49.4*	3.2	1.9**
Total	21.6	33.7	41.8	2.8	17.6

* $X^2=21.79$, p=0.001; [a] breastfed children should also be given 1-2 snacks as desired;

**$X^2=94.56$, p<0.001;

Results in Table 8 show significant differences (P<0.001) in the proportions of children who had minimum or more meal frequency. More children aged 6-9 months (57.1%) met their minimum meal frequency that children aged 12-23 months (1.9%). Information on the diversity of food consumed by children segregated by sex and age category is presented in Table 9.

Table 9 Dietary diversity among children by sex and age category

Age of child (Months)	Level of Dietary Diversity	Male (%)	Female (%)	Total (%)	Chi-square	p-value
6-9	No diversity(<4 groups)	96.9	97.4	97.1	0.015	0.71
	Minimum or more (≥4 groups)	3.1	2.6	2.9		
9-12	No diversity(<4 groups)	86.5	82.2	84.8	0.176	0.47
	Minimum or more (≥4 groups)	13.5	17.2	15.2		
12-23	Minimum or more (≥4 groups)	77.0	73.8	75.4	0.239	0.38
	Minimum or more (≥4 groups)	23.0	26.2	24.6		

Results in Table 9 show that the majority of children were having complementary foods that were not diversified. There were no significant differences in dietary diversity across the sexes and age categories among the children. Mothers were then asked to explain the source of knowledge on child feeding and the results are shown in Figure 10.

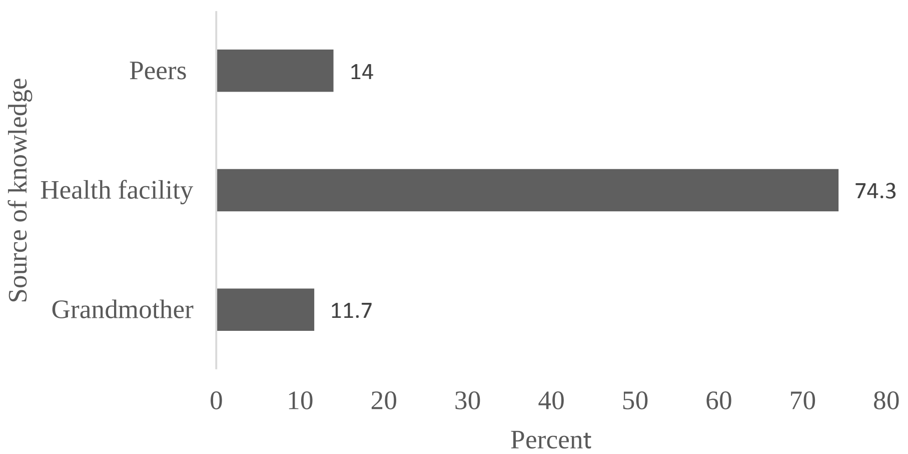


Figure 10 Source of knowledge for mothers and caregivers on child feeding

Figure 10 shows that the main source of knowledge on child feeding were health facilities. However, over one tenth of the mothers got advice from peers (14%) and grandmothers (11.7%). To find out factors that affected dietary diversity among the children, binary regression analysis was run and the results are shown in Table 10.

Table 10 Determinants of child dietary diversity in the study area

Predictor variables	B	S.E	Sig.
Minimum meal frequency	-.306	0.735	0.677
Age category mother	.249	0.369	0.500
Sex of household head	1.567	0.998	0.116
Marital status of mother or caregiver	-1.952	0.941	0.038*
Household size	-.216	0.428	0.614
Mother's education	1.646	0.614	0.007**
Age category of child	1.144	0.380	0.003**
Number of under five children in household	0.249	0.318	0.433
Sex of child	0.125	0.363	0.730
Number of feeding per day	0.561	.274	0.040*
Constant	**-9.834**	**1.930**	**0.000**

Table 10 shows that the determinants of child dietary diversity included marital status of the mother or caregiver, education of the mother or caregiver, number of feedings per day and age category of the child.

4.2.3 Results from focus group discussions on child feeding practices

Focus group discussions showed variations in child feeding by mothers and caregivers. The reasons for variations in child feeding practices among mothers and caregivers can be deduced from the following quotes recorded during FGD.

FGD1: "When the mother discovers that she is pregnant, she is supposed to terminate breastfeeding immediately. In this case, the child should be given complementary food even if the child is below six months of age. If a mother who is pregnant breastfeeds her child then the child will fall sick".

FGD2: "Some children do not get enough breast milk and they cry more frequently. Introducing complementary foods early ensures that children eat enough food and they stop crying".

FGD 3 “During periods of food scarcity, the children are badly affected because there is no maize which is normally used for preparing complementary foods. Adults are better off than children because they consume different types of foods to survive the scarcity of the common staples. Infants and young children would still require porridge from maize”.

FGD4 “When food is scarce, we reduce the quantity and frequency of feeding the children in line with the food that is available”.

The FGDs further revealed that in all communities men did not have a direct role in feeding the children. Culturally men were looked at as providers in the home and the task of feeding children was left to women. The following statements demonstrate how cultural practices affect child feeding practices in the study area.

FGD 1: “Mothers are the ones responsible for feeding children. Men cannot know how to handle a child”.

FGD 2: “Mothers are the ones who stay near the fire, preparing food for the family. It is not respectful for a woman to allow a man to prepare complementary food while she is around”.

FGD 3: “The mother is the one who stays with the child all the time and she is the one who should be responsible for feeding the child".

FGD4: “Men’s responsibility is to provide resources for the family and not preparing food. As long as the man is providing money to the household, a woman is happy to prepare and provide for the meals”.

On the actual feeding of the child, mothers and caregivers explained that they ensured that the porridge was not too hot for the child to eat. This was done by putting food on a spoon and putting the spoon and the food into the mothers’ mouths to feel how hot the food was. When the mother was certain that the food was cool enough, it was given to the child. This process was repeated until the child had eaten enough feed. When a child was not willing to eat or was difficult to feed, mothers and caregivers employed different techniques to ensure that the child ate the food. The practices included using other siblings to encourage the child to eat, persuading the child by rewarding it with other favorable foods, diluting the food and feeding the child with the mother’s hands while the child sat on the mother’s lap, feeding the child while on the breast and in extreme cases, forcing the child to eat by pinching the nose to force the child to swallow the food (**Table 26**). Where a child refused to eat, mothers kept the food in covered containers until the time when the child was willing to eat. Food was reheated and fed to the child within a period of less than five hours to prevent deterioration.

Generally the foods lacked diversity and micronutrient rich foods such as fruits, green vegetables and legumes were not incorporated in complementary foods. Mothers and caregivers lacked knowledge of processing legumes such as soybeans. Some mothers were milling the soybeans without treating them and therefore they complained that the flour took long to cook and the porridge had beany flavour which was not liked by many. Mothers and caregivers also mixed damaged and discoloured maize with clean grains and mill into flour.

Due to other household chores that demanded time from the mothers and caregivers, frequency of feeding the children was reduced. Mothers and caregivers also observed that whole maize flour changed its taste and flavour after about seven days. This discouraged mothers from using whole maize flour for preparing complementary food.

4.3 Nutritional status of children

4.3.1 Anthropometric characteristics of the children

The descriptive statistics of the anthropometric characteristics of the children are presented in Table 11.

Table 11 Anthropometric characteristics of the children 6-23 months by sex

Variable	Sex of the child			
	Male	Female	*t-test*	p-value
Mean age (Months)	14.1±5.1	13.9±5.4	0.33	0.730
Mean height (cm)	72.7±5.7	71.3±5.8	2.15	**0.030**
Mean weight (kg)	9.1±1.6	8.8±1.4	2.92	**0.004**
Height-for-age Z-scores (HAZ)	-1.9±1.6	-1.6±1.5	-1.18	0.238
Weight-for-age Z-scores (WAZ)	-0.94±1.3	-0.69±1.0	-1.96	**0.050**
Weight-for-height Z-scores (WHAZ)	0.10±1.1	0.24±0.97	-1.95	**0.05**

Table 11 shows that male children were significantly taller than female children (p=0.03) and had a higher mean weight that female children (p=0.004). The results further showed that male children had significantly lower weight –for-age z scores than female children (p=0.05). Information on nutritional status of children by sex is presented in Table 12.

Table 12 Nutrition status of children by sex

Indicator	**Male**		**Female**		**Total**	
Height- for- Age (HAZ)	**n**	**%**	**n**	**%**	**N**	**%**
≥-2 SD Z-scores (Normal growth)	76	48.7	84	57.1	160	52.9
≤-2 >-3 SD Z-scores (moderate stunting)	42	26.9	46	31.1	88	29.0
<-3 SD Z-scores (Severe stunting)	38	24.4	17	11.6	55	18.2
Weight- for- Age (WAZ)						
≥-2 SD Z-scores (Normal growth)	128	82.1	128	87.1	256	84.5
≤-2 >-3 SD Z-scores (moderate underweight)	21	13.5	19	12.9	40	13.2
<-3 SD Z-scores (Severe underweight)	7	4.5	0	0	7	2.3
Weight-for-Height (WHZ)						
≥-2 SD Z-scores (Normal growth)	151	96.8	145	98.6	296	97.7
≤-2 >-3 SD Z-scores (moderate wasting	5	3.2	2	1.4	7	2.3
<-3 SD Z-scores (Severe wasting)	0	0	0	0	0	0

Results in Table 12 show that a higher proportion of male children were stunted than female children. However, there were no significant differences in wasting and underweight between male and female children. The prevalence of different forms of malnutrition among the children is presented in Table 13.

Table 13 Nutritional status of children by age category

Age (months)	Height for age <-3SD	Height for age <-2SD	Weight for height <-3SD	Weight for height <-2 SD	Weight for age <-3 SD	Weight for age <-2 SD	No. of children (N)
6 – 11	10.2	36.7 [a]	0	3.1[c]	2.3	14.1[d]	128
12 -23	22.5	54.5[b]	0	1.7 [c]	2.2	16.3[d]	178
Total	17.3	47.1	0	2.3	2.3	15.4	306

Values with different superscripts in the same column are significantly different ($p<0.05$) from each other.

Prevalence of stunting and underweight varies with age among the children. There were significant differences in prevalence of stunting between children aged 6-11 months and those aged 12-23 months **($p<0.05$)**. Higher prevalence of stunting was observed among children aged 12-23 months. Prevalence of wasting was low across the age categories.

4.3.2 Factors associated with nutritional status of the children

The association of various household characteristics and prevalence of stunting was firstly tested using Chi-square test to find out if they influenced stunting among the children. The results are presented in Table 14.

Table 14 Chi-square test of factors associated with child stunting

Mediator for stunting	Not stunted (%)	Stunted (%)	Chi-Square	P-value
Household size				
1-4 People	102 (60.7)	66 (39.3)	7.964	
>4	60 (44.4)	75 (55.6)		**0.003**
Age category of Mother				
16-19 years	26 (38.8)	41 (61.2)		
20-34 year	115 (59.6)	78 (40.4)		
≥35 years	21 (48.8)	22(51.2)	9.63	**0.011**
Age category of children				
6-8 months	44 (62.9)	26 (37.1)		
9-11 months	39 (59.1)	27 (40.9)		
12-23 months	79 (473)	88 (52.7)	5.868	**0.05**
Meal frequency				
Minimum or more	19 (37.3)	32 (62.7)		
Below minimum	114 (49.8)	119 (51.1)	2.289	0.087
Dietary Diversity				
No diversity	137 (84.6)	113 (80.1)		
Diversified	25 (15.4)	28 (19.9)	1.023	0.195

Table 14 shows that household size, age category of the mother and age category of the child the factors that had significantly ($p<0.05$) strong associations with stunting. Using bivariate Logistic Pearson correlations of the variables, different household characteristics and child feeding practices were tested to find out if they were predictors for stunting among children. These results are presented in Table 15.

Table 15 Bivariate Pearson correlation of factors associated with stunting in children

Predictor Variables		Stunting (Yes vs. No)	Household size (> 4 vs. ≤4)	Number of under-fives (>2vs. (≤ 2)	Caregiver read or write (Yes vs. No)	Mother educated (Yes vs. No)	Age category of child (6-11 vs.12-23 mo)	Age of mother (≥20 yrs. vs. <20 yrs.)
Stunting (Yes vs. No)	Pearson r	1						
	Significance							
	N	303						
Household size (> 4 vs. ≤4)	Pearson r	-.150**						
	Significance	**.009**						
	N	303	303					
Number of under-fives (>2vs. (≤ 2)	Pearson r	.070	.157**					
	Significance	.227	.006					
	N	303	303	303				
Caregiver read or write (Yes vs. No)	Pearson r	-.034	.171**	.002				
	Significance	.559	.003	.978				
	N	303	303	303	303			
Age category of child (6-11vs.12-23 mo)	Pearson r	.138*	-.022	-.009	.002	-.005		
	Significance	**.016**	.698	.874	.978	.929		
	N	303	303	303	303	303	303	
Age of mother (≥20 yrs. vs. <20 yrs.)	Pearson r	.158**	-.363**	.072	-.060	.096	-.050	
	Significance	**.006**	.000	.210	.302	.094	.388	
	N	303	303	303	303	303	303	303

**Correlation is significant at the 0.01 significant level (2-tailed)

* Correlation is significant at the 0.05 significant level (2-tailed)

Results in Table 15 show that household size greater than 4 people per household, age category of the child from 12 to 23 months and age of the mother below 20 years were significant correlates of stunting among the children.

4.3.3 Child morbidity and care practices among households

The common illnesses and symptoms reported by mothers included malaria, diarrhoea and cough. Over periods of two days and two weeks before the study, 28.7% and 25.8% of the children had diarrhoea, respectively. Coughing was reported in 41.9% and 36% of the children. Fever with difficult breathing, a proxy for pneumonia, affected 4.3% and 6.6% of the children. Mothers and caregivers of children who had diarrhoea took different actions to manage the diarrhoea as shown in Figure 11.

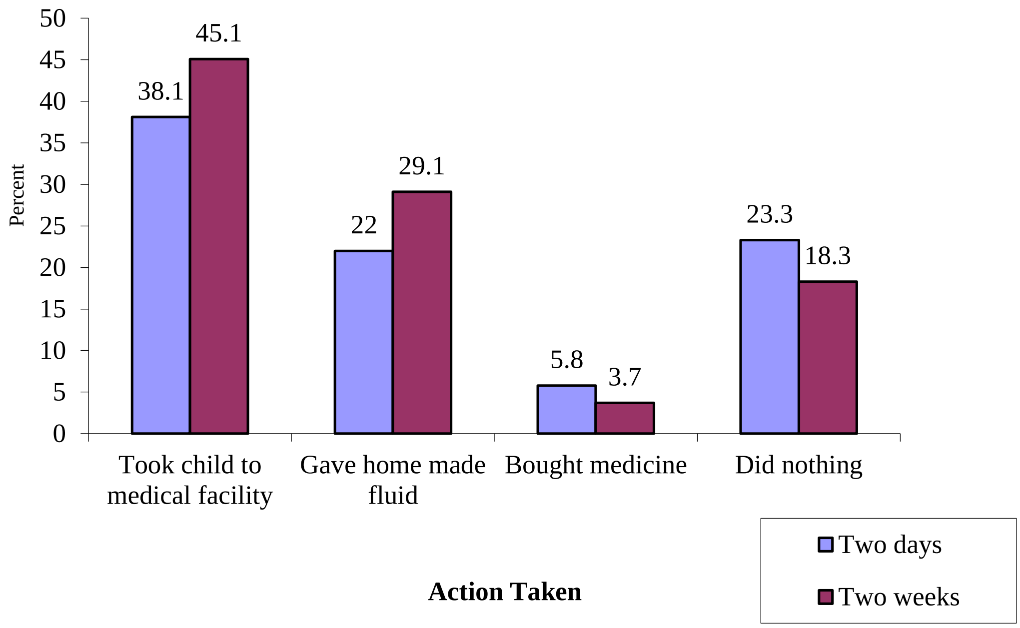


Figure 11 Management of diarrhoea by mothers and caregivers

Figure 11 shows that a higher proportion of mothers and caregivers took their children to health facilities for treatment when they had diarrhoea. However, some mothers gave their children home made fluids such as the salt-sugar solution locally called *Thanzi* ORS in Malawi. About one fifth of mothers and caregivers did not take any action to manage the diarrhoea.

4.4 Contamination of raw materials of complementary foods by spoilage and pathogenic microorganisms

4.4.1 The physical environmental factors in food storage

The majority of households (70.9%) stored their maize grain in synthetic bags while a quarter (25.5%) of the households stored in locally constructed granaries. Storage materials for maize flour included plastic pails (1.5%), clay pots (1.1%) and woven baskets (1.1%). Information on the physical factors of the environment where the flour samples were collected in the households is presented in Table 16.

Table 16 Physical factors in storage environment for maize flour

Factor	Minimum	Maximum	Mean (SD)
Daily Temperature in:			
Food storage container (^oC)	16.0	36.7	20.4±3.2
Food storage environment (^oC)	16.4	39.4	20.6±3.7
Daily Relative humidity in:			
Food storage container (%)	23.6	59.1	48.6±8.1
Food storage environment (%)	21.6	59.4	48.3±8.4

Results in Table 16 show that minimum temperatures ranged from 16.0 ^oC to 16.4 ^oC and the maximum ranged from 36.7 ^oC to 39.4 ^oC. Relative humidity was around 59%. The conditions were generally warm and dry in the storage environment. The mean temperatures and relative humidity are within the recommended storage conditions for maize flour.

4.4.2 Food spoilage and losses in storage

There were various causes of food spoilage reported by mothers and caregivers in the study area. About 42.2% of the households reported that their maize grain got spoiled in storage. The common causes of damage and spoilage reported by mothers and caregivers are presented in Figure 12.

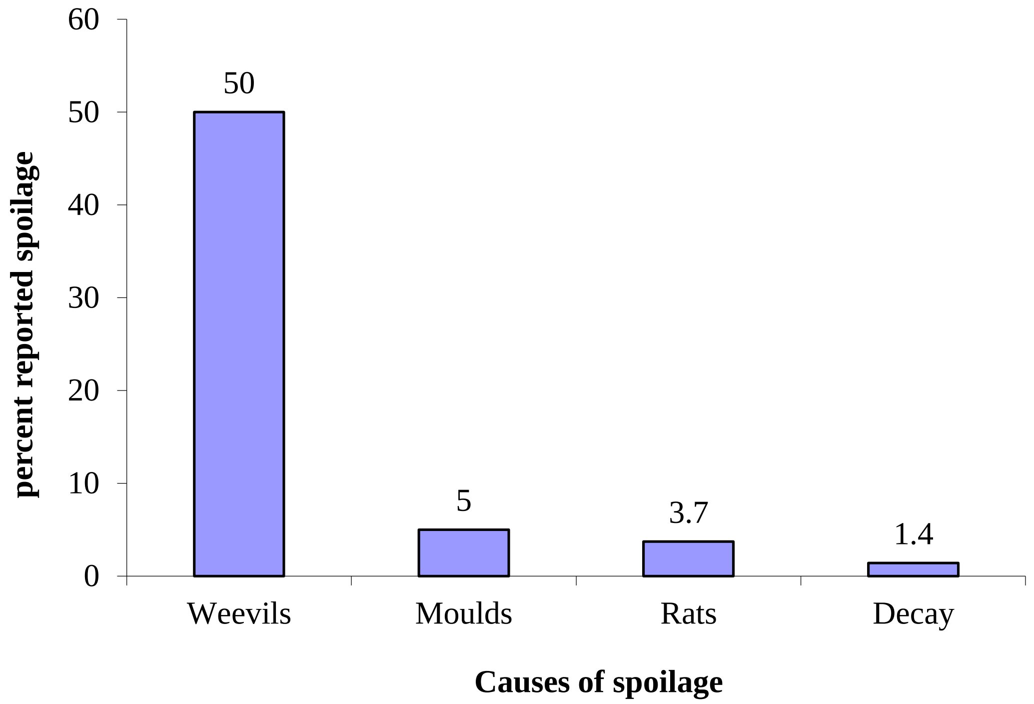


Figure 12 Causes of food damage and spoilage in storage

Figure 12 shows that weevils were the most common cause of grain spoilage and food loss in the households. Moulds, rats and food decay were also reported to contribute to food spoilage in the households. Different proportions of moulds and *Aspergillus* were determined in the maize flour samples using colored pictures shown in Plate 3.

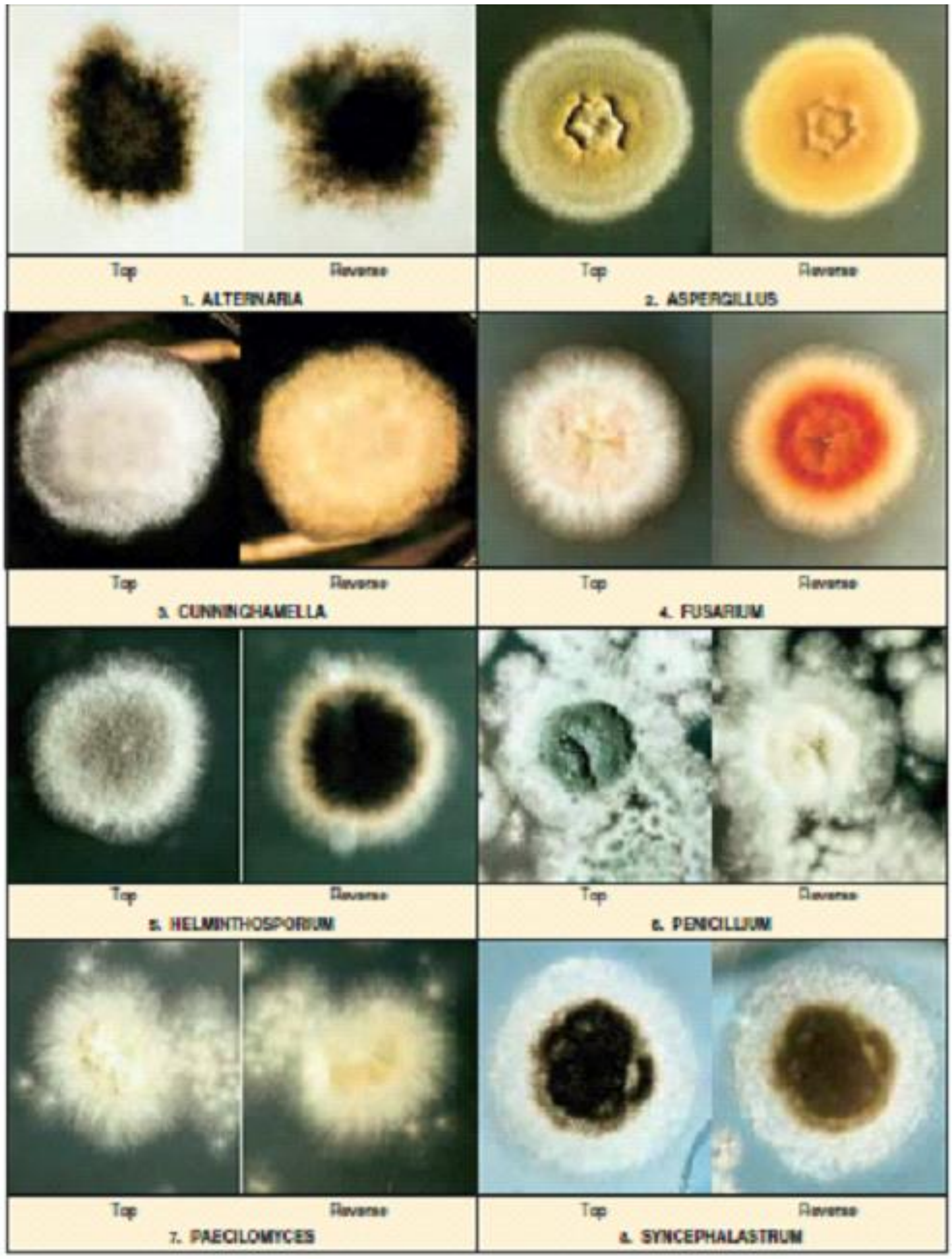


Plate 3 Morphological characteristics used for identifying Aspergillus in food samples

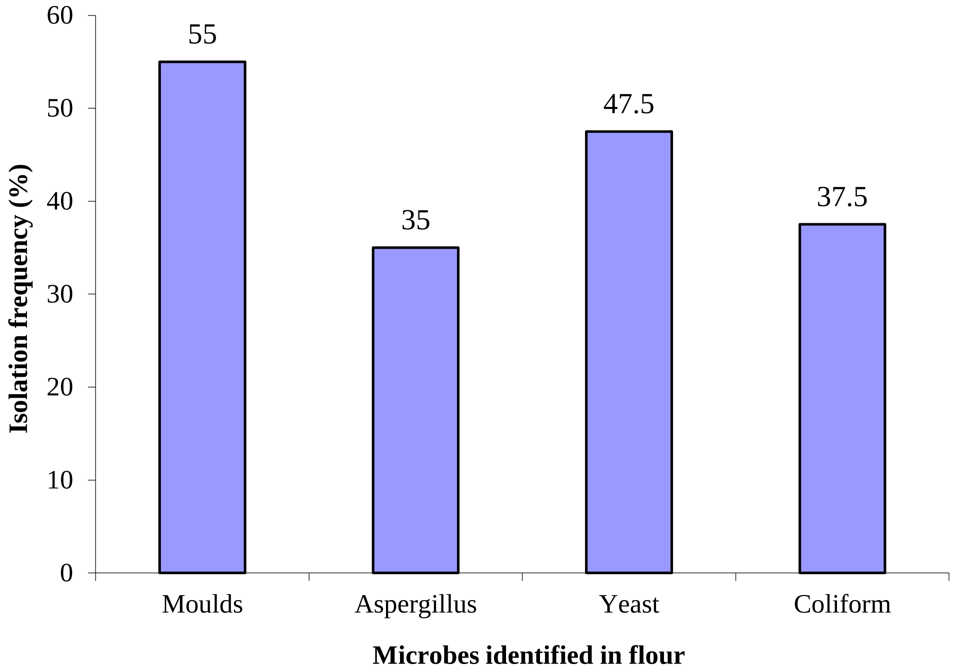


Figure 13 Isolation frequency of microbes in maize flour

Figure 13 shows that moulds and yeast formed the majority of microbes contaminating the flour samples (22/40 and 19/40 respectively). The correlation between mould counts in flour samples and storage temperature and relative humidity is shown in Table 17.

Table 17 Correlation between mould counts, storage temperature and humidity of maize flour

Variable	Temperature	Relative humidity
Temperature	1	
Relative humidity	-0.885**	1
Mould Count (Log_{10}cfu/ml)	-0.320*	0.273

**p<0.01, *p<0.05

Mould count was negatively but significantly ($p<0.05$) correlated to environmental temperature where the food was stored in the household ($r=0.32$). Increase in temperatures reduced relative humidity.

4.4.3 Total viable microbes, moulds, yeasts and coliforms

Total viable counts and other microbes were detected I 29 flour samples. The other samples (11) had not growth in petri dishes. Total viable microbes and moulds were found to be high in the flour samples (3.37 ± 0.56 Log_{10}cfu/ml and 2.04 ± 0.75 Log_{10}cfu/ml respectively). Yeast and coliform contamination was low as presented in Table 18.

Table 18 Microbial load in maize flour samples from sampled households

Variable	No. of Obs.	Mean (Log_{10}cfu/ml)	Standard National Limit (cfu/ml)	% (n) Samples with counts > National Limit
TVC	29	3.37 ± 0.56	5.0	86.2 (25)
Moulds	29	2.04 ± 0.75	2.0	69.0 (20)
Yeast	29	1.38±1.11	2.0	37.9 (11)
Coliform	28	1.40±1.06	1.0	17.2 (5)

The majority of samples had TVC levels and mould counts greater than the recommended national limit. Table 19 presents information on levels of aflatoxin in flour samples in comparison to national standard limits.

Table 19 Aflatoxin levels in flour samples

Variable	No. of Obs.	Mean (ppb)	Standard National Limit (ppb)	% (n) Samples with counts > National Limit
AFB1	33	0.37 ±0.86	3.0[a]	6.0 (2)
AFB2	33	0.03 ±0.06	3.0	0 (0)
AFG1	33	0.03 ± 0.08	3.0	6 (2)
AFG2	33	0.46 ±1.21	3.0	0 (0)
Total AF	33	0.93 ± 2.3	3.0	12.1 (4)

[a]Codex Alimentarius Committee CAC), CODEX Standard 193-1995

Aflatoxin was detected in 33 samples of maize flour. Generally the average levels of aflatoxin B1 in the flour samples (0.37 ±0.86 ppb) were lower than the standard National limit (3.0ppb). About 6% of the samples had AFB1 levels higher than the standard National limit. Aflatoxin G2 and G1 were in higher quantities in the flour samples followed by aflatoxin B1.

4.5 Determination of hygienic preparation of complementary foods for children

4.5.1 Existing practices of handling food in the study area

Existing practices of processing and handling of complementary foods by mothers and caregivers before the intervention were established. This information is presented in Table 20.

Table 20 Existing practices of processing and handling of complementary food

Stage	Process	Standard Available	Observations made
Processing of maize into flour	Winnowing and removing stones or any debris	Not available	Just winnowing and removing only the rotten grains, no sorting, no grading and no cleaning of grain
Milling	Use hammer mill	Flour prepared according to the design of the maize mill	- Maize from different sources milled in succession without cleaning the mill - Possibility of cross contamination
Drying of flour	Spread mat on open ground and spread the flour to dry	Not available	- Flour exposed to dust - Dirty mats used for drying - Animals roaming around - No measurement of moisture levels
Storage	Keep in plastic pails, bags and woven baskets	No standards	- Temperatures not controlled - Humidity not controlled, - Poor ventilation - Storage place not standard - Mud floors smeared with clay soil regularly
Cooking of porridge	Use pots not cleaned with detergents for cooking, Carry flour by hand and add into the pot Water used for cooking not treated	Not available	- Different utensils washed in the same water - Hands not washed before cooking - Cooking place not clean - Porridge cooked for a short time and not thoroughly cooked. - Cooling porridge before feeding the child - Feeding utensils not thoroughly cleaned

Table 20 shows that mothers and caregivers had no standard protocols for preparing complementary foods. The existing practices and lack of standard procedures demonstrated the gaps that necessitated the development and adaptation of messages on recommended practices supported by demonstration exercises to improve hygiene and sanitation practices among mothers and caregivers. Poor hygiene among mothers and caregivers was determined by prevalence of diarrhoea among the children which was 28.7% (two days) and 25.5% (two weeks) respectively before the study. Table 21 presents information on the factors that were associated with the prevalence of diarrhoea among children.

Table 21 Association between hygiene practices and prevalence of diarrhoea among children

Explanatory Variable	**B**	**S.E**	**p-value**
Constant	9.223	2.506	0.000
Hand washing before handling food	-2.577	0.837	**0.002**
Covering drinking water	-3.267	2.794	0.242
Food covered during cooking	0.290	0.056	0.139
Food utensils cleaned thoroughly	0.464	0.831	0.577
Personal hygiene	1.880	1.388	0.176

Table 21 shows that hand washing by mothers or caregivers when handling food was significantly associated with reduction in prevalence of diarrhoea among the children ($p<0.05$). The results further show that covering drinking water was also strongly associated with reduction in diarrhoea among the children.

4.5.2 Change in food handling practices among mothers and caregivers after training

Results of the final evaluation of participants to the training intervention showed significant changes in the proportions of mothers and caregivers who followed the recommended practices as shown in Table 22.

Table 22 Food handling practices among mothers and caregivers before and after training

Recommended Practice	Before training		After training			
	n	%	n	%	χ^2	p-value
Sorting and cleaning grains before milling into flour	20	50.0	30	75.0	5.33	0.04
Cleaning cooking utensils before cooking	26	65.5	40	100.0	16.97	<0.01
Keeping and preparing food in clean environment	21	52.5	35	87.5	11.67	<0.01
Washing hands with soap and clean water before handling food	6	15.0	39	97.5	55.31	<0.01
Observing personal cleanliness during cooking food	15	37.5	34	85.0	19.01	<0.01
Cooking food thoroughly	16	40.0	30	75.0	10.03	<0.01
Covering food during cooking	16	40.0	36	90.0	21.97	<0.01
Covering food during keeping	20	50.0	37	92.5	17.64	<0.01
Using water from protected sources	33	82.5	39	97.5	5.00	0.03
Covering water during storage in the home	9	22.5	38	95.0	43.38	<0.01
Water stored in clean utensils	20	50.0	38	95.0	20.31	<0.01
Aware about aflatoxin and its dangers in food	20	50.0	35	87.5	13.09	<0.01

Table 22 shows significant changes ($p<0.01$) in the proportions of mothers and caregivers who followed recommended practices when preparing maize flour and porridge. The observed changes in behaviour are presented in Table 23.

Table 23 Observed change in behaviour and practices among mothers and caregivers

Practice before intervention	Practice six months after intervention
Personal Hygiene	
- Clothes not clean - Hands rarely washed - Hair not covered during cooking	- Wearing clean clothes when preparing food and feeding children, - hair was covered always when handling food - hands washed regularly with soap and clean running water before handling food
Cooking pots and serving plates	
- Pots not thoroughly washed with detergents - Pots washed with in dirty water - Pots cleaned only inside - Plates not cleaned after feeding the child	- Pots were always washed thoroughly inside and outside with clean water before and after cooking - Plates washed after feeding the child and dried properly
Water Hygiene	
- Water not covered in storage - Water obtained from unprotected sources such as open wells and streams - Leaves put in water buckets during transportation to household	- A larger proportion cover water in storage - Water drawn from protected sources such as boreholes and protected covered shallow wells.
Food processing and preparation	
- Homestead surroundings littered with animal dung and refuse - Maize grain not sorted, graded or cleaned - Complementary food (porridge) undercooked.	- Free movement of animals controlled by keeping animals in enclosures or tended by people in designated areas - Homestead surroundings cleaned every day. - Wholesome maze grain for complementary feeding selected and sorted - Maize cleaned and soaked before milling. - Complementary food cooked thoroughly over a longer period of time.

Table 23 shows that, six months after training, mothers and caregivers demonstrated correctly the recommended practices and followed what they were taught during training. There was also a significant decline in prevalence of diarrhoea ($p<0.05$) from 28.7% during baseline to 8.6% six months after training. The maize flour was dried thoroughly and sanitation was improved on the surfaces where the flour was dried. Table 24 shows variations in hygiene scores among mothers and caregivers before and after training.

Table 24 Analysis of variance in hygiene practices before and after training

Hygiene score	Mean	SD	95% CI	
Before intervention	5.90	3.21	(4.87-6.93)	
After intervention	10.88	1.31	(10.46-11.29)	
Total	8.39	3.491	(7.61-9.16)	
ANOVA	**SS**	**MS**	**F**	**Sig.**
Between Groups	495.012	495.012	82.506	0.000
Within Groups	467.975	6.00		
Total	962.988			

Table 24 shows that the mean hygiene scores increased significantly ($p<0.001$) after training (10.8 vs. 5.9) among mothers and caregivers who followed correct practices and those who did not. The change in hygiene practices was significant after training ($p<0.05$).

4.5.3 Summary of child feeding practices in the study area

The detailed summaries of child feeding practices among mothers and caregivers which formed the foundation for the training intervention are presented in Table 25. The summaries include the behaviours of mothers and caregivers when feeding children, implication of the behaviours on child health and suggested actions that should be taken to improve child feeding practices among mothers and caregivers.

Table 25 Summary of maternal behaviour and practices affecting complementary feeding in the study area

Behaviour identified	Implication on the child	Suggested Actions to be taken to change behaviour
Over one fifth (22.9%) of the children were not introduced to complementary feeding at the right age of six months.	The children are at risk of undernutrition due to low nutrient intakes and infections at an age earlier than six months.	Train mothers, caregivers and community cultural leaders on importance of starting giving complementary foods to children at the age of six months and promote peer-counseling on infant and young child feeding.
Lack of diversity in complementary foods given to children.	Children are at risk of suffering from undernutrition and micronutrient deficiencies as diets that are low in diversity tend to be low in micronutrients.	Train mothers and caregivers how to incorporate micronutrient rich foods such as fruits, green vegetables and legumes into complementary foods.
Reduced frequency of feeding children by mothers due to lack of time for preparing food.	Children are at risk of undernutrition (stunting and wasting) due to inadequate intake of energy and nutrients. Such children will be susceptible to frequent infections.	Promote energy and time saving technologies to allow mothers to prepare adequate food and to feed their children more frequently. Encourage men to feed the children.
Use of shriveled, discoloured and damaged maize grains and groundnuts in complementary foods to feed children.	Children are at risk of exposure to aflatoxin and other mycotoxins which are common in shriveled and damaged groundnuts. Aflatoxin is associated with growth failure and stunting in children.	Train mothers, caregivers, community leaders on the dangers of aflatoxin and the correct quality of groundnuts and maize to process into complementary food.

Table 25 Summary of maternal behaviour and practices affecting complementary feeding in the study area …cont.

Behaviour identified	Implication on the child	Suggested Actions to be taken to change behavior
Mixing raw soybeans with maize without subjecting the soybeans to any treatment before milling into flour for preparing complementary foods.	Children are at risk of consuming anti-nutritional factors such as trypsin inhibitors which cause growth failure and undernutrition.	Train mothers, caregivers and community leaders how to roast or boil soybeans to denature antinutritional factors before milling into flour
Whole maize flour changing its taste and flavour after seven days and when stored in plastic pails.	The flour is affected by lipolysis activities that lead to rancidity of fats due to oxidation process. May also result from increased microbial activities due to increased water activity	Train mothers and caregivers to dry whole maize flour and store in cool dry environment. Promote use of appropriate storage materials.
Poor hygiene and sanitation around homesteads, littered with refuse and animal dung.	Risk of infections and food contamination with coliforms from animal wastes.	Integrate water, sanitation and hygiene interventions into infant and young child feeding practices.
Mothers and caregivers have limited knowledge of preparing nutritious complementary foods.	Low energy and nutrient dense food may be fed to children and may lead to undernutrition.	Train mothers and care givers on how to process and prepare energy and nutrient dense complementary foods.
Mothers and caregivers pinching the child's nose to force the child to swallow food as it gasp for air.	Children do not eat enough food as they are overwhelmed by the pinching of the nose, children may chock with food and make eating an unpleasant experience.	Train mothers and caregivers on recommended practices for active or responsive feeding of children.
Mother's perceptions that she could not produce enough milk	The child may be undernourished and fall sick frequently.	Train mothers on correct attachment of the baby to the breast and feeding on demand

CHAPTER FIVE

DISCUSSION

The socio-demographic characteristics of the households in this study showed that the average household size in the study area was 5±1.8 persons per household (**Table 5**) reflecting larger household sizes than the national household size of 4.2 (MG, 2009). Large household sizes in poor resource setting are associated with increased demand on household resources and poor child care practices as resources are allocated to other pressing household needs other than child care. The average number of underfive children per household was 1.4 children with the female to male ratio of 1:1.1. This shows that there were more female than male children underfive years of age in the households. Families with large household sizes tend to be constrained in terms of resources, making it difficult for mothers and caregivers to provide adequate care and support to children (Moestue and Huttly, 2008). Large size families also tend to have overcrowded households where sanitation and hygiene may be poor. Children in such households may fall sick frequently from diseases such as diarrhoea leading to increased malnutrition (Katona et al., 2008). In this study, training of mothers and caregivers created awareness of the importance of washing hands and cleaning of cooking and serving utensils to prevent food contamination and reducing prevalence of diarrhoea. There were no significant differences in socioeconomic characteristics among the households.

Literacy levels were low among the mothers and caregivers as reflected by the majority just attaining primary education (**Table 6**). Women who have more years of schooling tend to have better health and well-being and healthier behaviors (Feinstein et al. 2006). Literacy of the mother or caregiver may also determine the methods and approaches used to pass on technical messages to mothers and caregivers during training. Mothers and caregivers who cannot read or write may not understand messages that are disseminated using printed materials. In such circumstances, demonstrations and role plays may be helpful. In this study, emphasis was put on hands-on practical activities to ensure that every mother and caregiver was able to follow the recommended hygiene practices during complementary feeding.

5.1. Child feeding practices

The study has shown that the complementary food given to the children lacked diversity and comprised of cereals (grains), and the common food being porridge made from refined maize flour only with 7% solids. Consumption of foods from other food groups in addition to cereals increased with an increase in the ages of the children (**Table 7**). Since complementary foods were prepared from mostly cereals, the diversity of the foods provided to the children was low (**Table 9**).

As children's ages increased, mothers started feeding them family meals in addition to complementary foods. This may explain why consumption of vitamin A rich vegetables and other fruits and vegetables was higher among children aged 12-23 months compared to children aged 6-11 months. The majority of children, consumed porridge and slightly over one tenth of the children consumed *nsima* (thick porridge) and mashed potatoes. *Nsima* is a thick porridge prepared with maize flour comprising of 25% solids and 75% water and eaten with vegetable or meat sauces. Consumption of foods from at least 4 food groups per day is recommended as in most populations it implies that the child has a high likelihood of consuming a diet that is nutritionally adequate (WHO, 2010).

This study further showed that the majority of children were not consuming complementary foods that met the minimum dietary diversity requirement. Dietary diversity differed significantly as the age of the child increased from 9 to 11 months to 12-23 months ($p<0.001$). Children aged 12-23 months are old enough to eat family foods and therefore their diets tended to be more diversified than that of children below the age of 12 months. Further analysis of the data showed that mothers and caregivers from households that had different types of foods prepared complementary foods that were significantly more diversified than those who did not have ($p<0.01$). To improve the nutritive value of the maize porridge, some mothers added raw soybeans to maize and milled it into flour. However, soybeans contain trypsin inhibitors, chymotrypsin inhibitors and phytic acid which are antinutritional factors which may lead to low nutrient intake and growth failure in children (Kirk, 2010). The recommended practice is that soybeans should be roasted or boiled and de-hulled to destroy trypsin and chymotrypsin inhibitors and to remove phytic acid before processing into flour for preparing complementary foods. Some mothers incorporated discoloured, shriveled and damaged groundnuts to maize before milling into flour. Such types of groundnuts are likely to be contaminated with moulds and aflatoxin and may expose the children to the risks of aflatoxicosis (Matumba, 2012). Exposure to aflatoxin is associated with growth failure and stunting in children (Gong et al., 2004). Mothers therefore demonstrated limited knowledge in processing and preparation of complementary foods from soybeans.

It is normally recommended that mothers and caregivers should prepare mixed dishes to ensure that children should eat other foods that they cannot normally eat when cooked separately (Picado and Mtimuni, 2010). Results of this study showed that the majority of mothers and caregivers were not preparing mixed dishes to improve the nutritive value of the complementary foods. Prolonged consumption of complementary foods that are not diversified may result in chronic nutrient deficiency and prevalence of underweight and stunting among the children.

The study has also shown that significant determinants of child dietary diversity included the marital status of the mother, mothers' level of education, age category of the child and meal frequency of the child (**Table 10**). Since mothers and caregivers prepare complementary foods from the household staple food maize, it is likely that households headed by women may not afford to give diversified complementary foods to their children due to financial and labour constrains which affect procurement or production of diversified foods.

Consumption of muscle foods, dairy products and eggs was low in the study area (**Table 7**). Foods of animal sources were normally bought from the markets and most households could not afford to buy. However, since foods of animal sources are good sources of micronutrients, such as iron, calcium and vitamin A, low consumption of these foods may lead to micronutrient deficiencies. Incorporating foods rich in iron and vitamin A into complementary foods may increase their nutrient density. Mothers should, therefore, be taught to add thinly shredded fish, meat, mashed green leafy vegetables and cooking oil to complementary foods to increase protein, iron, energy and vitamin A and C intake (Swindale and Bilinsky, 2005; FAO, 1997). In this respect, interventions that increase production of diversified foods by households should be integrated into any nutrition programme and promoted among households. Nutrition education should also promote integration of different types of foods into the family diets alongside staple foods to increase diversity and nutritive quality of the complementary foods (Bezner-Kerr et al., 2014). Nutrition education sessions should also include demonstration of food recipes to enable mothers select and prepare complementary foods that are acceptable and nutrient dense to meet nutrient requirements of their children. Training mothers in groups based on age categories of their children may assist to avoid confusing mothers and caregivers with divergent messages.

In addition to provision of diversified foods, meal frequency is another important element in complementary feeding. The frequency of feeding children determines the adequacy of nutrient intake in a given period of time. The World Health Organization (2010) recommends that children should be fed at least four times a day with three main meals and one or two snacks in between meals. Feeding children more frequently ensures adequate nutrient intake and good nutrition. In this study, 51.5% of the mothers and caregivers fed their children at least twice per day and only 41.5% fed their children at least four times per day and 6.9% gave their children only breast milk. Meal frequency differed significantly among children of different age categories (P<0.001) (**Table 8**). These results reveal the gaps that exist in complementary feeding practices among mothers and caregivers in the study area. Since younger children spend more time with mothers than the older ones, meal frequency was higher among the younger children (6-8 months). Knowledge of the mother on the correct frequency of feeding the child was dependent on the age of the child. More mothers whose children were younger knew the correct feeding frequency than those whose children were older (5.3% for 12-23 months old, 18.6% for 9-12 months old, 62.8% for 6-8 months old). These results may reflect mothers' exposure to messages on child feeding practices. Mothers of younger children (<12 months) tended to take their children to growth monitoring centers every month to have their children vaccinated against common childhood illnesses and weighed to determine their growth. During growth monitoring sessions, mothers are given health talk by the medical personnel which include key nutrition messages on child feeding.

In the case of mothers or caregivers whose children were over 12 months, the majority were not taking their children for growth monitoring because they had completed the mandatory vaccination at 9 months. These findings imply that mothers and caregivers should be provided with correct information on the recommended feeding of children of different age categories within the age range of 6 to 23 months. The other explanation is that since most children aged 12-23 months had started eating thick porridge and family meals, mothers thought thick porridge would take longer for the child to feel hungry again than infants who ate thin porridge. Meal frequency for children aged 12-23 months was also low because the meal pattern of the children started following the family meal patterns.

Marital status of the mother or caregiver may have a direct effect on the feeding practices of children. Being a single parent, women, especially in rural areas of Malawi tend to be predisposed to poverty; making them constrained in terms of financial resources. Due to high poverty levels among single family women who need to fend for themselves, it becomes difficult for them to care and provide for their children. The Welfare monitoring survey conducted by the National Statistical office in 2009 in Malawi showed that female headed households had a higher dependency ratio (1.46) than male headed households (1.04) and that 40% of female headed households were caring for orphans (NSO, 2009). These attributes predispose female headed households to deprivation of resources which may affect child care practices. It should be emphasized that young children require frequent feeding because of the small capacity of their stomachs which cannot take in more food at a time (MG, 1992).

5.2 Knowledge of complementary feeding practices among mothers and caregivers

Cultural beliefs, food scarcity and lack of diversity contribute to reduced frequency of child feeding which exposes the children to inadequate energy and nutrient intake and put them at risk of undernutrition.

Poor maternal knowledge on infant and young child feeding may have contributed to poor child feeding practices in the study area. It is important to note that grandmothers played important roles in introduction of complementary foods to the infants. Grandmothers formed part of the sources of information and knowledge on child feeding practices among the mothers and caregivers (**Figure 10**). Grandmothers influenced young mothers to introduce complementary foods earlier than six months. Targeting grandmothers with nutrition information on complementary feeding may therefore assist to bring positive behaviour change that will contribute to adoption of recommended complementary feeding. The influence of grandmothers on complementary feeding practices has also been reported in studies conducted in Northern Malawi (Kerr et al., 2008), in Kenya (Nduati et al., 2011) and in rural Uganda (Nankumbi and Muliira, 2015). Due to strongly held beliefs that elderly women are custodians of culture, young mothers tended to adhere more to advice from elderly women than from medical personnel. However, another interesting finding is the role of peers who also influenced over one tenth (14%) of the mothers. Use of peer to peer nutrition education in rural communities may help to cascade message dissemination among mothers and caregivers. The risk is that if the peers are not provided with correct information they may influence others to follow incorrect child feeding practices.

5.2.1 Influence of culture on complementary feeding

Culture influences and defines the roles of men and women on child care and feeding practices. Communities in the study areas believed that women were the ones who were supposed to prepare and cook food for the children and not the men. Women perceived that it was imperative that they should be responsible for feeding children. Similar findings were reported in studies conducted in Dowa and Kasungu districts in central Malawi (CARE Malawi, 2012) From these findings, it is apparent that in a community that is agro-based and where the majority of women work on the farms, it would be difficult to feed children adequately and frequently as mothers alternated roles of caring for children and working on the family farms. In such situations, integrating behaviour change communication into nutrition education would assist to demystify some of the strongly held cultural beliefs about the roles of men in child care practices.

5.2.2 Child feeding practices used by mothers and caregivers

This study has further revealed several important issues that need urgent attention and action not only in the study area but also other rural areas of Malawi (**Table 25**). Some mothers complained that they could not produce adequate milk to feed their child. Mothers with such perceptions should be supported with correct information that would give them confidence to breastfeed successfully. The correct information should include frequent feeding of the baby to stimulate breast production and milk letdown. Such mothers should also be assisted to attach their children to the breast correctly and to breast feed their children on both breasts until the child has had enough.

Mothers and caregivers in the study area were involved in different economic activities such as mall- scale businesses and farming, which kept them away from home for long periods of time. Due to time constraints, the mothers and caregivers could not feed their children frequently In some cases, children were cared for by older siblings who could not prepare proper complementary food for the children. A small proportion of mothers gave snacks to their children including bananas, boiled potatoes and baked food products. With low meal frequencies, the children could not get adequate energy and other nutrients to meet their daily requirements. Failure to provide minimum meal frequency is associated with stunting among children aged 6-23 months (**Table 12**). Training mothers on recommended meal frequencies for children of different age categories and providing them with skills in preparation and storage of complementary foods, which can be fed to children while the mothers are not around may improve child feeding practices in the study area. These results therefore means that the hypothesis that there were no significant differences in the proportions of mothers and caregivers who followed the recommended feeding practices and those who did not is rejected.

5.3 Nutritional status of children

The prevalence of stunting and underweight was high among the children (**Table 12 and Table 13**). Prevalence of stunting tended to increase with the increase in age of the child. Children aged 6-11 months had lower prevalence of stunting (36.7%) than those aged 12-23 months (54.5%). Children aged 6-11 months are mostly dependent on breast feeding and tend to always be with their mothers; therefore receiving more attention and feeding frequency than children who are aged 12-23 months. At the age of 12 months, most children start eating most of the family meals and by the age of 23 months they may be weaned off the breast. With low meal frequency (**Table 8**) and low dietary diversity, such children may fail to attain their potential height for age or weight for age (**Table 13**). The prevalence of stunting in the study area is higher than the national prevalence of 30.9% (NSO & ICF, 2017).

The prevalence of stunting among children varied with the sex of the children. More male children were stunted than female children ($p<0.05$) (Table 11). Stunting among the children of different sexes may be attributed to maternal perception on child development. Mothers and caregivers asserted that male children developed quicker than female children in terms of meeting some developmental milestones such as beginning to stand and walking. Male children tended to be more active than female children. These observations were similar to what has been documented in a study by Connellan et al., (2000) which showed that male children are more physical and more active than female children. Female children have been found to focus on talking, looking at colours while male children tend to like physical activities. In this study mothers reported that they paid more attention to female children in terms of frequency of feeding. Due to the same perception that male children developed faster than female children, breast feeding was terminated earlier in male than in female children. By being more active than female children, male children expended more energy than female children. The energy expenditure might have been worsened by low energy and nutrient intake due to early termination of breastfeeding. This therefore might have culminated into increased prevalence of stunting and underweight among the male children.

On the other hand, prevalence of wasting is low in the study area just in line with the national trends.

Strong and significant correlations were observed between stunting and age of the mother, household size and age of the child ($p<0.05$) (**Table 14**). This implies that being a young mother aged below 20 years increases the risk of the child being stunted. Generally young mothers are resource constrained and may not ably take care of the child. Coupled with lack of experience and misinformation from grandmothers (Kerr, Dakishoni and Shumba 2008; Nduati, 2011), young mothers may not follow recommended child feeding practices, putting children at high risk of stunting. The age of the child may also determine how and how much food a child may take. As the child transits between breast feeding and total consumption of family meals, nutrient intake may not be adequacy due to lack of diversity in the complementary foods. Families with large household sizes tend to be constrained in terms of resources and this makes it difficult for caregivers to provide adequate care and support to children (Mostue and Huttly 2008). Large size families also tend to have overcrowded households where sanitation and hygiene may be poor due to difficulty to enforce appropriate hygiene behaviours or due to lack of appropriate amenities for sanitation (Aunger, et al., 2016). Children in such households may fall sick frequently leading to increased malnutrition (Katona et al. 2008).

This study showed that over one third of mothers had given birth to between 5 and 9 children; reflecting large family sizes. Most mothers aged between 21 and 34 years had more than one child under the age of five years to take care of. The high number of siblings in the households would lead to reduced family resources to care for each child.

Since aflatoxin is produced by moulds as a means of adaptation to changes in environmental factors such as water stress or variations in temperature, presence of moulds in complementary foods is an indication of the risk of exposure to aflatoxin which interferes with protein synthesis leading to stunting in infants and young children (Khlangwiset and Wu, 2010). Common childhood illnesses such as pneumonia, malaria and diarrhoea may have adverse effects on the nutritional status of the children. In this study, over periods of two days and two weeks before the study more than a quarter of the children had diarrhoea and other children suffered from fever with difficult breathing, a proxy for pneumonia coughing. Diarrhoea and fever lead to reduced food and nutrient intakes in children and increased demand for nutrients (NSO & ICF, 2017). If not managed properly, these illnesses can lead to weight loss and faltering of growth in children.

To manage the diarrhoea, some mothers took the sick children to medical facilities for treatment; others gave children home- made fluids such as the salt-sugar-water solution commonly known as *Thanzi* ORS in Malawi. Some mothers bought medicines from local shops to treat the children. Such actions assisted in reducing the severity of diarrhoea among the children. Diarrhoea is caused by consumption of food and drinking water that is contaminated by pathogenic microbes. This may be the case when the person handling or preparing food does not observe recommended hygiene practices such as washing hands with soap, washing utensils with detergents and ensuring general body hygiene. Mothers and caregivers should, therefore, be trained in good sanitation and hygienic handling of food and water to reduce prevalence of diarrhoea among the children.

5.4 Microbial contamination of raw maize flour for preparing complementary food

Total viable counts were high in the food samples with moulds, coliforms and yeast being predominant microbes (**Table 18**). Different levels of aflatoxin were also detected in the flour samples from different households (**Table 19**). The presence of aflatoxin in complementary food samples presents a risk to the health of the children since aflatoxin is associated with liver cancer, stunted growth and reduced immunity (Khlangwiset and Wu, 2010). The presence of microbes in the maize flour used for preparing complementary foods reflects the need for observing strict hygiene practices when handling and preparing the food. Contamination of food with coliforms may lead to foodborne infections such as diarrhoea and other disorders of the gastrointestinal tract (Andrew, et al. 2017). Such disorders would result in poor health and undernutrition among children.

Environmental factors such as temperature and relative humidity influence the contamination of maize with yeast, moulds and mycotoxins. Temperature and humidity affect the water activity of the food substrate which may enhance or prevent moulds and other microbes from growing. In this study, the temperatures in the storage environment of the flour ranged from 16.0 ^{o}C to 36.7 ^{o}C while relative humidity ranged between 23.6% and 59.1 % (**Table 16**). The temperature ranges were within the range (13 ^{o}C to 37 ^{o}C) required for the growth of moulds. This may explain why flour samples were contaminated with moulds and aflatoxin. The prevalence of moulds and aflatoxin in this study was lower than those reported in other studies conducted in Rwanda (Nishimwe et al., 2017) and in Kenya during some outbreaks of aflatoxicosis (Mwihia et al., 2008). There were significant correlations between temperature of the environment where the food was stored and mould counts ($p<0.05$) (**Table 17**). Temperature and humidity were negatively associated with mould infestation respectively. The results showed that as temperature increased, relative humidity decreased and therefore reducing the water activity (A_w) to the levels that are not favourable for the moulds to multiply. Since flour is hygroscopic, it is important that it should be stored in cool and dry place to prevent the flour from absorbing moisture from the air.

The study showed that mothers and caregivers had problems with storage of flour to maintain flavour and taste (**Table 25**). It was learnt that whole maize flour kept for over seven days tended to change colour and flavour. Flour is susceptible to spoilage when stored in humid conditions where it absorbs moisture or when stored for too long. DeMan (1990) asserted that under humid conditions and when stored for over a week, flours develop off flavour that affects the quality of the cooked product. Whole maize flour also contains fats which undergo rancidity during storage that results in off-flavour in the cooked product from the flour (Shobha, Kumar, Putaramanaik and Screemasetty, 2011). A study conducted in the Northern Region of Malawi showed that flour stored in plastic pails deteriorated faster than flour stored in woven baskets and polyethylene sacks (Mphwanthe, Kalimbira and Geresomo, 2016). Poor storage conditions and unregulated temperatures may therefore explain why the majority of flour samples were contaminated with aflatoxin and moulds in the study area (**Table 18 and Table 19).** Complementary food prepared using flour contaminated with moulds may not be accepted by children or children may not eat adequately resulting in low energy and nutrient intake.

The results of this study (**Table 18**) further show that microbial contamination of complementary food is widespread in the study area with TVC and mould counts respectively in over four fifth and over two thirds of samples, being above the National Standard Limit (Malawi Bureau of Standard [MBS], 2015b). Less than one tenth of the samples had AFB1levels above the Codex Alimentarius Committee CAC) limit for ready to eat foods. Though widespread in the maize flour samples, aflatoxin B1 concentration was below the national standard limit. This may be attributed to the method of preparation of maize flour in Malawi where the majority of the mothers and caregivers dehull the maize and soak it for two to three days before milling into flour. Since mould tend to adhere to the skins of the maize grain, dehulling removes most of the moulds and aflatoxin from the maize grain. Soaking of the dehulled grain further washes away moulds and aflatoxin before milling the grain into flour. Since aflatoxin cannot be destroyed by cooking, these findings provide evidence that children in Dedza district are exposed to aflatoxin. Observing personal hygiene, sorting, drying, grading and cleaning of maize grain along the complementary food value chain would assist to reduce microbial contamination and aflatoxin in complementary food.

Mould infestation and decay of grains in store caused food spoilage resulting in food losses among households (**Figure 12**). Decaying of the food in store may reflect increased microbial activities in the food due to high water activity. Poor ventilation and humid conditions in food store may also contribute to food decay. Apart from causing damage to the grain, weevil attack may lead to increased water content in the grain due to increased metabolic processes which may create conducive environment for mould growth and production of mycotoxins, including aflatoxin. Slightly over half of the mothers and caregivers had ever heard about aflatoxin in food but did not know how to prevent it. The majority (82.8%) of households in the study area experienced food scarcity during certain months of the year. With food scarcity and poverty among rural households in Malawi, Matumba (2013) observed that it was "practically impossible for the people to discard contaminated food".

The findings of this study compare well with other studies conducted in Africa. A study conducted in Kenya by Wafula (2017) reported total coliform counts of 4.56 log_{10}cfu/ml and 4.96 log_{10}cfu/ml respectively in raw milk from rural and slum areas of Nairobi. In Ghana, a study conducted in Tamale showed coliform contamination levels of 1.17±1.07 log_{10}cfu/ml in common spices and spice blends (Bakobie, Addae, Duwiejuah, Kobbina and Miniyila, 2017). In these studies, lack of observation of hygiene protocols was implicated. Contamination of food with coliforms is associated with poor hygienic conditions and may result in children suffering from diarrhoea. Providing knowledge and training mothers and caregivers on recommended hygiene practices such as washing hands with soap and cleaning cooking and serving utensils may prevent and reduce coliform contamination of complementary foods in the study area. This therefore means that the hypothesis that there was no contamination of locally processed complementary food in the Mayani EPA in Dedza district is rejected.

5.5 Hygiene practices among mothers and caregivers

Four critical control points were identified in the complementary food value chain to mitigate microbial contamination (**Figure 9**). Mothers and caregivers were trained on hygiene and recommended food preparation. After the training intervention, there was significant increase in the proportion of mothers who followed and practiced the recommended hygiene practices. Prevalence of diarrhoea declined from 28.7% at baseline to 8.6% after training (**Table 22**). The critical control points included i) the point where the maize grain is prepared for milling into flour, ii) the point where the flour is dried, ii) the point of storing the flour and iv) during cooking of the porridge.

5.5.1 Existing practices among the mothers and caregivers

The research team and the mothers and caregivers went through the procedures and stages through which mothers and caregivers go during processing and preparation of porridge for complementary feeding. It was important to go through such a process so that critical control points could be identified. Each process was analyzed to note the risks that it presented to the complementary food. The first critical control point identified was the stage where the maize grain is collected for milling. The process of winnowing the maize grain before milling exposes the maize to the air and this may incorporate mould spores into the grain which if not kept in cool and dry place may lead to growth of moulds in the flour. The instrument for winnowing the grain may be contaminated with different types of fungi as it may be used for handling different types of foods. It is therefore important to ensure that such instruments are cleaned thoroughly to mitigate contamination of subsequent food materials that would pass through it. The hands of the person handling the grain may also be contaminated with different types of microbes that may contaminate the grain. Therefore washing hands with soap and running water would assist to get rid of the microbes.

The results showed that mothers and caregivers mixed damaged and discoloured grains with clean and wholesome maize before milling into flour. The practice of incorporating damaged, shriveled and discoloured grains may be another conduit of moulds and aflatoxin into the maize flour and eventually into the complementary food. In this case several interventions are suggested at this stage of handling the grain. The interventions should include washing hands with soap and clean running water by the food handler to get rid of any microbes including mould spores that might be in the hands. Thorough cleaning of utensils with clean water and drying them completely before using them to handle the grain would also reduce contamination. Studies have shown that most moulds multiply at water activity 0.82 and humidity of 85% (Beuchat & Montville, 2001). Soaking maize grain over night before milling into flour may assist to destroy mould spores because they cannot survive in water. Soaking the grain will also assist to wash away the spores since they are found on the surface of the grain (Matumba, 2013). At a point of milling and drying maize flour, the flour should be dried at low moisture levels (about 15%) to reduce microbial activities. If moisture content is high, microbial activities would increase and lead to spoilage of the flour. Storage conditions for the flour should be ideal to maintain the quality of the flour. The environment should have low temperatures (below 21 ºC) and relative humidity of between 55% and 65% (WFP, 2011). In addition to these measures, since cooking temperature cannot destroy aflatoxin, only grains that are clean and wholesome should be milled into flour for complementary feeding.

The fourth critical control point identified is the cooking of the food. The majority of microbes are destroyed by heat during cooking. Critical cooking temperatures of 70 degrees Celsius for 10 minutes or 60 degrees Celsius for 12 minutes have been suggested (National Foundation for Sanitation {NFS}, 2006). Since the food is prepared under local conditions in rural areas where mothers and caregivers do not have modern equipment such as thermometers for measuring temperature during cooking, mothers were trained on the indicators of porridge that is correctly and thoroughly cooked. Normally the porridge should be cooked until the flour gelatinizes and attains a thick viscosity which forms a thin layer on the surface. Mothers and care givers were also trained to feed the children before the porridge was cold to prevent recontamination. The developed intervention has been packaged into a training manual for communities as part of promoting recommended complementary feeding practices in rural communities in in central Malawi.

Further observation showed that mothers and caregivers were not aware of standard practices for processing maize and legumes into flour for preparing complementary food. Mothers and caregivers did not know the proportions of mixing maize and soybeans when preparing soy maize blend. The proportions of maize and soybeans differed among mothers and caregivers and the ratios varied from 2:1, 3:1 and 5:1 which was contrary to the recommended ratio of 4:1 (maize to soybeans) (MG, 1992). Some mothers and caregivers mixed raw soybeans with maize without subjecting the soy beans to any treatment such as boiling or roasting before processing into flour. Coupled with short cooking time, the porridge was smelling raw soybeans and children did not like it. In addition, such types of flour changed taste and flavour after being kept for over seven days (**Table 25**). The flours were kept in plastic pails with lids, woven baskets and synthetic bags. Flour stored in plastic pails changed flavour and taste faster than that stored in woven baskets and synthetic storage facilities (Mphwanthe, et al., 2015).

5.5.2 Change in hygiene and food preparation practices

The training intervention led to significant changes in the hygiene and food preparation practices. The findings agree with results of other studies conducted in South Africa (Phaswana-Mafuya and Shukla, 2005), Indonesia and Pakistan (Saleem et al. 2014) where mothers demonstrated significant behaviour change after an education intervention. Targeting individuals with training on specific health behaviours may result in adoption of positive practices and improved outcomes of health and nutrition attributes of interest when the trained individual is motivated with the outcome of the intervention. The motivators may include improved child health, improved nutrition and reduced morbidity among the children (Nankumbi and Muliira, 2015). A study conducted by Saleem et al (2014) in Pakistan showed that training mothers for 30 weeks in use of a high protein food in complementary foods led to increase in linear growth of children. In a study conducted in Eastern Cape Province of South Africa by Phaswana-Mafuya and Shukla (2005), regular water supply, availability of sanitation facilities and consumer knowledge were highlighted as motivators to improved hygiene practices. In this study, caregivers reported that practices such as washing hands before preparing food and feeding the child, washing cooking and eating utensils resulted in children not having diarrhoea frequently. Binary logistic regression analysis showed that hand washing was significantly associated with reduction in prevalence of diarrhoea among the children (**Table 22**).

In a study conducted in Mchinji and Balaka districts in Malawi by Seetha et al., (2017) in which mothers were trained for 21 days using the Positive Deviance Hearth concept, the results showed significant improvement in child care practices which resulted in reduced incidences of diarrhoea among the children. The results further showed significant reduction of wasting among the children. In this study, reduction in prevalence of diarrhoea among the children may be attributed to the training intervention in improving hygiene and child care practices.

The majority of mothers and caregivers were in the reproductive age category (15-49 years) (**Table 5**). The relationship between age and adoption of new technology has been reported in some studies (Mwangi and Samuel, 2015). In a formative study conducted by Greenland et al. (2013) in Indonesia on hand washing by new mothers, results showed that new mothers were keener to learn new things than older mothers. Young people are less risk averse and more willing to try new technologies than old ones. However, this study did not assess age difference in adoption of the practices. The training intervention created awareness among mothers and caregivers of the importance of following recommended hygiene practices to prevent food contamination and foodborne illnesses.

Due to low literacy levels among the mothers and caregivers, emphasis was put on hands-on practical activities during training to ensure that every mother and caregiver was able to follow the recommended hygiene practices during complementary feeding. High levels of illiteracy among mothers and caregivers may be highlighted as one of the challenges in the study area. Women who have more years of schooling tend to have better health and well-being and healthier behaviours (Feinstein et al. 2006, Vaughan, 2010). Literacy may also determine the methods and approaches used to pass on technical messages to mothers and caregivers during training. Mothers and caregivers who cannot read or write may not understand messages that are disseminated using printed materials. In such circumstances, demonstrations and role plays may be helpful. Assessment of hygiene practices and prevalence of diarrhoea after the intervention showed improvement in the practices and reduction in prevalence of diarrhoea respectively.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study had four specific objectives which were, to determine the infant and young child feeding practices among mothers and caregivers, to assess the nutritional status of children aged 6-23 months; to determine the presence of aflatoxins and enumerate occurrence of moulds in locally processed complementary foods and to determine the sanitation and hygiene protocols used by mothers and caregivers to develop a HACCP based intervention.

The results of the study showed that meal frequency was low among the majority of children in the study area. The proportion of children who were given diversified diet was also very low and determinants of dietary diversity included maternal education, household size, age category of the child and marital status of the mothers. From these findings, it is concluded that infant and young child feeding practices among mothers and caregivers in Mayani EPA in Dedza district are not satisfactory.

From the results of assessment of nutritional status of the children, it is concluded that prevalence of undernutrition indicated by stunting and underweight among children aged 6-23 months in Mayani EPA in Dedza district is very high and that maize flour used for preparing complementary food is contaminated with moulds, coliforms, and yeast and that aflatoxin levels are below the national limits.

From the study, it is further concluded that provision of tailor-made training to mothers and caregivers during complementary feeding period improves heir hygiene and sanitation practices.

6.2 Recommendations

Based on the findings of this study, the following recommendations should be considered to advance this work further.

1. The Government of Malawi should consider incorporating food safety into the infant and young child feeding policy so that promotion of recommended complementary feeding practices should not only focus on dietary adequacy but also on food safety and hygiene.
2. The HACCP strategy that has been developed in this study should be integrated into the training curriculum for the community health workers (HSAs) and frontline extension workers so that it can be used as a tool for assessing hygiene practices in communities and training them to bring positive behaviour change.

3. The mean age of mothers and caregivers is low in the study area and the mean household size is greater than the national mean household size. It is recommended that further research should be conducted to investigate the linkages between maternal age, household size and child nutritional status.
4. Further research should also be conducted on exposure of children to aflatoxin and its effect on child growth focusing on analysis of aflatoxin in cooked complementary foods and in blood samples of children aged 6-23 months.

REFERENCES

Adams, M., and Motarjemi, Y. (1999). Basic food safety for health workers. *WHO*, Geneva. *Retrieved October 20, 2014, from www.who.int/foodsafety/publications/capacity/en/2. pdf.*

Andrew, A.K., Michael, M., Mandha, J. and Yiga, P. (2017). Microbial profile of sun dried Fermented mud fish (*Claria s. anguiliaris*) locally known as Abil Alier sold in local markets in South Sudan. *International Journal of Food Science and Nutrition, 2 (1): 32-36. Accessed* Retrieved July 30, 2018 from www.foodscience.com.

Arimond, M. and Ruel, M.T. (2004). Dietary diversity is associated with child nutritional status. Evidence from 11 demographic and health surveys. *Journal of Nutrition, 134(10): 2579-85.*

Association of Official Analytical Chemists. (1990). Official Method of Analysis, 15th Ed. AOAC, Arlington, Virginia.

Aunger, R., Greenland, K., Ploubidis, G., Schmidt, W., Oxford, J., Curtis, V. (2016). The Determinants of Reported Personal and Household Hygiene Behaviour: A Multi-Country Study. PLoS ONE, 11(8): Doi:10.1371/journal. pone.0159551.

Aworh, O.C. (2008).The role of traditional food processing technologies in national development: the West African experience. International Union of Food Science and Technology, 1: 1-18.

Babu, S. C., Subrahmanyam, P., Chiyembekeza, A. J. and Ng'ong'ola, D. (1994). Impact of aflatoxin contamination on groundnut exports in Malawi. *African Crop Science Journal, 2 (2). 215-220. ISSN 1021-9730*

Badham, J. and Sweet, L. (2010). Stunting: An overview; *Sight and Life magazine, 3, 40-47.*

Bakobie, N., Addae, S., Duwiejuah, A., Cobbina, A. and Solomon, M. (2017). Microbial profile of common spices and spice blends used in Tamale, Ghana. *International Journal of Food Contamination, 4(10), Doi:10.1186/s40550-017-0055-9.*

Bandyopadhyay, R., Kumar, M. and John, L. (2007). Relative severity of aflatoxin contamination of cereal crops in West Africa. *Food additives and contaminants, 24. 1109-14. Doi: 10.1080/02652030701553251.*

Bankole, S. A. and Adebanjo, A. (2003). Review: Mycotoxins in food in West Africa: current situation and possibility of controlling it. *African Journal of Biotechnology, 2 (9), 254-263.*

Baumgartner, A. E.·, Lindblade, K., Gieseker, K., Rogers, H.S., Kieszak, S., Njapau H., Schleicher, R., McCoy, L.F., Misore, A., DeCock, K., Rubin, C., Slutsker, L. (2005).

Case-control study of an acute aflatoxicosis outbreak, Kenya. Aflatoxin Investigative Group. Environmental Health Perspective, 113(12):1779-83.

Bbosa, G.S., Kitya, D., Lubegga, A., Ogwal-Okeng, J., Onokbonggo, W.W. and Kyegombe, D.B. (2013). In Review of the Biological and Health effects of aflatoxins on body organs and body systems. Published online by IntechOpen Limited. Retrieved April 5, 2019 from http://creativecommons.org/licenses/by/3.0.

Benson, T. (2001). In Microbiological Applications Laboratory Manual in general microbiology. 8th Edition, The McGraw-Hill, New York.

Bhaumik, S.K., Dimova, R. and Gang, I.N. (2013). Is women's ownership of land a panacea in Developing countries? Evidence from land-owning farm households in Malawi. William Davidson Institute Working Paper Number 1055.

Bezner Kerr, R., Shumba, L. Dakishoni, L., Lupafya, E., Snapp, S.S., Berti, P.R., Nyantakyi-Frimpong, H., Luginaah, I., Nalivata, P., Kunkwezu, B., Kanyama-Phiri, G., Jones, A., Katundu, M., Nkhonya, Z., Msachi, R., Chitaya, A., Maona, E., Gondwe, T., Nkhonjera, P.,

Mkandawire, M., Kanyimbo, P. and Gondwe, G. (2014). Farmer-led climate change adaptation

strategies to improve food security, Nutrition and Soil Health: *Policy Recommendations.*

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. and Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. Maternal and child undernutrition Study Group; Lancet. 3;382(9890):427-451. Doi: 10.1016/S0140-6736(13)60937.

Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., Ezzati, M., Mathers, C., Rivera, J.I. (2008). Maternal and Child Undernutrition: global and regional exposures and health consequences. Maternal and child undernutrition Study Group; The *Lancet Series, 371 (9608):243-60. Doi: 10.1016/S0140-6736 (07)61690-0.*

Bolarinwa, O.A. Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. Nigerian Postgraduate Medical Journal, 22:195-201

Bryan, F.L. (1992). Hazard analysis critical control point evaluations: A guide to identify hazards and assessing risks associated with food preparation and storage. World Health Organization, Geneva, 1992.

Butta, Z.A., Das, J.K.., Rizvi, A., Gaffey., M., Walker, N., Horton, S. and Black, R. (2013). Evidence based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *The Lancet Nutrition Intervention Review Group, and the Maternal and child nutrition Study Group.*

CARE Malawi. (2012). Maziko Project baseline nutrition survey report for Dowa and Kasungu districts. Funded by Care Canada and Care USA. Lilongwe, Malawi.

CARE Malawi. (2013). Maziko project nutrition trend survey report for Dowa and Kasungu districts. Funded by Care Canada and Care USA. Lilongwe, Malawi.

Chitowe, M. (2013). Improving protein content in complementary foods in Malawi. MSc Thesis. Bunda College of Agriculture, University of Malawi.

Chiutsi, G., Heil, E., Kalimbira, A.A., Masangano, C., Mtimuni, B.M., Krawinkel, M.B., and Jordan, I. (2017). Reduced morbidity motivated adoption of infant and young child feeding practices after nutrition education intervention in rural Malawi. Journal of *Ecology of Food and Nutrition, 56 (4): 329-348, DOI: 10.1080/03670244.2017.1338181*.

Connellan, J., Baron-Cohen, S., Wheelwright, S., Batiki, A. and Ahluwalia, J. (2000). Sex differences in human neonatal social perception. Journal of Infant Behaviour and Development, 23: 113-118, p//so163-6383 (00) 00032-1.

Danaei, G., Andrews, K.G., Sudfeld, C.R., Fink, G., McCoy, D.C., Peet, E., Sania, A., Fawzi, M.C.S., Ezzati, M. and Fawzi, W.W. (2016). Risk factors for childhood stunting in 137 developing countries: A comparative risk assessment analysis at global, regional, and country levels. *PLoS Med 13(11): e1002164. doi:10.1371/journal.pmed.1002164*

DeMan, J.M. (1990). In Principles of Food Chemistry. Second Edition, Van Nostrand Reinhold, New York.

Ehiri, J.E., Azubuike, C.M., Ubbaonu, N.C., Anyanwu, C.E., Kasimir, M.I., and Ogbonna, O.M. (2001). Critical control points of complementary food preparation and handling in eastern Nigeria. Bulletin of the World Health Organization. 79 (5). 423-433.

Etzel, R.A. (2002). Mycotoxins. Journal of American Medical Association, 287 (4):425-427. doi:10.1001/jama.287.4.425.

Feinstein, L., Sabates, R., Anderson, T.M., Sorhaindo, A. and Hammond, C. (2006). Measuring the effects of education on health and civic engagement: *Proceedings of the Copenhagen symposium – © OECD 2006.*

Fikadu, T., Assegid, S. and Amente, L. (2014). Factors associated with stunting among children of age 24 to 59 months in Meskan district, Gurage Zone, South Ethiopia: A case-control study. BMC Public Health. 14. 800. https/doi.org/10.1186/1471-2458-14-800.

Flick, U. (1998). An Introduction to qualitative research. Theory, method and applications. London: Sage. Food and Agriculture Organization. (2010). Crops primary equivalent. Retrieved January 8, 2016 from www.fao.org.

Food and Agriculture Organization. (2009). Daily calorie intake in Malawi. Rome, Italy.

Food and Agriculture Organization. (2007). Guidelines for measuring household and individual dietary diversity. Version 2: Rome, Italy.

Food and Agriculture Organization. (1997). Agriculture, food and nutrition for Africa. A resource book for teachers of Agriculture. Information Division, Food and Agriculture Organization of the United Nations. Rome Italy.

Food and Agricultural Organization, (1993). Guidelines for the application of the hazard analysis and critical control point (HACCP) system. Food and Agricultural Organization, Codex Alimentarius Commission. Rome, Italy.

Gelineau-van, W.J., Voss, K.A., Stevens, V.L., Speer, M.C. and Riley, R.T. (2009). Maternal Fumonisin exposure as a risk factor for neural tube defects. *Advances in Food and Nutrition Research. 56:145-81. Doi: 10.1016/S1043-4526 (08) 00605.0*

Gibson, R.S. (2005). In Advanced of Nutritional Assessment. Oxford University Press, 7th Edition.

Gibson, R.S. (1990). In Principles of Nutritional Assessment. Oxford University Press, 6th Edition.

Golden, M., Seaman, J. and Erhardt, J. (2014). Emergency nutrition assessment for standard monitoring and relief in transition (SMART).

Gong, Y.Y., Hounsa, A., Egal, S. Turner, P.C., Sutcliffe, A.E., Hall, A.J., and Wild, C.P. (2004).Post weaning exposure to aflatoxin results in impaired child growth: A longitudinal study in Benin, West Africa. *Journal of Environmental Health Perspectives, 12: (13).*

Gong, Y.Y., Egal, S., Hounsa, A., Turner, P.C., Hall, A.J., Cardwell, K.F., and Wild, C.P. (2003). Determinants of aflatoxin exposure in young children from Benin and Togo, West Africa: the critical role of weaning. *International Journal of Epidemiology, 32 (4):556-62.*

Gong, Y.Y., Cardwell, K., Hounsa, A., Egal, S., Turner, P.C., Hall, A.J. and Wild, C.P. (2002). Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo cross sectional study. *British Medical Journal*, 325 (7354): 20-21.

Greenland, K., Iradati, E., Ati, A., Maskoen, Y.Y., and Aunger, R. (2013). The context and practice of handwashing among new mothers in Serang, Indonesia: A formative research study. BMC Public Health, 13:830, Doi.org/10.1186/1471-2458-13-830.

Hotz, C., and Gibson, R.S. (2001). Complementary feeding Practices and dietary intakes from complementary foods amongst weanlings in rural Malawi. *European Journal of Clinical Nutrition*, 55, 841-849.

Ibeanu, V.N., Ene-Obong, H.N., Peter-Ogba, G.U., and Onyechi, U.A. (2015). Microbiological Evaluation and shelf-life of seed flour mixes used for infant feeding in Rural northern Nigeria. *African Journal of Biotechnology, 14(20),1718-1723.*

International Food Policy Research Institute. (2013). Aflatoxins: Finding solutions for improved ood safety. Institute for International Agriculture. (2014). Research on Soybeans. Retrieved December 6, 2014 from www.iita.org/crops/.

Jelliffe, D.B. (1966). The assessment of the nutritional status of the community. *World Health* ***Organization Monograph, Series No. 53, Geneva, 50-84.***

Jiang, Y., Jolly, P. E., Preko, P., Wang, J.S., Ellis, W. O., Phillips, T. D., and Williams J.H. (2008). Aflatoxin-related immune dysfunction in health and in human immunodeficiency virus disease. *Journal of clinical and developmental immunology, 790309. Doi:10.1155/2008/790309.*

Kaaya, N.A. and Kyamuhangire, W. (2006). The effect of storage time and agro-ecological zone on mould incidence and aflatoxin contamination of maize from traders in Uganda. *International Journal of Food Microbiology, 110: 217-223.*

Kalanda, B.F, Verhoeff, F.H., and Brabin, B.J. (2006). Breast and complementary feeding practices in relation to morbidity and growth in Malawian infants. *European Journal of Clinical Nutrition, 60(3):401-7*

Katerere, D.R., Shepherd, G.S. and Faber, M. (2008). Infant malnutrition and chronic aflatoxicosis in Southern Africa: Is there a link? *International Journal of Food Safety, Nutrition and Public Health, 1(2), 126-136.*

Katona, K., and Katona, J. (2008). The interaction between nutrition and infection. *Journal of Clinical Infectious Diseases, 46(10):1582- 1588.*

Kerr, B. R., Dakishoni, L., Shumba, L., Msachi, R. and Chirwa, M. (2008). "We grandmothers know plenty". Breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. *Social Science Medicine, 66 (5):1095-1105.https://doi.org/10.1016/j.socscimed.*

Khlangwiset, P., and Wu, F. (2010). Costs and efficacy of public health interventions to reduce aflatoxin-induced human disease. *Food* additives and contaminants. Part A, Chemistry, analysis, control, exposure and risk assessment. *International Society for Mycotoxicology. 27, 998–1014.*

Kiessling, H.K. (1986). Biochemical mechanism of action of mycotoxins. Pure Applied Chemistry, 58 (2):327-338, http://dx.doi.org/10.1351/pac198658020327.

Lobo, M.A., Moeyaert, M., Cunha, A.B. and Babik, I. (2017). Single-Case design, analysis and quality assessment for intervention research. *Journal of neurologic physiotherapy, 41(3):187-197. Doi:10.1097/NPT.0187*

Lusweti, N. (2014). Aflatoxin exposure and stunting in young children in Sub-Saharan Africa. Conference presentation, Nairobi, Kenya

Makoka, D. (2013). The impact of maternal education on child nutrition: Evidence from Malawi, Tanzania and Zimbabwe. Demographic and Health Surveys Working Papers; USAID, 2013.

Malawi Government. (1992). Weaning facts for Malawian families. Ministry of Health and Population. Capital Hill, Lilongwe

Malawi Government. (2005). Food and nutrition security policy. Ministry of Agriculture and Food Security, Lilongwe, Malawi.

Malawi Government. (2006). Malnutrition in Malawi: A silent crisis – invest now: Malawi Nutrition profiles; Office of the President and Cabinet, Lilongwe.

Malawi Government. (2007a). Infant and young child nutrition policy. Ministry of Health; Capital Hill, Lilongwe.

Malawi Government. (2007b). National Nutrition Policy and Strategic Plan. Office of the President and Cabinet, Capital Hill, Lilongwe.

Malawi Government. (2010). Nutrition Education and Communication Strategy. Office of the President and Cabinet, Capital Hill, Lilongwe.

Malawi Government. (2011). Health Sector Strategic Plan II. Ministry of Health and Population, Capital Hill, Lilongwe.

Malawi Government. (2015a). The cost of hunger in Malawi: Social and economic impact of child undernutrition, implications on national development and Vision 2020. Survey Report. The New Partnership for Africa's Development, World Food Programme and United Nations Economic Commission for Africa.

Malawi Bureau of Standards. (2015b). Quality management systems-requirements. MS-ISO 9001:2015.

Malawi Government. (2019). Climate and Seasons of Malawi. Department of Climate Change and Meteorological Services, Blantyre. *Retrieved April 6, 2019 from www.metmalawi.com.*

Maleta, K. (2006). Epidemiology of undernutrition in Malawi. Nutrition chapter, *Epidemiological Reviews*. Division of Community Health, College of Medicine, Blantyre, Malawi.

Mamiro, P.S., Kolsteren, P., Roberfroid, D.,Tatala, S., Opsomer, A.S., and Van Camp, J.H. (2005). Feeding practices and factors contributing to wasting, stunting, and iron-deficiency anaemia among 3-23-month old children in Kilosa District, Rural Tanzania. Journal of Health, Population and Nutrition: 23 (3) 222-230.

Marriot, B.P., White, A., Hadden, L., Davies, J.C. and Wallingford, J.C. (2012). World Health Organization (WHO) infant and young child feeding indicators: associations with growth measures in 14 low-income countries. Journal of Maternal and Child Nutrition. 8 (3):354-70. doi: 10.1111/j.1740-8709.2011.00380.

Martorell, R., Horta, B.L., Adair, L.S., Stein, A.D., Richter, L., Fall, C.H.D. and Lopes, D. (2010). Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low- and middle-income countries. *Journal of Nutrition, 140 (2), 348-354. https://doi.org/10.3945/jn.109.112300.*

Matumba, L. (2013). Aflatoxin in Malawi: Prevalence, actions and way forward. World Mycotoxin Journal, 6 (4):367-373. https://doi.org/10.3920/WMJ2013.1563.

Matumba, L., Chamango, A. and Munthali, W. (2012). Guidelines for the management of aflatoxin contamination in groundnuts and maize in Malawi. Ministry of Agriculture and Food Security, Lilongwe.

Matumba, L., Monjerezi, M., Khonga, E.B. and Lakudzala, D.D. (2010). Aflatoxins in Sorghum, sorghum malt and traditional opaque beer in southern Malawi. *Journal of Food Control*, 22 (2) :266-268. https://doi.org/10.1016/j.foodcont.2010.07.008.

Mittal, A., Singh, J. and Ahluwalia, S. K. (2007). Effect of maternal factors on nutritional status of 1-5-year-old children in urban slum population. *Indian Journal of Community Medicine, 32(4):264-267: http://www.ijcm.org.in/text.asp?2007/32/4/264/37691.*

Mostue, H. and Huttly, S. (2008). Adult education and child nutrition: the role of family and community. *Journal of Epidemiology and Community Health, (62):153-159. Doi:10.1136/Tech.2006.058578.*

Monyo, E.S., Osiru, M., Siambi, M. and Chinyamunyamu, B. (2010). Assessing occurrence and distribution of aflatoxins in Malawi. Biological Sciences, Entomology Papers, 2010, 1-40: Retrieved January 6, 2015 from openurl.ac.ukWorldcCat®Google ScholarEdit library *access links*

Monyo, E.S., Njoroge, S.M.C., Coe, R. Osiru, M., Madinda, F., Waliyar, F., Thakur, R.P.,Chilunjika, T. and Seetha, A. (2012). Occurrence and Distribution of aflatoxin contamination in groundnuts (Arachis hypogaea L) and Population density of Aflatoxigenic Aspergilli in Malawi. Journal of Crop Protection, 42: 149-155.

Moon, E.-Y., Rhee, D.-K. & Pyo, S. (1999) In vitro suppressive effect of aflatoxin B1 on murine eritoneal macrophage functions. *Toxicology, 133, 171–179.*

Mphwanthe, G., Kalimbira, A.A. and Geresomo, N.C. (2015). Consumption and wastage of home-fortified maize flour products in northern Malawi. South African Journal of Clinical Nutrition, 28(4):00-00

Mtimuni, B.M., Nkhoma, O., Katundu, M. and Geresomo, N.C. (2008). Baseline nutrition survey, Ntchisi ADP, Malawi: Fisheries and HIV/AIDS in Africa: Investing in sustainable solutions. Regional programme of the World Fish Center and the Food and Agriculture Organization of the United Nations.

Mtimuni, B.M., Nkhoma, O., Katundu, M. and Geresomo, N.C. (2010). Dietary survey, Ntchisi ADP, Malawi: Fisheries and HIV/AIDS in Africa: Investing in sustainable solutions. Regional Programme of the World Fish Center and the Food and Agriculture Organization of the United Nations.

Mugenda, A. G. (2003). Research Methods: African Centre for Technology Studies (ACTS). Nairobi, Kenya

Mulenga, H. and Geresomo, N. (2011). Relationship between weight gain and dietary diversityamong pregnant women attending antenatal clinic at Mlale hospital in Lilongwe district. A research project report submitted to the Faculty of Agriculture in partial fulfillment for the award of the degree of Bachelor of Science in Nutrition and Food Science; Bunda College of Agriculture, University of Malawi.

Mutungi, C.M. (2006). Effects of Dehulling maize grains and treatment with chemical additives on the levels of aflatoxins during muthokoi making and preparation. *MSc Thesis.* University of Nairobi, Kenya.

Mwangi, M., and Samuel, K. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. Journal of Economics and *Sustainable Development, 6 (5):208–16.*

Mwihia, J.T., Staetmans, M., Ibrahim, A., Njau, J., Muhenje, O., Guracha, A. and Lewis, L. (2008). Aflatoxin levels in locally grown maize in Makueni District, Kenya. *East African Medical Journal, (7)311-317. http://doi.org/10.4314/ea.nj.v85i7.9648.*

Nankumbi, J., and Muliira, J.K. (2015). Barriers to Infant and Young Child feeding Practices. A Qualitative study of primary caregivers in rural Uganda. *Journal of Health, Population and Nutrition, 33 (1): 106-116.*

National Statistical Office. (1992). Malawi Demographic and Health Survey Reports. Zomba, Malawi National Statistical Office and ORC Macro. (2004). 2004 Demographic and Health Survey Report. Zomba, Malawi.

National Foundation for Sanitation. (2006). Hazard Analysis and Critical Control Point Training Series; *HACCP Manager Certification Training, NSF International.*

National Statistical Office. (2009). National Micronutrients Survey Report. Zomba, Malawi.

National Statistical Office. (2009). Welfare Monitoring Survey Report. Agriculture Statistics Division, Zomba, Malawi.

National Statistical Office and ORC Macro. (2010). 2010 Malawi Demographic and Health Survey Report. Zomba, Malawi.

National Statistical Office and ICF. (2017a). Malawi Demographic and Health Survey 2015-16 Zomba, Malawi, and Rockville, Maryland, USA.

National Statistical Office. (2017b). Summary of demographic, social and economic indicators.

Statistical Yearbook. Malawi Government, Zomba.

National Statistical Office. (2018). 2018 Malawi population and housing census. *Preliminary*

Report. Malawi Government, Zomba.

Nduati, R., Arum, S. and Kageha, E. (2011). Beliefs and attitudes around infant and young child feeding in Kenya. Rapid qualitative assessment. Ministry of Health, Kenya.

Nishimwe, K., Wanjuki, I., Karangwa, C., Darnell, R., and Harvey, J. (2017). An initial characterization of flatoxin B1 contamination of maize sold in the principal retail markets of Kigali, Rwanda. *Journal of Food Control, 73:574-580,* doi:*0.1016/j.foodcont.2016.09.006.*

Nyamete, F.A., Bennink, M. and Mugua, J.K. (2016). Potential of Lactic Acid Fermentation in reducing Aflatoxin B1 in maize based gruel in Tanzania. African Journal of Food, Agriculture, Nutrition and Development: 16 (3).

Onwuegbuzie, A.J. and Leech, N.L. (2007). Sampling Designs in Qualitative Research: Making the Sampling Process More Public. The Qualitative Report, 12(2), 238-254. Retrieved April13, 2018, from http://nsuworks.nova.edu/tqr/vol12/iss2/7.

Okoth, S.A. and Ohingo, M. (2004). Dietary aflatoxin exposure and impaired growth in young children from Kisumu District, Kenya: Cross sectional study. African Journal of Health Science, 11(1-2):43-54.

Ozaltin, E., Hill, K. and Subramanian, S.V. (2010). Association of maternal stature with offspring mortality, underweight, and stunting in low-to middle-income countries.

Journal of American Medical Association, 303(15), 1501-1516. Programme for AppropriateTechnology in Health (2012). Infant and young child nutrition project report. United States Agency for International Development, Washington DC.

Picado, J.I. and Mtimuni, B.M. (2010). Consulting with caregivers. Formative research to determine the barriers and facilitators to optimal infant and young child feeding in three regions of Malawi. USAID's Infant and Young Child Nutrition Project.

Phaswana-Mafuya, N., Shukla, N. (2005). Factors that could motivate people to adopt safe hygienic practices in the Eastern Cape Province, South Africa. African Journal of Health Sciences, 5 (1):21–28. [PMC free article] [PubMed] [Google Scholar].

Rasheed, S., Haider, R., Hassan, N., Pachon, H., Islam, S., Jalal, C.S. and Sanghvi, T.G. (2011). Why does nutrition deteriorate rapidly among children under 2 years of age? Using qualitative methods to understand community perceptives on complementary feeding practices in Bangladesh. Food and Nutrition Bulletin, 32(3):192-200. Doi:10.1177/156482651103200302.

Rios, D.L., Gokah, I.B., Kauma, B.C., Matumba, L., Njoronge, S. and Chimseu, A. (2013). Malawi Programme for Aflatoxin Control (MAPAC). Advancing Collaboration for Effective Aflatoxin Control, http://10.150.35.18:6510/www.aflatoxinpartnership.org/uploads/MAPAC.

Saleem, A.F., Mahmud, S., Ansari, N.B., and Zaidi, A.K.M. (2014). Impact of maternal education about complementary feeding on their Infants' nutritional outcomes in low- and middle-income households: A Community-based randomized interventional study in Karachi, Pakistan. Journal of Health Population and Nutrition, 32(4):623-633.

Singh, A., Misra, V., Thimmulappa, R.K., Lee, H., Ames, S., Hoque, M.O., Herman, T.G., Baylin, S.B., Sidransky, D. and Gabrielson, E. (2006). Dysfunctional KEAP1-NRF2 interaction in non-small-cell lung cancer. PLOS Med. 3, e420.

Schutz, Y.B. and Garrow, J.S. (2000). Energy substrate balance and weight regulation. In Human nutrition and Dietetics, pp137-148, Edinburgh: Churchill, Livingstone.

Seetha, A., Tsusaka, T.W., Munthali, T.W., Musukwa, M., Mwangwela, A., Kalumikiza, Z. and Okori, P. (2017). How immediate and significant is the outcome of training on diversified diets, hygiene and food safety? An effort to mitigate child undernutrition in Malawi. Journal of Public Health Nutrition, doi:10.1017/S1368980017003652

Shobha, D., Kumar, K., Putarramanaik, M. and Screemasetty, T.A. (2011). Effect of antioxidant on the shelf Life of quality protein maize flour. *Indian Journal of Fundamental and Applied Life Sciences, 1(3)129-140.*

Soko, M., Matumba, L., Gokah, I. and Kauma, B. (2011). Aflatoxin in Malawi: Prevalence, Actions and Way Forward. Department of Agricultural Research services, and Ministry of Industry and Trade, Capital City Lilongwe, Malawi

Swindale, A. and Bilinsky, P. (2005). Household Dietary diversity Score (HDDS) for measurement of household food access: Indicator Guide, Food and Nutrition Technical Assistance. The Journal of Nutrition, 138: (12): 2448-53.

Tatala, S.R. (2007). Effect of germination of finger millet on nutritional value of foods and effect on food supplement on nutrition and anaemia in Tanzanian children. Tanzania Health Research Bulletin, 9 (2): 77-86. Doi:10.4314/thrb.v9i2.14308.

Thakwalakwa, C., Phuka, J., Flax, V., Maleta, K. and Ashorn, P. (2009). Prevention and treatment of childhood malnutrition in rural Malawi: Lungwena nutrition studies. *Malawi Medical Journal; 21(3):116-119.*

Thuita, F., Omwega, A. and Muita, J. (2002). Child care practices and nutritional status of children aged 0-2 years in Thika, Kenya. East African medical journal. 79. 524-9.10.4314/eamj.v79i10.8814.

Toure, O. and Cairncross, S. (2009). Implementation of the Hazard Analysis Critical Control

Points (HACCP) method to improve microbiological food safety in peri-urban Mali. Thesis,London School of Hygiene and Tropical Medicine, Keppel Street, London.

Turner, P. C., Moore, S. E., Hall, A. J., Prentice, A. M., and Wild, C. P. (2013). Modification of immune function through exposure to dietary aflatoxin in Gambian children. *Environmental Health Perspectives, 111, 217–220.*

Turner, P. C., Collinson, A. C., Cheung, Y. B., Gong, Y., Hall, A. J., Prentice, A. M., and Wild, C. P. (2007). Aflatoxin exposure in utero causes growth faltering in Gambian infants. International Journal of Epidemiology, 36, 1119–1125.

United Nations Children's Fund, World Health Organization and World Bank. (2018). Joint Child malnutrition Estimates. Global Database on Child Growth and Malnutrition. Joint Estimates, 2018 Edition.

United Nations Children's Fund. (2013). Multiple Indicator Cluster Surveys: Manual for Anthropometry Measurements for Survey Coordinators.

United Nations Children's Fund. (2009). The State of the World's Children 2009; Maternal and Newborn Health.

United Nations Children's Fund and Food and Agriculture Organization. (1998). Infant and Young Child Feeding: Model Chapter for Textbooks for Medical Students and Allied Health Professionals. Guiding Principles for Complementary Feeding.

United Nations Children's Fund. (1997). The conceptual framework of the causes of malnutriton. United Nations.

Vaahtera, M., Kulmala, T., Ndekha, M., Kullinan, T., Salin, M.L. and Ashorn, P. (2001). Breastfeeding and complementary feeding practices in rural Malawi. Acta Paediatric, 90 (3), 328-332.

Vaughan, R.P. (2010). Girls' and women's education within Unesco and the World Bank, 1945-2000 Compare: *Journal of Comparative and International Education, 40: (4), 405-423, Doi:10.1080/03057925.2010.490360.*

Veneman, A.M. (2009). Tracking Progress on Child and Maternal Nutrition: A survival and Development priority. United Nations Children's Fund (UNICEF), www.childinfo.org ISBN:978-92-806-4482-1

Victora, C.G., Mercedes deOnis, Hallal, P.C., Blo¨ssner, M. and Shrimpton, R. (2010). Worldwide timing of growth faltering: Revisiting implications for interventions. Journal of Pediatrics: 125 (3). Retrieved July 20, 2018 from www.aappublications.org/news.

Wagacha, J.M. and Muthomi, J.W. (2008). Mycotoxin problem in Africa: Current status, implications to food safety and health and possible management strategies. International Journal of Food Microbiology, 124: 1-12.

Wanjala, G.W., Mathooko, F.M., Kutima, P.M. and Mathala, J.M. (2017). Microbiological Quality and raw pasteurized milk marketed in and around Nairobi region. African Journal of Food, Agriculture, Nutrition and Development, 17(1):11518-11532.

Wayua, F. (2017). Nutritional and Health Challenges of Pastoralist Populations in Kenya. African Journal of Food Agriculture Nutrition and Development, 17 (1): 11592-11602 Doi: 10.18697/ajfand.77.16810.

Williams, J.H., Phillips, T.D., Jolly, P.E., Stiles, J.K., Jolly, C.M. and Aggarwal, D. (2004). Human Aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences and interventions.

Williams, J. H. (2008). Aflatoxin-related immune dysfunction in health and in human immunodeficiency virus disease. *Clinical and Developmental Immunology, 1–12.*

World Food Programme. (2011). Technical specifications for the manufacture of maize meal for local purchase. *Version 3.6, Retrieved April 11, 2019 from www. Wfp. Org.*

World Health Organization. (2010). Indicators for assessing infant and young child feeding practices: Part 3; Country profiles. World Health Organization Press, World Health Organization, Geneva, Switzerland.

World Health Organization Multicenter Growth Reference Study Group. (2006). WHO child growth standards based on length/height, weight and age. International Journal of Pediatrics *Supplement, 450, 76-85.*

World Health Organization. (1983). Measuring Change in Nutritional Status. Geneva.

Wu, F. and Khlangwise, P. (2010). Health Economic Impacts and cost-effectiveness of aflatoxi reduction strategies in Africa: case studies in biocontrol and postharvest interventions. Journal of *Food Additives and contaminants, 27:496-509.*

Zottarelli, L. K., Sunil, T.S. and Rajaram, S. 2007. Influence of parental and socioeconomic Journal,13 (6):1330–42. Doi:10.26719/2007.13.6.1330.

APPENDICES

APPENDIX 1: HOUSEHOLD QUESTIONNAIRE

Questionnaire for Assessing Complementary feeding among mothers and care givers in Dedza District

MODULE 1: IDENTIFICATION			
1.1	Date: day/month/year /____ /____ / 2015	1.6	Name of Respondent.
1.2	Name of Village:	1.7	Age of Respondent /___/____/Years
1.3	Name of T.A:	1.8	Name of Researcher:
1.4	District:	1.9	Name of Supervisor:
1.5	Household No.: /___/___/	1.10	Date of Data entry:

MODULE 2 : HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS		
2.1	Name of Household head :	
2.2	Sex of household head	Male......1, Female......2 (circle)
2.3	Age of Household Head *(in completed years)*	/_____/_____/
2.4	Marital Status of Household Head	Currently Married – monogamous..................1 Currently Married – polygamous....................2 Widowed...3 Divorced..4 Single..5
2.5	Marital Status of Respondent	Currently Married – monogamous..................1 Currently Married – polygamous....................2 Widowed...3

	(Respondent should be the mother or primary caregiver of the eligible child)	Divorced..4 Single...5
	In answering B6 to B10 exclude visitors (< 2 weeks)	
2.6	Total Number of members in this household	Male /_____/_____/ Female /_____/_____/
2.7	Total Number of children under 5 years	Male /_____/_____/ Female /_____/_____/
2.8	Total Number of children 5 to 14.99yrs	Male /_____/_____/ Female /_____/_____/
2.9	Total Number of people 15 to 64yrs	Male /_____/_____/ female /_____/_____/
2.10	Total Number of people above 64yrs	Male /_____/_____/ female / _____/_____/
210	Occupation of household head	Farming……………………1 Other (Specify)………………2
	Education Attainment of Household head and Caregiver	
2.11	Can the household head read or write?	Yes..1 No..2
2.12	Can the caregiver/mother read or write?	Yes ....1 No..2
2.13	What is the highest level of education of the household Head?	Adult literacy..1 Junior Primary (std 1-4)...................................2 Senior Primary (std 5-8)..................................3 Junior Secondary (form1-2)..........................4 Senior Secondary (form 3-4) ....5 Tertiary...6 Don't know..7 Other – specify...88
2.14	What is the highest level of education of the	Adult literacy..1 Junior Primary (std 1-4)...................................2

	Caregiver/mother?	Senior Primary (std 5-8)..................................3 Junior Secondary (form1-2)............................4 Senior Secondary (form 3-4) ………...............5 Tertiary..6 Don't know..7 Other – specify...88
MODULE 3: HOUSEHOLD FOOD SECURITY		
3.1	Which foods are available in your household this period?	Maize grain------------------------------1 Maize flour--------------------------------2 Groundnuts--------------------------------3 Potatoes------------------------------------4 Cassava--------------------------------------5 Others--6
3.2	Where do you normally get your food?	Own production-----------------------1 Market------------------------------------2 Vendors---------------------------------3 Relief--------------------------------------4 Other (specify)--------------------------5
3.3	How do you store your food?	In a locally made granary-------------1 In a metallic silo------------------------2 In baskets--------------------------------3 In polyetherine bags--------------------4 In jute bags-------------------------------5 In clay pots-------------------------------6 In plastic pails---------------------------7 Others (specify)-------------------------------------8
3.4	Do you control the following where you store food: Temperature? Moisture?	Yes-------------1, No------------------2 Yes-------------1, No-------------------2
3.4	Are there any times when your household runs out of food?	Yes...................................1 No.....................................2

3.5	What coping strategies do you use when your household runs out of staple food? In the past seven days, how many times have you used the strategy?	Buy food.................................1 Piece work (Ganyu)...............2 Sell livestock..........................3 Reduce portion size...............4 Reduce meal frequency..........5 Other (specify)..6

MODULE 4: DIETARY DIVERSITY

Please describe the foods (meals, snacks and drinks) that you consumed yesterday during the day and night, whether at home or outside the home. Start with the first food eaten in the morning.

Question Number	**Food group**	**Examples**	**YES=1 NO=0**
4.1	CEREALS	Nsima, porridge, rice, Bread, thobwa or any other foods made from millet, sorghum, maize, rice, wheat	
4.2	VITAMIN A RICH VEGETABLES AND TUBERS	pumpkin, carrots, sweet potatoes that are orange inside, cassava leaves, sweet potato leaves.	
4.3	WHITE TUBERS AND ROOTS	White potatoes, white yams, cassava, or foods made from these.	
4.4	DARK GREEN LEAFY VEGETABLES	Dark green/leafy vegetables, including wild	

		ones + *locally available vitamin-A rich leaves such as cassava leaves etc.*	
4.5	OTHER VEGETABLES	Other vegetables (e.g. tomato, onion, eggplant) , including wild vegetables	
4.6	VITAMIN A RICH FRUITS	ripe mangoes, papaya, dried peaches	
4.7	OTHER FRUITS	Other fruits, including wild fruits	
4.8	ORGAN MEAT (IRON-RICH)	Liver, kidney, heart or other organ meats or blood-based foods	
4.9	FLESH MEATS	Beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds	
4.10	EGGS	Any types of eggs eaten	
4.11	FISH	Fresh or dried fish	
4.12	LEGUMES, NUTS AND SEEDS	Beans, peas, lentils, nuts, seeds or foods made from these	
4.13	INSECTS	Insect larvae, lake fly, ants, grasshoppers	

4.14	MILK AND MILK PRODUCTS	Milk, cheese, yogurt or other milk products e.g. chambiko	
4.15	OILS AND FATS	Cooking oil, Palm oil, fats or butter added to food or used for cooking, nsinjiro	
4.16	SWEETS	Sugar, honey, sweetened soda or sugary foods such as chocolates, sweets or candies	
4.17	SPICES, CONDIMENTS, BEVERAGES	Spices(black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages (phele, kachasu, Chibuku)	

MODULE 5: COMPLEMENTARY FEEDING PRACTICES (6-23 MONTHS)			
5.1	Name of eligible child		
5.2	Date of birth (Day/month/year)	/____/____/20___/	
5.3	Age of child *(completed months)*	/___/___/	
5.4	Sex of child	Male...................1 Female 2	
5.5	Age of mother /caregiver *(in complete years)*	/___/___/	
5.6	Is the child still breastfeeding?	Yes ....1 No...2	**I**f No go to E7a/ if yes, go to E8
5.7a	How old was this child when you stopped breastfeeding?	Never breast fed……………….1 0-6 months……………………...2 6-12 months...…………………3 12-24 months....………………...4	
5.7b	Why did you stop breastfeeding?	Medical advice............………1 Mother passed away…………2 Mother's illness………………..3 Pregnancy....…………………..4 Others *(specify)*……………..88	
5.8	How old was this child when s/he was first fed something other than breast milk? (including water, formula, juice, solid foods, mzuwa, tea, soft drinks)	Number of months ....|__|__| (Enter 99 if don't know)	
5.9	Did "*Child Name*" receive food yesterday?	Yes ....1 No...2	If 2 go to E12
5.10	How many times did "*Child Name*" receive food yesterday day and night?	Once..................1 Twice................2 Three times.......3 Four times......................4 Five times.......................5 More than Five times.....6	
5.11	What complementary foods did you give the child?	1.------------------ 1. Amount--------------(g) 2.------------------ 2. Amount--------------(g) 3.------------------- 3. Amount--------------(g) 4.------------------- 4. Amount--------------(g)	Please estimate the amounts
5.12	Did you give the child any snacks yesterday?	Yes..1 No..2	

5.13	If yes, what was given and how much?	1. Name of food and amount______ ______(g) 2. Name of food and amount______ ______(g) 3. Name of food and amount______ _____(g)	
5.14	Mention the most common foods which you give to your child.	1... 2... 3...	

CHILD DIETARY DIVERSITY: Now I would like you to describe the foods (meals and snacks) that "Child Name" ate yesterday from the time "Child Name" got up to the time "Child Name" went to sleep at night. Start with the first food or drink consumed in the morning. (Yes =1, No =0)			
5.15	Any food from grains, roots and tubers	*Nsima, porridge, grits, cassava, potato, thobwa or other locally available grains*	
5.16	Legumes and nuts	Groundnuts, soybeans beans, peas, Bambara, lentils, nuts, seeds or foods made from these	
5.17	Dairy products	Milk, yoghurt, chambiko, cheese (breast milk).	
5.18	Flesh foods	Meat, fish, poultry, liver, kidney, mice, wild meat	
5.19	Eggs	Any type of eggs (chicken egg, duck egg, guinea fowl egg, turkey egg)	
5.20	Vitamin A rich fruits and vegetables	ripe mangoes, papaya, pumpkin, cassava leaves, Amaranthus, pumpkin leaves, dried peaches + *other locally available dark-green vegetables*	
5.21	Other fruits and vegetables	other fruits and vegetables (including wild ones)	

MODULE 6: CHILD MORBIDITY AND HEALTH			
Now I would like you to explain the health condition of your child for the past two weeks.			
6.1a	Did your any of your children aged 6-23 months show any of the following signs in the past two days? (Yes=1, No=2)	Diarrhoea------------------------------ Fever with chills (malaria)----------- Fever with difficult breathing---------- Coughing-------------------------------	If no diarrhoea go to 6.2a
6.1b	If the child had diarrhoea, what did you do?	Gave the child home-made fluids--------1 Took child to health facility---------------2 Took child to medicine man---------------3 Bought medicine from a shop-------------4 Did nothing-----------------------------------5	
6.2a	Did your any of your children aged 6-23	Diarrhoea-------------------	If no

	months show any of the following signs in the past two weeks? (Yes=1, No=2)	Fever with chills (malaria)--------- Fever with difficult breathing--------	diarrhoea go to 6.3
6.2b	If the child had diarrhoea, what did you do?	Gave the child home-made fluids-------1 Took child to health facility-------------2 Took child to medicine man-------------3 Bought medicine from a shop-----------4 Did nothing---------------------------------5	
6.3	Did you feed your child when he/she was sick?	Yes -----------------------------1 No-------------------------------2	If 2 go to 6.5
6.4	In a day, from morning until going to bed, how many times did you feed your child when it was sick?	Indicate number of times------------	
6.5	Has your child ever been admitted to a feeding programme?	Yes------------------------1 No-------------------------2	If 2 go to Module 7
6.6	What type of programme was your child admitted to?	NRU ---------------------------------1 OTP ----------------------------------2 SFP------------------------------------3 Other specify------------------------4 None-------------------------------------0	

MODULE 7: ANTHROPOMETRY OF CHILDREN 6-23 MONTHS OLD

Name of child *(in full and capitalized)*	Sex M = 1 F = 2	Date of Birth (dd/mm/yy)	Length (cm)	Weight (Kg)	*Bilateral pitting oedema	**Immunized against measles?	**Given Vitamin A

<u>Key</u>: * Bilateral pitting oedema: 0 = none
1 = both feet
2 = both feet and legs
3 = generalized (feet, legs plus other body parts: arms and face)

** Measles & Vitamin A: 1 = Yes with health passport confirmation
2 = Yes without health passport confirmation
3 = No 4 = Not applicable.

APPENDIX 2: TRAINING OF MOTHERS AND CAREGIVERS IN MAYANI EPA, DEDZA DISTRICT ON THE IMPORTANCE OF FOOD HYGIENE IN COMPLEMENTARY FEEDING

Prepared by
Numeri C. Geresomo
Egerton University
Njoro Campus
KENYA

May, 2016

INTRODUCTION

The training sessions were conducted in the communities where participants lived. The sitting arrangement was informal and in a relaxed environment where people were free to interact with each other. The sessions were interactive in nature and the facilitator benefited from experiences of mothers and caregivers through story-telling and sharing of experiences. The delivery of the sessions involved lectures and demonstrations to provide mothers and caregivers with knowledge and skills. The following is a concise outline of the modules that were covered during the training sessions.

SESSION 1: INTERACTIVE LECTURETTE

1. Food contamination

Food becomes contaminated through various mechanisms such as soil, refuse, people, animals such as rodents, insects and during storage by the following means:

i. Microorganisms can be introduced into food from infected humans who handle the food without washing their hands thoroughly.
ii. Food and kitchen utensils and surfaces may become contaminated from other raw foods.
iii. Microbes can be transferred from one food to another by using the same knife and other utensil without washing the utensil in between uses.
iv. A food that is fully cooked can become re-contaminated if it touches other raw foods or drippings from raw foods that contain disease causing microorganisms.
v. If the person who is handling the food is not hygienic microbes may be transferred into the food.
vi. Unhygienic behaviours such as sneezing, coughing without covering the mouth may contaminate food.
vii. Dirty clothes and long uncovered hair may be sources of microbes that can contaminate the food.

2. Kitchen sanitation and hygiene

Sanitation and hygiene of the kitchen (or environment where food is prepared) are important to prevent food contamination and the spread of bacteria. The following should be done to prevent the spread of bacteria and other microbes in the place where food is stored or prepared;

i. Keep the area clean by sweeping and dusting surfaces; wash all surfaces that come into contact with food before and after use.

ii. Wash hands thoroughly with clean running water and soap before handling food.

iii. Wash containers or any other work surfaces used for food preparation and serving before and after use.

iv. Use clean utensils every time food is tasted while cooking.

v. Clean or sweep the floor of the cooking area as soon as it gets dirty.

vi. Put all wastes into a container and dispose them in designated place for waste disposal away from the kitchen or place where food is prepared.
vii. Prevent all animals from entering the areas for food processing, preparation or storage.
viii. Keep food covered wherever possible.
ix. Keep all food, tools and equipment on clean surfaces.
x. Store ingredients in covered containers.
xi. Always use clean equipment.
xii. Get rid of insects, rodents such as rats in a kitchen or store-room because these may contaminate the food.
xiii. Always use clean and safe water from safe sources such as boreholes, protected shallow wells or taps where available.
xiv. Always keep water used for cooking and washing in cleaned utensils and cover them.

3 Personal hygiene

Personal hygiene includes cleanliness of the body and clothes including the surrounding environment. Maintaining a high standard of personal hygiene and cleanliness assists in preventing food contamination. Even healthy people may carry bacteria on their body which may cause food poisoning if eaten together with food. A person can spread bacteria to food by touching parts of the body such as the nose, mouth, hair, or clothes. Therefore all persons preparing food should follow these rules;

i. Cover the hair completely with a clean cloth, hat or hairnet. Do not comb hair while handling and cooking food.
ii. Cover all cuts, burns, sores and abrasions with a clean, waterproof dressing.
iii. Do not talk much or cough/sneeze without covering the mouth because bacteria and other microbes can be transferred from the mouth to the food.
iv. Do not spit or blow nose where you are handling food.
v. Wash hands thoroughly with soap after using the toilet, eating, smoking, coughing, blowing nose, combing your hair, handling waste food and rubbish.
vi. Dry washed hands with air before handling food again. Do not rub hands with cloths that are used by several people.
vii. Always trim fingernails short to prevent microbes being transferred to food from inside finger nails.
viii. Avoid wearing jewelry, or only wear plain banded rings and sleeper earrings to prevent food contamination.
ix. Do not handle any food if you have sores, boils, septic spots, a bad cold, chest infection, sore throat or a stomach upset.
x. Do not cough or sneeze over food.
xi. The person handling food should also observe general body cleanliness i.e. bathing, wearing clean clothes.

SESSION 2 DEMONSTRATION ON WASHING OF HANDS AND UTENSILS

1. How to wash hands correctly

Wash hands using the steps:

i. Wet hands with clean running water
ii. Apply Soap to the hands thoroughly
iii. Lather the hands by rubbing your hands
iv. Rinse the hands thoroughly and air dry them

(Facilitator demonstrated correct hand washing and participants practised to wash hands)

2. Washing cooking, eating and storage utensils

The facilitator demonstrated how to wash cooking and feeding utensils correctly. Clean water and detergents were used. Mothers were encouraged to use local disinfectants such as ash for washing pots and plates using the steps:

i. Wet the pots or plates
ii. Apply detergents
iii. Rub or scrub the inside and outside thoroughly.
iv. Rinse with clean water until detergents are removed.
v. Dry utensils on a drying rack.
vi. Keep in dry and clean environment.

SESSION 3: DEMONSTRATION ON CLEANING, SORTING AND SOAKING OF MAIZE GRAIN

1. Sorting of the grain

Mothers and caregivers were trained to follow the following steps:

i. Put the grain on a clean dry surface where there is adequate light.
ii. Remove damaged, discoloured and decayed grains.
iii. Remove any contaminants such as stones, soil particles and other plant materials.
iv. Winnow the grain to ensure that all other trash are removed.

1. Washing the grain

The grain may have some contaminants adhering to the surface therefore wash the grain by:

i. Pouring the grain in clean water in a clean basin, pail or any other container.
ii. Wash the grain by rubbing it against other grains in water.
iii. Throw away the water and add clean water.
iv. Rinse the grain and throw away the water using for washing.
v. Washing may help to remove mould spores or aflatoxin from the surface of the grain.

2. Soaking the grain

Soak maize grain by following these steps:

i. Put grain in clean water in a clean utensil such as a clay pot, plastic pail or any other container and cover.
ii. Soak for about 12 hours.

3. Milling and drying the flour

i. Remove the grain from the water, rinse and dry on a clean dry surface.
ii. Mill the grain into whole grain flour.
iii. Dry the flour to the moisture content of below 15% (until the flour is dry enough to be blown off by wind).
iv. Keep in a clean dry container in a cool dry place.

Advantages of soaking maize:

i. Helps to remove microbes such as moulds which cannot survive in water.
ii. Ferments the starch and reduces bulkiness of the porridge.
iii. Reduces antinutritional factors such as phytates.

SESSION 4 PROCESSING OF SOYBEANS INTO FLOUR

Where mothers and caregivers want to add soybeans to maize, the following steps should be followed:

i. Sort the soybeans the same way maize grain was sorted.
ii. Remove shrivelled grains.
iii. Removed damaged and discoloured grain.
iv. Remove stones, soils and other plant trashes.
v. Boil soybeans in boiling water for about 45 minutes.
vi. Cool the water and peel off the coatings.
vii. Wash the grain and dry
viii. Mill into flour
ix. Sometimes instead of boiling, roast soybeans until light brown.
x. Mill into flour.

1. Advantages of boiling or roasting soybeans

i. Denatures antinutritional factors such as trypsin inhibitors.
ii. Removes the beany smell of the porridge.
iii. Makes porridge to cook faster.
iv. Improves the flavour of the porridge.

2. How to mix maize and soybeans

i. Add one part soybeans to four parts maize (e.g. one cup soybeans mixed with four cups of maize grain)

3. Demonstration of preparation of porridge that is well cooked and safe for the child

Mothers were taken through the process of cooking porridge that was hygienic and safe for the child to eat. All hygiene protocols were followed and each mother and caregiver followed the procedures and prepared porridge.

APPENDIX 3: ASSESSMENT OF SANITATION AND HYGIENE PRACTICES AMONG

SELECTED HOUSEHOLDS IN MAYANI EPA

CHECK LIST

Name of observer___________________________________
Date: ____
Name of village: __________________Household ID:___________________

Instructions to observer: Please fill in the form information based on your observations and answers from mother or caregiver

Date of visit	Practice	Observations
	Food storage environment	Temperature____________ Relative humidity________
		Environment clean? Y/N____________
	Storage of ingredients	Temperature__________________ Humidity____________________
	Hygiene during Food preparation	Are utensils clean? (Y/N)_______ Is the environment clean? (Y/N) ________ Is the person preparing food clean? (Y/N) ________ Did she wash hands correctly? (Y/N)_________ Did she wash utensils correctly? (Y/N)_________
	Choice of grain for making flour	Does she sort and clean grain? Y/N_________ Does she soak the grain? Y/N_____________ Does she know aflatoxin? Y/N____________
	Mixing of ingredients	Before cooking (Y/N)_________________ During cooking (Y/N)_________________ After cooking (Y/N)__________________
	Cooking	Is the food cooked thoroughly? Y/N_________
	Protection of food	Is the food Covered? - During cooking (Y/N)__________ - After cooking (Y/N)____________ - During keeping (Y/N)___________
	Source of water supply	Bore hole____________________ Protected shallow well________________ Unprotected well______________ Other (Name)_______________________
	Water storage	Covered? (Y/N)_______________ Clean utensils used? (Y/N)_________
	Any child with diarrhoea past two days?	Yes__________ No___________

Other observations:

List other observations and behaviours that you think are unhygienic and how they can be prevented.

APPENDIX 4: LETTERS OF APPROVAL

Tel (O): (265) 1 755 522
Fax (O): (265) 1 750 384

UNITY AND FREEDOM

DIRECTOR OF AGRICULTURAL EXTENSION SERVICES
P.O BOX 30145
LILONGWE 3
MALAWI

REF. NO. DAES 13/3/1

23rd June, 2015.

Mr Numeri C. Geresomo (Research Student)
Lilongwe University of Agriculture and
Natural Resources (LUANAR)
P.O. Box 219
Lilongwe.

Dear Sir,

APPROVAL TO CONDUCT RESEARCH AMONG SMALLHOLDER FARMERS IN MAYANI EPA IN DEDZA DISTRICT

Thanks for your letter of 2nd April, 2015, requesting for consent to conduct research among smallholder farmers, in Mayani Extension Planning Areas (EPA).

The Ministry of Agriculture, Irrigation and Water Development as one of the Ministries implementing nutrition activities in the country has no objection to the study being proposed. The Ministry will stand to benefit from the outcome of the study in its work of improving the nutritional status of farming households through food based approaches.

May we request that the results of the study be shared with the Ministry

Yours sincerely,

S. Kankwamba

DIRECRTOR FOR AGRICULTURAL EXTENSION SERVICES

Telephone: + 265 789 400
Facsimile: + 265 789 431
e-mail mohdoccentre@gmail.com
All Communications should be addressed to:
The Secretary for Health

In reply please quote No. MED/4/36c

MINISTRY OF HEALTH
P.O. BOX 30377
LILONGWE 3
MALAWI

20th May 2015

Numeri Chalumpha Geresomo
Egerton University

Dear Sir/Madam,

RE: Protocol # 15/4/1432: Effects of aflatoxin contamination mitigation practices in complementary food processing on nutritional status of children in Dowa district

Thank you for the above titled proposal that you submitted to the National Health Sciences Research Committee (NHSRC) for review. Please be advised that the NHSRC has **reviewed** and **<u>approved</u>** your application to conduct the above titled study.

- **APPROVAL NUMBER** : **NHSRC # 15/4/1432**
  The above details should be used on all correspondence, consent forms and documents as appropriate.
- **APPROVAL DATE** : **20/05/2015**
- **EXPIRATION DATE** :This approval expires **on 20/05/2016**
  After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the NHSRC secretariat should be submitted one month before the expiration date for continuing review.
- **SERIOUS ADVERSE EVENT REPORTING** :All serious problems having to do with subject safety must be reported to the National Health Sciences Research Committee within 10 working days using standard forms obtainable from the NHSRC Secretariat.
- **MODIFICATIONS**: Prior NHSRC approval using standard forms obtainable from the NHSRC Secretariat is required before implementing any changes in the Protocol (including changes in the consent documents). You may not use any other consent documents besides those approved by the NHSRC.
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the NHSRC using standard forms obtainable from the NHSRC Secretariat.
- **QUESTIONS**: Please contact the NHSRC on Telephone No. (01) 724418, 0888344443 or by e-mail on mohdoccentre@gmail.com
- **Other:**
  Please be reminded to send in copies of your final research results for our records as well as for the Health Research Database.

Kind regards from the NHSRC Secretariat.

SECRETARY FOR HEALTH
2015 -05- 2 0
P.O. BOX 30377,
CITY, LILONGWE 3

……………………………………………

<u>FOR CHAIRMAN, NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE</u>

PROMOTING THE ETHICAL CONDUCT OF RESEARCH
Executive Committee: *Dr.B. Chilima (Chairman), Prof. E. Molynuex (Vice Chairperson)*
Registered with the USA Office for Human Research Protections (OHRP) as an International IRB
(IRB Number IRB00003905 FWA00005976)

BUNDA COLLEGE CAMPUS
P. O. Box 219, Lilongwe, MALAWI
Tel: (265) 01 277 222/260
Fax: (265) 01 277 364
Email: ngeresomo@bunda.luanar.mw

10 June, 2015

NHSC Secretariat
P.O. Box 30377
Lilongwe 3

Dear Sir,

APPLICATION FOR APPROVAL OF MODIFICATION OF PhD RESEARCH SITE-PROTOCOL NUMBER: NHSRC # 15/4/1432

I would like to apply for approval of change of research site for the Nutrition Research to be conducted in Mayani EPA in Dedza district instead of Chibvala EPA in Dowa district as approved under Approval Number NHSRC # 15/4/1432 on 20th May, 2015.

I am a lecturer in Human Nutrition at Lilongwe University of Agriculture and Natural Resources (LUANAR) at Bunda Campus and I am planning to conduct a nutrition research Dedza district in fulfillment of the requirements for the award of the degree of Doctor of Philosophy (PhD) at Egerton University in Kenya. The research will involve collecting data on household food security, household food consumption, child feeding practices and access to health services. The survey will also assess the nutritional status of children under three years of age. Anthropometric measurements such as weight and height/length will be collected. Food samples will also be collected and analysed for aflatoxin presence. The research will not collect any biological samples from the study populations.

I am seeking your consideration to approve the change of the research site for the following reasons:

1. The Sponsors of my scholarship, Lilongwe University of Agriculture and Natural Resources are implementing a Climate Change Project in Dedza district and would like my research work to be part of the outputs of the Climate change project. It is therefore the sponsor's conditionality for offering the scholarship.

2. The change in research site will not require any modification of the protocols to be used in the research because Dedza and Dowa districts fall within the same Lilongwe-Kasungu Plain Livelihood Zone, prevalence of stunting in Dowa district (51.6%) is not different from that of Dedza district (51.1%). Your consideration will be highly appreciated.

Your consideration will be greatly appreciated.

Numeri C. Geresomo
Research Student

Telephone: + 265 789 400
Facsimile: + 265 789 431
e-mail mohdoccentre@gmail.com
All Communications should be addressed to:
The Secretary for Health

In reply please quote No. MED/4/36c
MINISTRY OF HEALTH
P.O. BOX 30377
LILONGWE 3
MALAWI

6th June 2016

Numeri Chalumpha Geresomo
Egerton University

Dear Sir/Madam,

RE: Protocol # 15/4/1432: Effects of aflatoxin contamination mitigation practices in complementary food processing on nutritional status of children in Dowa district

Thank you for the above titled proposal that you submitted to the National Health Sciences Research Committee (NHSRC) for review. Please be advised that the NHSRC has **reviewed** and **approved** your application for **continuation** to conduct the above titled study.

- **APPROVAL NUMBER** : **NHSRC # 15/4/1432**
  The above details should be used on all correspondence, consent forms and documents as appropriate.
- **APPROVAL DATE** : **06/06/2016**
- **EXPIRATION DATE** :This approval expires **on 06/06/2017**
  After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the NHSRC secretariat should be submitted one month before the expiration date for continuing review.
- **SERIOUS ADVERSE EVENT REPORTING** :All serious problems having to do with subject safety must be reported to the National Health Sciences Research Committee within 10 working days using standard forms obtainable from the NHSRC Secretariat.
- **MODIFICATIONS**: Prior NHSRC approval using standard forms obtainable from the NHSRC Secretariat is required before implementing any changes in the Protocol (including changes in the consent documents). You may not use any other consent documents besides those approved by the NHSRC.
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the NHSRC using standard forms obtainable from the NHSRC Secretariat.
- **QUESTIONS:** Please contact the NHSRC on Telephone No. (01) 724418, 0888344443 or by e-mail on mohdoccentre@gmail.com
- **Other:**
  Please be reminded to send in copies of your final research results for our records as well as for the Health Research Database.

Kind regards from the NHSRC Secretariat.

SECRETARY FOR HEALTH
2016 -06- 06

Rage Majamanda
FOR:CHAIRMAN, NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE

PROMOTING THE ETHICAL CONDUCT OF RESEARCH
Executive Committee: *Dr.B. Chilima (Chairman), Dr B. Ngwira (Vice Chairperson)*
Registered with the USA Office for Human Research Protections (OHRP) as an International IRB
(IRB Number IRB00003905 FWA00005976)

EGERTON UNIVERSITY

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www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

CERTIFICATE OF MASTERS AND DOCTORATE RESEARCH PROPOSAL CORRECTIONS

TO BE FILLED IN QUADRUPLICATE

1. Students Full Name: Numeri Chalumpha Geresomo Telephone No. +265999335199
   Reg. No. HD18/0432/14 Degree PhD Year of Reg. 2014
   Department: Human Nutrition Faculty: Health Sciences

2. **Research proposal**
   Title: Effects of Aflatoxin Contamination Mitigation Practises in Complementary Food Processing on Nutritional Status of Children in Dedza District.
   Sponsor: Lilongwe University of Agriculture and Natural Resources (CABMACC scholarship)
   Candidates Signature: Numeri Chalumpha Date: 11/02/16

3. **TO BE FILLED BY CHAIRMAN OF DEPARTMENT POSTGRADUATE COMMITTEE**

   I confirm/do not confirm on behalf of the Department that the corrections/amendments have to the best of my/our knowledge been effected.
   Name: Dr. Elizabeth Kamau Mbuthia
   Signed: [signature] Date: 11/02/16

   EGERTON UNIVERSITY
   11 FEB 2016
   CHAIRMAN
   HUMAN NUTRITION DEPARTMENT

4. **TO BE FILLED BY THE CHAIRMAN FACULTY POSTGRADUATE COMMITTEE**

   I certify that the above candidate has incorporated the corrections recommended by the Faculty. I therefore recommend/do not recommend that the proposal be now forwarded to Graduate school.
   Name: DR RAYMOND HAMM
   Signed: [signature] Date: 12/02/16

   EGERTON UNIVERSITY
   P.O. BOX 536, EGERTON
   12 FEB 2016
   FACULTY OF HEALTH SCIENCES

Transforming Lives Through Quality Education
Egerton University is ISO 9001:2008 Certified

BOARD OF GRADUATE SCHOOL
EGERTON UNIVERSITY NJORO
DATE RECEIVED 12.2.16

5. **TO BE FILLED BY GRADUATE SCHOOL**

I confirm that I have received/not received the following:

Minutes of Faculty Postgraduate committee/Board ☐ Certificate of correction ☐

Proposal forwarding form ☐ Proposal ☐

Name: Amkata

Signed: [signature] Date: 23/2/16

c.c. Candidate
Chair, Department Postgraduate Committee
Chair, Faculty Postgraduate Committee
Director, Board of Postgraduate Studies

EGERTON **UNIVERSITY**

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Email: bpgs@egerton.ac.ke
www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref:...HD18/0432/14 **Date:.......8th.April.2016.......**

Mr. Numeri Chalumpha Geresomo
Dept. of Nutritional Sciences
Egerton University
P. O. Box 536
EGERTON

Dear Mr. Geresomo

RE: CORRECTED PROPOSAL

This is to acknowledge receipt of two copies of your corrected proposal, entitled **"Effects of Aflatoxin Contamination Mitigation Practices in Complementary Food Processing on Nutritional Status of Children in Dedza District."**

You are now at liberty to commence your fieldwork. However note the following:

1. You must register each semester
2. Pay your fees every semester
3. Submit progress reports every four (4) months (Masters) or six (6) months (PHDs). Without this, your thesis/project will not be accepted. Forms are available at the Board
4. You are expected to publish one (1) paper (Masters) or two (2) papers (PhD) in peer-reviewed journal and present them before issuance of "Intent to submit Thesis/Project" forms by the board

Thank you.

Yours sincerely,

DIRECTOR, BOARD OF POSTGRADUATE STUDIES, EGERTON UNIVERSITY P.O. Box 536, EGERTON
11 APR 2016

Prof. Michael A. Okiror
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

c.c. Supervisors
COD, Nutritional Sciences
Dean, Health Sciences

MAO/vk

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Egerton University is ISO 9001:2008 Certified

APPENDIX 5: PAPERS WRITTEN AND PUBLISHED

1. Geresomo, N.C, Mbuthia, K.E., Matofari, J.W., and Mwangwela, A.M. (2017). Child Feeding Practices and Factors (Risks) Associated with Provision of Complementary Foods Among Mothers of Children Age 6–23 Months in Dedza District of Central Malawi. *Journal of Nutrition Ecology and Food Research, 4, 14–21*

2. Geresomo, N.C., Mbuthia, E.K., Matofari, J.W., and Mwangwela, A.M. (2017). Risk Factors
Associated with Stunting among Infants and Young children aged 6 - 23 months in Dedza District of Central Malawi. *African Journal of Food Agriculture Nutrition and Development, (4):12854-12870, DOI:10.18697/ajfand.80.16730*

3. *Geresomo,* N.C., Mbuthia, K.E., Matofari, J.W. and Mwangwela, A.M. (2017).
Targeted Training Intervention increased Adoption of Recommended Hygiene Practices among Caregivers during Food preparation and Complementary Feeding in Dedza District of Central Region of Malawi. Ecology of Food and Nutrition (57), Issue 4, Pages 301-313 published online: 20 Jul 2018