SAFETY AND QUALITY OF COMMERCIAL CEREAL-BASED COMPLEMENTARY FOODS PRODUCED AND MARKETED IN MWANZA REGION

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EXTENDED ABSTRACT

Commercial cereal-based complementary foods (CBCF) for infant porridge are increasingly produced and sold in developing countries including Tanzania. A cross-sectional study was conducted to determine the safety and quality of commercial cereal-based complementary foods produced and marketed in Mwanza region. Twenty differently formulated cereal-based complementary food products (CBCFs) from 20 processors were purchased from supermarkets and retail shops in Mwanza region. Proximate composition, mineral contents (Ca, Fe and Zn), anti-nutrients (tannins and trypsin inhibitors) and microbiological counts (total coliforms and *Salmonella spp*) were determined. Assessment of commercial CBCF processors on the food safety knowledge and good hygiene practices was also done using structured questionnaire. Processors had moderate knowledge on food safety and hygienic practices but low capital and poor processing technology used renders them fail to implement their knowledge into practices. The sampled CBCFs were found to be mainly prepared from finger millet, rice, popcorns, peanuts, soy beans, undehulled wheat, white sorghum, sesame seed, pearl millet and cardamon.Proximate composition of the CBCFs wasmoisture: 7.55-11.06%, ash:1.97 - 4.82%,crude protein:6.88 - 15.12%, crude fat:2.67 - 9.68%, crude fibre:2.82 - 8.31%, total carbohydrates: 54.43 - 73.04%, energy: 306.06 - 381.24 kcal/100g.Mineral contents (in mg/100g) in commercial CBCFs were: calcium: 59.56 - 145.45, iron: 1.07 - 5.05, zinc: 1.04 - 3.31. Tannins ranged from 0.19 - 3.12% and the *in vitro* trypsin inhibitors (TIs) concentrations ranged from 2.76to 9.91mg/g. Total coliform counts in the samples ranged from zero to 2.5×10^{1}cfu/g. Eleven CBCFs (55%) had total coliforms countsbelow 10cfu/g hence conformed to TZS 180:2013 and CODEX standards (2006). *Salmonella* was not detected in samples making all samples conform to TZS 180:2013 and CODEX Standard (2006) respectively.Majority of CBCFs had low content of protein, fat, energy iron, zinc and calcium. Also, they had

moisture, dietary fibre, anti-nutrients (Tannins and Trypsin Inhibitors) and coliforms higher than the recommended limits as required by TZS 180:2013and CODEX standards (2006).Therefore, there is a need to improve training on proper formulation (proportions) and CBCF processing so as to improve levels of deficient nutrients. The government authorities should take effective control and monitoringof processors so as to make sure that all CBCFs are properly formulated, processed and comply with national and/or international standards.

DECLARATION

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

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DEDICATION

This work is dedicated to My father Joseph Masunzu, My mother Mrs Juliana J. Masunzu, My wife Esther Reuben and My first son Moses N. Masunzu who have always been my source of inspiration, and to my friends and relatives whose support and perseverance enabled me to conduct and complete this study.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANFs	Antinutritional factors
AOAC	Association of Official Analytical Chemists
CAC	Codex Alimentarius Commission
CBCFs	Cereal Based Complementary Foods
cfu/g	colony forming unit per gram
DFTNCS	Department of Food Technology Nutrition and Consumer Sciences
EAS	East African Standards
FAO	Food and Agriculture Organisation
Freq	Frequency
g	gram
GAP	Good Agricultural Practices
GHP	Good Hygienic Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Points
IDA	Iron Deficiency Anaemia
Max	Maximum
Min	Minimum
MJNUAT	Mwalimu Julius Nyerere University of Agriculture and Technology
ml	mililitres
NBS	National Bureau of Statistics
PDCAAS	Protein Digestibility Corrected Amino Acid Score
PEM	Protein Energy Malnutrition
QA	Quality Assurance
SD	Standard deviation

SIDO	Small Industries Development Organisation
SUA	Sokoine University of Agriculture
TBS	Tanzania Bureau of Standards
TDH-MIS	Tanzania Demographic Health and Malaria Indicators Survey
TFDA	Tanzania Foods and Drugs Authority
TFDC	Tanzania Food, Drugs and Cosmetics
TFDCA	Tanzania Food, Drugs and Cosmetics Act
TI	Trypsin Inhibitor
TIA	Trypsin Inhibitor Activity
TZS	Tanzania Standards
UNICEF	United Nations Children's Emergency Fund
UNIDO	United Nations Industries Development Organisation
WHO	World Health Organisation
WMA	Weight and Measure Agency
%	per cent

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

WHO and UNICEF's global recommendations for optimal infant feeding as set out in the global strategy are exclusive breastfeeding for 6 months (180 days) and nutritionally adequate and safe complementary feeding starting from the age of 6 months with continued breastfeeding up to 2 years of age or beyond. It is therefore recommended that, breastfeeding on demand continues with adequate complementary feeding up to 2 years or beyond (WHO, 2009).

Complementary foods prepared at home, health post, community centre or at industrial level should be safe, that is, should not exceed maximum allowable levels of microorganisms and anti-nutrients, and provide adequate essential nutrients such as; energy, protein, iron, zinc, calcium, and vitamin A, B and C, which are necessary for child's growth, body immunity and preventing malnutrition of the 6 months to 2 years old children (Mamiro*et al*., 2004; Mosha*et al*., 2000; WHO, 2009; TFDA, 2013).

1.2 Production of Cereal–based Complementary Foods

Commercial cereal–based complementary foods (CBCFs) are available in our local markets, retail shops and supermarkets. They are usually prepared from local staples by small scale food processors using simple processing techniques (Mosha*et al*., 2000; Laswai*et al*., 2009). Staple foods such as cereal, root or tuber and major protein source usually a legume or oilseed, are processed into flour then stored for variable lengths of time prior to cooking of prepared complementary flour (Laswai*et al*., 2009; Anigo*et al*., 2010; Magnani*et al*., 2012). Preparation of dry flours or powders from staple foods is done through a sequence of processes, which may vary according to the level of technological sophistication. This sequence involves cleaning and physical separation of inedible or undesirable parts of the raw foods; washing, possibly precooking, drying, size reduction (milling) and packaging (Laswai*et al.*, 2009; Magnani*et al.*, 2012). The production of commercial complementary foods provides a complementary food option for families such as; preparation of children's meals would take less time, and meals would be safe and nutritious (Magnani*et al.*, 2012).

1.3 Problem Statement and Justification

Tanzania Demographic Health and Malaria Indicators Survey (TDH-MIS) done by National Bureau of Statistics (2016) reported that, among East African countries, Tanzania has severe stunting prevalence of 34% higher than Uganda (33%) and Kenya (26%). Also, NBS (2016) reported that Tanzania has prevalence levels of 14% and 5% of underweight and wasted children of under 5 years of age, respectively. In Mwanza region, prevalence for stunting has increased from 34.2% in 2014/15 to 39% in 2015/16 whereby the prevalence for underweight was 14.1%. The level of stunting prevalence in Mwanza was higher than other cities such as Mbeya (38%), Arusha (36%) and Dar es Salaam (15%) (NBS, 2016).

Globally, WHO (2009) estimated that, each year more than 1.5 billion episodes of diarrhoea occur in children less than five years of age in developing countries, resulting in over three millions deaths, more than half of these infections may be transmitted through contaminated food. In Tanzania, the National Bureau of Statistics (2016) reported that, in the 2 weeks before the TDH-MIS, 12% of children under 5 had diarrhoea whereby among these children and only 43% were taken to a health facility or provider for advice or treatment. This could be due to consumption of unsafe complementary foods and/or drinking of non-potable water.

Due to population growth and increased rural to urban migration, there has been a significant shift from home-based complementary food preparations to commercial processing. This shift has resulted into increased availability of complementary food formulations in the Tanzania market. The main objective of complementary food formulations is to improve the protein and micronutrient contents (Mosha*et al*., 2000; Laswai*et al*., 2009).

However due to poor formulation and preparation, many of these foods are poor in protein and micronutrient contents and safety of these foods is questionable. That means, the food products from small-scale processors may contain; unacceptable levels of microbial loads and anti-nutritional factors; high dietary bulk, high concentration of fiber and starches; low contents of protein, vitamins (such as vitamin B) and minerals (such as iron, calcium, zinc and phosphorus) (Laswai*et al*., 2009; MuhimbulaandIssa-Zacharia, 2010).

This is because most of the processors use low quality ingredients due to high cost of raw materials and low price of their products they get in the market, as well as long storage because of slow market take-off of these products. Another factor is availability and reliable supply of portable water, which is very important for hygienic food processing. As a result, these complementary foods are processed and stored under unhygienic conditions. Also, due to inaccessibility of capital, most processors do not afford to establish properly designed places solely meant for food processing. Thus, majority of processors are not registered by the recognized authorities such as Small-scale Industries Development Organization (SIDO), Tanzania Bureau of Standards (TBS) and Tanzania Food and Drug

Authority (TFDA). This may be due to lack of awareness, technical and financial constraints (SIDO and UNIDO, 2008; Confederation of Tanzania Industries, 2013; TFDA, 2013). Hence, the processors are not aware of the regulatory standards for cereal-based weaning foods, and precautions to take on risk foods including infant foods during processing, transport and storage (TFDA, 2013).

Therefore, there is a need for an in-depth study of these complementary foods to evaluate their safety and quality with the objective of protecting consumers (young children) and consequently promoting good health especially of the infants and young children and do fair trade.

The results of this study will provide information on the status of safety and qualities of commercial CBCFs produced and marketed in Mwanza, which could be used as an alert to customers or caregivers and guide the responsible authorities to set up strategies for their control, interventions or improvements for the betterment of the society.

1.4 Objectives

1.4.1 Overall objectives

To assess the chemical and microbiological quality of commercial CBCFs produced and marketed in Mwanza region.

1.4.2 Specific objectives

i. To study the handling practices along commercial CBCF processing chain in order to propose measures for improvement.
ii. To determine the nutritional composition of the commercial cereal-based complementary foods (CBCFs).

iii. To determine the anti-nutrients levels of the commercial cereal-based complementary foods (CBCF) produced by small-scale food processors as per Tanzania infant foods.

iv. To determine the microbiological quality of the commercial cereal-based complementary foods (CBCFs).

1.5List of Manuscripts

i. Food safety knowledge and handling practices of cereal-based complementary food producers and microbiological quality of their products.

ii. Nutrients and anti-nutrients content of the commercial cereal-based complementary foods produced and marketed in Mwanza region.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Complementary foods refers to cereal based food or any other food suitable, or represented as suitable, as an addition to breast-milk, or follow-up formula for infants from the age of six completed months or for young children up to the age of five years (TFDA, 2013).

Cereal-based complementary foods of Tanzania and other developing countries are based on starchy staples, usually cereals such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), finger millet (*Eleusinecoracona*) and rice (*Oryzasativa*) or non-cereals such as cassava (*Manihotesculenta*), round potato (*Solanumtuberosum*), sweet potato (*Ipomoea batatas*), yams (*Dioscoreaspp*) and plantains (*Musa para-disiacasapientum*). Nutritional problems associated with the use of these starch staples in complementary foods have been widely reported (Mosha*et al*., 2000; WHO, 2009; Magnani*et al.*, 2012).

According to NBS (2010), about 50% of young children in Tanzania suffer from protein-energy under nutrition (PEU) while more than 45% of children under the age of five suffer from various micronutrient deficiency disorders. The immediate cause of these conditions is inadequate intake and poor utilization of nutrients, which begins in the complementary feeding period and amplifies in the subsequent years.Therefore, it is important to ensure safety and quality of complementary foods (Laswai*et al*., 2009; WHO, 2009).

2.2 Safety of Cereal-based Complementary Foods (CBCFs)

The safety of complementary foods can be defined as the certainty that they will not cause harm to infants and children when prepared and fed as recommended. More specifically, food safety can be thought of as the set of conditions and practices during the production, processing, storage, distribution, preparation and secondary (domiciliary) storage of complementary foods that are necessary to protect them from pathogenic microorganisms, exogenous chemical contaminants, naturally occurring toxic substances and newly formed toxic compounds produced during food storage, processing, or preparation (WHO, 2009).

2.2.1 Biological contamination of cereal-based complementary foods (CBCFs)

Food safety can be compromised by bacteria, moulds, viruses and parasites contamination which can cause food-borne infectious diseases. Diarrhoeal diseases are the major food-borne infections, although enteric fevers, brucellosis, poliomyelitis, helminthic infections and other disease are also of concern. Pathogens associated with diarrhoea in hospitalized children in developing countries are *Rotavirus, Escherichia Coli (Enterotoxigenic and enteropathogenic), Shigella, Campylobacter jejuni, Vibrio cholera and Salmonella (non typhi)* (Anigo*et al.*, 2010; WHO, 2009).

Sources of microbial contamination include polluted water, dust, flies, domestic animals, dirty processing and storage equipment as well as food handlers. Raw foods themselves may harbour pathogens or these may be introduced during processing, preparation, feeding, or secondary storage. Contamination during storage is a function of time and temperature, which may allow survival and/or proliferation of microorganisms if storage conditions are sub-optimal (WHO, 2009; Kimanya*et al.*, 2010).

Microbial contamination of complementary foods can be prevented by effective sorting, cleaning and storing raw materials and other non-perishable items in a safe place (e.g. labelled, clean, closed containers); using safe water for washing raw materials, processing equipment, and frequent washing of hands; keeping food preparation surfaces meticulously clean; avoiding contact between raw and finished products; protecting finished foods from dirty utensils, hands, insects and domestic animals; using clean feeding utensils; personnel hygienic practices should be implemented; the food processing facility should be clean, free from pests; with proper waste management (WHO, 2009).

2.2.2 Chemicals contaminants in cereal-based complementary foods (CBCFs)

Undesirable chemical substances may be introduced into the food supply as a result of environmental contamination. Mycotoxins, the toxic secondary metabolites of certain fungi (moulds) may cause acute intoxication and longer-term mutagenic, carcinogenic and teratogenic effects. Mycotoxin such as aflatoxins and fumonisins are found in oilseeds (e.g. groundnuts), cereals, tree nuts and some fruits under conditions of high ambient temperature and humidity (Kimanya*et al.,* 2010). Compliance with good agricultural/manufacturing (GAP/GMP) practices is of utmost importance in controlling post-harvest growth of moulds that can produce mycotoxins but as well prevent other chemical contaminants such as pesticide residues and endogenous anti-nutritional factors in processed food (Ikujenlola*et al.*, 2015).

CBCFs for infant and young children should contain no or allowable levels of pesticides residues.The maximum pesticide residue limit for baby food is 0.01 mg/Kg (EC, 2003; Oppong-Otoo, 2014).High levels of pesticide residues in food results into serious concerns of possible carcinogenicity for infants and young children.Pesticides are categorised asorganophosphorous (e.g. methamidophos), organochlorine (e.g. lindane) andsynthetic pyrethroid pesticides (e.g. permethrin) (Oppong-Otoo, 2014).

CODEX (2006) recommends that, CBCFs shall be prepared with special care under good manufacturing practices, so that pesticides residues which may be required in the production, storage or processing of the raw materials or the finished food ingredient do not remain, or, if technically unavoidable, are reduced to the maximum extent possible.These measures shall take into account the specific nature of the products concerned and the specific population group for which they are intended. Also, CBCFs should be free from residues of hormones, antibiotics as determined by means of agreed methods of analysis and practically free from other contaminants, especially pharmacologically active substances (EC, 2003; Akoto, *et al*., 2013).

2.3 Quality of Cereal-based Complementary Foods (CBCFs)

Beyond the aforementioned concerns regarding food safety, the quality of food can be assessed in terms of its nutritional value, nutrient bioavailability, functional and organoleptic properties and ease of preparation. In each case, food-processing techniques may influence these aspects of food quality (Laswai*et al*., 2009; Chen *et al.*, 2013).

2.3.1 Nutritional value of cereal-based complementary foods

The nutritional value of foods depends on their nutrient content and the bioavailability of these nutrients. The bioavailability of nutrients can be defined as their potential for release and absorption during the digestive processes and their effective metabolic use. Bioavailability depends on; the food processing techniques applied (e.g. thermal treatment); the presence of anti-nutritional factors (e.g. phytates, enzyme inhibitors); the health of the child, particularly the presence of enteric infections may further affect nutrient bioavailability (Laswai*et al*., 2009; Chen *et al.*, 2013).

2.3.2 Anti-nutritional factors in cereal-based complementary foods

Anti-nutritional factors in foods are those food components that interfere with the digestion, absorption or some other aspect of metabolism of a nutrient(s) contained in foods while others such as cyanogens are carcinogenic (Chen *et al.*, 2013). Anti-nutritional factors represent a considerable number of different chemical compounds having a wide range of metabolic effects. Some of these factors such as enzyme inhibitors, phytates, lectins and allergenic factors such as enzymes are quite common while others may be specific to just a few plant species such as cyanogens in cassava, gossypol in cotton seed and favism factors in broad beans and other legumes (Mamiro*et al*., 2004; Laswai*et al*., 2009; Chen *et al*., 2013).

2.3.3 Importance of malting and fermentation on safety and quality of cereal-based complementary foods

High dietary bulk and high viscosity are factors which affect the quantity of food a child could consume per meal; this invariably affects the quality of the nutrients available to the children (Laswai*et al*., 2009). The traditional complementary foods are associated with high viscosity which causes choking and suffocation of infant during feeding. This condition causes the child caregivers to dilute the gruel/porridge to make it less viscous hence lowering its nutrient density (Mosha*et al*., 2000; Laswai*et al*., 2009). The complementary food that will support growth and maintain good healthy living must contain adequate nutrients and be of low viscosity (Oluwamukomi*et al*., 2003). The problem of high dietary bulk of the gruels and high content of anti-nutrients in cereal-based complementary foods could be solved using malting process (i.e. soaking, germination then drying), grinding, cooking and fermentation or other processes such as extrusion (Laswai*et al*., 2009). Malting could improve the nutrient availability as well as reduce anti-nutritional factors that may affect the utilization of their nutrients and the health of the consumers (Oluwamukomi*et al*., 2003).Despite of this importance, malting and fermentation of cereals is rarely done or not done at all by small-scale food processors (Anigo*et al*., 2010).

2.4 Requirements for CBCFs and Processors

2.4.1 Tanzania Food and Drugs Authority: Acts, regulations and guidelines

Standards, Acts, regulations and guidelines have been developed for use by those who may wish to engage in importation or manufacture of pre-packaged food for sale in Tanzania. According to Tanzania Food, Drugs and Cosmetics Act of 2003 section 18-(1) says “No person shall manufacture for sale, sell, supply or store products regulated under this Act except in premises registered under this section for that purpose”. Also, section 22-(41) of the Act says “Notwithstanding the provisions of this Act or any other written laws, no person shall, on or after the appointed day, manufacture for sale, sell, offer, supply or import any product regulated under this Act unless (a) the product is registered in accordance with the provisions of this Act; (b) the person holds the appropriate licence or permit required and issued by the Authority”.

Tanzania Food, Drugs and Cosmetics (Marketing of Foods and Designated Products for Infants and Young Children) Regulations (2013) number 15 says “General, safety, quality and essential composition requirements for infant formula, follow up formula, formula for special medical purposes intended for infants and complementary food shall be in accordance with national standard or in case there is no national standard, international standard”. Also TFDC regulation number 18 says “Any person shall not manufacture, import, distribute, sell, or expose for sell any breast-milk substitute or complementary food unless the product has been registered with the Authority and the person is in possession of a permit issued by the Authority”.

Requirements for labelling of pre-packaged foods are provided in regulations number 17 of Tanzania Food, Drugs and Cosmetics (Marketing of Foods and Designated Products for Infants and Young Children) Regulations of 2013.

2.4.2 Standards for Processed cereal-based foods for infants and young children- Specifications

TZS 180: 2013 is a Tanzania standard for processed cereal-based foods for infants and young children set by Tanzania Bureau of Standards. This standard was adopted from East African Standards prepared by the Technical Committee responsible for nutrition and foods for special dietary uses. The Committee is composed of representatives fromnational standards bodies, regulators, academia, the private sector and consumer organizations in partner states. This standard is based on codex standard (CODEX, 2006).It is an international standard for processed cereal-based foods for infants and young children.

The TZS 180:2013 shows specifications for nutrients, anti-nutrients and microbiological limits for processed cereal-based foods for infants and young children (Appendix 1).

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CHAPTER THREE

3.0 FOOD SAFETY KNOWLEDGE AND HYGIENIC PRACTICES OF COMMERCIAL CEREAL-BASED COMPLEMENTARY FOOD PROCESSORS AND THE MICROBIOLOGICAL QUALITY OF THEIR PRODUCTS.

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3.1 Abstract

A cross section study was used to assess food safety knowledge and hygienic practices of 20 commercial cereal-based complementary food (CBCF) processors in Mwanza region, whereby semi-structured questionnaire and direct observation were used as tools for primary data collection. Also CBCFs from these processors purchased from retail and supermarkets were used for detection and enumeration of total coliforms and *Salmonella* and the results were compared with the TZS 180:2013.

The results showed that all CBCF processors were registered by SIDO and they were trained on food formulation, food safety and hygienic practices by SIDO and other trainings they attended. Lack of capital and technical support were major challenges which cause them fail or partially implement their knowledge during their food processing for safe and quality products. Also,high charges for premises and product registration and business licensing were major constraints for them to comply with TFDA Act of 2003.

20 commercial CBCFs purchased from supermarkets and retail shops in Mwanza city were analysed for Coliforms and *Salmonella* contamination at SUA DFTNCS laboratories. Total coliforms in the CBCFs ranged from zero to 2.5×10^{1}cfu/g. Eleven CBCFs (55%) had total coliforms counts less than 10cfu/g hence conformed to TZS 180:2013.*Salmonellaspp*were not detected in all samples hence all CBCF samples complied withTZS 180:2103 and CODEX Standards (2006).

All food processors should be time-to-time trained on hygiene practices and food safety. Also, government and other stakeholders should help the processors to address their challenges includingprovision of modern food grade processing equipments so as to ensure production of safe and quality cereal-based complementary foods for infants and young children.

3.2 Introduction

3.2.1 Knowledge of processors on commercial cereal-based complementary food (CBCF) processing.

Commercial cereal-based complementary foods (CBCFs) for infant porridge are increasingly produced and sold in developing countries including Tanzania to complement continued breastfeeding. Little has been done to analyse the knowledge and technical knowhow of commercial cereal-based complementary food processors as well as the nutrient contents of their products (Joosje*et al.,* 1997).

It is essential that the knowledge and technical knowhow for formulating the foods in proportions that would meet the daily requirements of the infants and young children should be adequate (WHO, 2006). The commercial CBCF processors and their workers should be well skilled in complementary food formulation. Knowledge of effective procedures gained to integrate technology, quality and hygiene in foods into development actions and publications including technical guidelines, information on specific products, their properties and nutritional value, and an overall synthesis will enhance the production and productivity through the use of better raw materials and improved processing practices (Aworh, 2008).

Training should be imparted on various aspects such as quality food production, improved food production technologies, product packaging and marketing. Awareness about the importance of the improved technologies including high yielding of food quality and better processing practices has to be brought about through organizing field demonstrations and exhibitions (Krešića*et al.,* 2008).

Demonstration on processing, value addition and product development will help the processors, workers, communities, entrepreneurs and members of self-help groups (children) in understanding the important role of complementary foods and the role they can play in enhancing income, nutrition security and sustaining the livelihood of poor people(Krešića*et al.,* 2008). Training and skill development to small-scale complementary food processors, awareness generation on the nutritional value of the complementary foods to children care and general public and capacity building in different aspects of food production, processing, utilization, marketing and allied aspects is very important to strengthen its operational software (Kumara and Popat, 2010).

3.2.2 Microbiological quality of commercial cereal-based complementary food processing

Microorganisms that contaminate cereal grains may be from air, soil, water, insects, rodents, birds, animals, humans, storage and shipping containers as well as handling and processing equipment (WHO, 2008). Many factors that are part of the environment influence microbial contamination of cereals includes; rainfall, drought, humidity, temperature, sunlight, frost, soil conditions, wind, insect, bird and rodent activity, harvesting equipment, storage, handling and moisture control (Bullerman and Bianchini, 2010; Muhimbula and Issa-Zacharia, 2010).

Microflora of cereals and cereal products varies from molds, yeasts, bacteria (psychrotrophic, mesophilic and thermophilic/thermoduric), lactic acid bacteria, rope-forming bacteria (*Bacillus spp*), pathogenic bacteria, coliforms and enterococci. Pathogenic bacteria that contaminate cereal grains and cereal products and cause problems include *Bacillus cereus, Clostridium botulinum, Clostridium perfringens, Escherichia coli, Salmonella*and *Staphylococcus aureus.* Coliforms and Enterococci also occur as indicators of unsanitary handling and processing conditions and possibly faecal contamination (WHO, 2008; Bullerman and Bianchini, 2010).

Total coliforms refer to a large group of gram-negative, rod-shaped bacteria that share several characteristics. The group includes thermotolerant coliforms and bacteria of faecal origin, as well as some bacteria that may be isolated from environmental sources(WHO, 2008).

Microbial contamination leading to infections and poor nutrient associated with complementary foods may contribute significantly to deaths of many infants and children aged less than five years worldwide each year. This issue is increasingly becoming important in national and international debates about agriculture, nutrition and health (WHO, 2006 and 2008). Based on literature, complementary foods prepared under unhygienic conditions are frequently heavily contaminated with pathogens and may thus be a major factor in causing diarrhoea diseases and associated malnutrition (Oluwafemi and Ibeh, 2011).

Education of small-scale food processors in food safety principles, particularly complementary food processing must be of high priority so as to prevent food borne diseases such as diarrhoea. Educational programmes based on the hazard analysis critical control point (HACCP) approach, taking into account sociocultural factors, should be integrated into all national infant-feeding or food and nutrition programmes (WHO, 2006; Oluwafemi and Ibeh, 2011).

3.3 Materials and Methods

3.3.1 Study area

This study was conducted in Mwanza region covering two municipalities namely Ilemela and Nyamagana.

3.3.2 Selection of commercial CBCF processors and data collections

Selection of processors was according to the list provided by SIDO offices in Mwanza whereby 20processors were registered as commercial cereal-based complementary foods (CBCF) processors. All of processors weresmall and medium scale- food processors.
Semi structured questionnaire and direct observation were used as tools for primary data collection based on food safety knowledge and hygienic practices from 20 commercial CBCF processors (Appendix 2).

3.3.3 Sample collection

Twenty cereal-based complementary foods were randomly selected from the supermarkets and retail shops located in Mwanza city. Collected samples were then sent to Morogoro region at SUA-Department of Food Technology Nutrition and Consumer Sciences (DFTNCS) laboratory for detection and enumeration of total coliforms and S*almonella.*

3.3.4 Microbiological analysis of samples: Detection and enumeration of coliforms and *Salmonella* in samples (commercial CBCF)

Detection and enumeration of total coliforms and *Salmonella spp* in the sample was done according to the methods described by Ciira (2003) and ISO 4831:2006 respectively.

3.3.4.1 Detection and enumeration of total coliforms

Coliform bacteria were enumerated by the membrane filter method using m-FC medium. Three replicates of twenty five (25) grams from each CBCF sample were homogenized with 225 ml of Buffered Peptone Water (OXOID), then filtered through sterile bacteriological filters (0.45 mm, Sartorius, Germany) using a sterile all glass membrane filter assembly (Whatman, UK). After filtration the filter was aseptically transferred onto a surface dried sterile m-FC agar plate and incubated at 37^{o}C for 24 hours. Typical coliform like colonies developed on m-FC agar were isolated,restreaked to ensure purity and maintained on sterile nutrient agar slants. The confirmation of coliform isolates was carried out in brilliant green lactose bile broth (BGLB). The isolates were inoculated into 10 ml sterile BGLB tubes and incubated at 37^{o}C for 24 hours and checked for gas production. Gas production in Durham tubes submerged in BGLB medium was considered confirmatory for coliform bacteria.

Results for the positive tubes were expressed in MPN/g (Presumptive coliforms per gram) by selecting three consecutive dilutions and compared with number of positive tubes from MPN table (ISO 4831: 2006).

3.3.4.2 Detection and enumeration of *Salmonella*

The presence or absence of *Salmonella*CBCF samples was detected by the procedures described by Ciira (2003) and ISO 6579 (2017).For each sample three replicates were carried out where by twenty five (25) grams of the samples were mixed with 225ml of

Buffered Peptone Water (pre-enrichment- non selective liquid medium)and incubated at 30^{o}C for 24hours. After incubation, 0.1 mlof the cultured sample obtained was inoculated with Rappaport Vassiliadis (RV) broth (enrichment selective liquid media) and incubated at 41.5^{o}C for 24hours. The culture obtained were inoculated on petri dishes containing two selective solid media namely Xylose Lysine Desoxycholate (XLD agar) and Brilliant Green Agar (BGA) for each replicate by stripping with a loop and incubated at for 37 °C for24 hours.The detection of *Salmonella*was by observing the typical red colonies on the XLD agar and red to pink-white colonies surrounded by brilliant red zones in the BGA.

3.3.5 Statistical analysis

Data from questionnaire were processed by editing, coding and analysing by using a Statistical Package for the Social Science (IBM SPSS Version 20, 2011). The data were then presented as frequency and percentages.

Data from microbiological analysis (coliforms and *Salmonella spp*) were also analysed using a Statistical Package for the Social Science (IBM SPSS Version 20, 2011). Descriptive statistics were used to summarize the data. One way Analysis of Variance (ANOVA) was used to determine significant difference between CBCF processorsat 5% level of significance. Means were separated by Tukey Honest Significant Different (HSD). Results were expressed as mean ± standard deviation and presented in tabular form.

3.4 Results and Discussion

3.4.1 Food safety knowledge and hygienic practices of commercial CBCF processors in Mwanza region

3.4.1.1 Demographic information

Demographic characteristics of respondents processing commercial cereal-based complementary foods (CBCF) showed that 60.0% of processors were located atNyamaganawhereby only 40.0% of the processors were found at Ilemela districts (Table 1). All of these processors were categorised as small and medium-scale food processors. 80% of the commercial CBCF processors were female where 20% were males. 75% respondents were aged between 31 to 50 years, 15% were aged between 18 to 30 years and 10% were above 50 years of age. Majority of respondents were married (95%) and while 5% were widows.

Level of education for processors was; primary level of education (15%), secondary (ordinary) level of education (75%). There was no any respondent who had attained higher education level (bachelor degree).

Table 1: Demographic characteristics of complementary food processors in Mwanza

Parameter	Freq	%
Location of respondent		
Nyamagana district	12	60.0
Ilemela district	8	40.0
Gender of respondent		
Male	4	20.0
Female	16	80.0
Age of respondent (years)		
Less than 18	0	0.0
18-30	3	15.0
31-50	15	75.0
Above 50	2	10.0
Marital status		
Single	0	0
Married	19	95.0
Widow	1	5.0
Education level		
Primary	5	25.0
Secondary	15	75.0
Higher education (Bachelor degree)	0	0.0

Food safety knowledge and hygiene practices are important components for any food producers to prevent food contamination and reduce food-borne incidences to the target consumers. In order to succeed in this, education of food processors will greatly impact on his/her understanding food safety factors and good hygienic practices (Cleland and Van Ghee, 1998).

Supporting above results, Abdallah*et al.* (2009) reported 72% of the people in the food handling and processing were females and 48% had primary school education higher than our results which showed 23.8% primary school educated processors. Abdallah*et al.*

(2009) stated that, under *ceteris peribus,* educated household members tend to be more productive in economic activities and other related opportunities than non-educated household members. Educated processors can easily be trained and well understand the food safety risk factors, it is expected that they could understand better the quality requirements and expected hygiene needed in producing safe marketable complementary foods.

3.4.1.2 Raw materials sources, packaging and storage

All commercial CBCF processors in Mwanza buy their raw materials from the market (Table 2). Factors considered by these processors when purchasing their raw materials from the market were; price (5%), quality (10%) whereby 85% considered both factors. The results implied majority understood the importance of using safe raw materials although they were sensitive to the prices of the raw materials as the criterion for procurement. The quality factors that were considered before purchasing raw materials were; level of damages to the grains, maturity of grains and objectionable odours from the raw materials.

Processors stored their raw materials at home (70%) whereby 30% stored their raw materials at their food processing premises (Table 2). 95% processors package their raw materials in sealed containers whereby 5% stored raw materials under the floor with no packages. All commercial CBCF processors clean their raw materials, and general procedures they used were sorting, washing with water, sieving by water and winnowing (Table 2).

Table 2: Raw materials source, packaging and storage

Parameter	Freq	%

Source of raw materials		
Buy from the market	21	100
Produce myself	0	0
Factors considered for purchasing raw materials		
Price	1	5.0
Quality	2	10.0
All mentioned above	17	85.0
Packaging of raw materials		
In sealed container/bags	19	95.0
No packages used	1	5.0
Storage of raw materials		
At home	14	70.0
Storage room in premise	6	30.0
Cleaning of raw material		
Yes	20	100
No	0	0
Basic raw materials cleaning procedures		
Sorting	0	0
Washing	0	0
Sieve by water	0	0
Winnow	0	0
All of mentioned above	20	100

3.4.1.3 Spoilage of raw materials; its sources and handling methods

Majority of commercial CBCF processors (95%) didn't face spoilage of their stored raw materials while only 5% faced raw materials spoilage (Table 3). All processors were aware about the cause of spoilage in raw materials. All respondents indicated insects, rodents and moulds as major sources of raw materials spoilage. Also, all respondents said they would discard spoiled raw materials (Table 3).

Table 3: Spoilage of raw materials

Parameter	Freq	%
Do you know the problems caused by improper waste disposal?		
Yes	20	100
No	0	0
Do you face spoilage problems of your stored raw materials?		
Yes	1	5.0
No	19	95.0
Major sources of raw materials spoilage		
Insects	0	0
Rodents	0	0
Moulds	0	0
All of the above	20	100
Handling of spoiled raw materials		
Discard it	20	100.0
Use as animal feed	0	0

Food hygiene principles require food processing premises to be separated from a living house or be far from animal sheds (CAC, 2003). The reason is that close vicinity to this place will increase chances for food contamination and spread of diseases. Proper waste disposal is another concern in food processing to reduce contamination and environmental pollution (CAC, 2003). The CBCF processors depended on municipal solid waste collection and dug pits for solid waste disposal. Good news was that all processors had an understanding of problems that might be caused by improper waste disposal (Table 3). According to CAC (2003) on hygienic principles and good practices, improper waste disposal could bring about food contamination and environmental pollution which renders food unfit for human consumption and lead to disease eruptions, respectively.

3.4.1.4 Processing environment, equipment and procedures

Food processing was done at home by 55% while 45% had designated premise for food processing (Table 4). Generally, all the processing sites were free from environmental pollutions such as air pollutions. Almost all processors (90%) had a processing area which had no smooth floor and walls, enough ventilation and food-grade (i.e. stainless and smooth) equipment for food processing (Table 4).

All commercial CBCF processors had food processing flow chart (i.e. written procedures to follow during food processing) for making their particular products (Table 4). This was mainly contributed by the training they got form SIDO and other food processing trainings. The flow chart included major food processing methods such as; thorough washing of raw materials, sun drying, blending, milling and packaging.

On the other hand, malting (which includes soaking, germinating and drying steps) and fermentation processes were not used by all commercial CBCF processors (Table 4). This could have affected the quality of their final products specifically the dietary fibre contents, mineral and anti-nutrient concentrations.

Table 4: Processing environment, equipment and procedures used

Parameter	Freq	%
Where is food processing conducted?		
At home	11	55.0
Processing premise	9	45.0
Is processing site free from pollutions?		
Yes	20	100
No	0	0
Is processing area smooth and well ventilated?		
Yes	2	10.0
No	18	90.0
Are there food grade equipments for processing?		
Yes	2	10.0
No	18	90.0
Is there processing flow chart?		
Yes	20	100
No	0	0
Basic processing methods used were:		
Thorough washing	0	0
Sun drying	0	0
Blending	0	0
Milling	0	0
Packaging	0	0
All of the above	20	100
Are malting and/or fermentation part of your processing steps?		
Yes	0	0
No	20	100

NB: Data for table 4 were collected using direct observation.

3.4.1.5 Product packaging, labelling details and its storage

Polyethylene bags were used by 80% processors to pack their final products and only 20% used paper bags (lined with a thin polyethylene sheet in the interior wall) (Table 5). The majority used polyethylene bags due to high price of the paper bags as compared to polyethylene bags. Paper bags are of advantages than polyethylene bags because they prevent sun light into the product preventing oxidation reactions which cause rancidity hence extend the shelf life of the final product (Krešića*et al.*, 2008).

It was observed that, products were packaged in package size of 500 grams was used but majority products were packaged in a 1kilogram net weight packages. These packaging sizes with different net weights give a customer an opportunity to purchase an affordable product. Storage of the products was at normal or room temperature at their store or at the market shelf (Table 5).

The majority (95%) CBCFs were labelled with production and expiry dates (Table 5). Only 10% of the sampled CBCF products had batch numbers on their label while 90% CBCF products had no batch number indicated on their labels. On the other hand, 55% products had barcodes whereas 45% had no barcodes on their labels (Table 5). Labelling of the product is a mandatory requirement to all processors; it helps in products recall and traceability (TFDA, 2013).

The majority of respondents (95%) said they would discard the defective products whereby 5% said would reject to receive the returned defective product.

Table 5: Product packaging, labelling details and storage

Parameter	**Freq**	**%**
Do you package your product?		
Yes	20	100
No	0	0
Type of packaging materials used		
Polyethylene bags	16	80.0
Paper bags	4	20.0
Product storage environment		
Normal or room temperature	20	100
Controlled temperature and humidity	0	0
Do products have production and expiry dates?		
Yes	19	95.0
No	1	5.0
Do products have batch number?		
Yes	2	10.0
No	18.0	90.0
Number of products with barcode		
Yes	11	55.0
No	9	45.0
What to do when defective product is returned by a customer?		
Reject to receive it	1	5.0
Receive and discard it	19	95.0
Receive and use it as animal feed	0	0

3.4.1.6 Personnel medical records and hygiene

Most of the processors (95%) did not have records for medical examination for every six months of production whereby only 5% had personnel medical examination records (Table 6).

It is a mandatory requirement that every personnel involved in food processing to be medically examined at first appointment and after every six months. The aim is to ensure safety of the food products (TFDA, 2013).

Adequate hand washing facilities such as soap and potable running water was observed in 70% processors. Also, it was observed that all respondents had latrines enough to accommodate all members involved in food processing (Table 6). These results were mainly contributed by food processing training they got from SIDO, TFDA and other training they attended.

The majority (95%) respondents were observed to wash their hands before starting food processing, after visiting toilets and blowing nose, after handshaking and after touching non-food materials (Table 6). These results were supported by Kitagwa (2008) in his study conducted in Kenya reported that, 93% of food handlers had an understanding and were practising hand washing before handling of food. In contrast to our results, Ikojie*et al.* (2005) in Nigeria reported very low level of hand washing practices and personnel hygiene among food handlers despite the fact that they had enough education on personnel hygiene particularly hand washing practices. This scenario supports the fact that, having knowledge may not necessarily be translated into real practices that is the intended behaviour.

Only 45% respondents were observed to wear protective gears (uniforms) during food processing where by majority (55%) did not wear protective gears (uniforms) of which it could result to cross-contamination of food products (Table 6). High cost of protective gears was one of the reasons of not wearing protective gears despite the fact that they have the knowledge about the role of wearing protective gear during food processing. 35%

respondents said they wore protective gears for personal protection to prevent contamination while 65% wore protective gears for both protection and smartness (Table 6).

Generally, personal and food protection is important component of good hygienic practices for production of safe food products. Wearing of protective gears during food processing prevent cross contamination especially physical and microbial contaminants from personnel sources which may pose health problems to consumers especially infants and young children. Also protective gears protect one from bodily injuries that may occur during processing and keep outfit clean and stain-free (Muhimbula and Issa-Zacharia, 2010).

Table 6: Personnel medical records and hygiene practices

Parameter	**Freq**	**%**
Periodic medical exam of personnel		
Yes	1	5.0
No	19	95.0
Provision of adequate hand washing soap and portable water		
Yes	14	70
No	6	30
When do you wash your hands?		
Before starting food processing	1	5.0
After visiting toilets and blowing nose	0	0
After handshaking and touching non-food materials	0	0
All mentioned above	19	95.0
Adequate latrines to accommodate all processors		
Yes	20	100
Wearing of protective gears/uniforms during food processing		
Yes	9	45.0
No	11	55.0
Purpose of wearing protective gears		
For protection	7	35.0
For smartness and protection	14	65.0

3.4.1.7 Quality of water used for food processing

All processors used pre-treated water from Mwanza urban water supply authority (MWAUWASA) for food processing and sanitary activities (Table 7). All processors did not treat water used for making their food products. Water was mainly used for; cleaning of raw materials, sanitation of processing equipment and room, and for ensuring personnel hygiene.

However, untreated water is good source of pathogenic microorganisms such as *Escherichia coli*, *Campylobacter*, *Salmonella* and the like, which may lead to food-borne diseases such as diarrhoea that are dangerous to infants and young children. The use of unsafe water in hand washing, cleaning of processing equipment and processing room in general would contaminate the food (CAC, 2003; Muhimbula and Issa-Zacharia, 2010).

Table 7: Characteristics of water used for food processing

Parameter	Freq	%
Source of water		
Urban water supply Authority (MWAUWASA)	20	100
Water treatment process		
Filtration	0	0
Water treating chemicals	0	0
Boil	0	0
Do not treat	20	100

3.4.1.8 Food processors registration and trainings

All processors were registered by Small Industries Development Organization (SIDO) in Mwanza and they attended food processing trainings offered by SIDO in collaboration with Tanzania Food and Drugs Authority (TFDA) lake zone (Table 8). The training was mainly based on cereal-based food processing, food safety knowledge and good hygienic practices (GHP).

It was also observed that only one processor was registered by TFDA. This was against the TFDC Act of 2003 which requires all food processors, their food premises and their food products to be registered by the TFDA (TFDA, 2003). The other (19) food processors were not registered due to high costs of premise and product registration, respectively.

Table 8: Food processing business registration and trainings

Parameter	Freq	%

Processors registered by SIDO		
Yes	20	100
No	0	0
Processors registered by TFDA		
Yes	1	5.0
No	19	95.0
Attending food processing training		
Yes	20	100
Trained on practising Good Hygienic Practices (GHP)		
Yes	20	100
Visited by Government officers for inspection and advices		
Yes	9	45.0
No	11	55.0

Therefore using findings in Table 8, we can generalise that the processors in Mwanza region have received formal training in food safety and good hygienic practices, although the challenge observed was translating the knowledge into practices. This was due to the efforts made by government officers from Tanzania Food and Drugs Authority (TFDA), Small Industries Development Organisation (SIDO) in collaborating with non-government organizations (NGOs) and other stakeholders in providing trainings in educating small scale food processors in; good hygienic practices for production of safe food products for infants and young children.Van Camp *et al*. (2007) reported that, despite the fact that most processors had received formal training on hygienic practices; most of them were observed operating in a semi-clean and non-conducive environment whereby safety and wholesomeness of food may be compromised. Also, Green (2008) reported that, despite majority of food handlers having knowledge about important food hygiene and safety issues, their practices are notably below acceptable standard. This implies that food processors should fully commit to implement their knowledge on hygienic practices and food safety so as to ensure food safety and quality.

Marais and Conradie (2007) reported that over 70% of the managers and food handlers in small and medium enterprises (SMEs) had not received any formal training in food safety. Also a study conducted by Kitagwa (2008) revealed that none of the food handlers had received any formal training in food hygiene in Eldoret, Kenya.

On the other hand, only 45% of the processors were recently visited by government officers from TFDA, TBS and WMA for inspection and advice whereby majority (55%) were not inspected (Table 8). This was because they had no food processing premises, that is, they carry food processing at their homes. Also, another reason was that, government officers provoke and harasses them therefore they do mostly escape visitations of government officers.

3.4.1.9 Cereal-based complementary food (CBCF) formulations

All processors obtained CBCF formulation knowledge through attending different trainings including SIDO (Table 9). Majority (60%) produced CBCFs for the purpose of; improving child health, taste improvement and earning money (Table 6).

Table 9: Complementary food formulation details

Parameter	Freq	%
Source of Complementary formulations		
SIDO plus other trainings	20	100
Purpose of food formulation/production		
For child health improvement	3	15.0
For taste improvement	1	5.0
For earning money	4	20.0
All mentioned above	12	60.0

Despite the fact all processors were trained by SIDO on food formulations, they used different ingredients formulations in making their products (Figure 1). Ingredients used by all processors in formulating their CBCF products were; Finger millet (100%), Soybeans (100%), Corn (95%), Peanut (95%), Rice (80%), Undehulled wheat (60%), White sorghum (60%), Sesame seeds (55%), Pearl millet (15%), Cardamom (5%), Amaranthus (5%), Cassava flour (5%), Carrots (5%), Baobab powder (5%) and Avocado (5%) (Figure 1).

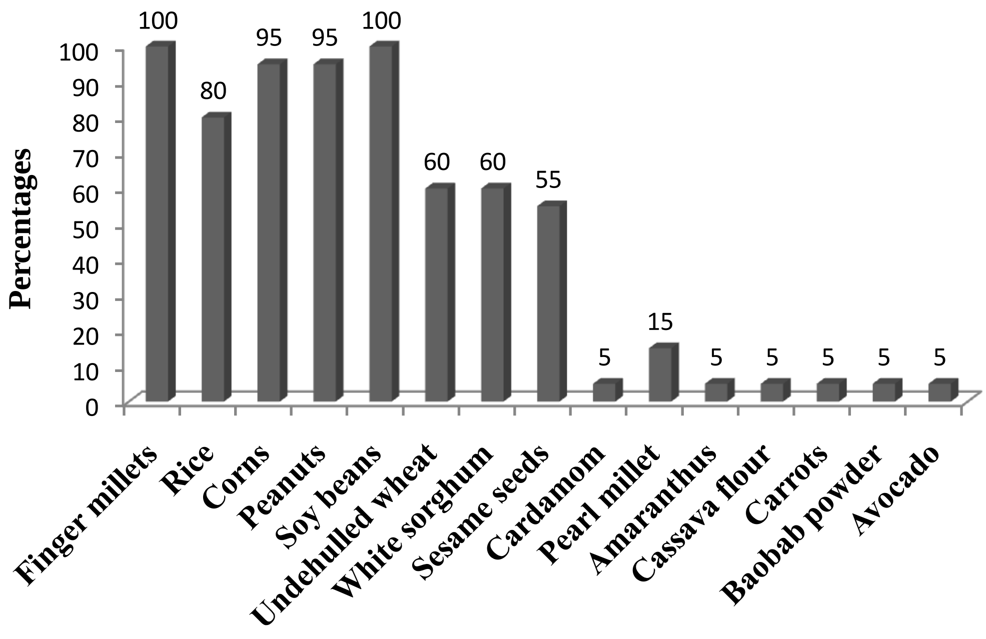

Figure 1: Ingredients used in CF formulation by 20 processors in Mwanza

Proper formulation of food could result to improved food products with high protein and minerals (e.g. Ca, Fe, Zn, P, Mn and Na) contents as well as low in dietary fibre and anti-nutrients with little or no harmful microorganisms (Mosha*et al.*,2000;Laswai*et al.*, 2009).

3.4.1.10 Food quality assurance

Food safety assurance system includes taking precautions during food processing in order to prevent, reduce or eliminate contaminants to the food(CAC, 2003: Muhimbula and Issa-Zacharia, 2010). In this study, food processors were asked few questions to assess their understanding and practices on food quality and safety assurance.

The majority (75%) mentioned the factors for ensuring product quality as being the; selection of good quality raw materials, conducting good hygienic practices, and proper product packaging and storage (Table 10).

On the other hand, 80% processors cited poor quality raw materials, unhygienic processing environments, poor packaging of products as major factors that could render unsafe products. Only 10% of respondents cited both poor quality raw materials and unhygienic processing environments as the only factors causing production of unsafe food products (Table 10).

To ensure food quality and safety, the majority (90%) respondents cited precautions to take during food processing were; avoiding use of poor quality or contaminated raw materials, avoiding use of non-potable water during food processing as well as avoiding use of unclean hands and equipment (Table 10).

Processors were asked to cite indicators which reflect product is unfit for human consumption. The majority (55%) cited bad smell, damaged product’s package, colour change and expiry dates as major indicators for knowing unfit food product for human consumption, while 25% respondents cited product's expiry date only, 15% cited damaged product's package, 5% respondent cited bad smell and product's colour change and being mouldy, respectively as indicators for unfit food for human consumption (Table 10).

Table 10: Complementary food safety assurance

Parameter	Freq	%
Product safety assurance		
Using quality raw materials	1	5.0
Conducting good hygienic practices	3	15.0
Proper product packaging and storage	1	5.0
All of the above	15	75.0
Factors that make food unfit for human consumption		
Poor quality of raw materials	1	5.0
Unhygienic processing conditions	1	5.0
Poor food packaging and storage	0	0
First two mentioned above	2	10.0
All of mentioned above	16	80.0
Precautions to take during food processing		
Avoid use of poor quality or contaminated raw materials	1	5.0
Avoid use of non-portable water during food processing	0	0.0
Avoid use of unclean hands and equipment	1	5.0
All mentioned above	18	90.0
How to know unfit food product for human consumption?		
Bad smelling	0	0.0
Damaged package	3	15.0
Colour change and become mouldy	1	5.0
Expire date exceeded	5	25.0
All mentioned above	11	55.0

Any food processor whether small, medium or large scale, must ensure safety of its food products and, great precautions need to be practiced here (CAC, 2003: TFDA, 2013).

3.4.1.11 Challenges faced by commercial CBCF processors in Mwanza region

The major challenges addressed by all processors were; high cost of raw materials, poor quality of raw materials, unstable market for their products, harassment from government officers, insufficient funds/low capital investment and poor government support.

Therefore, government and/or non-government organisations should facilitate small scale processors in improving their food premises, processing materials and equipments for CBCF processing. This could be through provision of financial and technical support. Also, reduction of fees for premise or product registration and business licensing should be done.

Table 11: Challenges facing commercial CBCF processors

Parameter	Freq	%
Major challenges associated with complementary food production		
High cost of raw materials	20	100
Poor quality of raw materials	20	100
Unstable market for the products	20	100
Harassment from government officers	20	100
Insufficient funds/low capital investment	20	100
Poor government support	20	100

3.4.2 Microbiological quality

Commercial cereal-based complementary foods produced and marketed in Mwanza region were analysed for Coliforms and *Salmonella*. The results were summarized in Table 12 below.

3.4.2.1 Coliforms contamination

Total coliforms counts in the CBCFs ranged from 0cfu/g to 2.5×10^{1}cfu/g (Table 12). Eleven (55%) CBCFs samples had total coliforms counts less than 10cfu/g hence conformed to TZS 180:2013.

Table 12: Total Coliforms and *Salmonella* content in commercial cereal-based complementary foods

Processor	Total Coliforms (CFU/g) Mean±SD	*Salmonella spp.* Mean±SD
1	$1.4\times10^{1}\pm1.0^{fgh}$	0.00
2	$1.2\times10^{1}\pm1.0^{defgh}$	0.00
3	9.0 ± 1.0^{cdefg}	0.00
4	6.0 ± 1.0^{abc}	0.00
5	$1.4\times10^{1}\pm2.0^{efgh}$	0.00
6	$2.2\times10^{1}\pm2.0^{ij}$	0.00
7	$1.0\times10^{1}\pm2.0^{cdefg}$	0.00
8	8.0 ± 1.0^{bcd}	0.00
9	$1.7\times10^{1}\pm2.0^{hi}$	0.00
10	$1.4\times10^{1}\pm2.0^{efgh}$	0.00
11	3.0 ± 2.0^{ab}	0.00
12	8.0 ± 1.0^{bcd}	0.00
13	9.0 ± 2.0^{cdef}	0.00
14	7.0 ± 1.0^{bcd}	0.00
15	$1.4\times10^{1}\pm2.0^{fgh}$	0.00
16	8.0 ± 2.0^{bcde}	0.00
17	9.0 ± 2.0^{cdef}	0.00
18	$1.5\times10^{1}\pm3.0^{gh}$	0.00
19	0.00^{a}	0.00
20	$2.5\times10^{1}\pm3.0^{j}$	0.00

Means ± SD. Values are on dry weight basis (dwb)

Means within a column with same superscript letters are not significantly different ($p<0.05$)

High coliform contamination in samples could be due to faecal contaminated water and/or poor hygienic practices such as poor hand washing of processors after toilet visit, during food processing and packaging (WHO, 2008). However, observing hygiene principles and avoiding use of contaminated materials in food formulation is necessary to have lower bacterial load in the final products (Muhimbula and Issa-Zacharia, 2010).

Akambi*et al.* (2010) recorded lower levels of Coliforms counts (<10 cfu/g) in his formulated cereal-soybean complementary foods. This suggests a high level of hygiene practices throughout food processing and appropriate packaging and storage environment.

3.4.2.2 *Salmonella* contamination level of cereal-based complementary foods

Salmonella was not detected in all CBCF samples (Table 12). That means, all CBCFs conformed to TZS 180:2013 and CODEX standards (2006). This could be due to good hygiene practices of food handlers and processing equipments as well as the use of portable water during food processing. The processing and storage conditions were unfavourable for growth and multiplication of *Salmonella* in CBCFs.

According to TZS 180:2013, CODEX standards (2006) and USDA (2010), all CBCFs for human consumption should not contain *Salmonell*a as it indicates faecal contamination of food which causes enteric fever and diarrhoea to consumers (WHO, 2006; Muhimbula and Issa-Zacharia, 2010).

3.5 Conclusion

CBCF processors in Mwanza had knowledge on hygienic practices and food safety assurance, although majority failed to translate this knowledge into practices due to financial constraints they faced. Sufficient funds is required by processors purchasing;

high quality raw materials, food grade processing equipments and machines, uniforms and protective gears and all necessary facilities required for a food processing premise.

Majority processors used cereal-legume blending in making their products. This could be the reasons as to why their products have inadequate proteins, energy and essential mineral contents as recommended for infants and children feeding. Therefore, training on proper preparation and formulation of ingredients especially soybeans processing should be improved and frequently done. Efforts should also be made so that processors incorporate animal proteins sources (e.g. sardines and fishes), edible insects and vegetables in their products formulations so that their products yield high in proteins, energy and mineral contents.

Microbiological quality of food is highly related with the quality of raw materials used, hygienic practices of personnel and sanitary conditions of the processing environment as well as storage conditions of the final products. Products with higher pathogenic microorganisms such *Salmonella spp*results to diseases such as diarrhoea, vomiting and/or death to consumers.

Although commercial CBCF processors in Mwanza are facing many challenges, they are doing their best in producing safe commercial CBCF products.Government and other interested stakeholders should support these processors through time-to-time trainings and provision of up-to-date processing equipments so as to ensure safe and quality commercial cereal-based complementary foods are produced for promoting growth of infants and young children.

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CHAPTER FOUR

4.0 NUTRIENTS AND ANTI-NUTRIENTS CONTENT OF THE COMMERCIAL CEREAL-BASED COMPLEMENTARY FOODS PRODUCED AND MARKETED IN MWANZA REGION.

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4.1 Abstract

Twenty commercial cereal-based complementary foods were purchased from retail and supermarkets in Mwanza region. These samples were analysed for proximate composition, minerals content and anti-nutrients contents. The results showed that proximate composition ranging from: 7.55% to 11.06% (moisture), 1.97% to 4.82% (ash), 6.88% to 15.12% (crude protein), 2.67% to 9.68% (crude fat), 2.82% to 8.31% (crude fibre), 54.43% to 73.04% (total carbohydrates), 306.06 Kcal/100g to 381.24 Kcal/100g (energy content).

Mineral contents (in mg/100g) in commercial CBCF ranged from: 59.56 to 145.45 (Calcium), 1.07 to 5.05 (Iron), 1.04 to 3.31 (zinc) respectively. Tannins ranged from 0.19% to 3.12% and the *In vitro* trypsin inhibitors (TIs) concentrations ranged from 2.76mg/g to 9.91mg/g.

The majority (75%)CBCFs had higher moisture which could support microbial growth and shortens products’ shelf life. They also had lower contents of protein, energy and essential

mineral contents than recommended by TZS 180:2013 and CODEX standards (2006). Also, the products had higher amount of dietary fibre, which increase bulkiness and lower nutrient density, and higher amount of anti-nutritional factors (tannins and trypsin inhibitors) which inhibit protein digestibility and bioavailability of minerals. Thus, these products cannot provide essential nutrients required for the growth and development of infants and young children.

Therefore, there is a need for processors to be more trained on proper formulation and preparation of the CBCFs. Also, the government authorities should make sure that, all CBCFs are properly formulated and processed before they enter the market so that they comply with national and/or international standards.

4.2 Introduction

The main nutritional problems in Tanzania and other sub-Saharan African countries are Protein and Energy Deficiencies (PED), Iron Deficiency Anaemia (IDA), Vitamin A Deficiency (VAD) and Iodine Deficiency Disorders (IDD). In Tanzania, PED affects 28% and IDA 32% of the general population with children under 5 and pregnant and lactating women being the most susceptible (Mosha*et al.*, 2000; Laswai*et al.*, 2009). Major food-related causes of malnutrition include inadequate feeding, foods with low energy and nutrient density, low bioavailability of nutrients, poor access to food, use of poor processing methods and microbial contamination (Laswai*et al.*, 2009). According toLaswai*et al.* (2009), this situation may be improved by the use of appropriate and sustainable intervention approaches, which include development of low cost, nutritious complementary foods using locally available, underutilized cereals, legumes and oil seeds, and use of affordable bio-enrichment processing techniques such as fermentation of complementary cereals, legumes or oilseed mixtures at the household level.

Many of the traditional complementary foods used in developing countries are of low nutrient density. Traditional complementary foods in Tanzania are based on starchy staples, usually cereals such as maize, rice and finger millet and non-cereals such as cassava, sweet potatoes, yams, bananas and plantains (Mosha*et al.,* 2000). FAO/WHO/UNICEF emphasized the use of local foods formulated in the home rather than centrally produced fortified foods for complementary feeding (Laswai*et al.,* 2009).
Plants commonly synthesize a range of secondary metabolites as part of their protection against attack by herbivorous, insects and pathogens or as means to survive in adverse growing conditions (Bora, 2014). If farm or domestic animals or humans consume these plants, these compounds may cause adverse physiological effects. The term anti-nutrients refers to defence metabolites, having specific biological effects depending upon the structure of specific compounds which range from high molecular weight proteins to simple amino acids and oligosaccharides (Satinder*et al.,* 2011). Phytic acid, saponins, polyphenols, lathyrogens, alpha-amylase inhibitors, trypsin inhibitors, tannins and lectins are anti-nutrients found in grains and legumes (Bora, 2014). Anti-nutrient substances from nutritional point of view, interferes with normal growth, reproduction and health, when consumed regularly in amount existing in a normal component of diet therefore should be considered as harmful and toxic (Mosha*et al.,* 2000; Laswai*et al.,* 2009). A significant part of human population relies on legumes as staple food for subsistence, particularly in combination with cereals. They are unique foods because they are rich in nutrient content including starch, protein, dietary fibre, oligosaccharides, phytochemicals (especially the isoflavones in soybean) and minerals. Their nutritional content contributes to many health benefits to humans. So, the knowledge regarding various anti-nutritional substances

present in foods as well as techniques to reduce them in the diet is essential for health and wellbeing of the population (Bora, 2014).

In Mwanza region and other areas of Tanzania surrounded by water bodies such as lakes and ocean, incorporation of sardines or fish-based complementary foods could help increase protein, nutritional energy and essential mineral contents of complementary foods and therefore be able to meet nutritional requirements of children for growth, development and prevent or reduce stunting prevalence and other nutritional disorders. This study was, therefore, carried out to assess nutrient content (proximate composition), mineral and anti-nutrient contents of commercial CBCF produced and marketed in Mwanza region.

4.3 Materials and Methods

4.3.1 Study population

This study was conducted in Mwanza region. Commercial cereal-based complementary foods (CBCFs) from small scale food processors in Mwanza region were used for determining their safety and quality in relation to improving nutritional and health status of infants and young children.

4.3.2 Sample collection

Twenty cereal-based complementary foods were randomly selected from the supermarkets and retail shops located in Mwanza city covering Nyamagana and Ilemela municipalities. The samples were then sent to Morogoro region at SUA-Department of Food Technology Nutrition and Consumer Sciences (DFTNCS) laboratory for analysis of proximate composition, minerals contents and anti-nutrient contents of sampled commercial cereal-based complementary foods.

4.3.3 Materials and methods

Analytical grades chemicals and reagents used were obtained from SUA at DFTNCS laboratories. The CBCF samples were homogenized to avoid inter and intra unit variations for a better representative of laboratory sample from sample. And, analysis was done in triplicates.

4.3.3.1 Moisture content

Moisture content was determined following AOAC procedures using official method no. 925.40 (AOAC, 2005). Ten grams of CBCF sample was weighed in tarred aluminium dish with a cover and evenly distributed. With cover removed, the dish and cover were placed in an air- dry oven (HERAEUS) maintained at 105 °C until constant weight and dried at least for 4 hours. Thereafter the dishes were covered and placed in a desiccator for 30 minutes to reach ambient temperature. The moisture content (MC) was determined by the difference of weight before and after drying the sample in an oven as follows

$\%\text{Moisture} = \frac{(\text{M1}-\text{M2}}{(M1-M)} \text{ x } 100$..Equation (3)

Where:

M_1 = mass in g of the dish with sample before drying, M_2 = mass in g of the sample after drying

M= mass in g of the empty dish

4.3.3.2 Dry Matter (%)

Dry matter was calculated based on moisture content according to AOAC (2005), that is;

Per cent dry matter = 100 % -%Moisture...Equation (4)

4.3.3.3 Ash content

Ash content of the CBCF samples was determined according to the AOAC (2005) using method 950.49. Ash fraction was determined by the incineration of dried sample (3grams)into the dried crucible (pre-dried in the furnace) in a muffle furnace (Carbolite) at 550°C for 4hours.The ash was cooled in desiccator for 30 minutesand weighed. Percent residual weight in the crucibles was reported as the ash content in the sample and expressed as:

$\% \text{ Ash } (g/100g) = \frac{M2-M}{M1-M} \times 100$...Equation (5)

M_2 = mass in g of the crucible with ash

M = mass in g of the empty crucible, and

M_1= mass in g of the crucible containing the sample.

4.3.3.4 Crude protein

Crude protein content of the samples was determined using the micro-Kjeldahl method 920.87 (AOAC, 1995). The method consisted of three basic steps: i) digestion of the sample in sulphuric acid with a catalyst, which resulted in conversion of nitrogen to ammonia; ii) distillation of the ammonia into a trapping solution; and iii) quantification of the ammonia by titration with a standard solution.

About 0.25g of dried samples were weighed onto tared filter papers and quantitatively transferred into digestion tubes. About 10 g of catalyst (mixture of 10g potassium sulphate, 0.5 g copper sulphate and 1.0 g titanium) were added into each tube with samples. Five ml of concentrated sulphuric acid were added to each tube. Samples were digested using Tecator digestion system (Model 1016 digester, Sweden) for 3 hours to obtain a clear greenish solution. The digest was cooled and one tube at a time was mounted in the distillation unit (Foss Tecator, Model 2200 Kjeltec auto distilling unit, Sweden).

Thirty ml of water were added to the digest followed by 30 ml of 40% sodium hydroxide and steam distilled for 3 minutes. About 50 ml of the distillate was collected in conical Erlenmeyer flask containing 20 ml of 2% Boric Acid. The distillate was thereafter titrated with 0.1N hydrochloric acid. Blank determination was carried out in the same manner using reagents without a sample.

Nitrogen content was calculated from the relationship:

$$\%N = \frac{(1.4007 \text{ x } [\text{titre ml} - \text{blankml}] \text{x Normality of acid used}}{W} \text{ x } 100 \ldots\ldots\ldots\ldots\ldots\ldots\text{Equation (6)}$$

Where:

N = Total Nitrogen

W = original weight of the digested sample

Percentage crude protein was calculated from the percentage nitrogen using the factor 6.25.

Per cent crude protein (g/100g) = %N x 6.25……………………………. Equation (7)

4.3.3.5 Crude fat (Ether Extract)

Crude fat content of food samples was determined by the method as described in AOAC (2000) methods No. 960.39. Fat determination was carried out using the Soxtec extractor. During the process Soxtec extractor was fitted up with 150ml of Petroleum spirit (40 – 60^{o}C). Then a 5g of dry sample was accurately weighed into extraction thimble that was previously dried in an oven. The thimble was then plugged lightly with cotton wool and placed in the pre-weighed extraction cup. The cup was then placed on the heating mantle while making sure that the joints were tight to prevent solvent losses. The source of heat was then adjusted such that the solvent boiled gently for 30 minutes. The cup containing extracted fat was placed in the oven at 105^{o}C and dried to constant weight. The cup was then cooled in the desiccator and weighed after cooling. Then the extracted fat was determined using the formula;

The per cent crude fat (% Ether Extract, %EE) was calculated as follows:

$\%EE\ (g/100g) = \frac{(W3-W1)}{W2}$ x 100……………………………………………..Equation (8)

Where:

%EE = Per cent ether extract, W1 = Weight of empty extraction cup, W2 = Weight of sample, W3 = Weight of cup and fat

4.3.3.6 Crude fibre

Ankom fibre analyzer (model ANKOM 220) was used to determine crude fibre content as outlined by AOAC (1995) in official method 920.86. About 1g of sample was taken for crude fibre determination. The sample was first digested by dilute (0.125M H_2SO_4) for 30 minutes and washed three times with hot water. The residues were then digested by dilute alkali (0.125M KOH) for another 30 minutes and washed by hot water three times. Digested residues were dried in the oven for 12 hours, cooled and weighed. The residues were then placed in the muffle furnace and incinerated at 550^{0}C for two hours, cooled and weighed again. Total fibre content was taken as difference between residues before and after incineration.

% Crude fibre (g/100g) $= \frac{(W1-W2)}{W3} \times 100$……………………………………..Equation (9)

Where:

W1=Weight of sample residues before incineration (g)

W2=Weight of sample residues after incineration (g)

W3=Weight of sample used (g)

4.3.3.7 Total carbohydrate

The total carbohydrate content was determined by difference, according to AOAC (2000) that is, 100% - other proximate chemical compositions, using the following formula;

Total carbohydrate = 100 – (% CP + % EE + % CF + % Ash content + %MC)..equation (10)

Where: CP = Crude protein, EE = Ether extract, CF = Crude Fibre, MC = Moisture content, AC = Ash content.

4.3.3.8 Energy values

Energy value was calculated using the Atwater's convention factors that is, energy values for the collected samples was calculated by multiplying percentage fat, percentage protein, percentage carbohydrates by the Atwater factors of 9, 4, and 4 respectively (AOAC, 2000).

Thus, Energy (KCal/100g) = [(Carbohydrate x 4) + (Fat x 9) + (protein x 4)].Equation (11)

4.3.3.9 Mineral content

The minerals content of samples namely Calcium (Ca), Iron (Fe) and Zinc (Zn) were carried out by AOAC (2000) method No. 968.08. These minerals were determined by using Atomic Absorption/Flame Emission Spectrophotometer (Model; UNICAM 919 AAS, Cambridge-UK).

Standards were set at highest sensitivity. On reading each corresponding lamp and wavelength were set. Zeroing was done after setting on flame and setting the wavelength (Calcium: Ca lamp, λ=422nm; Iron: Fe lamp, λ=248nm and Zinc: Zn lamp, λ=213nm).

Mineral contents (mg/100g) were calculated and expressed in mg/100g on dry weight basis as follows:

$$\text{Mineral content (mg/100g)} = \frac{\text{GR x EVx D.F x100g}}{\text{1000 x SW}} \text{.................................Equation (12)}$$

Where:

GR = Graph readings in parts per million

EV= Extraction volume of sample (ml)

D.F = Dilution factor

1000 = Conversion factor to mg/100g

SW = Sample weight (g)

4.3.3.10 Tannins

Tannin content of sample was determined following method described by Vijay and Rajendra (2014). Two grams of sample were taken into 15 ml centrifuge tubes vortexed for 1 minute. 10ml of 0.5% ethanolicand hydrochloric acid, and 1.0 ml of the sample extract were taken into 50 ml volumetric flask containing 20 ml distilled water. 0.5 ml of Foli-Ciocalteuphenol reagent added. Standard solution of tannic acid with the concentration 100 µg/ml prepared and diluted serially with distilled water to obtain dilution of 0 to 10 µg/ml. 5 ml of 35% sodium carbonate added and diluted to 40 ml with distilled water. The contents mixed by inversion and incubated at room temperature for 30 minutes. Absorbencies read at 725 nm using UV/Visible spectrophotometer (X-ma 3000 UV/Vis). Tannin content of samples was calculated as Gallic acid equivalent per gram of sample extract (GAE/g).

$$\text{Tannins(mg GAE/g)} = \frac{\text{GR x EVx D.F}}{\text{SW}} \text{...Equation (13)}$$

Where; GR = Graph readings in parts per million, EV= Extraction volume of sample (mls), D.F = Dilution factor, SW = Sample weight.

4.3.3.11 Trypsin inhibitor

Trypsin inhibitor activity (TIA) was determined by the methods described by Mbata (2009). One gram portions of the sample was extracted by soaking overnight at 4°C in 50 ml of 0.01NaOH, pH was adjusted to 8.4-10.0.The suspension was diluted so that 2 ml of the sample extract inhibited 40 - 60% of standard trypsin used in the analysis. For the analysis on inhibition of trypsin, synthetic benzoyl DL arginine-p-nitroaniline (BAPNA) was used as substrate. TIA was defined as mg of pure trypsin inhibited per g of food sample at 410 nm. Thus, pure trypsin sample was computed as shown below:

$$\text{TIA (mg/g)} = \frac{(2.632 \text{ x D x A1 })}{\text{S mg pure trypsin inhibited/g sample}} \quad \text{......Equation (14)}$$

Where:

TIA = Trypsin Inhibitory Activity

A1 = change in absorbance due to trypsin inhibition /ml diluted sample extract

D = dilution factor and S = weight of sample (g).

4.3.4 Statistical analysis

Data were analysed using a Statistical Package for the Social Science (IBM SPSS Version 20, 2011). Descriptive statistics were used to summarize the data. One way Analysis of Variance (ANOVA) was used to determine significant difference between CBCF processorsat 5% level of significance. Means were separated by Tukey Honest Significant Different (HSD). Results were expressed as mean ± standard deviation and presented in tabular form.

4.4 Results and Discussion

4.5.1 Proximate composition of commercial CBCF produced and marketed in Mwanza region

Moisture content of CBCFs ranged from 7.55% to 11.06%(Table 13). There was significant difference ($p<0.05$) in moisture content between most of the samples (Table

13). Only 25% of CBCFs were found to have moisture contents within the recommended maximum limit of 8% TZS 180:2013. The majority(75%) of samples had moisture higher than 8% that is recommended by TZS 180:2013.

Higher moisture contents in the products could be attributed to improper sun drying of the raw materials before milling or due to improper storage of products at high humidity. Therefore, processors should ensure effective drying of their raw materials and the final products. Also, instead of depending only on sun drying method, of which it's very challenging during rain seasons, the processors should use solar driers which are more effective and efficient than sun drying method.

According to Oduro*et al.* (2007), low moisture content is required for convenient packaging, transportation and storage of products, but the higher moisture content observed in this study was not low enough for convenient packaging and safe storage but rather may allow biochemical reactions and growth of microorganisms such as moulds and yeasts which reduce the shelf life of the final products.

Table 13: Proximate composition of commercial cereal-based complementary foods(I)

Processor	Moisture (%) Mean ±SD	Ash (%) Mean ±SD	Protein (%) Mean ±SD	Fat (%) Mean ±SD
1	8.71 ± 0.14^{fg}	1.97 ± 0.14^{a}	12.58 ± 0.40^{d}	5.58 ± 0.33^{c}
2	10.39 ± 0.28^{k}	4.78 ± 0.17^{f}	8.66 ± 0.16^{b}	4.86 ± 0.07^{b}
3	9.27 ± 0.06^{hi}	4.50 ± 1.10^{ef}	14.12 ± 0.54^{hij}	9.09 ± 0.04^{ijk}
4	8.30 ± 0.04^{de}	2.40 ± 0.23^{ab}	14.84 ± 0.44^{jk}	9.68 ± 0.16^{kl}
5	11.06 ± 0.26^{l}	2.43 ± 0.17^{abc}	9.84 ± 0.11^{c}	5.33 ± 0.05^{bc}
6	9.93 ± 0.02^{j}	4.45 ± 0.09^{ef}	14.34 ± 0.42^{hijk}	8.68 ± 0.29^{ghi}
7	8.71 ± 0.05^{fg}	2.087 ± 0.04^{a}	10.33 ± 0.06^{c}	8.19 ± 0.13^{fgh}
8	7.82 ± 0.15^{abc}	2.14 ± 0.07^{ab}	13.57 ± 0.92^{efgh}	7.78 ± 0.04^{ef}
9	10.6 ± 0.21^{k}	3.38 ± 0.49^{cd}	6.88 ± 0.38^{a}	2.67 ± 0.43^{a}
10	8.11 ± 0.03^{cde}	2.17 ± 0.04^{ab}	13.91 ± 0.34^{ghi}	5.69 ± 0.04^{c}
11	9.17 ± 0.05^{hi}	3.6 ± 0.05^{de}	12.97 ± 0.27^{def}	7.35 ± 0.38^{de}
12	7.59 ± 0.09^{ab}	2.05 ± 0.11^{a}	14.01 ± 0.08^{ghi}	9.76 ± 0.13^{l}
13	8.05 ± 0.06^{cde}	2.12 ± 0.12^{ab}	13.27 ± 0.30^{defg}	8.16 ± 0.29^{fg}
14	8.98 ± 0.09^{gh}	3.38 ± 0.09^{cd}	14.67 ± 0.07^{ijk}	9.37 ± 0.07^{jkl}
15	8.39 ± 0.05^{ef}	2.83 ± 0.07^{abcd}	12.86 ± 0.07^{de}	8.73 ± 0.17^{ghi}
16	7.78 ± 0.06^{abc}	4.41 ± 0.49^{ef}	15.12 ± 0.24^{k}	8.10 ± 0.08^{fg}
17	7.97 ± 0.10^{bcd}	2.44 ± 0.08^{abc}	13.96 ± 0.86^{ghi}	8.44 ± 0.09^{gh}
18	9.06 ± 0.09^{gh}	4.82 ± 0.10^{f}	13.72 ± 0.67^{fgh}	6.76 ± 0.23^{d}
19	7.55 ± 0.11^{a}	2.82 ± 0.09^{abcd}	14.26 ± 0.22^{hij}	8.44 ± 0.06^{gh}
20	9.53 ± 0.06^{i}	3.06 ± 0.17^{bcd}	12.98 ± 0.07^{def}	8.80 ± 0.16^{hij}

Means ± SD. Values are on dry weight basis (dwb)
Means within a column with same superscript letters are not significantly different ($p<0.05$)

Ash content of CBCFs ranged from 1.97% to 4.82% (Table 13). All samples from 20 processors conformed to the TZS 180:2013 and CODEX standards (2006) by having ash contents lower than the recommended maximum limit of 5.0%. Shimelis*et al*. (2010) reported higher ash content in Ethiopian produced complementary foods. Ndibalema (2011) reported that, the level of ash in food is an important nutritional indicator for mineral density and also a quality parameter for contamination, especially with foreign matter. The variations in ash values may have resulted from processing techniques such as dehulling, roasting and milling, given that most minerals are concentrated in the out layers of the grains. High ash content in food is an indication of high minerals content, although it may also be an indication of impurities in the samples (Ayoola*et al*., 2009).

Protein contents of the commercial CBCFs ranged from 6.88% to 15.12% (Table 13). Only 35% of all CBCFs conformed to the TZS 180:2013 by having protein contents higher than 14%. Therefore, the majority (65%) of these products had lower protein contents hence were not good sources of protein as required for promoting infants and young children's growth and development. Lower protein contents in CBCFs could probably be due to poor processing of soy beans or poor ingredients formulations as allCBCFs sampled had soy beans only with no other protein-rich sources such as sardines in their formulations (Fig. 1). Ndibalema (2011) formulated sorghum-soybean-with-sardines composite complementary foods which had protein content ranging from 17.36% to 21.60%. Also, Fausan*et al.* (2017) formulated ready-to-eat complementary foods from cereal (maize), oilseed (sesame) and animal polypeptide (crayfish) and the results showed appreciable higher protein content ranging from 20.78 to 28.09%. Amankwah*et al.* (2009) reported FAO/WHO recommended that, in order for the dietary protein to be used for the intended purpose of building and repairing body tissues, the proportion of protein to energy in the complementary foods must not be less than 15%. Low protein uptake is associated with weak immune system and protein energy malnutrition (PEM) in infants and young children, reproductive-age women, among other vulnerable groups (WHO, 2006).

Crude fat content ranged from 2.67% to 9.68% (Table 13). Only 35% of the commercial CBCFs had fat content within the recommended minimum limit of 8.5% (TZS 180; 2013; CODEX standards, 2006). Thus, majority (65%) didn't comply with TZS 180;2013 since they had lower fat contents than the standard (Table 13). That meant that, majority of commercial CBCFs in Mwanza were not good sources of fatenough for feeding infants and young children. In his study, Ndibalema (2011) reported an increased fat content with increase in soybean proportions in the formulations; therefore, processors should ensure sufficient quantities of soybeans in the formulations so as to yield high protein and fat contents in their products.

Fats enhance the taste and acceptability of foods. It is required in the body for cell metabolism and provision of energy. Dietary lipids provide essential fatty acids and facilitate the absorption of fat-soluble vitamins (FAO/WHO, 1994; Uauy*et al.*, 2000). Fats also increase the energy density of the gruels. However, fat content that is too high is not recommended because it dilutes the density of protein and micronutrients per 100g (Innis, 1991; Uauy*et al.*, 2000). Red sorghum-based extruded composite products had higher fat content compared to the white sorghum-based composite products (Ndibalema, 2011). However, high fat content in food can affect its shelf life stability because fat can undergo oxidative and/or hydrolytic deterioration which could lead to rancid products that are unfit for human consumption. Given the inappropriate packaging and poor storage conditions, food with high fat content are more likely to undergo rancidity and will spoil faster than those foods with low fat content (Uauy*et al.*, 2000).

CBCFs had a crude fibre ranging from 2.82% to 8.31% (Table 14). Only 45% of these products conformed to the TZS 180:2013 by having crude fibre within less than 5.0% whereby 55% had crude fibre higher than therecommended maximum limit of 5% (CODEX, 2006).

Red sorghum contains higher fibre content than white sorghum (Ndibalema, 2011). Although white sorghums were used in all formulations, the products still had higher fibre content than the maximum limits. Apart from using dehullingthe cereals, processors in Mwanza should have incorporated other processing techniques such as extrusion and germination. Using extrusion technology, Ndibalema (2011) produced extruded white sorghum-soybean complementary foods which had low fibre contents in range of 0.61–2.33%.

The higher amount of fibre than the recommended is attributed to the use of larger amount of undehulled cereals such as sorghum, maize, millet and wheat together, which are known to contain high fibre contents. Dehulling, malting and fermentation reduce dietary fibre in cereals (Laswai*et al.*, 2009; Ndibalema, 2011 and Chen *et al.*, 2013). Right amount of dietary fibre has beneficial effects on bowel transit time, affects glucose and lipid metabolism, reduces the risk of colorectal cancer, stimulates bacteria activity, and detoxifies the colon luminal content (Lee *et al*., 2007). However, high fibre in infant and young children's foods is highly associated with gut irritation and affects the efficiency of nutrients absorption and protein digestibility (Amuna*et al*., 2000). Fibre is an important dietary component in the diet for adults as it is known to play a role in prevention of constipation, overweight, cardiovascular diseases, diabetes and colon cancer (Whitney *et al*., 1990). However, too much fibre in the diet is not good for older infants and young children. Fiber has been reported to increase dietary bulkiness, hence limiting adequate food intake by infants and young children (Laswai*et al.*, 2009).

Table 14:Proximate composition of commercial cereal-based complementary foods(II)

Processor	Crude fiber(%) Mean±SD	Total Carbohydrates (%) Mean±SD	Energy (Kcal/100g) Mean±SD
1	5.45±0.21^{efg}	65.71±0.56^{gh}	363.40±3.54^{ef}
2	4.68±0.10^{cde}	66.63±0.37^{h}	344.88±2.34^{a}
3	7.48±0.28^{i}	55.54±1.59^{a}	360.44±5.65^{cde}
4	5.53±0.06^{fg}	59.24±0.69^{bc}	383.46±0.89^{klm}
5	6.45±0.22^{h}	64.89±0.31^{fgh}	346.89±0.84^{ab}
6	8.17±0.06^{ij}	54.43±0.20^{a}	353.18±1.74^{bc}
7	6.36±0.12^{h}	64.31±0.26^{fg}	372.31±0.10^{ghi}
8	8.45±0.20^{j}	60.23±0.25^{bcd}	365.24±1.06^{efg}
9	3.40±0.46^{ab}	73.04±1.22^{i}	343.71±6.48^{a}
10	8.31±0.90^{j}	61.82±0.97^{de}	354.09±3.37^{bcd}
11	6.21±0.07^{gh}	60.68±0.40^{bcd}	360.75±1.41^{cde}
12	4.84±0.12^{def}	61.76±0.12^{de}	390.89±0.71^{m}
13	2.84±0.20^{a}	65.57±0.32^{gh}	388.77±0.76^{m}
14	4.30±0.09^{cd}	59.30±0.13^{bc}	380.24±1.10^{jkl}
15	2.82±0.04^{a}	64.37±0.16^{fg}	387.47±1.04^{lm}
16	5.71±0.03^{gh}	58.88±0.34^{b}	368.87±1.56^{fgh}
17	3.91±0.20^{bc}	63.29±0.25^{ef}	384.92±0.45^{lm}
18	4.31±0.04^{cd}	61.32±0.12^{d}	361.03±2.29^{de}
19	5.97±0.11^{gh}	60.95±0.44^{cd}	376.86±0.46^{ijk}
20	4.50±0.08^{cd}	61.13±0.07^{d}	375.66±1.80^{hij}

Means ± SD, all values are on dry weight basis (dwb)
Means within a column with same superscript letters are not significantly different ($p<0.05$)

Total carbohydrate ranged from 54.43 to 73.04% (Table 14). Majority (75%) CBCFs had total carbohydrates above 60% as recommended by TZS 180:2013.Total carbohydrate content is highly affected by the percentage of protein, fat and fiber in the particular food. Low fat, protein and fibercontent results to high total carbohydrates in the food. High carbohydrate contents of complementary foods obtained in this study could be contributed by the inclusion of large proportions of cereals in formulations other than legumes and other non-cereal foods. Most cereal-based complementary foodscomposed of the following ingredients: finger millet, rice, popcorns, peanuts, soybeans, undehulled wheat, white sorghum, sesame seed, pearl millet and cardamom.

CBCFs formulated by Ndibalema (2011) had quantities of carbohydrates ranging from 67.35 to 77.46 % hence conformed to TZS 180: 2013 and CODEX standards. The product formulation was sorghum-soybean-with-sardines were produced using an extrusion technology. Thus, Mwanza CBCFs processors should incorporate increase ratios of cereal and legumes and adopt use of extrusion methods when processing.

The main function of carbohydrate is to supply the body with energy required for tissue maintenance and growth, heat generation and physical activities. Weight gain is a sensitive indicator of the adequacy of energy intake in young children given that basal metabolism accounts for 50-60% of total energy expenditure (WHO, 2000).

Energy content of CBCFs ranged from 343.71 to 390.89 Kcal/100g (Table 14). All samples had dietary energy contents lower than 440 Kcal/100g as the minimum limitrecommended by WHO(2002). Also, all samples had lower energy contents than 465-685 Kcal/100g as recommended by TZS 180:2013. Also, the dietary energy contents observed were below the recommended amount of 483.9 to 685.5 Kcal/100g for infant and young children (CAC, 1991). Therefore, in this study, all commercial CBCF were not good sources of energy for infants.

Lower dietary energy in CBCFs was due to lower percentages of protein, fat and carbohydrates in majority CBCFs. High dietary energy is essential for sparing protein from being used as a source of energy (WHO, 2006, Laswai*et al.*, 2009 and Ndibalema, 2011).

4.5.2 Minerals contents (Calcium, Iron and Zinc)

The calcium content in CBCFsranged from 59.56 to 145.45mg/100g (Table 15). The majority (65%) complied with TZS 180:2013 as they had mean values below

100mg/100g.Commercial CBCFs were therefore good source of calcium for infants and young children. The results can be compared with Ndibalema (2011) who formulated sorghum-soybean-with-sardines composite complementary foods which had appreciable quantities of calcium (77.57 – 272.37mg/100g). Adequate amounts of calcium is required to promote stronger teeth and bones development in growing infants and young children as well as muscle contraction, protein and nerve system functions (Mosha*et al*., 2000; Laswai*et al*., 2009). Low amount of calcium in food contributes to weak teeth, poor bone formation and rickets to young children. In adults, low calcium is associated with osteoporosis, especially in advanced ages. In addition, low calcium especially in blood could cause blood to clot leading to heart and muscles problem (Stenberg, 2010).

The CBCFs had iron contents ranging from 1.07 to 5.05mg/100g (Table 15). All samples had iron contents lower than the recommended minimum level of 10mg/100g (TZS 180:2013). Thus, all samples did not conform to the TZS 180:2013 and CODEX standards. With these results, we can conclude that all commercial CBCF produced in Mwanza region were not good sources of iron. Low iron content observed may be contributed by; presence of high content of anti-nutritional factors such as phytates and tannins in the product, poor processing such as dehulling of cereals or use of poor iron sources in formulating the CBCFs. Low amount of iron in cereal-based foods may lead to iron deficiency in infants and young children affecting biological functioning of the body as it is also the major blood cells component for carrying oxygen throughout the body (Mosha*et al*., 2000; Laswai*et al*., 2009). Iron deficiency is the most important cause of nutritional anaemia also called Iron Deficiency Anaemia(IDA), a malnutrition disorder affecting mostly under-five-years children in developing countries (WHO, 2006; Hallberg and Hulthen, 2000). Iron is vital for transporting oxygen in the bloodstream and for preventing anaemia. Iron also serves as an integral part of important enzyme systems in various tissues and as a transport medium for electrons within cells. For growing children, the need for iron increases with rapid growth and expansion of blood volume and muscle mass (Russell, 2001).

Table 15: Mineral content (mg/100g) of commercial cereal-based complementary foods

Processor	Calcium Mean±SD	Iron Mean±SD	Zinc Mean±SD
1	91.01 ± 0.34^{de}	3.47 ± 0.33^{fg}	1.72 ± 0.05^{def}
2	99.35 ± 0.77^{f}	1.24 ± 0.42^{bc}	1.35 ± 0.20^{abc}
3	138.90 ± 0.55^{i}	2.79 ± 0.47^{def}	2.23 ± 0.07^{hi}
4	113.86 ± 0.21^{h}	3.50 ± 0.12^{fg}	2.13 ± 0.12^{ghi}
5	147.45 ± 4.27^{j}	2.04 ± 0.88^{abcde}	1.65 ± 0.12^{cde}
6	109.19 ± 1.37^{gh}	1.86 ± 0.20^{abcd}	1.66 ± 0.17^{cde}
7	59.56 ± 0.58^{a}	1.56 ± 0.18^{abc}	1.65 ± 0.06^{cde}
8	91.39 ± 0.40^{de}	3.14 ± 0.24^{efg}	2.03 ± 0.24^{fgh}
9	71.92 ± 0.25^{b}	1.07 ± 0.11^{a}	1.23 ± 0.13^{ab}
10	91.94 ± 5.73^{de}	2.57 ± 0.65^{cdef}	1.84 ± 0.09^{efg}
11	107.01 ± 0.14^{g}	2.63 ± 1.39^{cdef}	1.44 ± 0.07^{bcd}
12	87.85 ± 0.27^{cd}	4.05 ± 0.06^{gh}	3.24 ± 0.06^{j}
13	63.75 ± 0.29^{a}	1.66 ± 0.13^{abcd}	1.07 ± 0.03^{a}
14	94.28 ± 0.43^{ef}	2.54 ± 0.18^{cdef}	2.46 ± 0.06^{i}
15	83.36 ± 0.72^{c}	2.07 ± 0.10^{abcde}	1.87 ± 0.12^{efg}
16	111.16 ± 0.22^{gh}	4.07 ± 0.92^{gh}	2.43 ± 0.04^{i}
17	76.85 ± 0.33^{b}	1.59 ± 0.31^{abc}	1.14 ± 0.06^{ab}
18	108.29 ± 0.36^{g}	5.05 ± 0.10^{h}	2.30 ± 0.08^{hi}
19	89.25 ± 0.58^{de}	1.67 ± 0.82^{abcd}	1.64 ± 0.09^{cde}
20	98.98 ± 0.21^{f}	2.23 ± 0.05^{bcde}	1.59 ± 0.09^{cde}

Means ± SD. All values are on dry weight basis (dwb)
Means within a column with the same superscript letters are not significantly different ($p<0.05$).

Zinc content in CBCFs ranged from 1.04 to 3.31mg/100g. The majority (85%) had zinc contents lower than 2.42mg/100g recommended by CODEX Standard (2006). The results implied that,majority commercial CBCFs produced in Mwanza region were not good sources of zinc. The low zinc in commercial CBCF may be attributed to raw materials being poor sources of zinc or poor formulation of food during processing. Zinc is required as a component of more than 200 enzymes and as a structural component of many proteins, hormones, hormone receptors and neuropeptides. Zinc also plays a central role in the immune system, affecting a number of aspects of cellular and humoral immunity (Shanker and Prasad, 1998; WHO, 2006). Feeding children with food containing appropriate amount of zinc will help in preventing diarrhoea, promote mental health, psychomotor development and healthy reproductive systems, among other functions (Ahmed *et al.*,2008; diGiloramo and WHO, 2002). Ndibalema(2011) reported that, the breakdown of protease resistant prolamins and the increase of the availability of minerals (e.g. iron and zinc) and essential amino acids (principally Lysine, Tyrosine and Methionine) occurs during germination of cereals. As a precaution, Ndibalema (2011) reported that germination process could lead to loss of some inorganic materials especially during steeping of legumes such as soybeans. Therefore processors should use germination, fermentation and extrusion methods in producing CBCFs so as ensure products with high bioavailable minerals.

4.5.3 Anti-nutrient contents of commercial cereal-based complementary foods

The CBCFs had Tannins level ranging from 0.19% to 3.12% (Table 16). Only 20% of CBCFs complied with TZS 180:2013by having less than 0.3% tannins. Also, trypsin inhibitors in CBCFs ranged from 2.76mg/g to 9.91mg/g (Table 16). Only 25% CBCFs complied with TZS 180:2013 as they had less than 5.0 mg/g of trypsin inhibitors. Therefore, majority (>75%) CBCFs contained levels of tannins and trypsin inhibitors higher than maximum limits of 0.3% and 5mg/g respectively, as recommended by TZS 180; 2013.

Table 16: Anti-nutrient content of commercial cereal-based complementary foods

Processor	Tannins (%) Mean±SD	Trypsin Inhibitors (mg/g) Mean±SD
1	1.17 ± 0.09^{abcde}	8.68 ± 0.10^{ghi}
2	1.85 ± 1.28^{defg}	9.91 ± 0.27^{k}
3	1.98 ± 0.40^{defg}	9.59 ± 0.07^{k}
4	2.08 ± 0.33^{efgh}	9.70 ± 0.09^{k}
5	1.64 ± 0.35^{defg}	8.59 ± 0.37^{gh}
6	1.53 ± 0.39^{cdefg}	8.53 ± 0.12^{gh}
7	2.45 ± 0.13^{gh}	8.77 ± 0.36^{ghij}
8	1.32 ± 0.19^{bcdef}	9.26 ± 0.11^{ijk}
9	0.46 ± 0.06^{ab}	8.92 ± 0.49^{hij}
10	2.35 ± 0.20^{fgh}	9.35 ± 0.31^{jk}
11	0.19 ± 0.05^{a}	5.86 ± 0.06^{e}
12	0.58 ± 0.07^{abc}	4.80 ± 0.09^{d}
13	3.12 ± 0.04^{h}	5.17 ± 0.11^{d}
14	0.27 ± 0.04^{ab}	8.28 ± 0.09^{gh}
15	1.01 ± 0.08^{abcd}	7.16 ± 0.11^{f}
16	0.17 ± 0.04^{a}	3.83 ± 0.14^{b}
17	0.43 ± 0.04^{ab}	4.53 ± 0.18^{cd}
18	0.35 ± 0.09^{ab}	3.87 ± 0.07^{bc}
19	0.22 ± 0.07^{a}	2.76 ± 0.22^{a}
20	1.12 ± 0.12^{abcde}	8.17 ± 0.23^{g}

Means ± SD. All values are on dry weight basis (dwb)
Means within a column with the same superscript letters are not significantly different ($p<0.05$).

Anti-nutritional factors such as trypsin inhibitors, tannins, oxalates,phytatesand polyphenols are the major undesirable constituents which restrict direct utilization of brans in diet (Satinder*et al*., 2011). They can be reduced or eliminated through different techniques such as fermentation, extrusion, germination (malting), stabilization treatments (Ndibalema, 2011; Satinder*et al*., 2011; Laswai*et al*., 2009). Sorghum contains high contents of tannins (Satinder*et al*., 2011).

Processing methods such as soaking, dehulling (for soybeans) and milling didn't have significant reduction in tannins and trypsin inhibitors to permissible levels. Therefore, in order to lower anti-nutrient contents such as tannins in cereal-based complementary foods, the processors should adopt other methods such as malting (soaking, germination and drying), extrusion and fermentation. For example, a study done by Ndibalema (2011) showed extruded products had significantly lower concentrations of tannin compared to the non-extruded products. Ndibalema (2011), the reduction of phytic acid, tannins, some flavonoids and proanthocyanidins has been observed during germination. Germination of sorghum is important for the preparation of supplementary foods with low paste viscosity and high energy density.

Also, by using stabilization treatments (defatting cereal brans using hexane), Satinder*et al*., (2011) reported reduction of tannins (in mg/g) from; 2.89 to 2.22 in wheat bran and 0.70 to 0.58mg/g in rice bran. Also trypsin inhibitors (in TIU/g) were reduced from; 54.2 to 53.0 in wheat bran and 53.8 to 50.4 in rice bran.

4.6 Conclusion

CBCFs produced and marketed in Mwanza were low in protein, fat, energy and mineral (Calcium, Iron and Zinc) contents. On the other hand, the products (CBCFs) had higher moisture, dietary fibre, anti-nutrients (Tannins and Trypsin Inhibitors).

Therefore, CBCF processors should be re-trained on proper formulation and processing of soybeans as it is a good source of protein. Also, processors should include protein-rich sources (e.g. fishes, sardines, edible insects) and vegetables in their food formulations. In addition to the processing methods they used, they should use other processing methods such as extrusion, fermentation and malting (i.e. soaking, germination and drying) methods. This will result to production of CBCFs which are; rich in energy, bioavailable proteins and minerals and with no or permissible levels of anti-nutrients and pathogenic microorganisms.

For sardines and fish consuming communities like in Mwanza region, increased consumption of formulated sardines or fish-cereal-legume complementary foods could improve the nutritional status of their children.

On the other hand, the government authorities should make effective monitoring and inspections to make sure that CBCFs are properly formulated and processed so that they comply with national and/or international standards.Punitive measures should beappended to non-compliance.

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CHAPTER FIVE

5.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Food processors were found to have little or moderate understanding of food hygiene and food safety issues.In most processors, hygienic practices observed during food handling and processing were below acceptable standards. This was revealed by coliform counts higher than the permissible levels.

Majority CBCFs didn't comply with standards in terms of their proximate composition, minerals, anti-nutrients and total coliform counts.

Therefore, adequate and time-to-timetraining onCBCF formulation and processing, food safety and hygiene practices, is highly required to all CBCF processors.

5.2 Recommendations

(i) CBCF processors should be trained on proper food formulations or preparation ingredients and processing of CBCFs so that their productsare of high protein, energy and mineral contents as required for infants and young children growth and prevent diseases such as malnutrition.

(ii) Processors should incorporate processes such as fermentation, extrusion and malting because they have impact on lowering dietary fibre, anti-nutrients and kill some pathogenic microorganisms hence resulting to foods with bioavailable nutrient and pathogen-free.

(iii) Food and nutrition experts should collaborate with SIDO in provision of time-to-time trainings to all CBCF processors on food safety knowledge and good hygiene practices at reasonable costs.

(iv) Government via SIDO and other stakeholders should help CBCF processors to purchase and use solar driers for drying their ingredients or products. Solar driers are convenient, efficient, time saving and prevent physical contaminants such as dust and flying insects as compared to sun drying method.

(v) Government should reduce premise and product registration fees respectively so that all commercial CBCF processors comply with and become recognized by TFDA and other government bodies.

(vi) Inspections and consultations by government officers such as TFDA officials should be done effectively and on time and if possible it should be free of charge to all small scale processors who want to register their premises and/or products.

(vii) Loans with easy terms and conditions should be given to all commercial CBCF processors who conduct processing at their homes. This will facilitate them to have their own processing premises and purchase food grade processing equipments and protective gears so that they can finally comply with TFDA, TBS and WMA requirements and regulations.

(viii) Government and public health stakeholders should promote or facilitate fortification of complementary foods with micronutrients especially vitamin A (boosts disease resistance), zinc (treats diarrhoea), iodine and Iron (prevent IDA) so as to can further reduce infants and child diseases, under nutrition and mortality.

(ix) Further studies need to be conducted in the study area so as to determine the multi-occurrence of various mycotoxins such as fumonisins, aflatoxins, Deoxynivalenol, HT-2 toxin and T-2 toxins from various ingredients used in formulation.

(x) Also, further studies should be done to determine the quantities of CBCFs consumed by children in Mwanza region. This will help to estimate the risks and effects of mycotoxins on child growth and development.

(xi) Further research should be done to assess the efficacy of the CBCF in promoting growth and wellbeing of children by using animal model to evaluate true protein digestibility and protein digestibility corrected amino acid scores (PDCAAS).

APPENDICES

Appendix 1: TZS 180: 2013. Requirements for processed cereal-based foods for infants and young children

SI. no	Characteristics	Requirements
(i)	Moisture content, % by mass, max.	Products ready for use: 4.0 Products for further processing: 8.0
(ii)	Total protein (quality at least 70 % that of casein) % by mass, min	14.0
(iii)	Fat, % by mass, min.	8.5
(iv)	Total carbohydrates, % by mass, min.	60.0
(v)	Total ash, % by mass, max.	5.0
(vi)	Ash insoluble in HCI, % by mass, max.	0.05
(vii)	Crude fibre (on dry basis), % by mass, max.	5
(viii)	Vitamin A, IU/100 g. min.	500
(ix)	Vitamin C mg/100 g, min.	25
(x)	Added Vitamin D, IU/100 g	300 to 800
(xi)	Thiamine (as hydrochloride) mg/100 g, min	0.5
(xiii)	Nicotinic acid, mg/100 g, min	5
(xiv)	Calcium, g/100 g, max.	1.0
(xv)	Phosphorus mg/100 g, min	250
(xvi)	Iron mg/100 g, min	10
	Anti-nutritional factors	
(xvii)	Cyanide mg/Kg, Max	10
(xviii)	Tannin % m/m, Max	0.3
(xix)	Trypsin Inhibitor mg/g, Max	5.0
	Microbiological limits for processed cereal-based foods-dried products requiring cooking before consumption	
(xx)	Coliform bacteria	10/g - 10^2/g
(xxi)	*Salmonella*	0/25g

Appendix 2: Questionnaire administered to commercial cereal-based complementary food (CBCF) processors on assessment of food safety knowledge and hygiene practices

Date: ………………………..

A: Demographic information

Q1. Name of the food processor(s)………………….and address ……………………......

Q2. Gender…………………………… (1) Male (2) Female

Q3. Age of respondent (years)……… (1) Below 20 (2) 20-30 (3) 31-40 (4) 41-50 (5) 51-60 (6) 61 and above

Q4. Marital status (1) Single (2) Married (3) widow

Q7. Education level of respondent…………………………………

(1) Primary (2) Secondary (3) Higher education (diploma and degree) (4) Not been at school

B: Raw materials specifications, storage and processing

Q2. How do you acquire the raw materials?

(1) Produce myself from farm

(2) Buy from farmers

(3) Buy from the market

(4) Others (specify)

Q3. What factors do you consider buying raw materials for processing?

(1) Price

(2) Quality

(3) Both

(4) Others (specify)

Q5. Which packaging materials do you use to store your raw materials? …………………..

(1) Under the floor (no package used)

(2) Sealed containers

(3) Others (specify)………………………..

Q7. Where do you store your raw materials?

(1) Storage room

(2) In the home I'm living

(3) Others (specify)

Q8. Are there any cleaning procedures for the raw materials? …………..

(1) Yes

(2) No

Q9. If yes, how do you clean your raw materials?

(1) Sorting

(2) Washing

(3) Sieving by water

(4) Winnowing

(5) All of the above

(6) Others (specify) …………………………………….

Q10. What methods do you use for raw materials processing?

(1) Thorough washing

(2) Drying

(3) Blending

(4) Milling

(5) All of the above

(6) Others (specify) …………………………………..

Q11. What are the purposes for your food formulation?

………………………………………………………………………………………………………

……………………………………………………………………………………………

Q12. Do you have any spoilage problems with your stored raw materials? (1) Yes (2) No

Q13. What are the possible sources of spoilage?

(1) Insects

(2) Rodents and mites

(3) Moulds

(4) Other microorganisms

(5) Others (specify) …………………………………

Q14. What do you do in case of spoiled raw materials in your store?

(1) Discard the spoiled raw materials

(2) Mix with fresh raw materials

(3) Sell as animal feed

(4) Others (specify) ………..

D: Sanitation and Personnel hygiene

Q1. Where do you carry out food processing?

(1) At home

(2) Special food processing premise

(3) Others (specify)

Q2. Is the site free from sources of contamination/pollution? (1) Yes (2) No

Q3. Are equipment/utensils for handling and processing of food grade? (i.e. smooth, stainless, no accumulation of dirt) (1) Yes (2) No

Q4. Is the processing area smooth with no crevices and with enough ventilation? (1) Yes (2) No

Q5. Are employees/processors medically examined at on first appointment and after every six months? (1) Yes (2) No

Q6. Are there hand washing facilities e.g. soap and running portable water? (1) Yes (2) No

Q7. Are there adequate latrines to accommodate all employees? (1) Yes (2) No

Q8. Do you wear uniforms (protective gears) during food processing? (1) Yes (2) No

Q9. If yes, what is the purpose of wearing uniforms?

(1) For identification

(2) For protection

(3) To be smart

(4) All of the above

(5) I don’t know

Q10. Where do you dispose your solid waste?

(1) Throw them in open space

(2) Communal collection municipal point

(3) Use as animal feeds

(4) Others (specify) ………………………

Q11. What is the source of water used in food processing?

(1) Municipal

(2) From lake

(3) Bore water

(4) Others

Q12. How do you treat water used for food processing?

(1) I don’t treat

(2) Boiling

(3) Adding water treating chemical

(4) Filtration

Q13. When do you hand wash during food processing?

(1) Before handling food

(2) After visiting toilets

(3) After handshaking with other people

(4) After blowing nose

(5) All the above

(6) Others (specify)

Q14. Is there a food processing flow chart? (1) Yes (2) No

Q15. Any work instructions and operating procedures? (1) Yes (2) No

Q16. Is there any processing step which involves pre-cooking, malting and/or fermentation? (1) Yes (2) No

Q17. What precaution(s) do you take during food processing?

(1) Avoid use of contaminated materials

(2) Use clean equipment and personel only

(3) Avoid mixing raw and processed food

(4) Use safe water in cleaning and processing

(5) All the above

(6) Others (specify)………..

Q18. What are the problems or challenges associated with complementary food processing?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

C: Training Knowledge on complementary food processing

Q1. Have you attended any training on complementary food processing? (1) Yes (2) No

Q2. What is your training category?

(1) SIDO

(2) TFDA

(3) SIDO AND TFDA

(4) Others (specify)

Q3. Do any of your training you ever attended included on good hygienic practices (GHP) for complementary food processing? (1) Yes (2) No

Q4. Do government officers visit you to provide advice on complementary food processing? (1) Yes (2) No

E: Business and Product information

Q1. Do you pack your product? (1) Yes (2) No

Q2. If yes, what type of packaging material do you use?

(1) Polyethylene bags

(2) Bottles

(3) Paper bags

(4) Others

Q5. Where do you obtain each of the complementary food formulation (brand)?

………………………………………

Q7. What do you think can make food unfit for human consumption?

……………………………………………………………………………………………

Q8. How would you know the product is unfit for human consumption?

(1) Bad smelling

(2) Damaged package

(3) Expiry date exceeded

(4) Change colour and become mouldy

(5) All of the above

(6) Others (specify) …….

Q10. What would you do when a customer or client returns your product(s) that is unfit for human consumption?

(1) Reject to receive it

(2) Receive and keep it on shelf

(3) Receive and destroy it

(4) Use it as animal feed

(5) Others (specify) ………………………….

Q11. How do you store your product?

(1) Under room temperature

(2) Under controlled temperature and humidity

(3) Others (specify)

Q15. Do you indicate production and expiry dates on product label? (1) Yes (2) No

Q17. Do you indicate batch numbers in your products? (1) Yes (2) No

THANK YOU FOR YOUR COOPERATION!!