Dietary quality assessment of existing practice and development of teff based enriched complementary food in Jimma Town Southwest Ethiopia.

M.Sc. THESIS

BY

Kiros Mezgebo Akelom

January, 2016

Jimma, Ethiopia

Dietary quality assessment of existing practice and development of teff based enriched complementary food in Jimma Town Southwest Ethiopia.

M.Sc. THESIS

BY

Kiros Mezgebo Akelom

Submitted to the School of Graduate Studies

Jimma University College of Agriculture and Veterinary Medicine

In Partial Fulfillment of the Requirements for the Degree of Master of Science (M.Sc.) in Post-harvest Management (Perishable)

Major Advisor: **Prof. Tefera Belachew (MD, M.Sc, PhD)**

Co- Advisor: **Dr. Neela Satheesh (PhD)**

January, 2016

Jimma, Ethiopia

APPROVAL SHEET

Jimma University College of Agriculture and Veterinary Medicine Department of Post-harvest Management

Thesis Submission for External Defense Request Form (F-07)

Name of Student: Kiros Mezgebo Akelom ID No. 06051/06
Program of study: M.Sc. In Post-harvest Management (Perishable)
Title: Dietary quality assessment of existing practice and development of teff based enriched complementary food in Jimma Town southwest Ethiopia.

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

Kiros Mezgebo ______________
Name and signature of student

We, the thesis advisers have evaluated the contents of this thesis and found to be satisfactory, executed according to the approved proposal, written according to the standards and format of the University and it is ready to be submitted. Hence, we recommend the thesis to be submitted.

Major Advisor: Professor Tefera Belachew (MD, MSc, PhD) ____________ ____________
Name Signature Date
Co-Advisor: Dr.Neela Satheesh (PhD) _______________ ____________
Name Signature Date
Internal Examiner (If Depends on the Verdict)
Name ____________________________ Signature _________________Date ______________

Decision/suggestion of Department Graduate Council (DGC)
____

_______________________________________ _________________ ______________
Chairperson, DGC Signature Date

_______________________________________ _________________ ______________
Chairperson, CGS **Signature** **Date**

DEDICATION

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

STATEMENT OF THE AUTHOR

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

Brief quotations from this Thesis are allowable without special permission provided that an accurate acknowledgment of the source is made. Requests for permission for extended quotation from or reproduction of this thesis manuscript in whole or in part may be granted by the Dean or Coordinator of the School of Graduate Studies or Head of the Department of Post-harvest Management when the proposed use of material is in the interest of scholarship. In all other cases, however, permission must be obtained from the author.

Name: Kiros Mezgebo

Place: Jimma University

Date of submission: January, 2016

Signature: _____________

BIOGRAPHICAL SKETCH

The author Kiros Mezgebo was born to his Father Mr. Mezgebo Akelom and his mother Mrs. Embafreshu Haftu in Meswaet, Southern zone of Tigray region on January 21^{st} 1988. He attended elementary and secondary school at Meswaet Primary School from 1996 to 2001 and high school at Tilahun Yigzaw Preparatory School from 2002 to 2005. He joined Haramaya University in 2006 and graduated with Bachelor of Science degree in Food Science and Post-harvest Technology in July 2009. He worked under Addis Ababa City Administration for six months and five years in Department of Post-harvest Management, Jimma University and joined the School of Graduate Studies, College of Agriculture and Veterinary Medicine of Jimma University on September 2013 to pursue his studies for Master of Science in Post-harvest Management.

ACKNOWLEDGEMENTS

I would like to present my heartfelt thanks to Jimma University (JUCAVM) for giving me the opportunity to conduct this study and provided me the internet and library services, and mostly for its continued support and facilitation of schedules, for sponsoring my graduate study, CASCAPE project for providing inputs and covering the whole expenses of the research.

I am deeply thankful to my advisors Prof. Tefera Belachew and Dr. Neela Satheesh for their invaluable and constructive comments, suggestions and guidance starting from the very beginning to the end of the study. My special appreciation also goes to Dr Ali Mohammed, coordinator of PHMIL project in Jimma University College of Agriculture and Veterinary Medicine, funded by DFATD, for sacrificing his time for facilitating and coordinating the project to offer this golden chance to all and for making his valuable strive to set up different trainings given by different scholars and professionals.

My last but not least gratitude goes to Jimma Town Health Extension officers and participants of the interview without whose active participation, support and necessary cooperation, this study would not completed successfully and my sincere thanks go to my parents, friends and for all those who supported me during the research.

LIST OF ACRONOMYS AND ABBREVIATIONS

µg	Micro Gram
µm	Micro Meter
AI	Adequate Intake
ANFs	Anti-Nutritional Factor
BMI	Body Mass Index
CASCAPE	Capacity Building for Scaling Up of Evidence-Based Best Practices in Agricultural Production In Ethiopia
CSA	Central Statistical Agency
db	Dry Base
DD	Dietary Diversity
DDS	Dietary Diversified Score
DFATD	Canadian Department of Foreign Affairs, Trade and Development
DM	Dry Matter
DRI	Dietary Reference Intake
EDHS	Ethiopian Demographic and Health Survey
Eq.	Equation
FAO	Food And Agricultural Organization
FMH	Federal Ministry of Health
FDREMH	Federal Democratic Republic of Ethiopia Ministry of Health
FPCF	Fortified Processed Complementary Food
FVS	Food Variety Score
g	Gram
g/d	Gram/Day
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
kcal	Kilo Calorie
KJ	Kilo Joule
LBW	Low Birth Weight
m.a.s.l	Meters Above Sea Level
MAM	Moderate Acute Malnutrition

MDGs	Millennium Development Goal
mg	Milligram
Mln	Million
MM	Moderate Malnutrition
mm	Millimeter
MT	Metric Tone
NGO	Non-Governmental Organization
PAHO	Pan American Health Organization
PHMIL	Post-Harvest Management to Improve Livelihoods
PLC	Private Limited Company
RDA	Recommended Daily Allowance
RDI	Recommended Dietary Intakes
RNIs	Recommended Nutrient Intakes
SBM	Soybean Meal
SCUK	Save the Children United Kingdom
Sd	Standard Deviation
STD	Sexual Transmitting Diseases
US	United States
UL	Upper Limits
UNICEF	United Nations International Children's Emergency Fund
UNU	United Nations University
USA	United State of America
USDA	United State Department of Agriculture
Vit	Vitamin
WAI	Water Absorption Index
WHO	World Health Organization

TABLE OF CONTENTS

Contents Page

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF TABLES IN THE APPENDIX

Dietary quality assessment of existing practice and development of teff based enriched complementary food in Jimma Town Southwest Ethiopia.

Major Advisor: **Prof. Tefera Belachew (MD, M.Sc, PhD)**

Co- Advisor: **Dr. Neela Satheesh (PhD)**

ABSTRACT

Consumption of variety of foods, diversified diet, and nutritionally adequate and good quality diet is essential for child health. However, the dietary quality of complementary foods in Jimma Town is not yet studied and given more attention. In line with this, Between February and April 2015, 384 under-two children living in Jimma Town were randomly selected and for their food variety score, dietary diversified score; and major nutrients, anti-nutrients and nutrient adequacy of complementary food samples were assessed. Formulations were also made to produce red teff based porridge with composite flour of soybean and papaya powder to evaluate the potential of improving the nutritional and sensory quality of porridge using germinated soybean flour and papaya powder. Eleven formulations of the composite flours were prepared using D-optimal mixture experiment with three ingredients with the help of Minitab Version 16 Statistical Software with ranges of 55-70% for red teff, 20-30% for soybean and 5-15% for papaya The major response variables of nutritional composition, functional propriety, anti-nutritional factor and sensory quality of the product were analyzed. Results showed that the based on 24 hours recall the mean FVS was 7.14 ± 4.07 (range 0 to 18), while DDS was 3.44± 1.75 (range 1 to 8). All complementary food samples collected from respondents were found nutritionally inadequate. Results of nutrient content of formulated porridge showed significance difference (P<0.05) in ash, fat, fiber, protein, carbohydrate, calorie, iron, calcium, zinc, β-Carotene , phytates, tannin, appearance, taste, mouth feel and overall acceptability of the porridge; and water activity, and water absorption capacity on composite flour. High blending ratio of germinated soybean increased fat, protein, gross energy, mineral, whereas papaya increased the carbohydrate value, β-carotene and sensory acceptability of porridge. The overall optimum point (fat 5.27-7.44 %, fiber 2.33-3.6%, protein 12.55-24.22%, carbohydrate 60.08-69.68%, calorie 376.3-385.56 kcal/100g, iron 12.55-34.86 mg/100g, calcium 201.49-293.57 mg/100g, zinc 4.05-5.58 mg/100g, β-carotene 0.608-5.737 mg/g and overall acceptance received hedonic ratings 4.02-4.97) were found in a range of red teff (60-70%), soybean (20-27.5%), and papaya (10-12.5%). The study showed the current status of dietary quality of complementary foods in the Town which helps for intervention of malnutrition; and the red teff, soybean and papaya potential to develop nutritionally enhanced porridge.

Key words: Food variety, dietary diversity, nutrient composition, porridge

1. INTRODUCTION

Dietary diversity refers to an increase in the variety of foods across and within food groups WHO/FAO (1996) capable of ensuring adequate intake of essential nutrients that promote good health (Ruel, 2002). Since no single food can contain all nutrients, Labadarios *et al.* (2011) noted that the more food groups included in daily diet the greater the likelihood of meeting nutrient requirements. With that background, Kennedy *et al.* (2009) argued that, a diet which is sufficiently diverse reflect nutrient adequacy.

Dietary quality and nutrient adequacy assessment is crucial for children health and for monitoring nutrients and energy requirements needed for growth and development (Lakshmi *et al*., 2005; Marriott *et al*., 2012). Dietary diversity (DD) that an individual consumer is commonly used measures for dietary quality. Healthy growth and development essentially need a balanced diet of nutrients and vitamins which includes a variety of foods from different food groups (vegetables, fruits, grains, and animal source foods) (Belachew *et al.,* 2004). Non-diversified diet can have negative consequence on individual health, wellbeing, as this kind of diet is not likely to meet micronutrient requirement (Kant, 2004).

Mostly porridge provide for children is a dish made by boiling grounded, cereal in water, milk, or both, with optional flavorings, usually served hot in a bowl or dish. It may be sweetened with sugar or honey and served as a savory dish. In Ethiopia after birth, a thick, hot porridge called "*genfo"* is eaten by the new mother and less viscous one for children. For a mother, it is believed to help to gain back strength and to heal quickly. Friends and family make the *genfo*. It is made with barley, whole wheat flour, and spiced butter (clarified butter). This study used teff, soybean and papaya as ingredient for developing formulated porridge. Teff, soybean and papaya are very useful for product development.

Teff (*Eragrostis teff* (Zucc.)) is a millet-like, tiny, and prolate spheroid grain (Zewdu and Solomon, 2007) with length ranging from 0.9 to 1.7 mm and width from 0.7 to 1 mm. The proximate composition (db) of teff is reported to be 9.4% – 13.3% protein, 73.0% carbohydrate 1.98% – 3.5% crude fiber, 2.0% – 3.1% fat and 2.7% – 3.0% ash (Bultosa and Taylor, 2004).

Teff is considered to have an excellent amino acid composition, with lysine levels higher than wheat and barley, as well as very high calcium, phosphorous, iron, copper, aluminium, barium, and thiamine (Mengesha, 1966). Teff is also gluten-free, and is gaining popularity as an alternative grain for persons with gluten sensitivity (Bultosa, 2007). Recently there is a growing interest on teff research to explore its potential for nutrition and economic merits such as starch extruded products (Sirawdink and Ramaswamy, 2011; Kebede *et al.*, 2010; Solomon, 2007), a composite with sorghum for *injera* making (Yetneberk *et al.*, 2005) and as a composite with wheat for bread (Mohammed *et al.*, 2012). Teff grain is carbohydrate rich cereal (Bultosa, 2007; Bultosa and Taylor, 2004). Germination also increases nutrient digestibility and mineral bioavailability (Ejigui *et al.*, 2005; Mugendi *et al.*, 2010; Rusydi and Azrina, 2012) which is important for food formulation and product development.

Major nutritionally important components of soybeans are proteins and lipids, some vitamins and minerals, and carbohydrates are major constituents quantitatively. Whole soy foods are also good sources of dietary fiber, B-vitamins, calcium, and essential omega-3 fatty acids (Lokuruka, 2010).

The other component used papaya is a powerhouse of nutrients and is available throughout the year. It is a rich source of three powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fiber. All the nutrients of papaya as a whole improve cardiovascular system, protect against heart diseases, heart attacks, strokes and prevent colon cancer. The fruit is an excellent source of β-carotene that prevents damage caused by free radicals that may cause some forms of cancer. It is reported that it helps in the prevention of diabetic heart disease. Papaya lowers high cholesterol levels as it is a good source of fiber. Papaya effectively treats and improves all types of digestive and abdominal disorders. It is a medicine for dyspepsia, hyperacidity, dysentery and constipation. Papaya helps in the digestion of proteins as it is a rich source of proteolytic enzymes. Papaya contributes to a healthy immune system by increasing resistance to coughs and colds because of its vitamin A and C contents. Papaya included in diet ensures a good supply of vitamin A and C that are highly essential for maintaining a good health (Aravind *et al.*, 2013).

Worldwide, malnutrition is an underlying cause of deaths for more than 3.5 million children under the age of 5 year. Around 13 million infants are born each year with low birth weight (LBW). Fifty five million children are wasted, and of these 19 million are severely wasted. About 178 million children around the world are stunted. Out of the estimated 178 million, 90 percent live in 36 countries, one of which is Ethiopia (Black *et al.,* 2008; Khan and Bhutta, 2010).

Ethiopia has witnessed encouraging progress in reducing malnutrition over the past decade. But, still high malnutrition rates in Ethiopia pose a significant burden in economic and social development (Fottrell *et al.,* 2009). Under-nutrition is one of the main problems causing high child mortality, accounting for 51% of all childhood deaths in Ethiopia (Assegid, 2006). In fact, malnutrition is the underlying cause of 57% of child deaths in Ethiopia (SCUK, 2009), with some of the highest rates of stunting and underweight in the world. Under-nutrition has an enormous impact on health, wellbeing and productivity. Major contributing factors to malnutrition among infants and children are poverty and low purchasing power of the family (Woldemariam and Genebo, 2002). The EDHS 2011 estimated the national prevalence of stunting among children at 44.4 %, the prevalence of underweight at 28.7 % and wasting at 9.7 %. Micronutrient deficiency, also known as “hidden hunger”, because it is less visible to the naked eye, is an additional, yet related issue in Ethiopia. In both 2008 and 2012 the Copenhagen Consensus rated interventions to reduce under-nutrition is first priority among ten of the world’s most important challenges (Copenhagen, 2012). Addressing the problem of under-nutrition is critical for achieving all MDGs.

To tackle the problem of malnutrition in poor nations, a number of targeted interventions have emerged. These include micro-nutrient and vitamin supplementation programs for young children (Save the Children, 2012). A broader approach is the provision of food aid. Ethiopia has a long history of receiving food aid (Gilligan *et al.,* 2009), yet the country’s record of child malnourishment remains poor and rates of malnutrition are among the highest in Africa (Christiaensen and Alderman, 2004).

Therefore, following food-based strategies are key to address hunger and malnutrition, and the desired characteristics of foods should have to include high nutrient density, low bulk property, as well as utilization of low cost and locally-available crops. This will ensure early adoption at home and at the village level (Mahgoub, 1999). Although Ethiopia has a fairly large livestock population, availability of meat and milk for local human consumption is limited, especially in rural areas where wealth index values are in the lower quintiles, according to Demographic and Health Survey report (Central Statistical Agency and ICF International, 2012). Despite children's high requirements for nutrients, their diets in developing countries are mostly comprised of cereals or starchy root crops which are provided in the form of porridge and eaten exclusively that result in deficiencies of key nutrients such as iron, zinc, calcium, riboflavin, vitamin A, and vitamin C (Allen ,2006).

According to Federal Democratic Republic of Ethiopia Ministry of Health (2003) the health problem of majority of the population of Ethiopia emanate from lack of adequate and balanced diet even though Ethiopia is a producer of a variety of agricultural products. Children's are the most affected social group by the problem. In case of Jimma Town, there was not found a study documented on dietary quality of 6-24 month age group but similar study was conducted by Nejat *et al.* (2015) in Jimma Zone on selected local administered district called *Woreda* (*Mana, Dedo and Omo-Nada*) which reported a low DDS. So, this study was intended in assessing dietary quality and nutrient adequacy of under two year children's complementary diet in Jimma Town and to investigate the potential of newly developed red teff based porridge fortified with soybean and papaya fruit powder which is essential in reduction of malnutrition among the most vulnerable group's particularly children aged 6-24 month and also to evaluate the nutritional profile and sensory acceptability of the newly developed red teff based porridge.

The major limiting factor to use soybean is beany flavour characteristics that leads to objectionable, limiting the use of soybean in formulation of infant foods. Anti-nutritional compounds are responsible for the bitterness and beany taste of raw soybean. Such chemicals include trypsin inhibitors; which prevent the action of the breakdown of protein by trypsin; haemaglutinins, which cause agglutination of red blood cells, phosphatidylcholine, which produces an objectionable flavour and bitterness and raffinose which cause flatulence according to Fouzia (2009) was soak, germinate during sample preparation and blend during formulation of the red teff based enriched porridge with papaya powder.

Assessment of dietary quality in 6-24 month age group is very important to recommend appropriate dietary interventions to prevent occurrence of chronic diseases. This study will also help in alleviating and intervention of malnutrition within the community through the development of nutritionally enriched and sensory accepted complementary foods prepared by formulating the blends of red teff flour, soybean flour and papaya powder.

Objective

General objective

- To assess dietary quality of complementary foods in Jimma Town and evaluate the effect of blending ratio of germinated soybean flour and papaya powder blending ratio on the nutritional and sensory quality of red teff flour based porridge.

Specific objectives:

- To asses food variety score, dietary diversity score and nutrient adequacy of infants diet based on 24 hour recall period

- To evaluate consumer acceptance of sensory properties of optimized formulation to produce better quality porridge.

- To determine the optimum formulations composition of for making of porridge with better nutritional value to use as complementary foods for children aged 6-24 month.

2. LITERATURE REVIEW

2.1. Dietary Quality

2.1.1. Food variety

Eating a wide variety of nutritious foods is important in childhood, when growth and maturation are occurring and future eating habits are being established. Variety is a primary factor in the development of lifelong healthy eating behaviors. Consumption of a wide variety of foods make it less likely that excessive or inadequate amounts of any particular nutrient or other food component will be consumed. Food variety can be defined in terms of foods that are biologically diverse or foods that are nutritionally distinct from each other. Variety further refers to choosing a range of items from within each food group, particularly from the plant-based food groups (vegetables, fruits and cereals) (NH and MRC, 2003).

Consuming a diet that consists of a wide range of food items has been shown to increase intake of energy and micronutrients in developing countries (Moursi *et al*., 2008 and FANTA, 2004). Doctors recommended cereals as the first food to be added to infant diets and a healthy diet for adults should have most of its calories in the form of complex carbohydrates such as cereals grain starch. Cereals and millets form the staple food of diets in about 75% of the countries of the world (Khader, 2001).

The recommendation to eat a wide variety of nutritious foods is a cornerstone according to Guidelines National Health and Medical Research Council (2003) and to Healthy Eating (Kellet *et al.*, 1998). Eating a varied diet of foods that are biologically diverse or nutritionally distinct from each other is key to achieving adequate coverage of the essential nutrients (Guidelines National Health and Medical Research Council, 2003 and Nicklaus, 2009). Amongst children increased food variety is associated with better dietary quality indicators (Steyn *et al.*, 2006).

2.1.2. Dietary diversity

Dietary diversity is particular importance to poor populations in developing countries where diets are mainly based on starchy staples, with little or no animal products, fruit nor vegetables (Underwood, 2000 and Ruel, 2003). Dietary diversity, closely related to dietary quality, had strong association with increased longevity and protection against chronic diseases (Kant *et al*., 1995).

Dietary diversity consists of the total number of food groups that contribute to the overall diet of an individual over a reference period (FAO, 2007) and dietary diversity is a better predictor of diet quality than that based on individual food items (Steyn *et al*., 2006). Greater dietary diversity was associated with improved nutrient adequacy in children 4–8 years of age in Kenya (Ruel *et al.*, 2004). Analysis of children aged 6–13.9 months from four developing countries concluded that there was promising evidence for the utility of dietary diversity as an indicator of inadequate nutrient intake (Dewey *et al.*, 2004)

Adequate nutrition during infancy and early childhood is fundamental to the development of each child's full human potential. It is well recognized that the period from birth to two years of age is a "critical window" for the promotion of optimal growth; health and behavioral development. Children are at greatest risk of nutritional deficiency and growth retardation between the age of 6 and 24 months. Around six months of age, introduction of complementary foods, along with sustained breastfeeding is required. Appropriate formulated complementary food helps promote growth, prevent stunting, and increase a child's chances for a healthy. Complementary foods should be varied and include adequate quantities of meat, poultry, fish or eggs, as well as vitamin A-rich fruits and vegetables every day. Where this is not possible, the use of fortified complementary foods and vitamin mineral supplements may be necessary to ensure adequacy of particular nutrient intakes (WHO, 2001).

2.2. Nutritional Quality and Consumption Trends of Soybean, Red Teff and Papaya

2.2.1. Nutritional composition, utilization and consumption trends of soybean

Historians believe that soybean (*Glycine max* (L.) Merrill)) is one of the oldest crops grown by human beings. It originated from Eastern Asia, probably in north and central China (Laswai *et al*., 2005). Soybean is strongly believed to have originated from the orient (Myaka *et al*., 2005). Soybean was first grown in Eastern Asia about 5000 years ago (BIDCO, 2005), about 5000 years after agriculture evolved making it one of the oldest cultivated crops.

Soybean cultivation reached Africa in the late 1800s; although little is known of the countries to which it was first introduced (Shurtleff and Aoyagi, 2007). The next record of cultivation of soybeans in Africa dates from 1903, when they were grown in South Africa at Cedara in Natal and in the Transvaal. In about 1907 soybeans were introduced to Mauritius and to Tanzania, at that time a German colony (Shurtleff and Aoyagi, 2007).

The world production of the soybean seeds (Table 1) in 2009/2010 growing season carried out about 260.6mln ton and the same importance producers of seeds and soybean meal are USA, Brazil , Argentina as well as China, which produced about 87% total quantity of soybean seeds. The main export countries of the soybean seeds are USA (about 44%), Brazil (about 33%) and Argentina (about 11%) and main importer are China (about 38%) (Rynek , 2010).

Table 1: Global production of soybean seeds (2009/2010)

Country/Region	Production, Mln ton
United States of America	94.8
Brazil	68,0
Argentina	54.5
China	14.5
India	9.1
Paraguay	6.7
Other	13.00
Total	260.6

Sources: Rynek, 2010

Soybean is cultivated in sub-Saharan Africa to a very limited extent (Laswai *et al*., 2005; Shurtleff and Aoyagi, 2007). During the last decade or so, the African continent accounted for 0.4% to 0.6% of the world's total production of soybean, the main producers being Nigeria (437 000 MT global production), South Africa (221 000 MT), Uganda (166 000 MT), Zimbabwe (83 000 MT), and Rwanda. Overall, about 19 African countries appear in the world soybean production statistics. These countries and the proportion (%) of African soybean production that each accounts for are: Nigeria (48.9%), Uganda (16.8%), South Africa (14.9%), Zimbabwe (8.4%), Ethiopia (2.7%), Rwanda (2.0%), Egypt (1.7%), and DRC (1.4%). Others are: Cameroon (0.8%), Benin (0.7%), Cote d"Ivoire (0.3%), Liberia (0.3%), Burkina Faso (0.3%), Zambia (0.2%), Gabon (0.2%), Tanzania (0.2%), Morocco (0.1%), Burundi (0.0%), and Madagascar (0.0%) (FAO, 2008).

Soybeans appear in various colours: black, brown, blue, green and yellow. Soybean is an important crop, providing primarily a high content of oil and protein. At present soybean is one of the most important oil and protein crops of the world. Soybeans contain 30 to 45% protein with a good source of all essential amino acids. The protein content of soybean is about 2 times of most other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk (Liu, 2004).The oil and protein content together account for about 60% of the weight of dry soybean flour; protein 38 % and oil 22 %. The protein content is high quality. It contains all the essential amino acids. With the exception of the sulphur containing amino acids, cysteine and methionine, in which soybean is deficient, other essential amino acid are present in sufficient quantities; noteworthy is the high amount of lysine which distinguishes soybean from other legumes and cereals. Soybean has 3% lecithin, which is helpful for brain development. Soybean seed contains up to 23% oil and can be more widely utilized than most of the food legumes. It is used as human food, for livestock feeds, as oil and for various industrial purposes (Myaka *et al*., 2005).

On average dry soybeans contain about 35% carbohydrates. The insoluble carbohydrates in soybeans include cellulose, hemicellulose, pectin and a trace amount of starch. Soybeans contain both water-soluble and fat-soluble vitamins. The water-soluble vitamins are mainly thiamine, riboflavin, niacin, pantothenic acid, and folic acid. Soybeans also contain vitamin C but the amount is negligible in mature soybeans, although it is present in measurable amounts in both immature and germinated seeds. The fat-soluble vitamins in soybeans are vitamins A and E, with essentially no vitamins D and K. Vitamin A is mainly present as the provitamin β-carotene and the content is negligible in mature seeds. As in most legumes, there is an abundance of potassium but not sodium, and soybeans are a very good source of phosphorus, although a significant proportion of it is present as phytic acid phosphorus which has only partial biological availability. Soybeans are also a good source of calcium and magnesium but poor in iron. The amounts of zinc, iron and iodine are minimal (Liu, 2004).

Soybean has an exceptionally high content of fat. The quality of fat is also good. On the other hand soy also contains high levels of antinutrients, especially phytate. There is a lack of studies on the potential negative effects of the antinutrients in soy in malnourished infants and young children (Hoppe *et al,* 2008). Soybean can contribute to poverty reduction and the eradication of malnutrition among children and expecting mothers (Myaka *et al*., 2005). Soybean also has one of the lowest levels of saturated fat among vegetable oils (BIDCO, 2005).

It is also rich in calcium, phosphorous and Vitamins A, B, and D, it has been referred to as the protein hope of the future. Moreover, isoflavones contained in soybeans are effective cancer-preventive agents for lowering risks of various cancers disease. Evidence also points to the beneficial effects of soybean isoflavones in the prevention of cardiovascular. There is the need to develop a different approach to offer the weary consumers the opportunity to feed on improved formulations with substantive health benefits from soybean combinations. A functional food, which combines many nutritional benefits of foods supplemented with soybeans, has been proposed to cater for a set of consumers whose health has been compromised such as those suffering from protein-energy-malnutrition, diabetes and obesity (Gomez *et al.,* 2003).Table 2 shows the high protein content of different parts of soybean. The importance of soybean is based on its high quality protein content compared to other grain legumes (common beans, groundnut, peas, and pigeon peas), livestock products (meat, milk, and egg), cereal products (wheat flour, finger millet flour, and maize flour), root and tubers products (cassava flour, round potatoes, and sweet potatoes) and plantain and banana.

Table 2: Protein, fat, carbohydrate and ash content (db %) in different parts of soybean

Component or part of soybean	Protein	Fat	Carbohydrate	Ash
Whole	40	20	34	4.9
Hull	43	23	29	5.0
Cotyledons	8	1	86	4.3
Hypocotyls	41	11	43	4.4

Source: Oshodi and Adeladun,(1993).

Soybean has high commercial value and contains all the amino acids required by the human body except methionine that can be found in cereals such as maize (Osho, 1995).Content of essential amino acids of soybean are shown in Table 3.

Table 3: Contents of essential amino acids in soybean products

Amino acids	Soybean seeds, % of DM	Soybean meal 44% CP, % of DM	SBM, g/16g
Arginine	2.45	3.49	6.79
Cystine	0.45	0.66	1.57
Histidine	1.0	1.21	2.58
Isoleucine	1.76	2.15	4.24
Leucine	2.2	3.66	8.21
Lysine	2.5	2.99	6.49
Methionine	0.5	0.6	1.50
Phenylalanine	1.6	2.35	4.93
Threonine	1.4	1.89	3.99
Tryptophan	0.51	0.66	1.05
Valine	1.5	2.24	5.22

Source: Banaszkiewicz, 2000

Soybean utilization options include: (i) weaning food, (ii) roasted soybeans (ingredients in traditional confectionery products and snacks), (iii) immature whole green soybeans (as vegetable), (iv) germinated soybean and soybean sprouts (as vegetable), (v) dehulled whole beans full fat flour (bakery and dietetic food), (vi) very finely ground full fat flour (as spray-dried milk alternative), (vii) oil source (shortening, margarine, cooking oil and salad dressing, paint, varnishes, printing inks, lecithin (Ahima, 2011), oil highly digestible (CGIAR, 2001), and (viii) soy meal for animals (soybean cake) (Laswai *et al*., 2005).

Processed soybeans have been widely used in many countries for many years as a source of energy and protein. Lipid fraction of the soybean seeds contains about 99% of triglycerides, in which content of polyunsaturated fatty acids (linoleic and linolenic) and unsaturated oleic acid is high shown in Table 4. In the lipid fraction of soybean seeds the fatty acids content about 80%, from what about 50% it is the linoleic acid (Zulu, 2005).

Table 4 : Fatty acid composition of soybean seeds and oil

Fatty acids	Soybean seeds % of DM	Soybean oil %
Palmitic	1.44	7-12
Stearic	0.54	2-5
Oleic	3.15	19-34
Linoleic	6.48	48-60
Linolenic	0.72	2-10
Arachidic	0.04	< 1.0

Sources: König *et al.,* 2004

The concentration of mineral components in the soybean seeds depend on different factors and the most of all on origin, conditions of tillage, variety and technological process. The soybean products contain the considerable quantities of phosphorus and potassium indicated in Table 5.

Table 5: Content of minerals in seeds and soybean products, g/kg

Mineral components	Soybean seeds	Soybean meal		SBM
		Mechanical extracted (cakes)	Solvent extracted 44% CP	
Ca	2.62	2.96	3.12	2.71
P	5.70	6.64	6.37	5.14
Mg	2.80	2.84	2.72	2.27
K	15.93	20.28	19.85	6.66
Na	0.29	0.33	0.18	0.30

Sources: Van Eys *et al.,* 2004; Banaszkiewicz, 2000

There are a number of seeds subjected to dehulling during processing basically to improve the appearance and quality of the final products. These legumes, which include soybean, are one of these products. Unlike some the seeds, removal of the hulls in legumes is not necessarily a requirement before consumption but to retain the fiber. While efforts have been made on the development of appropriate dehulling methods and techniques (Raji and Akaaimo, 2005), there is a need to investigate the effect of these processes on the quality of the final products.

The proximate composition of undehulled and dehulled soybean to moisture content variation is presented in Tables 6 and 7. Protein, fat, ash and fibre were decreasing with a decrease in moisture while carbohydrate increased. For the undehulled samples, significant differences between the values of protein occurred only at moisture contents below 10.2%. The proximate composition of dehulled soybean flour sample obtained at different moisture content, presented in Table 7, follows the same pattern as that of undehulled samples presented in Table 6, only that the dehulled sample has higher protein, fat and carbohydrate content and less ash and fiber. There is significant difference between protein contents below 10.2% moisture content. The rate of decrease of protein at lower moisture content is faster than at higher moisture content. It was observed that the dehulled samples have higher values than the undehulled at the same moisture level. This can be attributed to inclusion of bran in the undehulled samples which resulted in reduced percentage composition of endosperm. Protein is contained in the endosperm. The fibrous portion of soybean might have broken down to simpler non fibrous causing reduction in the bulk of fiber content of soy flour. Maillard reaction might have been responsible for reduction in protein, in the presence of heat; proteins (amino acids) would react with carbohydrate to form melanoidins (Baltes, 1982).

Table 6 : Proximate composition (in %) of flour from undehulled soybean at different moisture content.

MC	Protein	Fat	Fibre	Ash	CHO
19.8	37.46	23.61	8.64	8.04	12.25
17.4	36.38	23.08	8.12	7.92	14.8
15.5	35.43	22.56	7.49	7.66	16.86
13.8	34.63	21.72	7.19	7.48	18.98
12.4	34.02	20.54	6.87	7.36	21.21
11.4	33.42	19.62	6.63	7.41	22.72
10.2	32.51	18.24	6.72	7.57	24.92
9.4	29.77b	16.94	6.53	7.23	28.16
8.7	25.14	16.63	6.59	6.81	28.2
8.2	20.86	16.06	6.44	6.35	30.2

Source: Raji and Famurewa, 2008

Table 7: Proximate composition (in %) of flour from dehulled soybean at different moisture content**.**

MC	Protein	Fat	Fibre	Ash	CHO
22.1	40.73	26.3	7.87	7.34	17.76
18.9	40.04	24.92	7.28	6.58	21.38
16.2	39.44	23.51	6.42	6.54	24.09
14.1	37.72	23.45	6.22	6.32	24.29
12.4	36.53	22.98	6	5.97	26.52
11.2	35.76	22.14	5.78	5.8	28.52
10.2	34.64	22.25	5.63	5.62	31.86
9.2	31.12	21.27	5.36	5.36	36.89
8.5	28.48	20.62	5.2	5.28	40.42
8.1	24.53	19.9	5.03	5.04	44.5

Source: Raji and Famurewa, 2008

It can be concluded that in both dehulled and undehulled samples, flour yield was increasing as moisture content was reducing, showing that flour yield is not a function of hull present. Acceptability and proximate composition are however affected by the presence of hull. Generally the dehulled samples gave higher yield and better nutritive composition except for ash and fiber (Raji and Famurewa, 2008).

2.2.2. Nutritional composition and consumption trend of teff

Teff (*Eragrostis tef (Zucc.) Trotter*) is a unique durable crop grown over a wide range of environmental conditions in Ethiopia and has been utilized as food and supplements for majority of the human diet in Ethiopia (Sirawdink and Ramaswamy, 2011). It is as nutritious as major staple cereals like wheat, rice, oats and barley and even better in some aspects, containing more calcium, zinc, iron and potassium and being high in dietary fiber. It is a rich source of vitamins and is considered to be an excellent source of essential amino acids with higher levels than wheat and barley (Gebremariam *et al.,* 2012). The grain is too small, with average length and width of 1.20 and 0.75 mm respectively to separate the germ from the bran hence the germ and the entire seed is consumed. This results in a better nutrition provision and higher fiber content. The whole meal is used for making pancake like bread called *injera*. The flour can also be used to make other food products such as *qitta* (unleavened bread), porridge and home brewed traditional beverages like “*tella*” (local bear) and “*katikalla*”(distilled liquor). Unlike other cereals (wheat, maize, rice and barley) processed at an industrial level, diversified utilization of teff has been limited which could be attributed to its uniqueness to Ethiopia and an age old processing carried out at a house hold-level (Bultosa, 2004; Zewdu and Solomon, 2007),

Teff is mainly grown in Ethiopia and Eritrea has superior nutritional quality. It contains 11% protein, 80% complex carbohydrate and 3% fat. It is an excellent source of essential amino acids, especially lysine, the amino acid that is most often deficient in grain foods. Teff contains more lysine than barley, millet, and wheat and slightly less than rice or oats. Teff is also an excellent source of fiber, iron, calcium content, and high content of phosphorus, copper, and thiamine and other essential minerals found in an equal amount of other grains. Teff is nearly gluten-free, and is gaining popularity in the whole food and Health food industry in the U.S. as an alternative grain for persons with gluten sensitivity. Teff is very useful for persons with Celiac Disease (Doris, 2002).

Red teff, the least expensive form and the least preferred type, has the highest iron content. In persons living in areas of the country where consumption of red teff is most prevalent, hemoglobin levels were found to be higher with a decreased risk of anemia related to parasitic infection. As studies of the increased health benefits associated with high iron contents in red teff become elucidated, there is more acceptance of this grain in society. Today in Ethiopia, red teff is becoming more popular related to its increased iron content. The data composition tables available were not able to differentiate the iron content between red and white teff. The average iron content of teff is 62.71mg/4oz grain (Bultosa, 2002).

Teff starches had slightly lower hydrolyzed lipids (mean 8.9 mg/g) than maize starch (9.9 mg/g). The crude fat (ether extract) content of the teff starches (mean 0.29%) was relatively low as compared to that of maize starch (0.34%). The crude fat of that of grain teff is around 2% (db) (Nyakabau *et al.*, 2013). Crude fat (petroleum ether extract) consist mostly of non-starch lipids i.e., it is not endogenous to the starch. The low crude fat content in teff starch is most probably related to the low crude fat content of the grain. Bultosa (2002) found that the teff total starch lipid was higher than that of pearl millet (5.0 mg/g) and slightly higher than that of rice (7.6 mg/g).

In the carbohydrate fraction of grain teff, starch is the largest proportion (Umeta and Faulks, 1988). The mean amylose content of the teff starches varies from 28.2 to 28.4, depending of the method used for the determination, and on the teff variety analysed (Bultosa, 2002).

The grain of teff has a very good nutritive value, with grain protein content (10-12%) similar to other cereals. Besides providing protein and calories, teff is a good source of minerals, particularly iron. It has very high calcium content and contains high levels of phosphorus, copper, aluminium, barium and thiamine (Hager *et al.*, 2012). But the bigger nutritional importance that teff has, is the lack of gluten in the grain. This made it useful for patients with the celiac disease.

2.2.3. Nutritional composition and consumption trend of papaya

Papaya (*Carica papaya*) is native of tropical America but has now spread all over the tropical world. The fruit is usually cylindrical, large (weighing 0.5-2.0 kg), and fleshy. The flesh is yellow-orange, soft, and juicy. The central cavity contains large quantities of seeds that comprise about 15% of the wet weight of the fruit (Desai and Wagh, 1995).

In terms of nutrition, fruits are very good sources of several vitamins, mineral salts and dietary fiber, all of which are essential for good health. Papaya known as the wonder fruit of the tropics can provide the essential protective nutrition for the poorest section of the society. Papaya is nutritious and has much therapeutic value (Directorate of Extension, 2000). Papaya is unique among the fruit crops because of its high yielding potential and year round fruiting behaviour (Singh *et al.*, 1998). It is a good medicine for constipation and urinary disorders (Joseph, 2002).

Papaya is a common man’s fruit, which is reasonably priced and has a high nutritive value. Papaya has more carotene compared to other fruit such as apples, guavas, sitaphal and plantains, which help to prevent damage by free radicals. Unripe green papaya is used as vegetable, it does not contain carotene but all other nutrients are present (Table 8). It is also used in salads, pies, sherbets, juice and confections. Papaya when consumed regularly will ensure a good supply of vitamin A and C, which are essential for good health especially for eyesight and can help to prevent early age blindness in children. The fruit is rich source for different types of enzymes (Krishna *et al.*, 2008).

Table 8: Nutritive value of 100g of ripe and unripe papaya fruits

Constituents	Ripe papaya	Green papaya
Protein	0.6 g	0.7g
Fat	0.1g	0.2g
Minerals	0.5g	0.5
Fiber	0.8g	0.9g
Carbohydrate	7.2g	5.7g
Energy	32 kcal	27kcal
Total carotene	2740 µm	0
Beta carotene	888 µm	0
Mineral	0.5g	0.5g

Source: Krishna *et al.*, 2008

The fruits are low in calories and rich in natural vitamins and minerals. Papaya places the highest among fruits for vitamin C, vitamin A, riboflavin, folate, calcium, thiamine, iron, niacin, potassium and fiber shown in Table 9. The comparative low calorie content (32 kcal /100 g of fruit) makes it a favorite fruit for obese people who are on a weight reducing regime. Also, papaya ranks the highest per serving among fruits for carotenoids, potassium, fiber, and ascorbic acid content (Liebman 1992; 2008). Papaya contains 108 mg ascorbic acid per 100g of fresh fruit, which is higher than oranges (67 mg/100 g). Papaya fruit is highly appreciated world-wide for its flavour, nutritional qualities, digestive properties and serotonin content (Fernandes *et al.*, 2006). Papaya is a good source of serotonin (0.99 mg/100 mg), which has been associated with enabling the gut to mediate reflex activity and also decreasing the risk of thrombosis (Santiago *et al.*, 2011).

Table 9: Nutritional value of fresh (Matured) papaya per 100 g

Nutrient	Amount
Protein	0.61 g
Fat	0.14g
Calcium	24 mg
Carbohydrate	9.81 g
Dietary fibre	1.8 g
Energy	163 kJ
Vitamin A	328 µg
Thiamine(vit B1)	0.04 mg
Riboflavin (vit B2)	0.05 mg
Niacin (vit B3)	0.338 mg
Vitamin B6	0.1 mg
Folate (vit B9)	38 g
Vitamin C	61.8 mg
Calcium	24 mg
Iron	0.10 mg
Sodium	3 mg
Magnesium	10 mg
Phosphorus	5 mg
Potassium	257 mg

Source: USDA, 2011

Various pharmacological actions and medicinal uses of different parts of the papaya are reported with the crude extracts and different fractions from crude extracts of different parts of papaya. They have been used as traditional medicine for the treatment of various diseases. Many biologically active phytochemical from different parts of papaya tree (latex, seed, leaf, root, stem, bark and fruit) have been isolated from papaya and studied for their potency Table 10. Antifungal chitinase has been genetically cloned and characterized from papaya fruit. Classified a class IV chitinase based on amino acid sequence homology with other plant chitinase, the recombinant chitinase also exhibit antibacterial activity. Commercially available spray dried latex of papaya fruits has isolatable chamopapain which exhibit immunological properties (Krishna *et al.,* 2008).

Table 10: Medical function of different parts of papaya plant

Part	Medicinal uses
Latex	Anathematic, relieves dyspepsia, cures diarrhoea, pain of burn and topical use, bleeding haemorrhoids, stomachic , whooping cough
Ripe fruit	Stomachic, digestive, carminative diuretic, dysentery and chronic diarrhoea, expectorant, sedative and tonic, relieves obesity, bleeding piles, wound of urinary tract, ringworm and skin disease psoriasis
Unripe fruit	Laxative, diuretic, dried fruit reduces enlarged spleen and liver, use snakebite to remove poison, abortifaciant, anti- implantation activity and antibacterial activity
Seeds	Carminative, emmenagogue, vermifuge, abortifaciant, counter irritant, as paste in the treatment of ringworm and pasoriasis, anti-fertility agent in malic
Seed juice	Bleeding piles and enlarged liver and pectoral properties
Root	Abortifacient, diuretic, checking irregular bleeding from the uterus, piles, antifungal activity
Leaves	Young leaves as vegetable, Jaundice(fine paste), urinary complaints and gonorrhoea (infusion) dressing wound fresh leave, antibacterial
Flower	Jaundice, emmenagogue, febrifuge and pectoral properties
Steam bark	Jaundice, anti-haemolytic activity, STD, store teeth(inner bark), anti-fungal activity

Source: Krishna *et al.*, 2008

2.3. Effect of Processing on Nutrient Composition and Anti-Nutritional Factors (ANFs)

Plants have high amounts of essential nutrients, vitamins, minerals, fatty acids and fiber (Gafar and Itodo, 2011). Plant food contain high amounts of “anti-nutritive” factors (ANF) (Bardocz *et al,* 1996). The anti-nutritional factors (ANFS) may be defined as those substances generated in natural food stuffs by the normal metabolism of species and by different mechanisms (e.g. inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition (Kumar, 1992).

The most important anti-nutritional food constituent in diets in low-income countries in terms of negative nutritional impact is phytate, primarily contributed from cereal staples and secondarily from legumes and other plant foods. Phytate forms insoluble complexes with a range of nutrients, and thereby inhibits the absorption of protein and minerals, in particular iron, zinc and calcium. Another important anti-nutritional factor in foods having negative nutritional impact in low-income countries is polyphenol compounds present in different forms in fruits, vegetables, pulses and cereals. One of the most widespread groups of polyphenols with anti-nutritional properties is soluble tannins. The anti-nutritional effect of polyphenols is complex formation with iron and other metals, and precipitation of protein, which reduces absorbability. On the other hand, it has recently been discovered that some ant- nutrients may have beneficial effects when ingested in small quantities and can even help in the prevention of certain illnesses such as cancer and coronary disease (Muzquiz, 2004). Tannins are reported to have possible anti-carcinogenic effects (Butler, 1989).

The anti-nutritional factors can be eliminated or reduced by cooking or with other simple technologies (Vidal *et al*., 1994; Urbano *et al*., 1995) although processing will improve the nutritive utilization of protein. There are the traditional processing techniques include: (i) non-heat processing such as germination, de-hulling or fermentation and (ii) heat processing, such as cooking at atmospheric pressure, autoclaving or roasting. Most ANFs are heat liable, such as α-galactosides, protease inhibitors and lectins, so cooking would eliminate any potential effects before consumption. On the other hand, tannins, saponins and phytic acids are heat-stable, but can be reduced by de-hulling, soaking, germination and/or fermentation (Muzquiz and Wood, 2007). Hence, processing methods such as soaking, germination, fermentation, cooking and addition of enzymes have been reported by many researchers to alleviate the effect of ANFs and to improve the nutritional value of cereals and legume seeds (Sokrab *et al*., 2012; Mohamed *et al*., 2010, Mohiedeen *et al*., 2010, Osman *et al*., 2010 and Idris *et al*., 2007). Mainly, cooking and germination play an important role as they influence the bio-availability and utilization of nutrients and also improve palatability which incidentally may result in enhancing the digestibility and nutritive value (Oboh *et al*., 2000; Ramakrishna *et al*., 2006).

2.3.1. Soaking

Both whole grain and flours can be soaked. Usually the process lasts for 1-2 days, but soaking for some hours may also have beneficial effects, like reduction of phytate content. Soaking of flours results was in diffusion of water-soluble minerals, but also a reduction in the content of phytate. The extent of the phytate reduction depends on the type of cereals or legumes, pH, and length and conditions of soaking. Soaking of unrefined maize flour can reduce phytate content by up to 50%, and most of this reduction takes place during the first few hours of soaking (Hotz and Gibson, 2001).The content of other anti-nutrients such as saponins, trypsin inhibitors and polyphenols is also reduced during soaking (Mensah and Tomkins, 2003). If grains are soaked before milling it can improve flavour. If unsafe water is used for soaking enteropathogen microbes might multiply and result in a contaminated product. It is therefore important that such foods are boiled long enough to secure that pathogens are killed.

2.3.2. Germination and Malting

Legumes and grains can be soaked in water for up to 24 hours and allowed to germinate or sprout (i.e.; grow a new shoot). Grains are then dried, dehusked and milled. In this malting process some of the starch in the grains is degraded into sugars, protein quality and digestibility is improved and the content of riboflavin, niacin, and vitamin C is increased and the content of anti-nutrients is reduced. In one study the content of phytate in maize flour was reduced by 46% after germination (Mensah and Tomkins, 2003). Malting produces α-amylase which converts starch into sugars and thereby makes the porridge or gruel less thick. This is of special importance for children with moderate malnutrition as it allows more cereal or legume to be added thereby increasing the energy and nutrient density. Several studies have shown that the energy and nutrient intake can be improved if germinated amylase-rich flour is used for porridges or if some of this flour is added to porridge (Owino *et al.*, 2007). Soaking, which is part of germination and malting processes, can add pathogens to the product, so it should be ensured that the gruel or porridge is heated sufficiently before consumption (Mensah and

Tomkins, 2003). In conclusion germination and malting results in a number of beneficial effects of which the most important are increased energy and nutrient content and reduced levels of anti-nutrients.

2.4. Functional Properties

Some functional properties can be interpreted as a result of the thermodynamically favorable protein-water interactions (wetability, swelling, water retention, solubility) or unfavorable (foaming, emulsification). The interactions of protein with water are important in relation to dispensability, water absorption and binding, swelling, viscosity, gelation and surfactant properties as these properties influence the important functions of proteins in meat, bakery and beverage systems (Moure *et al.,* 2006).

Water activity speed up chemical/biochemical reactions (e.g. the Maillard reaction) increasingly take place and possibly change the microbiological stability, chemical stability, content of proteins and vitamins, color, taste and nutritional value, stability of the compound and durability, storage and packing, solubility and texture (Banu, 2002; Nicolau, and Turtoi, 2006, and Tatarov, 2007).

According to Omueti et al.(2009), Water holding capacity is the ability of a product to associate with water under a condition where water is limiting. The higher WAC of commercial diet compared with other diets may be attributed to the proportion of hydrophilic and hydrophobic amino acids in the protein and relative amount of carbohydrates. The more hydrophilic amino acids and the polysaccharide constituents, the more water make the diet absorb and bind (Otegbayo *et al.*, 2000). It is desirable for making thinner gruels with high Caloric density per unit volume. Sprouted and un-sprouted combinations, mixes that contained higher amount of corn flour showed higher WAI, which was due to their higher amylose/amylopectin ratio (Nicole *et al*., 2010).

Water holding capacity is the ability to retain water against gravity, and includes bound water, hydrodynamic water, capillary water and physically entrapped water. Germination, fermentation, soaking or thermal treatments (toasting/autoclaving) significantly improves water absorption capacity (Moure *et al.,* 2006). Proteins swell as they absorb water and it is an important functional property in foods like processed meat, doughs and custards where the proteins should imbibe and hold water without dissolving and concurrently impart body, thickening and viscosity. A highly soluble protein is required in order to obtain optimum functionality required in gelation, solubility, emulsifying activity, foaming and lipoxygenase activity (Riaz, 2006). Soluble protein preparations are easier to incorporate in food systems, unlike those with low solubility indices which have limited functional properties and more limited food uses.

Bulk density is a measure of heaviness of flour (Nicole *et al*., 2010) and is generally affected by the particle size and the density of the flour. It is very important in determining the packaging requirement, material handling and application in wet processing in the food industry (Adebowale *et al*., 2005).

The local formulated diets had significantly lower bulk density than the commercial product produce in food plants. This indicates that the gruel made from the formulated diets will have a lower dietary bulk. This is important in complementary foods because high bulk density limits, the caloric and commercial diet in take per feed per children and infants are sometimes unable to consume enough to satisfy their energy and commercial diet requirements (Omueti *et* al., 2009).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

This study was conducted at Jimma Town located in Oromia National Regional State, in Jimma Zone. Jimma Town is located at about 346km, Southwest of Addis Ababa. Its astronomical location is 7º 4’ North Latitude and 36º 5’ East Longitude. While, the laboratory analysis were conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) in Post-harvest Management laboratory and Debrezit Agricultural Research Center soil and plant research laboratory.

3.2. Field Survey

3.2.1. Sample size determination and sampling procedure

This cross- sectional study was carried out from February 12-30, 2015 in Jimma Town. The Town has a total estimated population of 121, 432 people living in 17,078 households-projected from 1994/6 population and housing census residing in three administrative divisions (‘‘kefitegnas’’). At the time of the study, the town had 21 “kebeles” (the smallest unit of local administration). One kebele was randomly selected from each of the three administrative divisions ‘‘kebeles’’ and multi stage stratified simple random sampling method was used to identify the study household infants. In the case where there were more than one eligible individual in the household, a lottery method was used to pick one from each household. In the event that there was no eligible infant in the selected household, the next door was visited.

The sample size was calculated using probability proportional to sample size-sampling technique using the formula shown in Eq.1 developed by Cochran (1977) for descriptive cross-sectional study employing expected prevalence of consuming quality diet to be 50% as there was no prior study on the subject, at 95% confidence level and 5% margin of error giving a sample size of 384.

$$n_o = \frac{Z^2\ x\ (p)(1-q)}{c^2} \longrightarrow n = \frac{n_o}{(1+\frac{n_{o-1}}{N})} \text{--------------------Eq.1}$$

Where;

n_o = the desired sample size Cochran's (1977), when population is greater than 10,000

n = Finite population correction factors (Cochran's formula, 1977), when population is less than10000

Z = is 95% confidence level i.e.1.96

P = 0.5 (percentage picking a choice, expressed as decimal used for sample size needed)

q = 1-P i.e. (0.5)

N = Total number of population

C = Confidence interval (0.05)

Data were collected using six health extension workers in each selected kebeles together with the researcher using a pre-tested questionnaire. All interviewers were working in the health care area and/or had previous experience with similar surveys. They all can speak Amharic and Oromiffa. The data collectors were given half day training on the interview techniques and on the questionnaire before data collection. During interviewer training, all sections of the survey, i.e. general questionnaire, 24-hour recall were explained and discussed.

A 24-hour recall provides information on the respondent's food intake during the 24 hours preceding the interview or during the day preceding the interview. Before starting the recall, the mother was asked, whether the last day was a usual day concerning the child's diet, e.g. did the child eat less due to illness or more/different food due to holiday. The mothers (care takers) were asked to whether they had fed their children each of those (predefined) food items over the last 24-hour starting from the previous day when the child woke up to the present morning before it had its first meal of the day.

First, a list of all the foods and drinks consumed was obtained. Every food was described as detailed as possible, e.g. Injera made from sorghum and teff. For composite dishes, a list of all ingredients was recorded. The recall was read all over again to the mother and she was asked, whether she had anything to add, like snacks or drinks.

To determine dietary diversity score, 24-hour recalls were conducted with mothers regarding their children's intake. This score was calculated using food categories based on the FAO guidelines for measuring individual dietary diversity (FAO, 2008). Each of the following eight food categories were assessed, and presence of a food in each was scored as 1: (a) grains, roots and tubers; (b) vitamin A-rich plant foods;(c) other fruits or vegetables; (d) meat, poultry, and sea food; (e) egg; (f) pulses/legumes/nuts; (g) milk and milk products, and (h) food cooked in oil/fat.

So a consumption of each food item in food groups was given the value of 1 if it was consumed at least once in a 24-hour time and a value of zero if not. The dietary diversity score (DDS) was calculated as a composite variable by summing up the scores of the eight food groups, which were either one or zero. This gives a score between 0 to 8 and median score 4.0 was used as cut-off point to dichotomize dietary diversity. Accordingly, those who had total dietary diversity score above 4 were labeled as having had diversified diet and the rest as having had non-diversified diet.

Infant's diet samples were collected using polyethylene plastic bottles with in ice box from 30 mothers who had 6-24 months aged child. Those samples which had the same ingredient were mixed up and were immediately dried on the same day at $60^{o}C$ using hot air oven. Then, the dried complementary food samples were stored at $4^{o}C$ until the samples were analyzed to quantify, moisture, ash, macronutrients protein, crude fat, carbohydrates, crude fiber , energy, micronutrients β-carotene, calcium, iron and zinc because some of these are the nutrients of interest in the concerning area of malnutrition and to calculate the nutrient adequacy. In addition, it was analyzed for possible inhibitors of nutrient absorption like tannin and phytates .This method was solved one of the limitation of all of the food tables based estimation of nutrient which do not account for nutrient losses during food processing, i.e. data for both raw and boiled/fried/dried etc.

The complementary food samples its nutrient adequacy were evaluated. The WHO recommendations and FAO, if these were not available; the USA RDA/USA minimum requirements (Garrow *et al.,* 1993; Savage King *et al.,* 1993) were used to estimate whether the children met their needs of energy and of the above mentioned nutrients (except moisture, ash).

Generally, the survey was conducted to get the data on local dietary quality of 384 children's diet; socio-economic and demographic data of care taker of infants using semi-structured questionnaire; and nutrient and anti-nutrient composition of infants' complementary foods diet by taking food samples from each administration divisions.

Ethical Consideration and Inform consent: Permission was obtained from Jimma City Administration and each 'kebeles' representative through a formal letter written from Department of Post-harvest Management, Jimma University. The participant (mothers or care takers) was informed about the purpose of the study and verbal consent was obtained before each interview.

3.3. Raw Material Collection and Sample Preparation

3.3.1. Raw material collection

Red teff grain named DZ-01 99 was collected from Debre Zeit Agricultural Research Center, soybean seed of variety clerk 63k was obtained from Jimma Agricultural Research Center and papaya fruit solo varty was collected from Gojeb Horazion Plantation PLC.

3.3.2. Sample preparation

I. Preparation of red teff flour

Red teff seeds were manually cleaned by siftings and winnowing and freed carefully from chaffs, dust and other impurities. It was then ground into flour by miller (Heavy-duty cutting mill, SM2000/695upm, Germany) and sieved through a 0.5 mm sieve and packed in plastic bags prior to analysis.

II. Preparation of germinated soybean flour

Soybean flour was prepared by using the method described by Tizazu *et al*. (2010). Soybean seeds were cleaned properly using dry cleaning methods to remove foreign materials. Then it was soaked in excess of water for about 18 hrs at room temperature. The soaked soybean seeds were washed using distilled water after the soaking water drained off. Then the soybean seeds were germinated for about 48 hrs at 25^{o}C and 95% of relative humidity in the growth cabinet (model: RGX250). Next, the germinated soybean seeds were dried for about 24 hrs using hot air oven at 50 ^{o}C. The dried soybeans were then milled into fine powder using a miller (Heavy-duty cutting mill, SM2000/695upm, Germany) and sieved through a 0.5 mm sieve and packed in plastic container untill to laboratory analysis.

III. Preparation of papaya powder

The harvested papaya fruits were sorted and washed with clean water. Papaya peel was removed using vegetable peeler or paring knife. It was sliced lengthwise in half on cutting board and seeds were scooped out and discarded with large spoon. Sliced papaya was dried using hot air oven method at 60 ^{o}C for 24 hr. Finally, it was then ground into powder by miller (Heavy-duty cutting mill, SM2000/695upm, Germany) and sieved through a 0.5 mm sieve and packed in black plastic container and stored until needed for analysis (Padmapriya, 2013).

3.4. Treatment Combinations and Experimental Design

The Lower and upper ranges of treatment combinations (coded form) are indicated in Table 11. This range was set based on previous reported result on complementary porridge quality prepared from grains, legumes and vitamin rich plant food considering WHO infant feeding guidelines. Eleven treatment combinations were generated via D-optimal Mixture design with three ingredients (red teff flour, soybean flour, and papaya powder) using Minitab version 16 statistical software as indicated in Table 12. The simplex design plot for the three -components of mixture formulations is presented in Figure 1, which shows the experimental point and the experimental region. Lack of fit was not come up with the eleven treatment combinations.

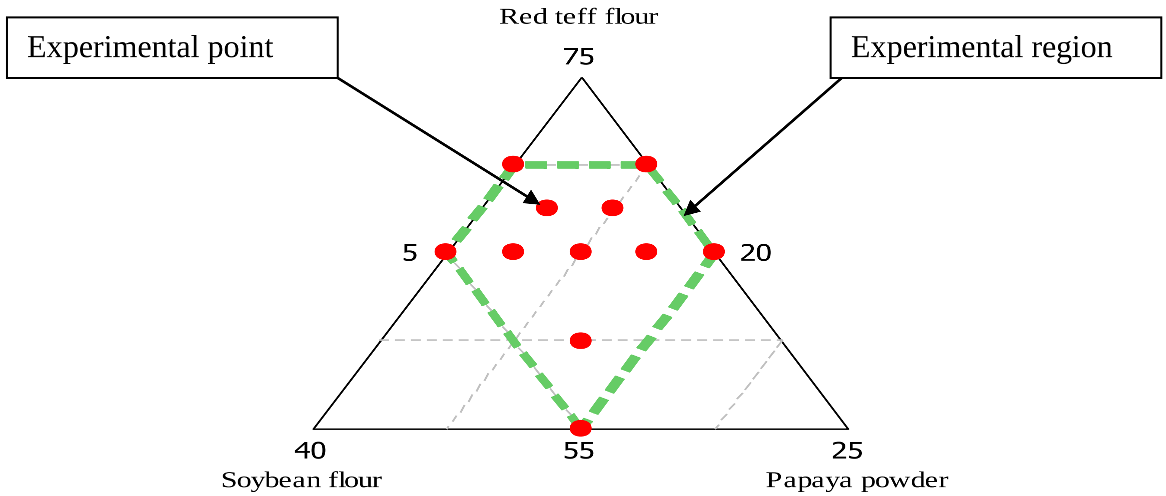


Figure 1: Simplex design plots of the three-component mixture formulations

Table 11: Lower and upper limit of ingredients in D-optimal design

Ingredients	Lower	Upper
Red teff flour	55	70
Soybean flour	20	30
Papaya powder	5	15

Source: FDREMH, 2006; Charles *et al.*, 2014; and Cameron *et al.*, 2009

Table 12: Formulations of red teff based complementary porridge blended with soybean flour and papaya powder

StdOrder	RunOrder	PtType	Blocks	Red teff flour	Soybean flour	Papaya powder
3	1	1	1	65	20	15
1	2	1	1	55	30	15
4	3	1	1	70	25	5
9	4	-1	1	65	22.5	12.5
7	5	-1	1	60	27.5	12.5
2	6	1	1	70	20	10
10	7	-1	1	67.5	25	7.5
11	8	-1	1	65	27.5	7.5
6	9	0	1	65	25	10
8	10	-1	1	67.5	22.5	10
5	11	1	1	65	30	5

3.5. Formulation of Red Teff Based Complementary Porridge

3.5.1. Preparation of red teff based porridge

The composite flour was mixed using an electrical blender for 2–3 min at 200rpm.The flour samples were packed and sealed in high density polyethylene bags. Porridges were prepared according to Onabanjo *et al*. (2009) from each eleven composite flours. Three hundred grams (300 g) composite flour was mixed with 300 ml of water in small plastic bowl. The rest 300 ml of distilled water was boiled in to the pan. After it was boiled, the slurry was mixed with boiled water and heated for 15 min at 90 ^{o}C with continuous stirring to avoid coagulation and sticking on the pan. After 15 min the pan with porridge was removed from the stove. Sample preparation procedure and all parameters (physico-chemical, nutritional and anti-nutrition) analysis data shown in Figure 2 was collected using the analysis procedures.

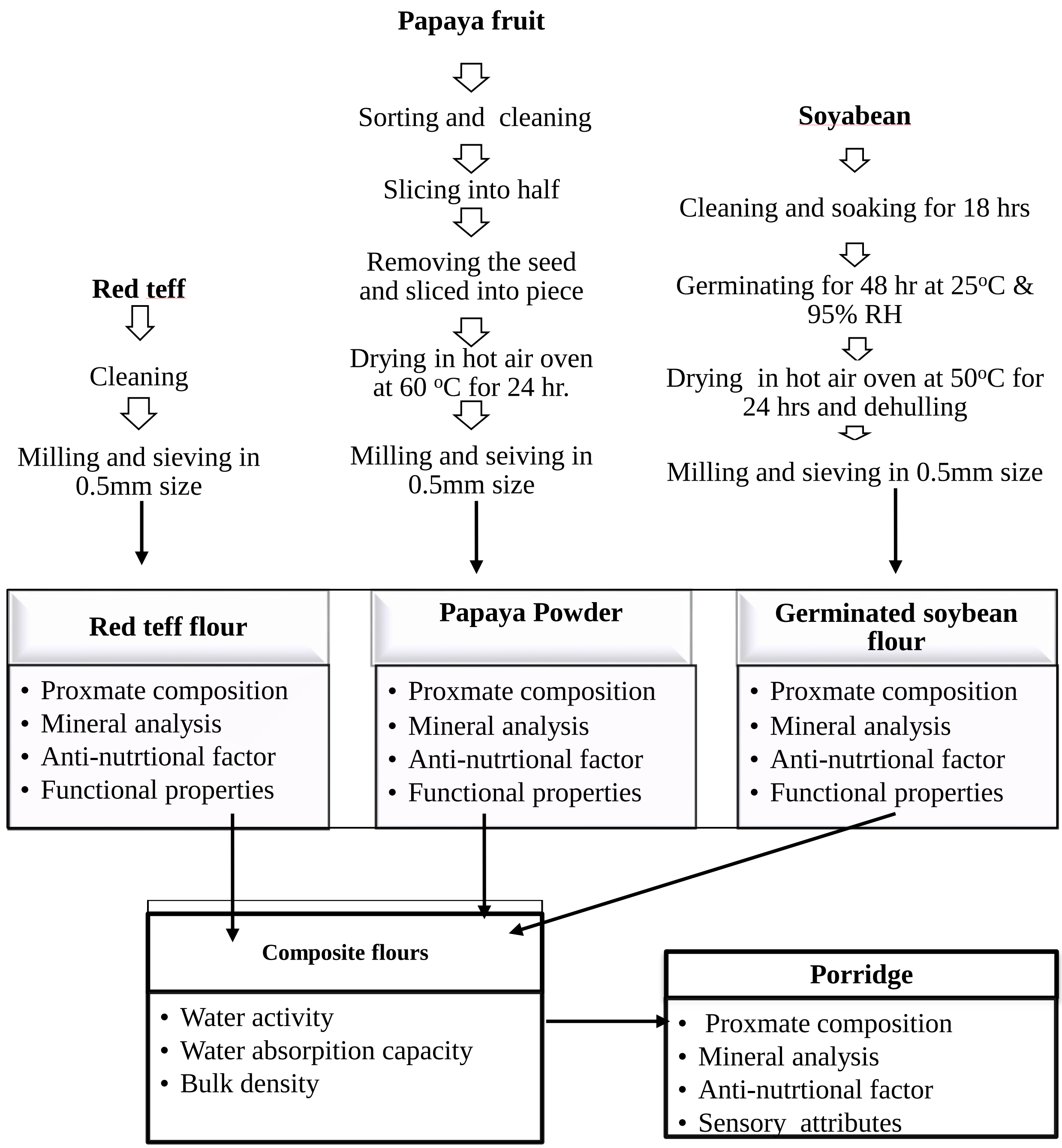


Figure 2: Flow diagram of experimental framework for preparation of flour samples of porridge (Onabanjo *et al*., 2009; Padmapriya, 2013; Tizazu *et al*., 2010)

3.6. Data Collection and Analysis Methods

3.6.1. Proximate composition

Proximate composition of each ingredient flour and formulated diets was determined. These data was collected in triplicate.

I. Determination of moisture content

The moisture content of the sample was determined using hot air oven method according to (AOAC, 2011, 925.10). The weight of the empty metal dish was taken using digital electronic balance (model: HCB1002, Malaysia) after being dried in hot air oven (model: Leicester, LE675FT, England) at 130 ^{o}C for 1hr and cooled in desiccators to room temperature. About 2 g of well-mixed sample was transferred on to the pre-dried dish and dried in oven for 6 hr at 102 ^{o}C. Then the weight of dried dish containing the sample was taken after it cooled down to room temperature in desiccators. The percentage of moisture content in sample was estimated using Eq.2

$$Moisture\ (\%) = \frac{(M_{intial} - M_{dried})}{M_{intial}} * 100\% \quad \text{-- Eq.2}$$

II. Determination of crude protein

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

Digestion: Food sample 0.3 g weigh was added into the digestion flask or larger test tube for digestion by addition of small volume (3-5ml) of concentrated H_2SO_4 (an oxidizing agents which digests the food), anhydrous Na_2SO_4 or K_2SO_4 that speed up the reaction by raising the boiling points of H_2SO_4 and a catalyst ($CuSO_4$, selenium, titanium or mercury) to speed the reaction. One gram of catalyst mixture was made of Na_2SO_4 or K_2SO_4 with anhydrous $CuSO_4$ in the ratio of 10:1 was used. During digestion any nitrogen in the food (other than that which is in the form of nitrates or nitrites) was converted into ammonia and other organic matter to CO_2 and H_2O.

Distillation: After digestion is completed, the content in the flask was diluted by water and a concentrated NaOH (40%) solution using distiller (model KDN-F-China). It was added to make the solution slightly alkaline and to liberate ammonia gas. The ammonia was then distilled into receiving flask that consist a standardized strong acid such as solution of excess boric acid (4%) or sulfuric acid for reaction with ammonia or sulfuric acid. The total nitrogen and percentage of protein content in sample was estimated using Eq.3 and Eq.4.

Calculation =Total nitrogen, percent by weight

$$Total\ nitrogen = \frac{(T-B)*N*14.007*100}{w}$$ ---*Eq.3*

Where:

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

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

N - Normality of standard hydrochloric acid

W - Weight in grams of the test material

*Crude protein = 6.25 * total nitrogen*--*Eq.4*

III. Determination of crude fat

Crude fat was determined using soxhlet extraction method according to (AOAC, 2011, 2003.06). Sample of 1.5g was weighed into a thimble. The thimble and contents were placed in to a 50 ml beaker and dried in oven for 2 hr at 102 ^{o}C. Thimble and contents was transferred in to extraction apparatus. The beaker was rinsed for several times with the solvent diethyl ether. The sample contained in the thimble was extract with the solvent diethyl ether in a Soxhlet extraction Soxhlet extractor (model: SZC-C fat extractor, china) for 6 hr. At the completion of the extraction, the extract was transferred from the extraction flask into a pre-weighted evaporating small beaker with several rinsing with the solvent. The diethyl ether was evaporated until no odor of it is detected. The beaker and contents was dried in the oven for 30 minutes at 102^{o}C to remove moisture. Then it was removed from the oven and cooled in desiccators. The beaker and content was weighed. The percentage of crude fat content in sample was estimated using Eq.5.

$$Crude\ fat(\%) = \frac{W2-W1}{Weight\ of\ sample}\ x\ 100\%$$ ---*Eq.5*

Where:

W_1= Weight of extraction flask before extraction

W_2 = Weight of extraction flask after extraction.

IV. Determination of crude fiber

The crude fiber was determined by the non-enzymatic gravimetric method (AOAC, 2000, 920.168). Two g food sample was placed into 600 ml beaker and 200 ml of 1.25% H_2SO_4 and 2 g pre weighed boiling chips was added. Then the beaker was placed on digestion apparatus and was boil exactly for 30 min., while shaking at 5 min intervals. The solution was passed through screen sieve and the digested sample was decanted. The digestion beaker was washed with 3 x 50 ml portion of near boiling point water and each was transferred into the screen for filtration. The residue left on the screen was transferred into 600 ml digestion flask by washing the screen with 200 ml (50mlx4) 1 % NaOH. It was then placed on digestion apparatus and boiled for 30 minute while shaking at 5 min interval. The digested sample was filtered in coarse porosity (75µm) crucible in apparatus at a vacuum of about 25mm. The residue was dried at 130 ^oC for 2 hrs and cooled in desiccators and weighed (M_1). The dried residue was ignited for 2 hrs at 600 ^oC until ashing was completed and then cooled in desiccators and reweighed (M_2). The percentage of crude fiber content in sample was estimated using Eq.6.

$$Crude\ fiber\ \% = \frac{M1-M2}{weight\ of\ sample} * 100$$ ---*Eq.6*

Where,

M_1 = mass of crucible and residue before ignition

M_2 = mass of crucible and residue after ignition

V. Determination of total ash

The crucibles which used for the analysis were clean, dry at 120 ^oC and igniting at 550 ^oC in furnace for 3 hours. Then the crucibles were removed from the furnace and cooled in desiccators. The mass of the crucibles were measured by analytical balance (M1). About 5g of the sample was weighed into crucibles (M2). The sample was dried at 120^oC for 1hr in drying oven. The sample was removed from the drying oven and carbonizes by blue flame of Bunsen burner by placing the sample dish on wire gauze. The sample was then placed in furnace (model: SX-5-12 box resistance furnaces, China) at about 550^oC until free from carbon and the residues appear grayish white (about 8 hours). The sample was removed from the furnace when the sample is not completely change to ash. It was moistened by the few drops of water and placed in an oven at 120^oC for 1hr and was re-ashed at 550^oC until white ash color was obtained. It was removed from the furnace and placed in the desiccators and weighed (M3). The ash content was determined by official method (AOAC, 2011, 923.03) and applying a simple formula shown in Eq.7.

$$Total\ ash(\%) = \left(\frac{M3-M1}{M2-M1}\right) * 100$$ -- *Eq.7*

VI. Determination of utilizable carbohydrates (CHO)

The total percentage carbohydrate content was determined by the difference method as reported by Onyeike *et al.* (1995). This method involved adding the total values of crude protein, lipid, crude fibre, moisture and ash constituents of the sample and subtracting it from 100 (Eq.8). The value obtained is the percentage carbohydrate constituent of the sample.

$$CHO(\%) = 100 - (\%M + \%\ CF + \%Ash + \%CFi + \%CP)$$ ------------------------------------*Eq.8*

Where:
M = Moisture content, CF = crude fat, CFi = crude fiber and P = crude protein

VII. Determination of calorific value/energy value calculation

Gross energy was calculated according to the method developed by Osborne and Voogt (1978). The gross energy content in raw and processed sample was calculated using Eq.9.

$$Caloric\ value\ (kilo\ calorie) = (protein \times 4) + (carbohydrate\ \times 4) +\ (fat\ \times 9)\text{-----}Eq.9$$

3.6.2. β-Carotene

β-carotene was determined according to the method of Sadler *et al.* (1990). Two grams of each sample was mixed with one gram of $CaCl_2.2H_2O$ and 50 ml extraction solvent (50 % hexane, 25 % acetone, and 25 % ethanol) and shaken in five minute intervals for 30 min at 4±1^oC refrigeration. Again 15 ml of deionized water was added and the solution was frequently shaken in five minute interval for additional 15 min stored at 4±1^oC. After the extraction phase, the organic phase, containing the ß-carotenoid was separated from the water phase, using a separation funnel, and filtered using what man filter paper No.1. The extraction procedure was carried out under subdued light to avoid degradation of carotenoid. β-carotene was estimated from a standard curve (R^2=0.998) of β-carotene standard product of Sigma Aldrich dissolved in the same solvent combination using double beam UV-Vis spectrophotometer (T80,China) at 450nm wavelength.

3.6.3. Anti-nutritional factors

I. Phytate determination

The method described by (Vaintraub and Lapteva 1988) was used for phytate determination. Five gram of dried sample was weighed and extracted with 10ml of 0.2N HCl for 1 hr at an ambient temperature and centrifuged (3000rpm for 30minut) using centrifuge (model 800-1). The clear supernatant was used for the phytate estimation. Then 2 ml of wade reagent was added to 3ml of the supernatant sample solution then it was homogenized and centrifuged (3000rpm for 10 minutes). The absorbance at 500nm was measured using double beam UV-Vis spectrophotometer (T80, China). The phytate concentration was calculated from the difference between the absorbance of the blank (3ml of 0.2N HCl +2ml of wade reagent) and that of assayed sample. The amount of phytic acid was calculated using phytic acid standard curve and result was expressed as phytic acid in µg/g fresh weight (Eq.10).

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

Calculation:

$$phytic\ acid\ in \frac{\mu g}{g} = \frac{Absorvance - Intercept}{Slope \times Density \times weight\ of\ sample} \text{---} Eq.10$$

II. Condensed tannin determination

The method described by Maxson and Rooney (1972) was used for condensed tannin determination. One gram of sample was added in a screw cap test tube and 10ml 1% HCl in methanol was mixed to the sample containing tube, the tube was closed with lid and allowed to shake on mechanical shaker for 24 hr at room temperature. It was centrifuged at 1000 gravity for 5minute using centrifuge (model 800-1) and 1ml supernatant was taken and mixed again with 5ml of vanillin-HCl reagent in another test tube and left for 20 minute until the reaction is completed and then the absorbance was read at 500nm using double beam UV-Vis spectrophotometer (T80, China).

Standard solution preparation: D-Catechin was used as the standard value of tannin in mg D-Catechin per g of sample. 40 mg of D-Catechin was weighed and dissolved in 100ml of 1% HCl in methanol (stock) then was taken 0, 0.2, 0.4, 0.6, 0.8 and 1ml of stock solution in a test tube and adjusted volume of each tube to 1ml with 1% HCl in methanol. In each tube 5ml of vanillin-HCl reagent was added and allowed for 20 minutes to complete the reaction. The absorbance was read at 500nm. Reference curve was prepared from the series of standard solution. The amount of tannin was calculated using tannin standard curve and result was expressed as tannin in mg/g fresh weight (Eq.11).

$$Tannin\ \ in\frac{mg}{g} = \frac{Absorvance - Intercept}{Slope \times Density \times weight\ of\ sample} \text{--} Eq.11$$

3.6.4. Mineral analyses

The contents of Ca, Zn and Fe in foods was measured by atomic absorption spectrophotometer (AAS) (Perkin-Elmer, Model 3100, USA) according to the method of Hernandez *et al.* (2004) after dry ashing of 5g sample. The resulting white ash was weighed, dissolved in 3ml of concentrated nitric acid and then finally diluted with deionized water in a 25ml calibrated flask. Then the solution was used to determine Ca, Zn, and Fe. Standard stock solution of iron, zinc and calcium was prepared by appropriate dilution. The samples and standards were atomized by using air –acetylene as a source of energy for atomization (AACC, 2000). For iron content determination absorbance was measured at 248.3nm and iron was estimated from a standard calibration curve was prepared from analytical grade iron wire with a range of 0, 0.05,2,4,8 and 16ml. For zinc content determination, absorbance was measured at 213.8nm and zinc level was estimated from a standard calibration curve prepared from ZnO. For calcium content determination, absorbance was measured at 422.7nm after addition of 1% lanthanum (i.e., 1ml La solution /5ml) to sample and standard to suppress interferences. Calcium content was then estimated from standard solution 0, 0.05, 2, 4, 8 and 16 ml prepared from $CaCO_3$.

3.6.5. Functional properties

I. Water activity

Water activity was determined using lab-master water activity meter (model CH-8853 Lachen made in Switzerland). For high precision measurement, the instrument was run hours before starting measurement. During this time temperature of the system was stabilized. The cup was cleaned and dried. The sample holder cup was filled to 2/3 with sample flour to be measured. The instrument cover was open-ended and checked the chamber. This was clean and absolutely dry. Sample cup containing the sample was open and inserted into measuring left chamber. The next cup was placed with its plastic cover (closed) in to a preconditioning chamber (right) to reach thermal equilibrium. The cover was pressed completely down and started analyzing the sample. The stability observation function was flash yellow led (analyzing) and waited until the buzzer sounds and flash green led stable light up. Finally, the water activity value was recorded before open the cover.

II. Bulk densities of the flour

Bulk density was determined by the method of Adeleke and Odedeji (2010) fifty g flour sample was taken into a 100 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a content volume. The volume of sample was record. Bulk density was calculated from the values obtained as follows:

$$Bulk\ density\ \left({}^{g}/_{cm^3}\right) = \frac{weight\ of\ sample}{volume\ of\ sample\ after\ tapping} \text{---} Eq.12$$

III. Water absorption capacity (WAC)

WAC which gives an indication of the amount of water available for gelatinization was determined according to method used by Edema *et al.*, (2005). Sample of 2.5 g was added to 30 ml distilled water in a weighed 50 ml centrifuge tube. The tube was agitated for about 5 min in before being centrifuged at 4000 rpm for 20 min. The mixture was decanted and the clear supernatant discarded. Adhering drops of water was carefully drained off as much as quantitatively possible and the tube was reweighed.

$$\%WAC = \frac{Weight\ of\ water\ bound \times 100\%}{Weight\ of\ sample\ (dry\ basis)} \text{--} Eq.13$$

3.6.6. Sensory evaluation

Eleven formulated complementary porridge samples were prepared and subjected to sensory evaluation. The evaluation was carried out based on appearance, aroma, taste, mouth feel and overall acceptability using a five point hedonic scale, where 1= dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately and 5 = like extremely (Kolapo and Oladimeji , 2008). A total 50 panelists (Mothers) (Wechsler, 2010) was randomly selected from Jimma Town. The consumer panelists were informed on the 5-point hedonic scale and its use prior to assessment. Freshly prepared porridge was served in randomly coded white plate and arranged randomly (Tewodros, 2009). Further, in analysis perfectly assessed samples were taken to data analysis. The sample was coded and subjected to statistical analysis to get means, frequency and percentages. During the evaluation panelists was asked to use water for palate cleaners in between each samples sensory analysis.

3.7. Data Analysis

The data collected from the survey were subjected to analysis of variance (ANOVA) by using SPSS version 20 statistical software. The data collected from the lab experiment was analyzed by using Minitab 16 software package. The statistical significance of the terms in the regression equations were examined by analysis of variance (ANOVA) for each response and the significance test level was set at 5% ($P < 0.05$). All data normality distribution were checked. The fitted models for all the parameters were generated three-dimensional contour plots. Graphical optimization was carried out to determine the optimum formula of red teff based porridge by substituting with some level of soybean and papaya in terms of nutrient composition and sensory attributes.

4. RESULTS AND DISCUSSIONS

During the survey, a total number of 384 respondents were interviewed and were completed with a respondent rate of 100%. Though it was explained to the mothers before starting the interview that would have no immediate benefit from answering questions, none of the mothers refused their participation. There was no questionnaire that had to be excluded for all analyses.

4.1. Socio-demographic Characteristics of Respondents

Household size was range 2-11 with mean of 4.21 ±1.27. With respect to type of household 235 (61.2%) were male headed and 149 (38.8%) female headed. Most of the care givers of the infants were 375 (97.7%) mothers followed by 6 (1.6 %) father, 1 (0.3 %) brother, sister, and adopter. marital status of caretakers, 334 (87%) were married, 16 (4.2 %) separated, 16 (4.2%) divorced and mean age of study population of care givers was 27±5.1 years ranging from 18 to 42. With respect to their educational status, 326 (84.9 %) of care givers had attended school. Out of these, 22 (5.7%) had bachelor degree and above, 24 (6.3%) diploma, 171 (44.5%) grade 7-12 with highest percentage, 109 (28.4%) grade 1-6 and, 1 (0.3%) who can read and write, and 57 (14.8%) illiterate. Out of total, 105 (27.5 %) were house hold wife with highest percentage, 95 (24.7%) daily labor, 94 (24.5%) merchant and 73 (19.0%) government employed, 7 (1.8 %) depends on hand craft, 5 (1.3 %) NGO employed, 4 (1.0) student and 1(0.3%) soldier. Out these, ninety five (24.7 %) had no income, 88 (22.9%) 200-600 Birr income, 79 (20.6%) 601-1001 Birr, 31 (8.1%) 1002-1502 Birr, 35 (9.1%) 1503-2004 Birr, 56 (14.6%) >2005 Birr income. The mean (±Sd) monthly incomes were 1144.177± 1408.6 Birr which ranges from 0-10,000 Birr.

Among socio-economic characteristic of participants (care givers of the child) the primary source of water of the household used were 304 (79.2%) piped water with highest percentage, 62 (16.1%) river, 12 (3.1%) borehole, 1 (0.3%) river and borehole; 1(0.3%) piped water, river and borehole,4 (1%) piped water and borehole. All of the care givers, 384 (100%) had toilet with pit type. The roofing material for the main house were 4 (1%) thatched; 380 (99.0%) corrugated sheets with highest percentage; wall material was 351(91.4%) with highest percentage mud, 4 (1%) wooden, and 29 (7.6%) iron sheet.

The main income earner of the house hold were 241 (62.8%) husband with highest percentage, 64 (16.7%) wife, 23 (6.0%) family, 56 (14.6%) both husband and wife. The main income sources of the participants were 162 (42.2%) with salary had highest percentage, 107 (27.9%) trade, 9 (2.3%) pension, 102 (26.6%) daily labor, and 4 (1.0%) salary and trade. Average money on food purchase monthly spent were 2 (0.5%) <200 birr, 126 (32.8%) 201 -500 birr, 161 (41.9%) 501-1002 birr with highest percentage, 46 (12.0%) 1003-1504 birr, 28 (7.3%) 1505-2006 birr, and 21 (5.5%)>2007 birr and with mean (± Sd) of 958.54 ±594.53 birr. Average money on food purchase monthly spent were ranges from 140-3800 Birr. Those who changed work in the last six month were 383 (99.7%) with No answer and 1(0.3%) Yes answer.

4.2. Dietary Quality Assessment (24 Hour Recall)

4.2.1. Food variety score

Forty two different food items in total were eaten by the children during the 24 hour period, corresponding to a theoretical maximum of the Food Variety Score (FVS) of 42. Findings from this study have shown that the maximum number of food items consumed by this population within the previous 24- hour period was eighteen. One to thirteen food items were consumed by most (90.1%) of the children. A mean FVS of 7.14 ± 4.07 (range 0 to 18) was acquired. This result was higher than study of Potts and Potts (2014) who reported a result of a highest number of food items consumed (17 food items) and was lower in mean FVS value of 9.37 ± 2.45 (range 2 to 17). Other studies result was also reported with higher mean FVS value of 12.93 ±4.47 and 7.52 (range of 1–24), 20.5 (range 13-29) (Musinguzi ,2012,Jane *et al*., 2012 and Hatlùy,1998).

FVS which are reflected as a simple add up of food items consumed were found to be low in general. A total of 42 different food items were noted and most of the children consumed between 1 and 13 food items within that previous 24-hour recall of the survey.

4.2.2. Dietary diversity score

Consumption of food groups was significantly associated with kebele as shown in Table 13. Grains, roots and tubers were highly significant among the three allocated kebeles (P=0.01) with frequency of for Mender Kochii 113(88.3%), Hermata Merkato 122(95.3%) and Bosa Addis kitto 127(99.2%). With respect to Vitamin A-rich plant foods, other fruits or vegetables; meat, poultry, and sea food; egg; pulses/legumes/nuts; milk and milk products ; and food cooked in oil/fat food groups were highly significant (P=0.001). Generally, larger proportion of the study participants in Bosa addis kitto were consumed all food groups with higher proportion followed by Hermata merkato and Mendera qochii. Children's tend to consume in higher and low percentage of food groups due to number of reasons, of which one could be lack of knowledge on the right diet or lack of access to the right kind of food due to overall food insecurity of the care taker (Azadbakht *et al.*, 2005; Savy and Martin, 2002; and Ahn *et al., 2006*). In general, children choose to eat the foods that are served most often, and tend to prefer to eat foods that are readily available in the home (Birch and Marlin, 1982).

Table 13: Cross tabulation of consumption of food groups by kebeles, Jimma town Southwest Ethiopia

	Place of respondents residence ("kebels")						*P*
	Mendera Qochii		Hermata merkato		Bosa addis kitto		
	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	
GR and TS	15 (11.7)	113(88.3)	6(4.7)	122(95.3)	1(0.8)	127 (99.2)	<*.0001*
VARPFS	93(72.7)	35(27.3)	60(46.9)	68(53.1)	47(36.7)	81(63.3)	<*.0001*
OFV	94(73.4)	34(26.6)	34(26.6)	94(73.4)	21(16.4)	107(83.6)	<*.0001*
MP and SF	125(97.7)	3(2.3)	102(79.7)	26(20.3)	101(78.9)	27(21.1)	<*.0001*
Egg	101(78.9)	27(21.1)	76(59.4)	52(40.6)	60(46.9)	68(53.1)	<*.0001*
Pu/le/Nu	109(85.2)	19(14.8)	122(95.3)	6(4.7)	32(25)	96(75)	<*.0001*
M and MP	94(73.4)	34(26.6)	39(30.5)	89(69.5)	60(46.9)	68(53.1)	<*.0001*
FCOF	128(100)	0(0.0)	103(80.5)	25(19.5)	127(99.2)	1(0.8)	<*.0001*

Where: P= P Value ; GRandT = Grains, roots and tubers; Vit A-RPFS = Vitamin A-rich plant foods; OFV other fruits or vegetables, MPandSF = Meat, poultry, and sea food; Pu/le/Nu = Pulses/legumes/nuts; M andMP = Milk and milk products; and FCOF = Food cooked in oil/fat.

Consumption diversified diet were highly significantly associated with residence ("kebeles") (P=0.0001). Study participants (care takers) whose residence in Bossa addis kitto were providing more frequently medium diversified diet (52.3%) and high diversified diet (22.7%) to their child compare to their counterparts (Table 14).

The mean DDS was 3.44± 1.75 (range 1 to 8). With regard to dietary diversity score, majority of the children 196 (51%) had low DDS (<4 food groups), about 148 (38.5%) had medium DDS (4 and 5 food groups) and 40 (10.5%) had high DDS (>5 Food Group). Out of the total only 188 (49%) of the participants feed a diversified diet from the eight food groups. This result is consistent with the studies that measured DDS using the 24- hour recall questionnaire among children by FANTA (2006).It was less than the mean dietary diversity score of 4.2 food groups, with a minimum of 2 and a maximum of 8 food groups; and higher in low dietary, medium diversity and lower in high dietary diversity compare to the study by Badake *et al*. (2014) which were 41.9%, 37.5% and 22.5% respectively. Other studies by Musinguzi *et al*. (2012), Potts and Potts (2014) and Hatlùy (1998) have reported higher results with a mean DDS value of 7.36 ±1.39 (ranged 1-9) and 4.19 ± .83 (range 1 to 6) and 5.8 (range 1 to 8) respectively. Generally, in this study there were low values of dietary diversity score which mean majority of the children were consumed low dietary quality. Dietary diversity by socio-demographic, socio-environment and socio-economic variables are shown in Table 14.

Consumption diversified diet were highly significantly associated with age of the care taker (P=0.0001). Care takers with age group 28-32 years were providing more frequently medium diversified diet (47.2%) and high diversified diet (11.2%) to their child compare to their counterparts. This might be due to economic independence, better income and low family size at this age group which enable to have diversified diet.

Consumption diversified diet were highly significantly associated with the education level (P=0.005). Care takers with education level of degree holder were providing more frequently medium diversified diet (54.5%) and high diversified diet (22.7%) to their child compare to their counterparts. This could be due awareness of educated people on providing balanced diet to children’s. Higher parental education has been associated with health consciousness in food choices (North and Emmett, 2000).Adolescents whose parents were relatively more educated had higher intakes of carbohydrates, protein, fiber, folate, vitamin A, and calcium; higher consumption of vegetables; and greater likelihood of consuming the recommended servings of dairy products (Xie *et al*., 2003).

Consumption diversified diet were highly significantly associated with occupation (P=0.0001). Care takers whose occupation merchants were providing more frequently medium diversified diet (50%) and high diversified diet (18.1%) to their child compare to their counterparts. This might be because of merchant’s purchasing power and income. More advantaged occupational levels permit increased access to medical care, enable one to have the funds for better housing and better nutrition, to live in safer neighborhood and increase his/her opportunity to engage in health-promoting behaviors’ ((López *et al*., 2003).

Consumption diversified diet were highly significantly associated with monthly income (P=0.0001). Care takers with monthly income 1503-2004 Ethiopian birr were providing more frequently medium diversified diet (51.4%) and high diversified diet (28.6%) to their child compare to their counterparts. Consumption diversified diet were highly significantly associated with way of making income (P=.001). Care takers making income with both salary and trade were providing more frequently medium diversified diet (100%) to their child compare to their counterparts. This could be due to better earning of care takers with both salary and trade. Consumption diversified diet were highly significantly associated with average money spent on food purchase monthly (P=0.0001). Care takers with average money spent on food purchase monthly 1505-2006 Ethiopian birr were providing more frequently medium diversified diet (53.6%) and high diversified diet (17.9%) to their child compare to their counterparts. This might be due to allocating of more money on food purchase.

Income is likely to mirror the availability of economic and material resources, and therefore influences dietary quality by making healthy food more or less affordable and accessible (Turrell and Kavanagh, 2006).

Table 14: Dietary diversity by socio-demographic, socio-environment and socio-economic variables, Jimma town, Southwest Ethiopia.

Variables	Respondents diversified diet during 24 hour recall			Chi-square	*P*
	<4 Non Diversified (n=196)	4 and 5 Medium diversified (n=148)	>5-High diversified (n=40)		
Socio-demographic Variables	Freq. (%)	Freq. (%)	Freq. (%)		
Type of household				.307	*.858*
Male headed	122(51.9)	88(37.4)	25(10.6)		
Female headed	74(49.7)	60(40.3)	15(10.1)		
Residence (kebeles)				115.729	<*.0001*
Mendera/Cochii	111(86.7)	16(12.5)	1(0.8)		
Hermata Merkato	53(41.4)	65(50.8)	10(7.8)		
B/A/kitto	32(25)	67(52.3)	29(22.7)		
Care taker				7.952	*.438*
Mother	192(51.2)	145(38.7)	38(10.1)		
Father	3(50)	1(16.7)	2(33.3)		
Brother	0(0)	1(100)	0(0)		
Sister	0(0)	1(100)	0(0)		
Adopter	1(100)	0(0)	0(0)		
Marital status				13.902	*.084*
Unmarried	2(33.3)	4(66.7)	0(0)		
Married	170(50.9)	131(39.2)	33(9.9)		
Separated	11(68.8)	3(18.8)	2(12.5)		
Divorced	6(37.5)	5(31.3)	5(31.3)		
Widowed	7(58.3)	5(41.7)	0(0)		
Gender				978	*.613*
Male	3(60)	1(20)	1(20)		
Female	193(50.9)	147(38.8)	39(10.3)		

Age of the care taker				30.367	*<.0001*
18-22 Years old	49(70.0)	18(25.7)	3(4.3)		
23-27 Years old	70(53.4)	50(38.2)	11(8.4)		
28-32 Years old	52(41.6)	59(47.2)	14(11.2)		
33-37 Years old	20(43.5)	19(41.3)	7(15.2)		
38-42 Years old	5(41.7)	2(16.7)	5(41.7)		
Education				25.037	*.005*
Illiterate	38(66.7)	19(33.3)	0(0)		
Can read and write	0(0)	1(100)	0(0)		
Grade 1-6	62(56.9)	37(33.9)	10(9.2)		
Grade 7-12	77(45)	70(40.9)	24(14)		
Diploma Holder	14(58.3)	9(37.5)	1(4.2)		
Degree Holder and above	5(22.7)	12(54.5)	5(22.7)		
Occupation				47.080	*<.0001*
Daily labor	62(65.3)	28(29.5)	5(5.3)		
Soldier	0(0)	1(100)	0(0)		
Merchant	30(31.9)	47(50)	17(18.1)		
Hand craft	2(28.6)	5(71.4)	0(0)		
Government employee	29(39.7)	31(42.5)	13(17.8)		
Housewife	69(65.7)	32(30.5)	4(3.8)		
NGO	3(60)	2(40)	0(0)		
Student	1(25)	2(50)	1(25)		
Monthly income				75.751	*<.0001*
No income	63(66.3)	29(30.5)	3(3.2)		
200-600 Birr	64(72.7)	22(25)	2(2.3)		
601-1001	37(46.8)	37(46.8)	5(6.3)		
1002-1502	11(35.5)	14(45.2)	6(19.4)		
1503-2004	7(20)	18(51.4)	10(28.6)		

>2005	14(25)	28(50)	14(25)		
Socio-environment variables					
Water source				13.303	*.207*
Piped water	145(47.7)	123(40.5)	36(11.8)		
River	37(59.7)	21(33.9)	4(6.5)		
Borehole	9(75)	3(25)	0(0)		
River and borehole	1(100)	0(0)	0(0)		
Pipe water ,river and borehole	0(0)	1(100)	0(0)		
Piped water and Borehole	4(100)	0(0)	0(0)		
Roofing material main house				2.352	*.308*
Thatched	1(25)	3(75)	0(0)		
Corrugated sheets	195(51.3)	145(38.2)	40(10.5)		
Wall material for the main house				6.454	*.168*
Mud	185(52.7)	129(36.8)	37(10.5)		
Wooden	1(25)	3(75)	0(0)		
Iron sheet	10(34.5)	16(55.2)	3(10.3)		
Socio-economic variables					
Main income earner				11.503	*.074*
Husband	114(47.3)	99(41.1)	28(11.6)		
Wife	36(56.3)	22(34.4)	6(9.4)		
Family	10(43.5)	8(34.8)	5(21.7)		
Both husband and wife	36(64.3)	19(33.9)	1(1.8)		
Way of making				26.960	*.001*

income					
Salary	73(45.1)	68(42)	21(13)		
Trade	49(45.8)	45(42.1)	13(12.1)		
Pension	3(33.3)	4(44.4)	2(22.2)		
Daily labor	71(69.6)	27(26.5)	4(3.9)		
Salary and trade	0(0)	4(100)	0(0)		
Type of work changed				1.599	*.450*
No	196(51.2)	147(38.4)	40(10.4)		
Yes	0(0)	1(100)	0(0)		
Average money spent on food purchase monthly				46.693	*<.0001*
<200 Birr	2(100)	0(0)	0(0)		
201 -500	86(68.3)	36(28.6)	4(3.2)		
501-1002	73(45.3)	69(42.9)	19(11.8)		
1003-1504	19(41.3)	23(50)	4(8.7)		
1505-2006	8(28.6)	15(53.6)	5(17.9)		
>2007	8(38.1)	5(23.8)	8(38.1)		

Freq = frequency

4.2.3. Nutritional quality and nutrient adequacy of complementary food of children

Access to adequate complementary foods is a necessary condition for improving infant and young child feeding. There is ample evidence that diets, if based solely on unmodified, locally available ingredients, are often inadequate to meet recommended energy and nutrient needs (WHO, 2001).

Complementary collected food samples macro and micro nutrient, energy and anti-nutrient contents are shown in Table 15-18. Macronutrient content of infants complementary foods per 100 gram in dry base protein content were vary from 8.5 % to 13.19 % with average value of 10.94 %, fat content from 1.93-10.73% with average of 5.71%, crude fiber content from 1.05-

3.25% with average of 2.2%, carbohydrate content from 70.30 to 82.13% with average value of 74.95%, total energy content from 372.47 to 423.55 Kcal/100g with average value of 391.99 Kcal/100g, moisture percentage from 3-5.78 with average of 4.44 and ash percentage from 1.14-2.88 with average of 2.085.

Table 15: Proximate composition (%) and energy (kcal/100g) content of children complementary foods in Jimma Town, Southwest Ethiopia.

Food type mixed	MC	Ash	CP	CFA	CFI	CHO	Energy
Macaroni , cerfam	5.78	2.61	12.31	4.53	2.85	71.92	377.71
Macaroni, rice	5.4	1.8	10.55	5.00	1.4	75.85	390.60
Bean,maize,wheat,maize,mango, cerfam	4.82	2.31	8.50	3.67	2.5	78.20	379.81
Milk, bread, oat, meat, injera	3.39	2.2	11.73	3.60	1.05	78.03	391.44
Injera, bread, busicut, potato	3	2.41	13.19	5.67	2.4	73.33	397.09
Biscuit, rice ,banana	4.23	1.35	7.04	8.40	1.65	77.33	413.08
Milk, macaroni	4.49	1.86	9.97	2.33	2.1	79.25	377.87
Atimit	4.6	2.81	10.85	7.80	3.1	70.84	396.96
Biscuit, rice, egg	4.4	1.23	11.43	10.73	1.9	70.30	423.55
Injera, milk ,banana ,egg, biscuit	5.4	1.7	14.95	1.93	2.2	73.82	372.47
Pasta, cerfam	4.7	2.16	10.55	5.07	2.7	74.82	387.09
Pasta	5.2	2.3	11.14	6.53	2.35	72.48	393.27
Injera, milk	3.58	1.14	8.50	2.80	1.85	82.13	387.72
Mitin	3.4	2.88	12.90	3.93	3.25	73.64	381.55
Atimit (oat,wheat)	4.2	2.52	10.55	8.67	1.7	72.36	409.65

Where: - MC= Moisture content, CP= Crude protein, CFA= Crude fat, CFI=Crude fiber, CHO= carbohydrate and kcal=Kilo calorie

According to Chessa and Kathryn (2003) the daily ration size g/d of a fortified processed complementary food (FPCF) reported result were 40, 60, and 50 for 6–11, 12–23, and 6–23 month age children respectively. Similarly other report stated that the hypothetical quantity consumed is approximately 53 g (202 kcal) for the 6-8 month-old children, 81 g (307 kcal) for the 9-11 month-old children and 144 g (548 kcal) for 12-23 month-old children and 269 g (1024 kcal) for 24-35 month-old children (Camila and Kathryn, 2009). These quantities represented the "dry weight" of the ration that would need to be consumed to meet the average energy intake of each age group, though it would be expected that the ration components would be diluted when prepared for feeding and thus the total weight and volume of food would be greater once diluted. As a result the quantified dietary adequacy of all complementary food samples for all age groups was below one which means that all diets were not nutrient adequate.

The average nutritional content of 50g on dry base in almost all types of complementary samples were below the daily requirement as a complementary food when compared to RDA of young children's and was below 50% to meet RDA requirement per 50g and 100g. Complementary nutritional quality of this study result was lower in protein and fat content and higher in Energy than a result reported by Chessa (2000) on nutritional characteristics of complementary foods per 100 g of dry product of USAID/WFP wheat soya blend and corn soy blend were 21.5, 17.2 Protein (g); 5.9, 6.9 Fat (g); and 355, 376 Energy (kcal) content respectively. Similar study result also reported on nutrient composition of fortified complementary foods per 100 g for 6–23 month age were 440 energy (kcal), 6-11 Protein (g), 12.7 Fat (g) was higher than present result (Chessa and Kathryn ,2003).

The codex alimentarius guidelines for formulated supplementary foods for older infants and young children FAO/WHO (1991) also propose an energy density of at least 400 kcal/100 g of dry food, a fat content between 20 and 40% of energy, corresponding to 10–25 g of fats or oils per 100 g of dry food which is higher than present result.

Institute of Medicine and WHO/FAO (2004) report on Adequate Intakes (AI) and Recommended Nutrient Intakes (RNIs) for 7-11 month-old infants of carbohydrate were 95 g/day, fat 30 (g/day), protein 11(g/day); for 1-3 year-old (12-35 months old) children carbohydrate 130 g/day, 30-40% of total energy intake fat (g/d) , and 13 (g/d) protein were higher than present result of complementary foods. This shows the diet had low dietary quality in meeting Recommended Nutrient Intakes (RNIs).

According to WHO/UNICEF (1998) report recommended protein nutrient intakes per day used were 9.1, 9.6 and 10.9 g/day for the respective age group of 6-8, 9-11 and 12-23 month age group which were a higher than the current result. Similarly Golden (2009) has also proposed recommended nutrient intake (RNI) for children with moderate acute malnutrition (MAM) living in poor environments expressed as nutrient energy densities (amount of nutrient/1000 kcal) were 24 g protein for locally available foods and 26 g protein for specially formulated foods when compared to the present study was higher in nutrient content.

As complementary foods are introduced to the diet, fiber intake increases; however, no adequate intake for fiber has been established. It has been recommended that from 6 to 12 months whole-grain cereals, green vegetables, and legumes be gradually introduced to provide 5 grams of fiber per day by 1 year of age (Agostoni *et al*., 1995).

Total energy content of collected complementary food samples varied from 372.47 Kcal/100g (teff injera, milk, banana, egg, and biscuit) to 423.55 Kcal/100g (Biscuit, rice, and egg) presented Table 15. Energy was higher in food type containing biscuit, rice, and egg in their diet. Food diet containing higher content of fat, protein and carbohydrate makes up the food to have higher energy content as result of carbohydrate, protein, and high fat content composition in the food (USDA and WIC, 2009). This result had higher Kcal content than a breastfed child 6-8 and 9-11 months of age needs only 200 and 300 kcal, respectively, in addition to breast milk from all complementary foods, and a breastfed child aged 12-23 months needs 550 kcal energy in addition to breast milk PAHO and WHO (2003) which is higher than this result (423.55 Kcal/100g).Energy requirements according to age group, as presented in the WHO/UNICEF (1998) 682 kcal/day were for 6-8 month aged, 830 kcal/day for 9-11 month aged, and 1092 kcal/day for 12-23 month aged. Energy requirement from food (kcal) of each age 6-8, 9-11, 12-23 month is 202,307, and 548 kcal (FAO/WHO/UNU, 2001)

According to Institute of Medicine and WHO/FAO (2004) report on adequate intakes (AI) and recommended nutrient intakes (RNIs) and upper limits (UL) of minerals for 7-11 month aged child were Calcium (mg/d) 270 AI, 400 RNIs and RDI; Iron (mg/d) 1.1 AI,40 UL,0.93 RNI and

RDI; and Zinc1.1 RDI, (mg/d) ,23-38 UL); for 1-3 year-old (12-35 months old) children require Calcium (mg/d) 270 AI, 400 RNIs, RDI ; Iron (mg/d) 1.26 AI, RDA, 40UL, 0.58, RNI, RDI; and Zinc 0.9 AI, RDA, 23-28 UL(mg/d).

Mineral composition of infants complementary foods Fe content were varied from1.08 to 5.60 mg/100g with average value of 3.12 mg/100g, Ca mg/100g from 19.86 to 201.69 mg/100g with average value of 96.13 mg/100g, and Zn content from 1.52 to 5.93 mg/100g with average value of 3.50 mg/100g as shown in Table 16.

Table 16: Mineral composition of children's complementary foods in mg/100g, Jimma Town, Southwest Ethiopia.

Food type mixed	Fe	Ca	Zn
Macaroni, cerfam	3.23	201.69	3.2
Macaroni, rice	2.24	177.8	3.54
Bean, maize, wheat, maize, mango, cerfam	4.26	155.08	2.69
Milk, bread, oat, meat,injera	4.12	133.43	5.52
Injera, bread, biscuit, potato	3.91	98.34	5.93
Biscuit, rice, banana	1.4	128.43	3.51
Milk, macaroni	1.21	103.7	5.1
Atimit	5.2	79.12	3.53
Biscuit, rice, egg	2.34	88.45	3.67
Injera, milk, banana, egg, biscuit	4.5	61.45	3.18
Pasta, cerfam	2.9	45.93	2.04
Pasta	1.08	49.72	1.52
Injera, milk	2.36	23.75	3.73
Mitin	5.6	75.19	2.36
Atimit (oat, wheat)	2.4	19.86	2.92

Complementary mineral characteristics of this study result was lower in Fe, Ca and Zn content than a result reported by Chessa (2000) on micro nutrient of complementary foods per 100 g of dry product of USAID/WFP wheat soya blend and corn soy blend were 17.9, 17.5 Iron (mg) ; 842, 831Calcium (mg); and 5.5, 5 Zinc (mg). Another similar study result reported on mineral content of fortified complementary foods per 100 g for 6–23 month age were 200-400 mg Calcium, 14 mg Iron, and 8.3 mg Zinc which was also higher than current result (Chessa and Kathryn, 2003). Sampled complementary food this study were not nutrient adequate at all for the stated age group according to recommended dietary allowance of infants under two year shown in Appendix I.

Beta carotene as provitamin A contributes to an entirely different set of functions by supplying a portion of the body’s requirement for retinol (vitamin A). In fact, a single molecule of beta carotene can be cleaved in the body to produce two molecules of vitamin A (National Research Council DC, 1989)

β- carotene content of infants complementary foods were varied from 0.09-1.69 mg/g with average value of 0.71 mg/g shown in Table 17. This result was less than the daily requirements of children under two years.

Table 17: β-carotene composition of children's complementary foods, Jimma Town, Southwest Ethiopia.

Food type mixed	β- carotene (mg/g)
Macaroni, cerfam	0.28
Macaroni, rice	0.67
Bean, maize, wheat, maize, mango, cerfam	1.69
Milk, bread, oat, meat,injera	1.05
Injera, bread, biscuit, potato	1.16
Biscuit, rice, banana	0.72
Milk, macaroni	0.58
Atimit	0.09
Biscuit, rice, egg	1.21
Injera , milk, banana, egg, biscuit	0.76
Pasta, cerfam	0.75
Pasta	1.07
Injera, milk	0.20
Mitin	0.16
Atimit (oat, wheat)	0.22

Compared to Golden (2009) proposed recommended nutrient intake (RNI) for children with moderate acute malnutrition (MAM) living in poor environments expressed as nutrient energy densities (amount of nutrient/1000 kcal) were 960 mg retinol for locally available foods and 1900 mg retinol for specially formulated foods were very low in β- Carotene content in the collected complimentary food from the household.

Based on Camila and Kathryn (2009) report on vitamin A UL for children 7-35 months of age is set at 600 μg /day which is very close to the recommended daily intake of 400 μg /day, allowing for a very narrow margin between adequate and excess intake. However, the no-observed-adverse-effect-level (NOAELp) for this age group is 6000 μg /day and the UL of 600 μg /day was derived based on an uncertainty factor of 10, allowing for a large margin of safety.

Phytates content of complementary food samples varied from 15.76 to 133.40 μg/g with average value of 70.62 μg/g and tannin content from 0.05 to 0.23 mg/g with average value of 0.13 mg/g as shown in Table 18. Phytate and condensed tannin were highest in *Mitin and Injera.* This might be due to high content of phytate in legumes and grains like teff and sorghum; and using of unprocessed or raw ingredient in preparation diet. This result shows that complementary foods had low dietary quality due to high consentient of anti-nutrition.

Table 18: Anti-nutrition composition of children complementary foods, Jimma Town , Southwest Ethiopia.

Food type mixed	Phytate (µg/g)	Tannin (mg/g)
Macaroni, cerfam	37.39	0.12
Macaroni, rice	26.05	0.09
Bean, maize, wheat, maize, mango, cerfam	70.38	0.09
Milk, bread, oat, meat,injera	53.57	0.21
Injera, bread, biscuit, potato	45.17	0.21
Biscuit, rice, banana	22.06	0.12
Milk, macaroni	36.76	0.08
Atimit	125.00	0.11
Biscuit, rice, egg	15.76	0.15
Injera , milk, banana, egg, biscuit	102.94	0.23
Pasta, cerfam	78.78	0.12
Pasta	86.13	0.07
Injera, milk	117.65	0.05
Mitin	133.40	0.12
Atimit (oat, wheat)	108.19	0.15

4.3. Red Teff Based Formulated Complementary Porridge Enriched With Soybean and Papaya Food (FCF)

The red teff based formulated complementary porridge components was selected based on the nutritional and sensory quality merit shown in this part. In the study area among most of the households used was teff grain as a main food for infants. Soybean was selected to improve the macro nutrient and mineral content of the complementary food. Papaya was also selected for its high potential to improve the vitamin content, sensory quality and health benefit of the product.

4.3.1. Proximate analysis

The proximate composition (moisture, ash, crude protein, crude fat, crude fiber and carbohydrate estimation) of the composite flours have been shown to affect functional property, anti-nutrition composition, nutritional and sensory quality of their products (Dhingra and Jood, 2001; Akhtar *et al*., 2008; Mashayekh *et al*., 2008).

The proximate values for ash, fat, crude fiber and protein, were higher in red teff and soybean substituted samples than in papaya. This Result agree with Joel *et al*. (2011) that showed better values of proximate with increasing levels of soya bean substitutions except for carbohydrate content and energy values which showed the reverse.

The proximate compositions of porridge prepared from different mixtures of composite flour and each of the three ingredients are presented in Table 19. Table 20 shows the p-value for mixture compositions of proximate analysis and the estimated regression coefficients along with their standard errors of all proximate compositions of porridge are summarized in Appendix I.

Table 19: Measured proximate content (%) and energy (kcal/100g) of red teff based formulated porridge and individual flour.

Formulation	Components			Proximate composition						
	RTF	SBF	PAP	MC	Ash	CFA	CFI	CP	CHO	Energy
FM1	65	20	15	6.8	3.19	5.27	2.51	12.55	69.68	376.30
FM2	55	30	15	5.5	3.99	7.13	3.45	19.84	60.08	383.88
FM3	70	25	5	5.8	3.87	6.27	3.07	15.61	65.39	380.40
FM4	65	22.5	12.5	6.3	3.23	5.67	2.37	13.86	68.57	380.70
FM5	60	27.5	12.5	5.7	3.55	6.47	2.93	17.65	63.70	383.61
FM6	70	20	10	6.6	3.25	5.36	2.33	13.57	68.88	378.09
FM7	67.5	25	7.5	6	3.61	6.20	2.77	15.32	66.10	381.48
FM8	65	27.5	7.5	5.6	3.70	6.69	3.13	19.70	61.18	383.70
FM9	65	25	10	6.1	3.35	6.14	2.60	16.20	65.62	382.51
FM10	67.5	22.5	10	6.2	3.34	5.74	2.49	14.44	67.79	380.62
FM11	65	30	5	5.2	4.11	7.44	3.60	24.22	55.43	385.56
Red Teff	100	0	0	8.10	3.31	2.60	3.20	12.26	70.54	354.57
Soybean	0	100	0	3.45	5.56	18.22	5.73	43.63	23.41	432.14
Papaya	0	0	100	8.39	0.63	0.16	1.93	0.88	88.01	357.01

Where: FM= formulation, RTF=Red teff flour, SB=Soybean flour, PAP=Papaya powder, MC=Moisture content, CFA=Crude fat, CFI=Crude fiber, CP=Crude protein, CHO= Carbohydrate, and Kcal=Kilo calorie

Table 20: Analysis of variance (ANOVA) p-values of proximate parameters and energy

Source	MC	Ash	CFA	CFI	CP	CHO	Energy
Linear	0.599	0.000	0.002	0.001	0.001	0.000	0.023
Quadratic	0.983	0.000	0.014	0.004	0.001	0.001	0.027
A*B	0.806	0.015	0.008	0.047	0.001	0.000	0.994
A*C	0.955	0.000	0.597	0.005	0.014	0.077	0.008
B*C	0.972	0.001	0.004	0.001	0.001	0.000	0.032

Where: MC=Moisture content, CFA=Crude fat, CFI=Crude fiber, CP=Crude protein, CHO= Carbohydrate, Kcal=Kilo calorie, A= Red teff, B=Soybean, and C=Papaya

I. Moisture content (MC)

The dry base moisture content of individual components and red teff based porridge were varied between 3.45-8.38 %, and 5.2-6.8% respectively. Moisture content did not show any significant difference between all possible interactions. But, there was values of MC (6.8%) with proportion of red teff (65 %), soybean (20 %) and papaya (15%) and values MC (5.2%) with red teff (65%), soybean (30%) and papaya (5%) of the product. The moisture contents of the composite porridge increased with 55% to 70% red teff and 5 to 15 % papaya substitution by a range of 5.5 -6.6 and 5.2 - 6.8% consecutively. Increase in moisture content has been associated with increase in fiber content (Akhtar et al., 2008; Elleuch *et al*., 2011; Maneju *et al*., 2011). Study done by Nair *et al*. (2013) was in contrast to this study which showed that with increasing soya flour the moisture content of the product was increased from1.87 of control to 4.08 for 10 % soya flour 3.52 for 20% soy flour and 0.84 for soy incorporated rice based traditional products. This might be due to germination and conventional drying during sample preparation.

Figure 3 showed the contour graph of moisture content as influenced by proportion of red teff, soybean and papaya. The regression model for moisture content is shown as Eq.14 (all independent variables in coded values) indicating quadratic effects with all three variables (A= Red teff, B=Soybean, C=Papaya)

MC (%) =7.976A-7.625B+11.844C+8.447+1.935AC+1.216BC-------------------------------Eq. 14

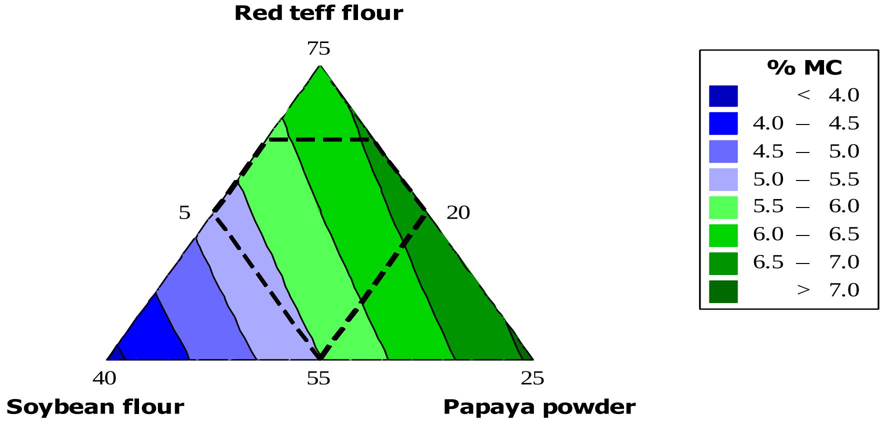


Figure 3: Contour plot of displaying moisture content (dry base) of porridge.

II. Total ash

The ash content gives an indication of the mineral composition of food materials (Omotoso 2005: Nnamani *et al.,* 2009). In this study ash value was found in the range of 3.19-4.11% in the porridge and 3.31% in red teff flour, 5.56 % in soybean flour and 0.63% in papaya powder. The lowest value (3.19%) corresponded to the sample containing 65% red teff, 20% soybean and 15% papaya. The ash content of porridge was highly significantly ($p<0.01$) affected by proportion of red teff, soybean and papaya in the mix (Table 20) in linear, quadratic model, between red teff with papaya, and soybean with papaya and significant different among red teff and soybean. The ash content of the blends was increased gradually with increasing proportion of soybean flour. This might with increasing level of soy flour substitution supporting the claims of Akpapunam (1997) and low ash content was observed as proportion of papaya increased in the mixture. This could obviously be due to the non significant quantity of ash in papaya which is 0.60 % ash (Padmapriya, 2013).

The findings reported by different studies are in agreement with the results found in the present study indicating an increase in ash content with the increase in soy flour supplementation in the red teff flour. A study conducted by Brou *et al.* (2013) reported that the ash content of flour blends increased from 2.33-2.55 % as the amount of soybean increases from 0% to 45% in the composite flour prepared from millet, maize and soybean composite flour. Another research done by Okoye *et al.* (2008) stated that ash contents of the blended products increased as the level of soybean flour inclusion increased. The ash content results showed that the malted soybean flour contained the highest minerals.

Figure 4 showes the contour graph of ash as influenced by proportion of red teff, soybean and papaya. The regression model for ash is shown as Eq. 15 (all independent variables in coded values) indicating quadratic effects with all three variables.

Ash (%) =8.1A+31.2B+78.5C-47.8AB-111.4AC-101BC--------------------------------------- Eq.15

Where :

A=Red teff, B=Soybean and C=Papaya

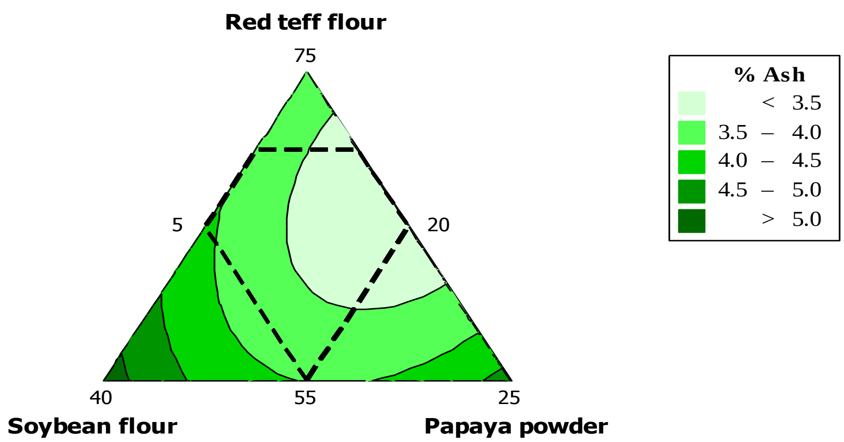


Figure 4: Contour plot of displaying ash content of porridge

III. Crude fat

Fat is an important source of energy for infants and young children. The fat content of human milk is high with about 50% of the energy coming from fat, underlining that fat requirements are high in early life.

The crude fat amount of the formulated components red teff, soybean and papaya were 2.60%, 18.22% and 0.16 % respectively whereas the crude fat levels of formulated porridge was ranged from 5.27% -7.44 %. There was a highly significance difference ($p<0.01$) in the linear model; significance difference ($p<0.05$) in the interaction of red teff with soybean, and soybean with papaya. There was no significant difference ($p > 0.05$) in the interaction between red teff with papaya. The fat level was low in FM1 (red teff 65%, soybean 20%, and papaya 15%) with percentage of 5.27 but higher in FM11 (red teff 65%, soybean 30%, and papaya 5%) having the highest percentage crude fat 7.44. As the amount of soybean flour increases from 20% to 30% the fat content of the porridge was showed increment from 5.27 to 7.44 and this occurs for the cause of the high amount of fat found in soybean.

This result was similar to Ayo *et al*. (2014) who reported effect of the added malted soybean flour on the quality of the acha based bread fat content was increased from 12.02-18.34% with an increase in the percentages (0-50%) of malted soybean flour. On other study the fat content was similarly increased from 0.5 to 2.4% in the composite breads produced from soy-bean flour substitution (Joel *et al*., 2011). Soybean is important in complementary foods because it adds fat (Martin *et al.,* 2010).The crude fat content of more soybean blend was higher than high proportion of containing red teff and papaya. This is due to the superior quality of soybean over red teff and papaya in terms of fat content (Meseret, 2011). Teff is also staple grain food from Ethiopia that has a favorable fatty acid composition compared with other staple foods (Michaelsen *et al*., 2011). Dietary fats function in the increase of palatability of food by absorbing and retaining flavors (Antia *et al*., 2006).

Figure 5 showed the contour graph of fat content as influenced by proportion of red teff, soybean and papaya. The regression model for fat is shown as Eq. 16 (all independent variables in coded values) indicating quadratic effects with all three variables (*A=Red teff, B=Soybean and C=Papaya*)

Fat (%) =6.96A+66.77B+13.50C-82.08AB-10.85AC-96.44BC-------------------------------- Eq.16

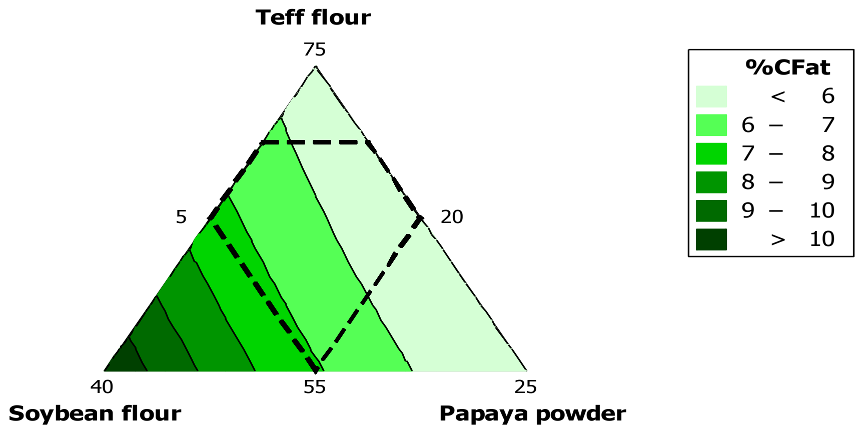


Figure 5: Contour plot of displaying fat content of porridge

IV. Crude fiber

The American Association of Cereal Chemists (AACC) (2001) adopted the definition of dietary fibre as the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibres promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation (FAO/WHO, 2004). It is known to be an important moderator of digestion in the small bowel and insufficient intake from the diet can result in inadequate faecal bulk and may affect overall health.

The crude fibers of the formulated porridges varied from 2.33 % to 3.60 %. The crude fiber content of the individual flour samples (red teff, soybean and papaya) were 3.20 %, 5.73% and 1.93 % respectively as shown in Table 19. The formulated complementary porridge crude fiber content showed highly significance difference in linear model whereas a significant difference (P<0.05) in the quadratic model. There was significant difference in the crude fiber contents of all formulated porridge made from mix up composite flour. Among the combination, the crude fiber content of the porridge was increased with an increase in the levels of soy flour and red teff flour supplementation. Similarly by other study on porridge containing maximum level of soybean flour has high content of crude fibre (Vandana *et al*., 2012). The crude fiber content of formulated porridge was higher than study report on breadfruit - soybean food (1.37 to 2.12%) (Steve and Funmilayo, 2005).

Similarly, other study indicated that crude fibre content of malted soybean flour had the highest crude fibre content of 5.18% (Nwosu *et al*., 2014). The soybean-acha biscuit was also accepted up to 30% added malted soybean with corresponding fiber content of 13.40% which is higher than crude fiber content of this study (3.60%) (Ayo *et al*., 2014). Red teff grains have a relatively high proportion of bran, which is high in fiber (Bultosa, 2007). Therefore, higher dietary fiber content is similarly expected with increased ratio of red teff. This indicated that red teff and soybean used in this study has higher fiber content and contributed for higher value as their proportion increased in the formulation.

Figure 6 showed contour graph indicating crude fiber increment with an increase in the concentration of soybean, red teff ; and papaya had the opposite effect. The regression model for crude fiber is shown as Eq. 17 (all independent variables in coded values) indicating quadratic effects with all three variables (*A= Red teff , B= Soybean and C=Papaya).*

Crude fiber (%) =6.1A+45.6B+94.9C-63.6AB-118.5AC+168BC------------------------------ Eq. 17

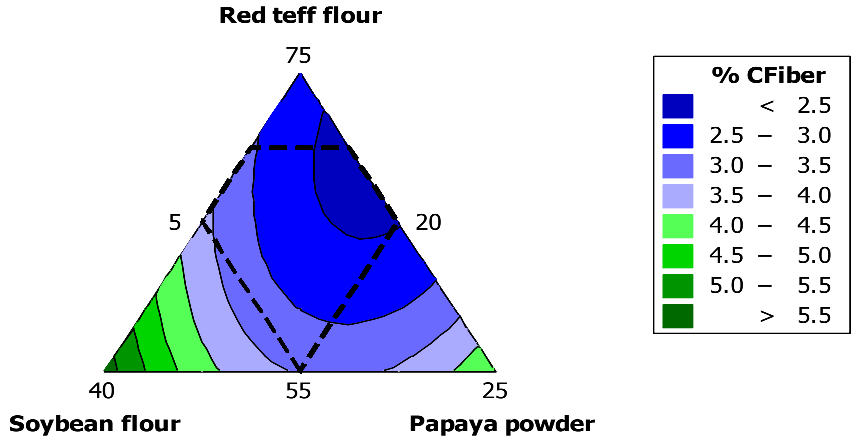


Figure 6: Contour plot of displaying crude fiber of porridge

V. Protein

Proteins are large molecules made up of amino acids bonded together by peptide linkages. They provide the essential amino acids, which are the initial materials for tissue synthesis and constituent of tissue protein. Thus, it was often referred to as the "currency" of nutrition and metabolism. A protein is important for the formation of regulatory compounds. Some hormones, all enzymes, and most other regulatory materials in the body are proteins substances. Proteins defend the body against disease (Young, 2001)..

The protein content of the components of porridge was 12.26 %, 43.63 % and 0.88 % for red teff, soybean and papaya respectively. Whereas the protein content of formulated porridges were ranged from 12.55 % to 24.22 % indicated in Table 19. The protein content of the porridge showed highly significance difference in linear model in the quadratic model (P<0.01). Highly significance variation was observed red teff with soybean, between soybean and papaya, and significant difference among red teff and papaya (Table 20).

There were high protein content result in germinated soybean flour and germinated soybean four substitution in the formulated porridge. This might be due to germination effect on protein content. In similar trend as reported by Malomo *et al*.(2012) germination of soybean causes 9.4% crude protein increment .The increase in protein content observed may be due to the synthesis of enzymes or a compositional change following the degradation of other components. Malted soybean flour had also the highest crude protein content of (38.5%) and fermented soy flour had higher protein content (46.28%) which supported the results of this study had been reported by (Nwosu *et al*., 2014 ;Ugwuona, 2009).The increase in protein content could be due to added malted soybean containing high percentage (36.49%) of protein (Wolf, 2012).

Similar study by Emmanuel *et al*. (2012) there was a progressive increase in the protein value with increase in soybean addition. Mashayekh *et al*. (2008) also reported increase in protein content of the bread as a result of the addition of soy flour. In fact, legumes are rich in proteins with the content ranged from 20 to 50% according to Singh *et al*. (2004).

Another findings indicated by Mariam *et al*. (2009) showed that the supplementation of wheat flour with teff caused insignificant reduction in protein content. Similarly red teff flour is lower in protein as compared to soybean and higher as contrast to papaya powder. Bultosa (2007) also reported similar result to this study in which teff grain protein content ranged from 11.1 to 8.7% with mean of 10.4%. Even though the average crude protein content of teff is in the range of 8 to 11 percent as reported by (Kaleab, 2014). Teff's amino acid composition is well-balanced with a relatively high concentration of lysine, a major limiting amino acid in cereals, is found in teff. Similarly, compared to other cereals, higher contents of isoleucine, leucine, valine, tyrosine, threonine, methionine, phenylalanine, arginine, alanine, and histidine are found in teff. Another important feature of teff is that it has no gluten (Hopman *et al*., 2008).

The amount of protein obtained is indicated in the contour graph (Figure 7). The results from the study have shown that mixing of soybean flour with red teff and papaya flour would result in considerable improvement in the protein content of the flour. This is because the high amount of protein content in soybean flour.

The regression model for protein is shown as Eq. 18 (all independent variables in coded values) indicating quadratic effects with all three variables (A=Red teff , B=Soybean and C=Papaya)

$$Protein = 39A + 704B - 303C - 1029AB + 570AC - 989BC \quad \text{Eq. 18}$$

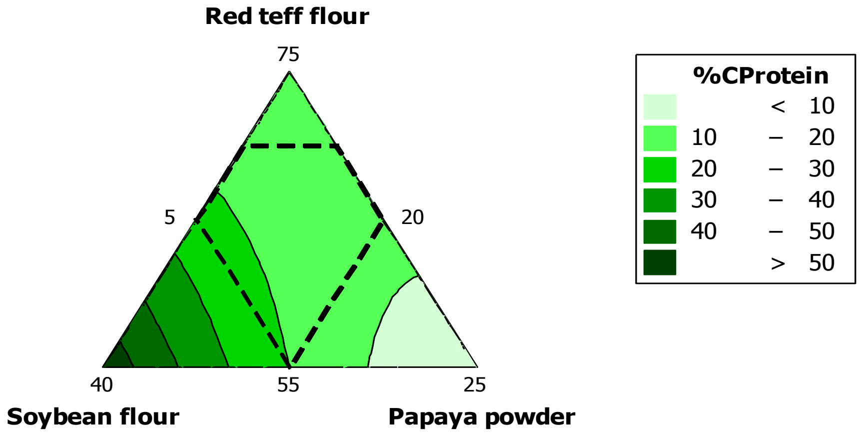


Figure 7: **Effects of formulation on protein content of porridge indicated by contour plot**

VI. Carbohydrate

Carbohydrates are an important source of energy in human diets comprising some 40 – 80% of total energy intake. There are several reasons why it is desirable that carbohydrates should provide the main source of energy (FAO/WHO, 1998). In addition to providing easily available energy for oxidative metabolism, carbohydrate-containing foods are vehicles for important micronutrients and phyto-chemicals. Dietary carbohydrate is important to maintain glycaemic homeostatis and for gastrointestinal integrity and function.

The carbohydrate in the main component flours was 70.54 %, 23.41 % and 88.01% in red teff , soybean flour and papaya powder. The carbohydrate of formulated porridges ranged from 55.43-69.68 %. Moreover, there was a decline as the amount of soybean increased which is stated in the contour graph (Figure 8). There was a highly significant difference (P<0.01) in the linear model of carbohydrate.

Even though there was no significance difference in quadratic model of carbohydrate, there was an increment from 55.43 % to 69.68% as the amount of papaya increased from 5% to 15%. The carbohydrate content of the porridge was enhanced as the ratio of papaya increased. This could be due high amount of carbohydrate content found in papaya whose major components of papaya dry matter are carbohydrates (USDA, 2009).

The carbohydrate content of the product has decreased from 69.68% to 55.43 % with increase in the percentages (20-30%) of the germinated soybean flour. The carbohydrate contents decreased with increase in the proportion of the soy flour in the soybean flour supplemented porridge. This trend supports the claim of (Rita and Sophia, 2010). Germination of soybean for sample preparation degrades carbohydrate. This may be due to an increase in respiration rate during germination that brings about the release of energy from the breakdown of carbon compounds (Malomo *et al*., 2012).

The carbohydrate content was increased from 60.08% to 68.86 in the formulated porridge as the ratio of red teff flour varies from 55% to 70%. This increment might be due to higher contents of carbohydrate in red teff. This could be due to complex carbohydrates content which make up to 80 percent of the teff grain and a starch content of approximately 73 percent, making teff a starchy cereal as reported by Kaleab (2014).

The regression model for carbohydrate is shown as Eq. 19 (all independent variables in coded values) indicating quadratic effects with all three variables (A=Red teff , B=Soybean and C=Papaya)

$$Carbohydrate=32.1A-740B+204C+1214.2AB-330.9AC+1353BC \quad \text{------------------------------} \quad Eq.19$$

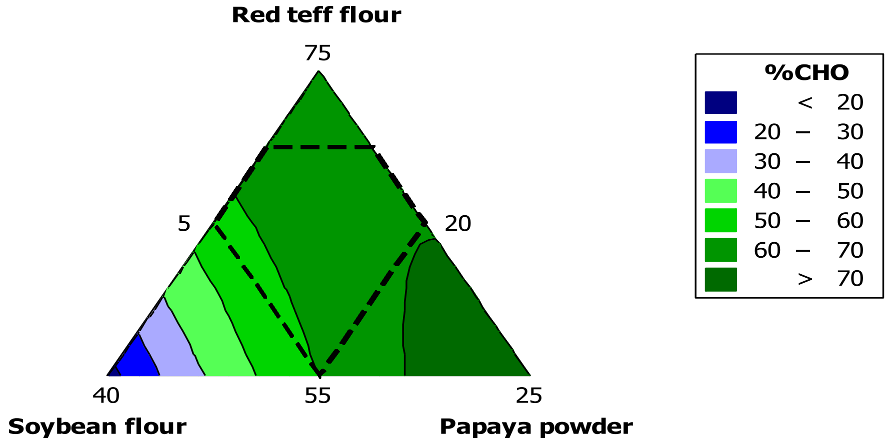


Figure 8: Contour plot of displaying carbohydrate content of porridge

VII. Gross energy

The gross energy in kcal per 100g of independent component sample red teff flour, soybean flour and papaya powder was 354.57, 432.14 and 357.01 respectively. While for the formulated complementary porridge varied from 376.30 to 385.56 kcal/100g. The amount of calorie in the final product showed highly significant difference ($P<0.01$) in linear and in the quadratic model; red teff with soybean; and soybean with papaya while it was no significant difference ($p<0.05$) between red teff and papaya. The amount of calorie obtained is indicated in the contour graph (Figure 9).

The statistical results regarding gross energy value of formulated porridge presented in Table 19 indicated that soy flour supplementation possessed significant effect on the gross energy of soy flour supplemented red teff flour and papaya powder. This observation may be attributed to the high content of gross energy in soybean. The sources of high energy level in formulated complementary food were linked to the high carbohydrate content in the red teff, papaya; proteins and lipids contents in the soybean. The formulated complementary food energy value (376.30-385.56 kcal/100g) is greater than recommendation of WHO (2003) for an infant complementary food in developing countries which is ranged from 200 to 300 kcal/day for infants under one year.

The energy needs from complementary foods for infants with "average" breast milk intake in developing countries (WHO/UNICEF, 1998) are approximately 200 kcal per day at 6-8 months of age, 300 kcal per day at 9-11 months of age, and 550 kcal per day at 12-23 months of age. In industrialized countries these estimates differ somewhat (130, 310 and 580 kcal/d at 6-8, 9-11 and 12-23 months, respectively) because of differences in average breast milk intake. Among breastfed children in developing countries, average breast milk energy intake is 413, 379 and 346 kcal /d at 6-8, 9-11 and 12-23 months, respectively (WHO/UNICEF, 1998).

The regression model for calorie is shown as Eq. 20 (all independent variables in coded values) indicating quadratic effects with all three variables.

Calorie=345.9A+456.9B-273.3C+1.5AB+857.8AC+588.9---------------------------------- Eq. 20

Where*:* A=Red teff , B=Soybean and C=Papaya

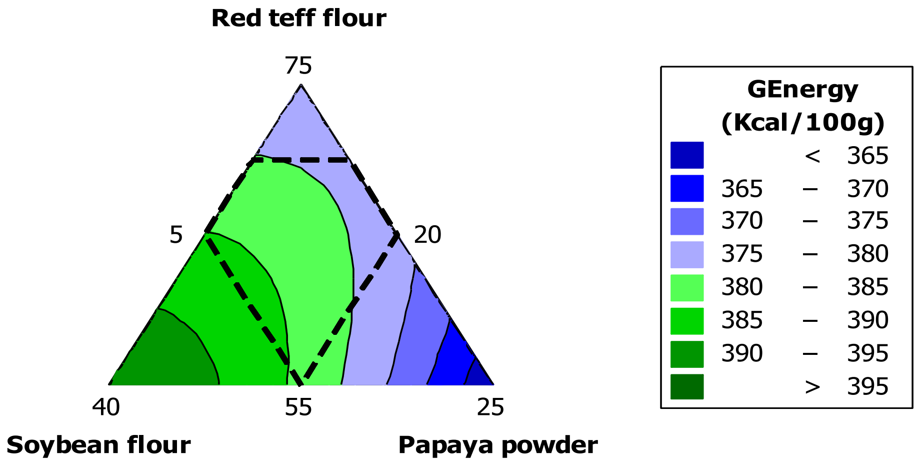


Figure 9: Contour plot of displaying calorie content of porridge

4.3.2. β- Carotene Content

Beta carotene is the best known of the carotenoids because (Groff *et al.*, 1995) it is one of the most abundant in our diet; (Olson *et al.*, 1996) in addition to its role as an antioxidant, beta carotene also possesses provitamin A activity (Handelman ,1996).

The β-carotene content of components was 0.193 mg/g in red teff flour, 0.424 mg/g soybean flour and 33.510 mg/g papaya. The β-carotene content of porridge sample varied between 0.245 mg/g to 5.737 mg/g as represented in Table 21 and the p-value for mixture compositions of β-carotene content shown Table 22.

Table 21: Measured percentage of β-carotene content red teff based formulated porridge and individual flour

Formulation	Teff flour	Soybean flour	Papaya powder	β- Carotene (mg/g)
FM1	65	20	15	4.916
FM2	55	30	15	5.737
FM3	70	25	5	0.245
FM4	65	22.5	12.5	2.816
FM5	60	27.5	12.5	3.626
FM6	70	20	10	1.420
FM7	67.5	25	7.5	0.608
FM8	65	27.5	7.5	0.744
FM9	65	25	10	2.052
FM10	67.5	22.5	10	1.746
FM11	65	30	5	0.351
Red teff	100	0	0	0.193
Soybean	0	100	0	0.424
Papaya	0	0	100	33.510

Table 22: Analysis of variance (ANOVA) p-values of β- Carotene parameters

Source	β- Carotene mg/g
Linear	0.003
Quadratic	0.015
A*B	0.826
A*C	0.004
B*C	0.011

A= Red teff, B=Soybean, C=Papaya

Highly significant difference ($P<0.01$) was resulted in β-carotene content of the formulated porridges in linear model, interaction between red teff with papaya and significant different ($P<0.05$) in quadratic model and soybean with papaya (Table 22). The increment of β-carotene content was parallel increase in the proportion of papaya powder (Figure 10). This is due to the high β-carotene content of papaya (Padmapriya, 2013).

The regression model for β-carotene was shown by (Eq.21) in the quadratic model with three variables.

β-carotene =-0.9A-9B+346.3C+18.3AB-387AC-312.8BC-------------------------------------- *Eq.21*
Where*:* A=Red teff , B=Soybean and C=Papaya

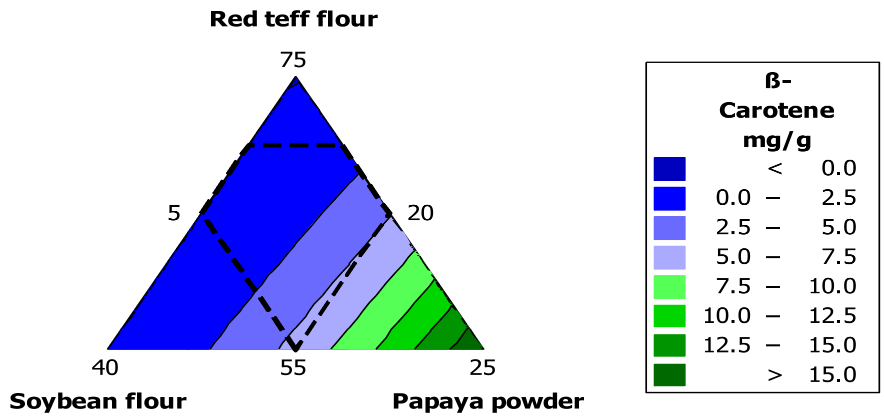


Figure 10: Contour plot of displaying β- carotene content of porridge

4.3.3. Mineral contents (Iron, Calcium and Zinc)

All micronutrients are essential to normal functions of biological processes and human health. Iron is involved in many vital functions in the human body. First, iron is important for oxygen transport. Further, iron is essential to brain function and development and severe iron deficiency can cause retarded mental development, which may be irreversible (Walker *et al*., 2007). Zinc is essential to growth, synthesis and maintenance of lean body mass, and to the immune functions. Through its position in metalloenzymes zinc plays a major role in vital processes such as nucleic acid synthesis, protein digestion and synthesis, carbohydrate metabolism, bone metabolism, oxygen transport and antioxidative defence. Zinc is often the limiting growth (type II) nutrient in diets in populations with high prevalence of malnutrition (Golden, 2009).

Mineral content of formulated porridges and individual component were analyzed for calcium, zinc and iron. Diagnostic tools like normal plot of residuals indicated that the residuals of all the parameters (minerals) content were normally distributed. Table 23 presents the mineral content in all porridge samples at the similarly Analysis of variance (ANOVA) for the p-values of minerals contents are summarized and shown in Table 24.

Table 23: Measured mineral content of formulated porridge and individual flour in mg/100gm

Formulation	Red teff flour	Soybean flour	Papaya powder	Fe	Ca	Zn
FM1	65	20	15	12.29	160.62	4.05
FM2	55	30	15	9.38	169.471	4.31
FM3	70	25	5	34.86	270.26	5.44
FM4	65	22.5	12.5	13.76	177.95	4.53
FM5	60	27.5	12.5	9.85	182.62	4.81
FM6	70	20	10	29.24	198.23	4.84
FM7	67.5	25	7.5	25.64	235.22	5.36
FM8	65	27.5	7.5	21.74	245.44	5.38
FM9	65	25	10	16.97	204.8	5.24
FM10	67.5	22.5	10	22.4	201.49	5.09
FM11	65	30	5	27.58	293.57	5.58
Red teff	100	0	0	38.00	179.30	5.23
Soybean	0	100	0	9.88	264.80	8.29
Papaya	0	0	100	0.94	28.70	0.32

Table 24: Analysis of variance (ANOVA) p-values of mineral content

Source	Fe	Ca	Zn
Linear	0.000	0.000	0.009
Quadratic	0.000	0.000	0.024
A*B	0.000	0.011	0.308
A*C	0.000	0.001	0.016
B*C	0.000	0.000	0.008

A= Red teff, B=Soybean, C=Papaya

The iron contents of the formulated porridges were found in a range of 12.29-34.86 mg/100g. Individual components of the formulated porridge iron content in mg/100gm were 38 in red teff flour, 9.88 in soybean and 0.94 in papaya powder. The compositions of Fe in the formulation showed highly significance different ($P<0.01$) both in linear, quadratic model and in all possible interaction of red teff, soybean and papaya.

The calcium contents of the formulated porridges were found in a range of 160.62-293.57 mg/100g. Individual components of the formulated porridge iron content in mg/100gm were 179.30 in red teff flour, 264.8 in soybean and 28.7 in papaya powder. Calcium content was found to be highly significant in linear, quadratic model and in the interaction of red teff with papaya ($P<0.01$) and significantly difference ($P<0.05$) in the interaction of soybean and papaya.

The zinc contents of the formulated porridges were found in a range of 4.05-5.58 mg/100g. Individual components of the formulated porridge zinc content in mg/100g were 5.23 in red teff flour, 8.29 in soybean and 0.32 in papaya powder. Zinc content was found to be highly significant in linear model and in the interaction of soybean with papaya ($P<0.01$) and significantly difference ($P<0.05$) in quadratic model and the interaction of red teff with papaya. Even though it was varied in the amount of 4.05-5.58 mg/100g as the amount of soybean increased, it did not show significance difference in interaction of red teff with soybean.

The results found that high amount Ca and Zn contents when there was high ratio of soybean flour in the porridge and Fe content was increased in the formulation as the proportion of red teff increased in the product. This could be due high iron content in red teff variety. As reported by Abebe *et al*. (2007) red teff has a higher iron and calcium content. A study result reported by Tewodros *et al*.(2013) was similarly indicated that grain teff has high iron content (36.2mg100g^{-1}) , low zinc (1.50mg100g^{-1}) and calcium (66.6mg 100g^{-1}) contents than flaxseed (4.3mg 100g^{-1}, 188.5mg 100g^{-1} and 267.7mg 100g^{-1}, respectively). Another study was also shown that grain teff is known for its high (37.7mg100g^{-1}) iron contents (Abebe *et al*., 2007). Higher mineral content (iron, calcium and zinc) in the present study found in different porridges was due to higher concentration of calcium and zinc in the soybean flour and iron in red teff flour used for formulation of this product.

The contour plots for iron, zinc and calcium are presented in Figure11a, 11b and11c respectively.

The regression model for mineral content i.e. iron, zinc and calcium is shown in Eq. 22, 23 and 24 respectively indicating quadratic effects with all three variables (A= Red teff, B=Soybean, C=Papaya).

Iron =279A+951B+408C-2070AB-1226AC-1064-- *Eq. 22*

Calcium=355A+1863B+3213C-2003AB-4073AC-8914BC------------------------------------- *Eq. 23*

Zinc =1.70A-11.52B-98.71C+36.23AB+114.65AC+137.67BC--------------------------------- *Eq. 24*

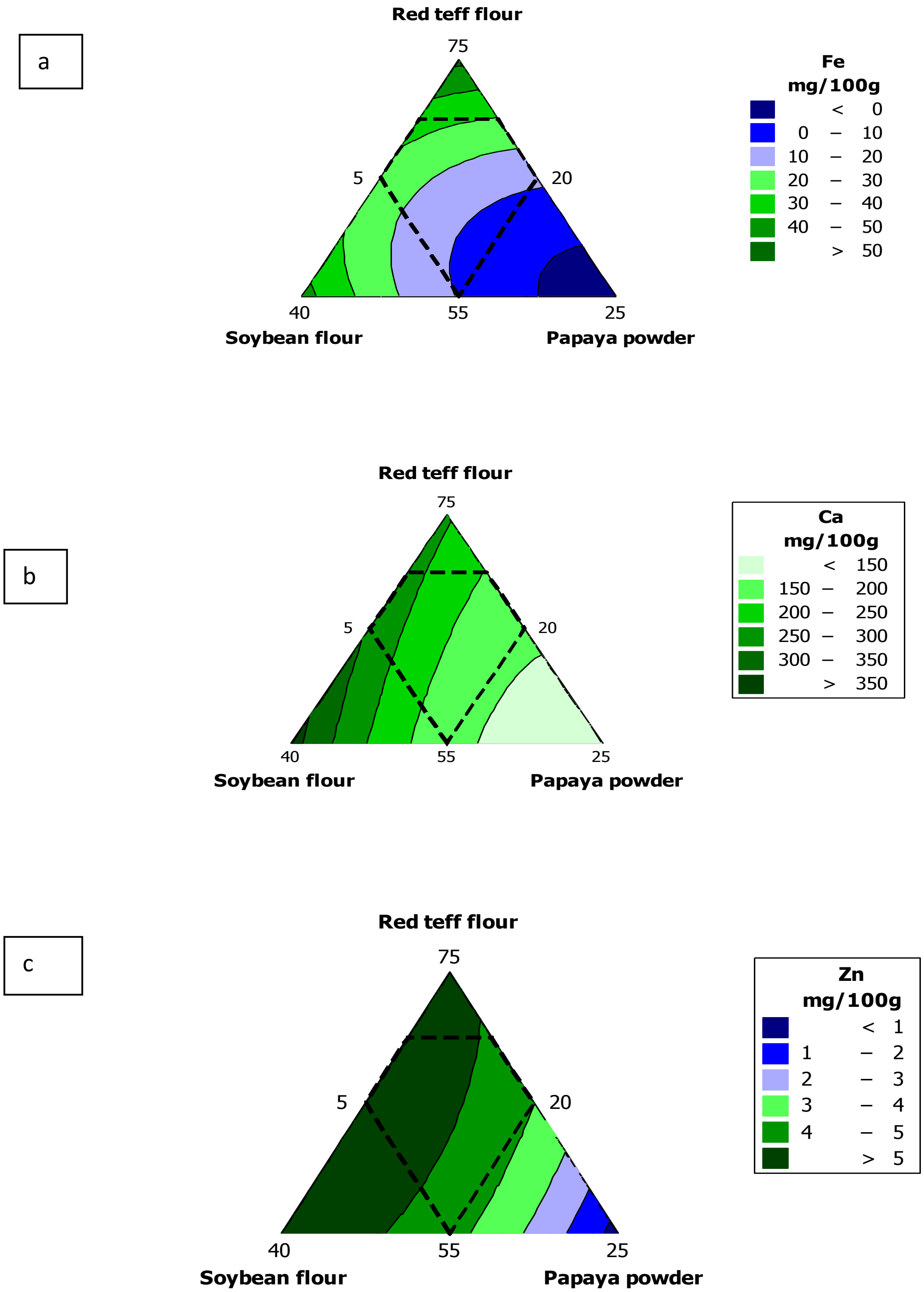


Figure 11: Contour plot of displaying a) iron content b) calcium content c) zinc content of porridge

4.3.4. Major anti-nutritional factors

The phytate and tannin contents are shown in Table 25. The influence of primary ingredients such as red teff, soybean and papaya on anti-nutritional factor of the porridge was analyzed using Analysis of variance (ANOVA). ANOVA results of p-values for models and combination products are summarized in Table 26.

Table 25: Measured values of anti-nutritional factors for porridge and individual flour

Formulation	Red teff flour	Soybean flour	Papaya flour	Phytate (μg/g)	Tannin (mg/g)
FM1	65	20	15	295.168	0.239
FM2	55	30	15	256.303	0.265
FM3	70	25	5	273.109	0.128
FM4	65	22.5	12.5	282.563	0.201
FM5	60	27.5	12.5	268.908	0.226
FM6	70	20	10	285.714	0.115
FM7	67.5	25	7.5	275.210	0.141
FM8	65	27.5	7.5	263.655	0.179
FM9	65	25	10	278.361	0.184
FM10	67.5	22.5	10	280.462	0.154
FM11	65	30	5	244.748	0.162
Red teff	100	0	0	295.168	0.111
Soybean	0	100	0	163.866	0.261
Papaya	0	0	100	232.143	0.542

Table 26: Analysis of variance (ANOVA) p-values of anti-nutritional factors

Source	Phytate	Tannin
Linear	0.011	0.007
Quadratic	0.043	0.005
A*B	0.011	0.009
A*C	0.313	0.022
B*C	0.042	0.021

A= Red teff, B=Soybean, C=Papaya

The phytate content of soy supplemented composite flours containing red teff, soybean and papaya is given in Table 25. The result showed a significant difference ($P<0.05$) effect on the linear, quadratic model, in the interaction of red teff with soybean and soybean with papaya and there was no significant difference ($P<0.05$) in the interaction of red teff with papaya. The amount of phytate content of porridge made from different composite flours ranged from 244.748-295.168 μg/g shown in Table 25. The phytate amount of individual flour red teff, soybean and papaya were 295.168 μg /g, 163.866 μg /g, and 232.143 μg /g respectively.

Phytates binds to minerals like calcium, iron, magnesium and zinc and make them unavailable for bio absorption (Nelson *et al.*, 1968). Anemia and other mineral deficiency disorders are common in regions where the diet is primarily a vegetarian (Erdman, 1979)

Tannins are a group of phenolic non-nitrogenous organic constituents, which are chemically classified into two broad categories namely hydrolysable and condensed tannins (McLeod, 1974). Tannins bind to proteins through hydrogen binding and hydrophobic interactions, thereby reducing their nutritional quality (Hahn *et al.*, 1984) and combine with digestive enzymes thereby making them unavailable for digestion (Abara, 2003). They also cause decreased palatability and reduced growth rate (Roeder, 1995).

The levels of tannin content showed a high significant difference ($P<0.01$) effect on linear, quadratic model and interaction between red teff with soybean and significant different ($P<0.05$) effect on interaction among red teff with papaya and soybean with papaya indicated in Table 26. The amount of tannin content of porridge made from different composite flours ranged from 0.115-0.265 mg/g as shown in Table 25. The tannin amount of individual flour red teff, soybean and papaya were 0.111 mg/g, 0.261 mg/g, and 0.542 mg/g respectively.

Amount of tannin in the porridge was increased as the amount of soybean flour increased. This result occurred because soybean contains high amount of tannin (Folake *et al.,* 2012). Findings of the present study are in agreement with that of Maqbool *et al*. (1987) who concluded tannin content of wheat rot is increased by the increasing supplementation level of soy flour. Peel and pulp of ripe papaya fruits also contains low amounts of anti-nutrients like tannin (10.16 mg/100 g of dry matter), phytate (3.29 mg/100 g of dry matter) and oxalate (1.89 mg/100 g of dry matter) creating in compatibility problems as reported by Onibon *et al*. (2007). Both phytate and tannin content have shown a reduction when it is contrast to the raw value. This might resulted from the different germination, soaking and heat treatment during processing. Phyto-chemical composition of teff grain result was reported with phytate content of 682-1374 mg/100 g and tannin 16 mg /100 g on dry matter (Kaleab, 2014).

Figure 12a and 12b showed the effects of flour formulation on phytate content and tannin content in contour graph respectively. The regression model for phytate and tannin content is shown as Eq. 25 and 26 (all independent variables in coded values) indicating quadratic effects with all three variables (A= Red teff, B=Soybean, C=Papaya).

$Phytate=128A-2106B+1118C+3764AB-1063AC+2595BC$---------------------------------------*Eq.25*

$Tannin=-0.997A-4.334B+9.718C+10.371AB-8.223AC-8.395BC$------------------------------ *Eq. 26*

Where: A= Red teff, B=Soybean, C=Papaya

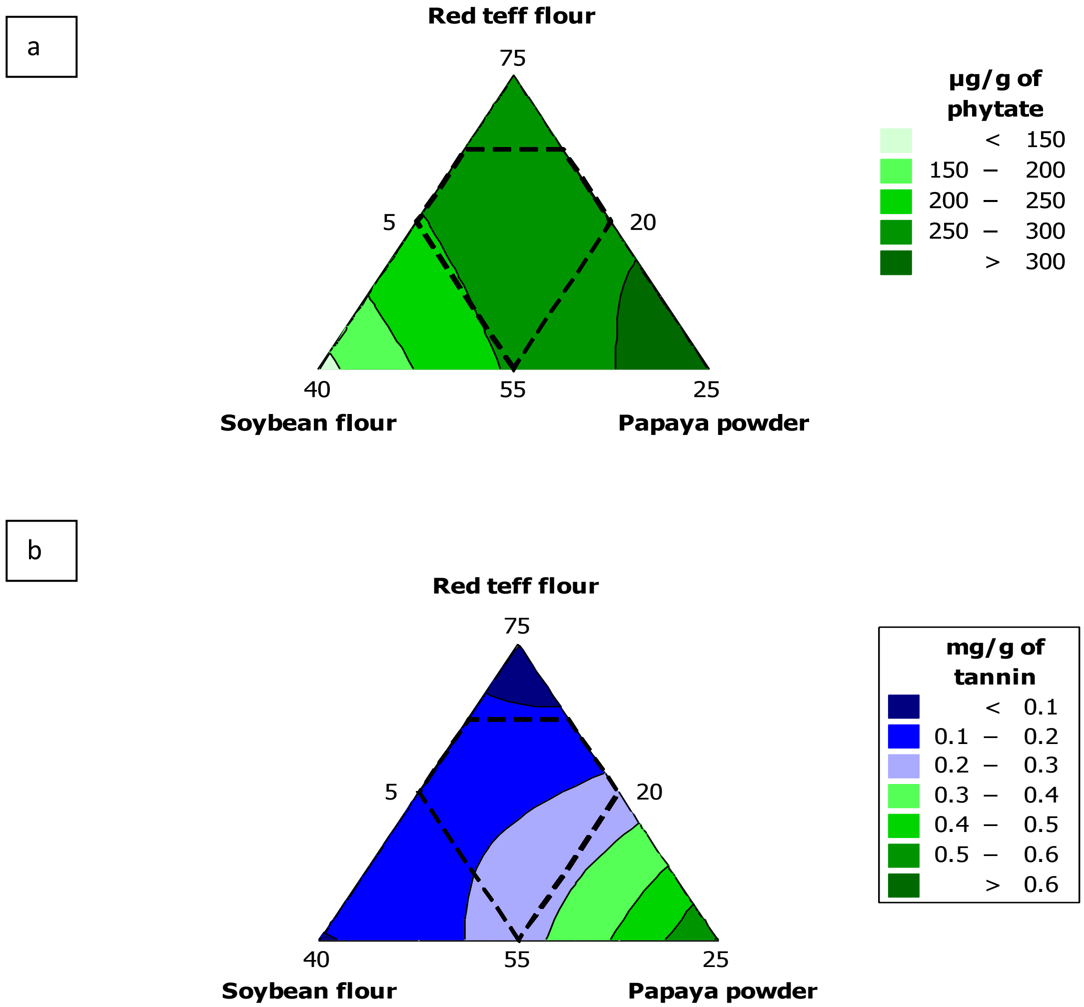


Figure 12: Contour plot of displaying a) Phytate content b) Tannin content of porridge

4.3.5. Functional properties

Composite flour functional properties such as water absorbance capacity (WAC), bulk density (BD), and water activity (aw) are summarized in Table 27. The estimated regression coefficients along with their standard errors of all functional properties of porridge were obtained and shown in Appendix I. Table 28 showed the summarized p-values obtained from ANOVA results for models and mixed products

Table 27: Measured functional properties of formulated flours and powder

Code	Red teff flour	Soybean flour	Papaya flour	A_W at 26 °C	% WAC	BD g/cm^3
1	65	20	15	0.347	156	0.836
2	55	30	15	0.343	147	0.813
3	70	25	5	0.382	106	0.847
4	65	22.5	12.5	0.356	136	0.885
5	60	27.5	12.5	0.345	132	0.877
6	70	20	10	0.38	124	0.833
7	67.5	25	7.5	0.373	112	0.855
8	65	27.5	7.5	0.359	108	0.847
9	65	25	10	0.357	116	0.833
10	67.5	22.5	10	0.364	120	0.893
11	65	30	5	0.362	100	0.787
Red teff	100	0	0	0.351	148	0.962
Soybean	0	100	0	0.345	108	0.769
Papaya	0	0	100	0.254	216	0.943

BD=Bulk Density, WAC= Water absorption capacity, aw =Water activity

Table 28: Analysis of variance (ANOVA) p-values of functional property

Source	A_W at 26 °C	WAC (%)	BD (g/cm^3)
Linear	0.534	0.002	0.073
Quadratic	0.005	0.006	0.139
A*B	0.039	0.846	0.084
A*C	0.243	0.002	0.598
B*C	0.210	0.003	0.043

A= Red teff, B=Soybean, C=Papaya,

BD=Bulk Density, WAC= Water absorption capacity, aw =Water activity

Water activity is an important basic element in foods. For a long time, the industry has known how important it is to check free water. The water activity (aw) measurement forms the basis of this and provides important information about the quality of a product. Finally it provides information regarding the possibility of microbiological growth on the surface. Only with this conclusions can be made about the stability and durability of a sample (Novasima, 2005). The water activity of red teff flour, soybean flour, and papaya powder were 0.351, 0.345 and 0.254 respectively. The formulated flours water activities ranged from 0.343 to 0.382. The regression model for water activity is shown as Eq. 27 (all independent variables in coded values) indicating quadratic effects with all three variables (A= Red teff, B=Soybean, C=Papaya) and water activity is illustrated in Figure 13a contour graph

$A_W = 0.774A + 1.236B + 0.034C - 2.537AB - 1.207AC + 1.326BC$ ------------------------------------ *Eq.27*

Where*:*

A= Red teff, B=Soybean, C=Papaya

Water absorption capacity is the ability of flour particles to entrap large amounts of water, such that exudation is prevented (Chen and Lin, 2002). It also refers to the total amount of water held by a starch gel under a defined state of conditions (Pinnavaia and Pizzirani, 1998). It is highly dependent on the crystalline properties of starch being high for starches with low crystalline and hence, is correlated to the amylose content of starch (Agama *et al*., 2008). Water absorption capacity varies with size, shape, presence of proteins, carbohydrates and lipids, pH and salts (Ezeocha *et al.*, 2011). Water binding capacity is affected by the presence of minerals like phosphorus in starch where starches having high phosphorus contents have high water binding capacities (Zuluaga *et al.*, 2007).

The water absorption capacity of red teff flour, soybean flour, and papaya powder were 148% (1.48), 108% (1.08) and 216% (2.16) respectively. The formulated flours water absorption capacities ranged from 100% to156%. The water absorption capacity decreased as the ratio of papaya powder decreased in the blends of flours and had the highest water absorption capacity as the proportion of red teff and papaya powder increased in the mix. A result reported by Iheagwara (2012) components with the lowest protein content had the lowest water absorption capacity was in contrast to this study result. Malted soybean flour had the highest water absorption capacity (3.0 ± 0.02) (Nwosu *et al*., 2014). According to Joana (2013) reported average values water absorption capacity of teff flour was 3.03 (±0.05) (ml/g) which is higher than this study.

In addition, it has been reported that hydrophilic constituents present in flours could increase water absorption capacity (Hodge and Osman, 1976). In partial conclusion, water absorption capacity of flour was closely linked to both amount of amino acids in different flours studied and availability of proteins functional groups in flour. However, high water absorption capacity was desirable in order to improve the viscosity reduction in food products (Oyarekua and Adeyeye, 2008).

WAC is shown in Figure 13 contour graph and the regression model for WAC value is shown as Eq. 28 (all independent variables in coded values) indicating quadratic effects with all three variables (Red teff, Soybean, Papaya).

WAC=136A-58B+3827C+142AB-4119AC-3728BC--- *Eq. 28*

A= Red teff, B=Soybean, C=Papaya

The density of the flour is important in determining the packaging requirement and material handling (Ezeocha *et al*., 2011). Bulk density among the different composite flours; the bulk density showed an increment from 0.787-0.893 gm/ml as the amount of red teff and papaya increased from 55-70 % and 5-15% as indicated in Figure 13c contour graph. The amount of bulk density was increased as the amount of papaya and red teff in the composite flour increased.

From Table 27 the bulk density of red teff was the highest (0.962 g/cm^3) followed by that of the papaya powder (0.943 g/cm^3) and malted soybean flour had the least bulk density(0.769 g/cm^3). The bulk density results indicated that malted soybean flour had more moisture than the other flours. Usually, the lower the bulk density of a food powder, the higher the moisture content. Compared to Joana (2013) reported average values bulk density of teff flour was 0.40 (±0.01) (g/ml) which is lower than this study.

The regression model for bulk density is shown as Eq. 29 (all independent variables in coded values) indicating quadratic effects with all three variables (A= Red teff, B=Soybean, C=Papaya).

$$BD=-0.320A-9.929B-3.895C+18.741AB+4.896AC+23.576BC \quad \text{------------------------- Equation 29}$$

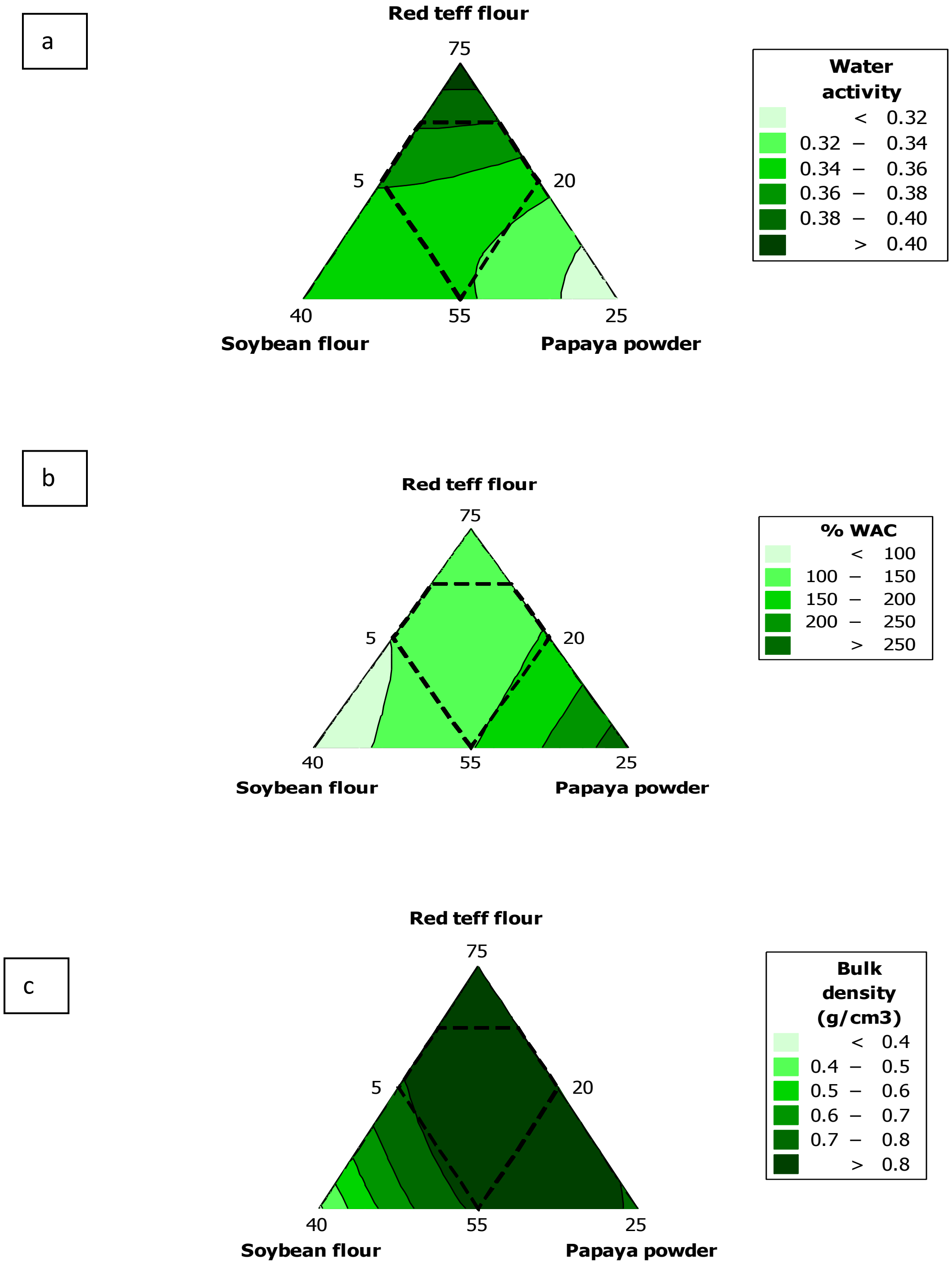


Figure 13: Contour plot of displaying a) water activity b) Water absorption capacity c) Bulk density of composite flours

4.3.6. Sensory evaluation

Sensory quality attributes evaluation of porridge produced from red teff, soybean and papaya flour at different mixture ratio is presented in Table 29. There was highly significant difference ($P<0.01$) in linear model of taste, in the interaction of soybean with papaya and significance difference in quadratic model, in the interaction of red teff with papaya. There was no significant difference in the interaction of red teff with soybean (Table 30). It was also indicated that there was high significance difference ($P<0.01$) in the linear and quadratic model; between red teff and soybean; soybean with papaya and significant difference ($P<0.05$) in the interaction of red teff with papaya of appearance. The linear and quadratic models for aroma was no showed significance difference ($P>0.05$) in the interaction between red teff with soybean and it was only significantly different ($P<0.05$) in the interaction of red teff with papaya, and soybean with papaya. The linear, quadratic model for the mouth feel in the interaction between red teff with papaya, and soybean with papaya showed a significance difference ($p<0.05$) but there was no significant difference ($P>0.05$) between interaction red teff with soybean. There was high significance difference ($P<0.01$) in the linear and quadratic model, and in all interactions of red teff, soybean, and papaya of overall acceptability.

The scores were generally high for all attributes of the products. The addition of malted soybean flour increased the average mean score of taste from 3.35-5.35 of soya-acha bread as the concentration (0-50%) of malted soybean increases. The increase in the average mean score could be due to the fact that malted soybean contains relatively high sugar content and some compound of sensory desire (Ayo *et al.*, 2014). The addition of malted soybean flour increased the mean score of the odor from 3.30-5.55 as the percentage (0-50%) of the bread increases. This could be due to inherent fat content of the malted soybean which at high baking temperature produces some volatile compounds which have been known to be desired (Fenema, 2005).The addition of malted soybean flour increased the mean score of the general acceptability from 3.50-4.40 as the concentration (0-50%) of the malted soybean flour increases. This could be due to the fact that the higher the concentration of the malted soybean flour, the acceptability is more.

Among the major soluble sugars in ripe fruits (glucose, fructose and sucrose), sucrose is most prevalent. During fruit ripening, the sucrose content was shown to increase from 13.9 ± 5.0 mg/g fresh weight in green fruit to 29.8 ± 4.0 mg/g fresh weight in ripe fruits (Gomez *et al.,* 2002).

Table 29: Sensory quality of porridge formulated from red teff flour, soybean flour and papaya powder

Formulation	Red teff flour	Soybean flour	Papaya flour	appearance	Aroma	Taste	Mouth feel	O.A
FM1	65	20	15	4.50	4.93	4.94	4.9	4.97
FM2	55	30	15	4.82	4.85	4.76	4.78	4.84
FM3	70	25	5	3.70	2.75	3.99	3.99	3.93
FM4	65	22.5	12.5	4.30	4.75	4.63	4.61	4.62
FM5	60	27.5	12.5	4.50	4.65	4.49	4.48	4.58
FM6	70	20	10	2.50	4.35	4.41	4.33	3.99
FM7	67.5	25	7.5	3.80	3.85	4.10	4.11	4.02
FM8	65	27.5	7.5	4.30	3.7	4.05	4.05	4.07
FM9	65	25	10	4.10	4.07	4.18	4.17	4.27
FM10	67.5	22.5	10	3.20	4.19	4.32	4.26	4.13
FM11	65	30	5	4.72	2.45	3.97	3.86	3.84

Appear= appearance; O.A = Overall acceptability; values indicating that 5- like very much, 4- like,3- neither like or dislike, 2- dislike and 1- dislike very much

Porridge formulations with the lowest aroma, taste, mouth feel and overall acceptability ratings were given for formulations those that had high amounts (30%) of soybean flours and low amount of papaya powder while those with low proportions soybean (20 %) and high proportion of papaya (15%) had the best score. Porridge with fairly balanced and intermediary proportions of red teff, low proportion soybean flour, and a high amount of papaya powder (15%) had the highest aroma, taste, mouth feel and overall acceptability score. But, appearance was lowest rating with those that had high amounts high amount of red teff (70%), lowest amount soybean (20%) and papaya (5%) had low score.

A similar result was reported by Kanyago *et al.* (2007) with addition of soybean up to 25% gave the porridge a good color, flavor and taste. There was enhancement in all the sensory characteristics in all the porridges except for appearance in porridge containing 67.5 % red teff, 22.5% soybean and 10 % papaya.

The overall result reported by Nair *et al.* (2013) also reveals that addition of soy flour at 20% was highly acceptable by the panel of judges but the addition of soybean more than 25% the acceptability was decreased.

Table 30: Analysis of variance (ANOVA) p-values of sensory quality parameters

Source	Appearance	Aroma	Taste	Mouth feel	Overall acceptability
Linear	0.005	0.053	0.009	0.013	0.000
Quadratic	0.002	0.057	0.027	0.044	0.001
A*B	0.004	0.684	0.273	0.725	0.001
A*C	0.015	0.048	0.027	0.012	0.000
B*C	0.007	0.015	0.007	0.031	0.008

A= Red teff, B=Soybean, C=Papaya

All the sensory attributes were increased as the amount of papaya increased. The sensory attributes such as appearance, aroma, taste, mouth feel and overall acceptance were illustrated by contour graph (Figure 14a, 14b, 14c, 14d and 14e respectively).

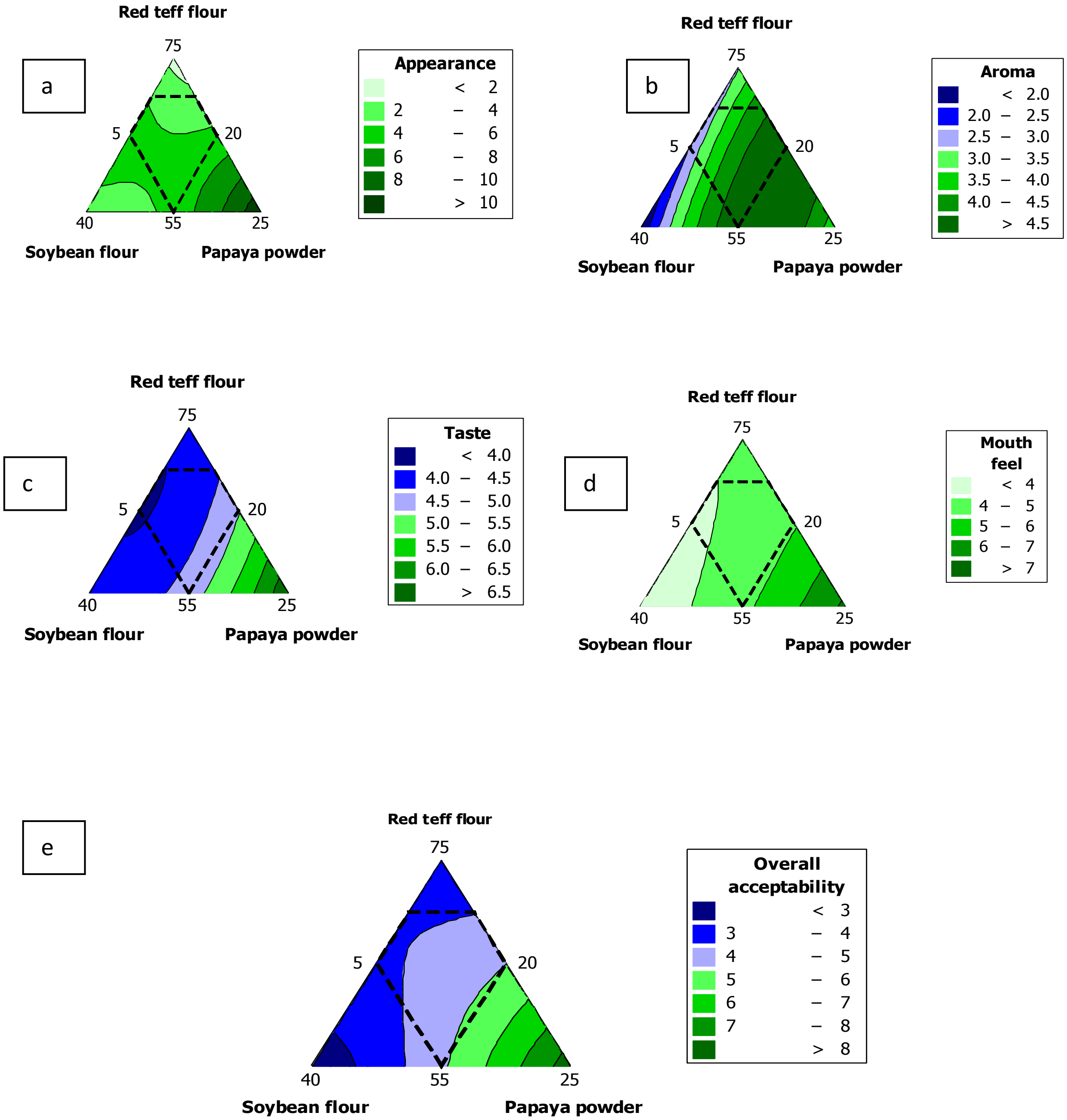


Figure 14: Contour plot of displaying a) Appearance b) Aroma c) Taste d) Mouth feel e) Overall acceptance of porridge

Sensory evaluation of the porridge showed that intermediate proportion of red teff, high amount papaya in combination with low amounts of soybean (20%) resulted in a highly ranked porridge formulation (Figure 14).

4.3.7. Region of optimum formulation

I. Micro and macro nutrient composition

The sweet point which includes all the optimum points (fat % and fiber %, protein %, carbohydrate %, gross energy Kcal/100gm, Iron mg/100gm, calcium mg/100gm, zinc mg/100gm, and β-carotene) is indicated in Figure 15. The sweet point was found in the porridge samples prepared within the range of red teff 60-70%, soybean 20-27.5 % and 10-12.5 papaya % (Figure15). From the optimal value it can be seen that the amount of soybean can be used from the lowest value to the maximum without affecting the nutritional content where as the optimum nutritional content was found at the maximum amount of soybean.

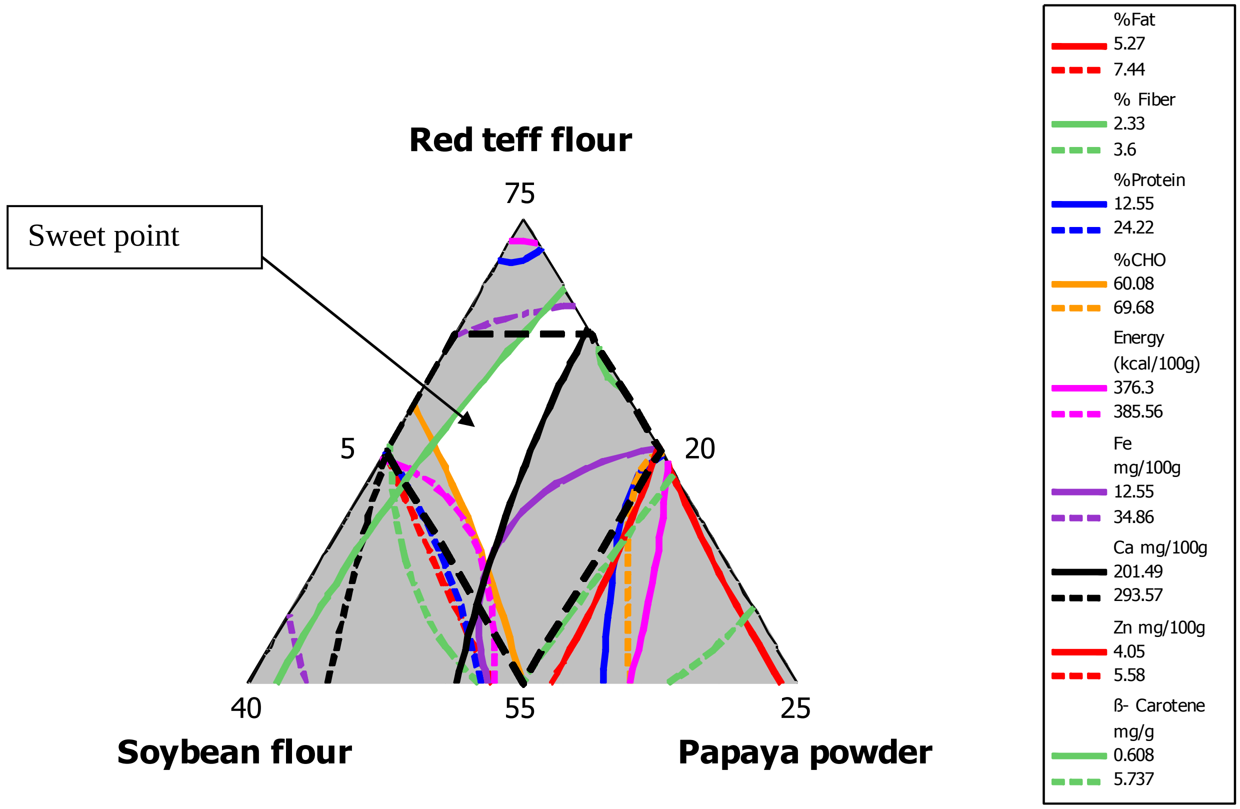


Figure 15: Overlaid contour plot of macro and micronutrients composition

II. Based on sensory evaluation

Although an optimal formation should maximize consumer acceptance, it is impossible to develop a product with all five sensory qualities that would satisfy consumers in most applications (Moskowitz, 1994). To obtain the optimum region therefore, and hence the ingredient formulation that would obtain optimum appearance, taste, aroma, mouth feel and overall acceptability for porridge, the contour plots for these attributes were overlaid in a single graph on same axis as shown in Figure 16. The sweet point was obtained by placing a range of appearance, taste, aroma, mouth feel and overall acceptance. The optimum region in this overlaid plot was where the criteria for all the five response variables (appearance, taste, aroma, mouth feel and overall acceptance) were satisfied and this region is found in the range of red teff 55-65%, soybean 20-30 % and papaya15 %.

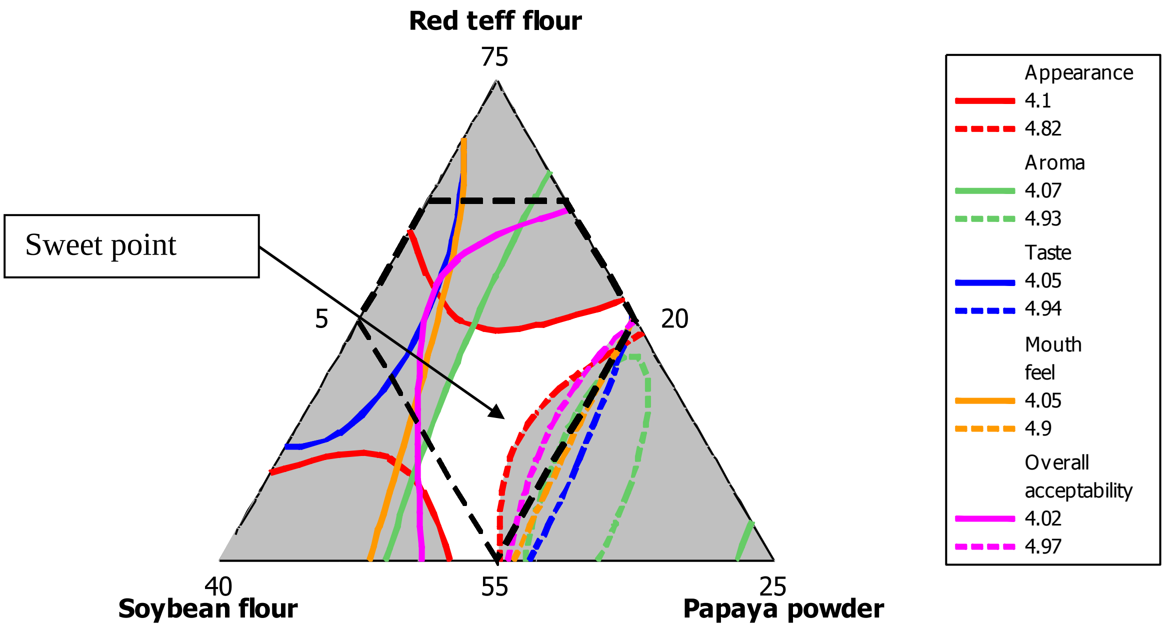


Figure 16: Overlaid contour plot of sensory quality

III. Overall optimal mixture compositions

In order to determine the optimum formulation, the regions of acceptability in the contour plot for protein, carbohydrate, fat, calorie, fiber %, iron, calcium, zinc and overall sensory attribute were superimposed. Superimposition of contour plot regions of interest (protein %, carbohydrate %, fat %, calorie kcal/100gm, %, iron mg/100g, zinc, calcium mg/100g and overall acceptance received hedonic ratings) resulted in optimum regions for porridge (Figure 17). The white region in these figures indicates that any point within this region represents an optimum combination of red teff, soybean and papaya, which results in desirable attributes. The overall optimum values were found in a range of red teff 60-70%, soybean 20-27.5 %, and papaya 10-12.5%.

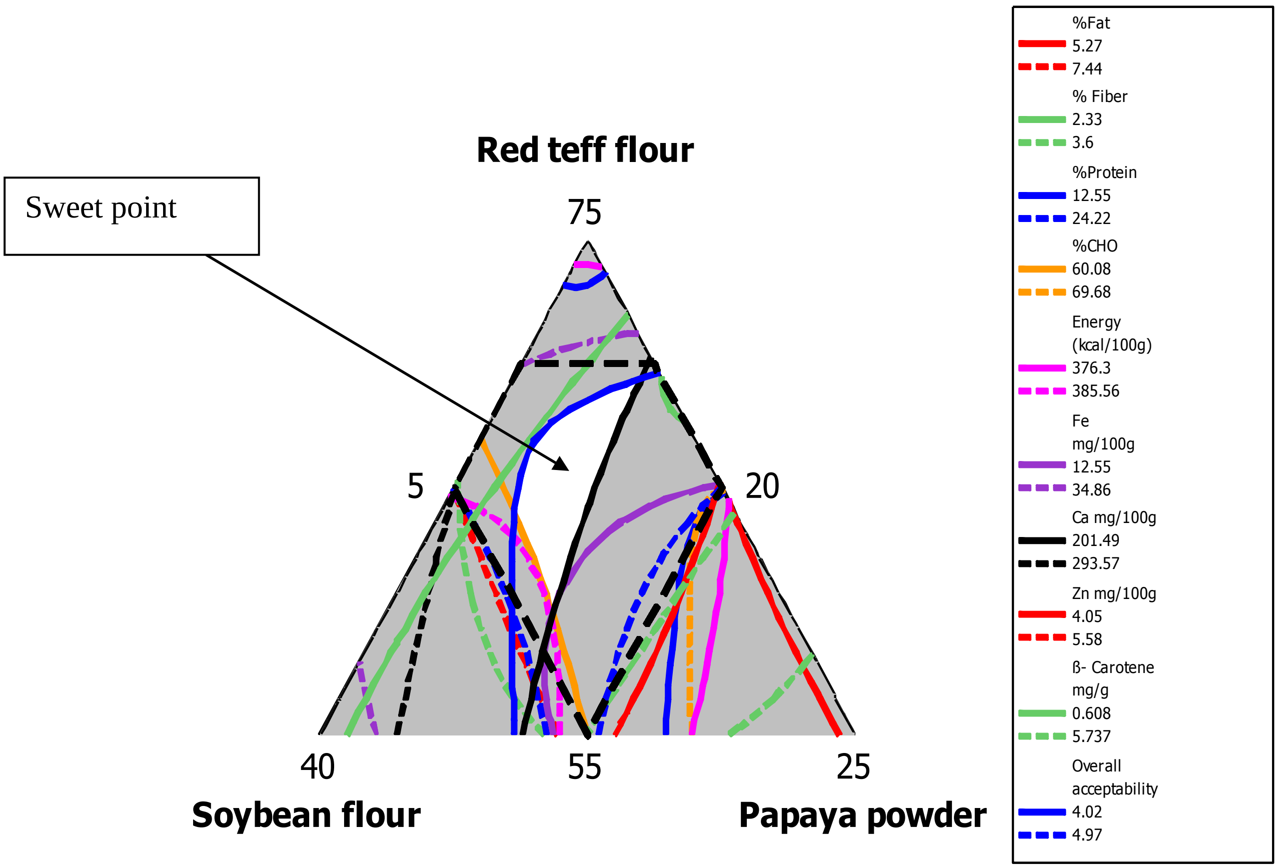


Figure 17: Overlaid contour plot of fat, fiber, protein, carbohydrate, energy, iron, calcium, zinc, β-carotene and overall acceptance of porridge

5. SUMMARY AND CONCLUSIONS

This study was conducted with the broad aim of assessing dietary quality of complementary foods and enhancing the nutritional composition and sensory quality of red teff based enriched porridge. Investigating DDS, FVS, nutrient adequacy, nutrient composition of red teff based porridge and anti-nutrition composition have significant implication for intervention and to lessen children malnutrition. The mean FVS was 7.14 ± 4.07 (range 0 to 18) within the previous 24- hour period. The mean DDS value was 3.44± 1.75 with majority of the children 196 (51%) had low diversity (<4 food groups), and about 148 (38.5%) had medium diversity (4-5 food groups). The average nutritional content in almost all types of complementary samples was nutrient inadequate and below the daily requirement as a complementary food. As a result, the research study was conducted to develop complementary food with the hypothesis of improving the nutritional quality and sensory acceptability of the product by combination of red teff with soybean and papaya powder for under two years children.

The result of this study indicated that, the protein, fat and energy contents were significantly improved with increasing the proportion (20-30%) of the soybean flour in the composite flour formula. β-carotene of the product increased significantly with the increasing proportion of papaya powder. The phytate, tannin concentration in the porridge was increased as the levels of soybean and papaya increases to 30% and 15% respectively. The sensory acceptability of almost all formulated complementary porridge scored better value in terms of appearance, aroma, taste and mouth feel and overall acceptability. Higher proportion of papaya presence in the formulation of porridge was showed good sensory acceptability. The overall optimum point was found in a range of red teff 60-70%, soybean 20-27.5 %, and papaya 10-12.5%.

Generally, the results of this study indicate that children's dietary diversity, food variety score and nutrient adequacy of children's complementary food were not satisfactory. Furthermore, most mothers were preparing only from cereal and starch rich root and tubers although variety of fruit and vegetables, legumes and animal source foods are available in the area with higher macro and micro nutrient content than cereal grains. The red teff, soybean and papaya resulted in a significant improvement in the porridge nutritional and sensory quality. The result revealed that red teff, soybean and papaya have good potential source for providing protein, fiber, carbohydrate, energy, β-carotene, and minerals rich complementary food. Formulation of a soybean, papaya containing red teff based porridge as complementary food produced a higher nutritional quality food with acceptable sensory characteristics when compared to the normal cereal-based porridge nutritional quality of the region.

6. RECOMENDATION

This study recommended successful use of locally-available, inexpensive different food groups in a meal that enhance nutritional and sensory quality of complementary foods and to prepare nutritionally rich complementary foods using red teff as main ingredient with soybean and papaya supplementation which results nutrient enrichment of infant diet that has great health benefit. Beside those, health extension works and child care givers should have to be attaining short term training on how to maintain and feeding quality food for less than two years infants

7. FUTURE LINE OF WORK

This study suggested future line of work on effect of traditional food processing method on nutritional and sensory quality of children complementary foods. Optimization of traditional food processing conditions on nutritional and sensory quality of children complementary foods is essential to know the extent of nutrient loss and to put solution for the caused loss. Effect of anti-nutritional factors on nutrient bioavailability of local foods in human body and complementary food safety assessment should have to work to have health diet.

8. REFERENCES

AACC, 2000. Approved Methods of the American Association of Cereal Chemists. Saint Paul, MN,USA.

Abara A. , 2003. Tannin content *of Dioscoreabulbufera*. *Journal of Chemical Society* Nigeria, 2003; 28:55-56.

Abebe, Yewelsew, Alemtsehay Bogale, K Michael Hambidge, Barbara J Stoecker, Karl Bailey, and Rosalind S Gibson, 2007."Phytate, zinc, iron and calcium content of selected raw and prepared foods consumed in rural sidama, southern ethiopia, and implications for bioavailability." *Journal of Food Composition and Analysis*. 20 (3): 161-168.

Adebowale, Y.A., I. A. Adeyemi and A.A. Oshodi, 2005. Functional and physicochemical properties of flours of six *Mucuna* species. *African Journal of Biotechnology*. 4(12), 1461-1468.

Adeleke, R.O. and J.O Odedeji, 2010. Functional properties of wheat and sweet potato flour blends. *Pakistan J. of Nut.,* 9(6):535-538.

Agama-Acevedoa E, Rosab A, Mendez-Montealvoa G, Bello-Pereza L, 2008. Physicochemical and biochemical characterization of starch granules isolated of pigmented maize hybrid. Starch/Starke 60: 433-441.

Agostoni C, Riva E, Giovannini M., 1995. Dietary fiber in weaning foods of young children. Pediatrics; 96(5):1002-1005.

Ahima, J. K. ,2011. Formulation of weaning food using composite of maize groundnut and soybean and assessing its nutritional effect using animal model (Doctoral dissertation).

Ahn BC, Engelhardt K, Joung H., 2006. Diet varty is associated with socio- economic factors. Ecology of food and nutrition, December ,;45(6):417-430.

Akhtar S, Anjum F, Rehman S, Sheikh M, Farzena K ,2008. Effect of fortification on the physico-chemical and microbiological stability of whole wheat flour. Food Chem., 112:156-163.

Akpapunam MA, Badifu GIO, Etokudo EP ,1997. Production and quality characteristics of Nigerian “Agidi*”* supplemented with soy flour. *J. Food. Sci. Technol.,* 34(2): 143-145.

Allen LH 2006; Causes of Nutrition Related Public Health Problems of Preschool Children. *J Pediat Gastroenterol Nutr* 43: S8-S12.

American Association of Cereal Chemists (AACC), 2001. The definition of dietary fibre. Report of the Dietary Fibre Definition Committee,39 p.

Antia, B.S., Akpan, E.J Okon, E.A and Umoren, I.U ,2006. Nutritive and anti nutritive of evaluation of sweet potatoes leaves. *Pakistan Journal of Nutrition* 5, 166-168.

AOAC, 2000 and 2011. Association of Official Analytical Chemists. Official methods of Analysi17th ed. of AOAC International. Washington, DC, USA.

Aravind , Debjit Bhowmik , Duraivel. S , Harish. G 2013 ,Traditional and Medicinal Uses of Carica papaya

Assegid, S.,2006. Household illness prevalence and its determinants among under five children in Gambella Special Wereda, South West Ethiopia (Doctoral Dissertation, Addis Ababa University).

Association of Official Analytical Chemists (AOAC), 2000. Official Method of Analysis, 16th
Ayo, J.A; Ayo, V.A; Popoola, C, Omosebi M and Joseph, L, 2014. Production and evaluation of malted soybean-acha composite flour bread and biscuit, Nigeria

AOAC., 2000. Association of Official Analytical Chemists. Official methods of Analysis 17th ed. of AOAC International.Washington, DC, USA.

Badake Q.D., I. Maina, M.A. Mboganie, G. Muchemi, E.M. Kihoro, E. Chelimo and K. Mutea ,2014.Nutritional status of children under five years and associated factors in Mbeere South District, Kenya.

Azadbakht L, Mirmiran P, Azizi F., 2005. Varty score of food groups contribute to specific nutrient adequacy in tehranian men. *Eur J Clin Nutr*.; 59:1233-40.

Baltes, W. 1982. Chemical changes in food by the Millard reaction. Food Chemistry. 9: 53-73.

Banaszkiewicz, T., 2000. Nutritive value of new rape cultivars stated in the tests for broiler chickens (in Polish). *Thesis University of Podlasie*, No. 61, pp.1-99, PL ISSN 0860-4371, Siedlce, Poland.

Banu, C. ş.a, 2002. Calitatea şi controlul calităţii produsel or alimentare, Agir. Bucureşti. 547p,

Bardocz S, Gelencser E, Pusztai A, 1996. Effects of antinutrients on the nutritional value of legume diets.Vol.1, Brussels: ESSE-EAEC.

Belachew, T., Haley, C., and Lindstorm, D., 2004. Differentials in measures of dietary quality among adolescents in Jimma zone, Southwest Ethiopia. *Ethiop Med J,* 46(2), 133-42.

BIDCO, 2005. Bidco Oil Refineries Ltd, Thika, Kenya.

Birch LL, Marlin DW, 1982. I don’t like it; I never tried it: effects of exposure on two-year old children’s food preferences. Appetite 3:353–360.

Black RE, Allen LH, Bhutta Z.A, 2008. Maternal and Child Undernutrition Group. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*;371: 243–60.

Brou Kouakou, N'Da-Kouassi A. Marie, Kouadio J. Halbin, Guehi Tagro, N'Guessan K. Florent, Gnakri Dago ,2013. Biochemical characterization and functional properties of weaning food made from cereals (millet, maize) and legumes (beans, soybeans). UFR - Food Science and Technology, Laboratory for Nutrition and Food Safety, University Nangui Abrogoua, Ivory Coast.

Bultosa, G. 2007. Physicochemical characteristics of grain and flour in 13 teff [Eragrostis teff (zucc.) Trotter] grain varieties. *Applied Sciences Research,* 3(12): 2042-2051.

Bultosa, G. and J. R. N. Taylor. 2004. Teff. In Encyclopaedia of Grain Science, eds Wrigley, C., Corke H., Walker C, 253–262, Elsevier, Amsterdam.

Bultosa, G., A.N. Hall and J.R.N. Taylor, 2002.Physico-chemical characterization of grain tef (*Eragrostis te f* (Zucc.) Trotter) starch.Starch/Stärke,54: 461-468.

Butler LG., 1989. Effects of condensed tannin on animal nutrition. In: ‘‘Chemistry and significance of condensed tannins’’ R.W. Hemingway and J.J.Karchesy Eds. Plenum Press, New York,; pp. 391-402.

Cameron T. Black, Heather F. Pahulu and Michael L. Dunn, 2009. Effect of preparation method on viscosity and energy density of fortified humanitarian food-aid commodities. *International Journal of Food Sciences and Nutrition, 60(S7): 219_228.*

Camila M. Chaparro (FANTA-2 Project/AED) and Kathryn G. Dewey, 2009. (University of California, Davis) use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings.

Central Statistical Agency [Ethiopia] and ICF International Ethiopian Demographic and Health Survey, 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International 2012.

CGIAR, 2001; Osho, S.M. 1989. Soybean processing for household use. In: B.N. Mbah and D.O. Nnanyelugo (eds.) Food crops production, utilization, and nutrition. Proceedings of a course held at the University of Nigeria, Nsukka 22 – 23 April pp 68 – 78.

Charles Tortoe, Paa Toah Akonor, Stephen Nketia, Margaret Owusu, Mary Glover-Amengor,Lynda Hagan, Alice Padi , 2014. Assessing the sensory characteristics and consumer Preferences of yam-cowpea-soybean porridge in the accra metropolitan area.*International Journal of Nutrition and Food Sciences; 3(2): 127-132.*

Chen MJ, Lin CW (2002) Factors affecting the water holding capacity of fibrinogen/ plasma protein gels optimized by response surface methodology. Journal of food science 67: 2579-2582.

Chessa K. Lutter and Kathryn G. Dewey, 2003. Proposed Nutrient Composition for Fortified Complementary Foods *Nutrition Unit, Pan American Health Organization, Washington D.C. 20037 and Department of Nutrition, University of California at Davis, Davis,* CA 95616-8669

Chessa K. Lutter, 2000. Processed complementary foods: Summary of nutritional characteristics, methods of production and distribution, and costs.

Christiaensen, L. and Alderman, H., 2004. Child Malnutrition in Ethiopia: Can Maternal Knowledge Augment the Role of Income. Economic Development and Cultural Change, 52(2): 287-312.

Cochran, W.G., 1977. Sampling techniques (3rd ed.). New York: John Wiley and Sons.

Desai, U. T.; Wagh, A. N. Papaya. In: Salunkhe, D. K.; Kadam, S. S., 1995. Handbook of fruit science and technology: production, composition, storage and processing. New York: Marcel Dekkerp. 297-313.

Dewey K, Cohen R, Arimond M, Ruel M., 2004. Developing and Validating Indicators of Feeding Frequency and Nutrient Density of Complementary Foods for the Breastfed Child in Developing Countries. Washington, DC/Davis, CA: International Food Policy Research Institute and University of California at Davis.

Dhingra S, Jood S ,2001. Organoleptic and nutritional evaluation of wheat breads supplemented with soybean and barley flour. *Food Chem.,* 77: 479-488.

Directorate of Extension, 2000. Kerala Agricultural University, Thrissur, Kerala, Part 1 and 2.

Doris Piccinin, M.S. R.D., 2002. More about ethiopian food: teff Department of Nutrition and Food Service from an interview with Tsegazeab Woldetatios, PhD, Agriculture Conctract Interpeter at Harborview Medical Center Christine Wilson, Editor April .

Edema, M.O., Sanni, L.O. and Sanni, A.I.,2005. Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. *African Journal of Biotechnology* 4(9): 911-917.

Ejigui, J., L. Savoie, J. Marin, and T. Desrosiers ,2005. Influence of traditional processing methods on the nutritional composition and antinutritional factors of red peanuts (Arachis hypogeal) and small red kidney beans (Phaseolus vulgaris). *Biological Sciences*, 5(5): 597-605.

Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H ,2011. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: Rev. Food Chem., 124: 411-421.

Emmanuel- Ikpeme C. A., I. O. Ekpeyoung1 and G. O. Igile , 2012. Nutritional and Sensory characteristics of an infant food based on soybean seeds (*Glycine max*) and tigernut Tubers (*Cyperus esculenta). Biochemistry Department, University of Calabar,* Nigeria.

Erdman JW. Jr., 1979. Oilseed phytates: nutritional implications. *J. Am. Oil Chern. Soc*, 56: 736-741.

Ezeocha VC, Omodamiro RM, Oti E, Chukwu GO , 2011. Development of trifoliate yam: Cocoyam composite flour for fufu production. *Journal of stored products and postharvest research* 2: 184-188.

FANTA, 2004. Increased number of different foods or food groups consumed. Measuring household food consumption: A technical guide.

FAO, 2008. Guidelines for measuring household and individual dietary diversity, version 4, Rome. Protein sources for the animal feed industry. Food and Agriculture Organization of the United Nations .

FAO and WHO , 2004. Proposals for a definition and methods of analysis for dietary fibre content. CX/NFSDU 04/3 Add. Codex committee on nutrition and foods for special dietary uses. Codex alimentarius commission.

FAO/WHO, 1998. Carbohydrate in human nutrition. Report of a Joint Expert FAO/WHO Consultation. FAO Food and Nutriton Paper 66. Food and Agriculture Organization, Rome. 140 p.

FAO/WHO, 1991. Codex standard for processed cereal-based foods (including guidelines on formulated supplementary foods for older infants and young children). World Health Organization, Geneva, Switzerland.

FAO/WHO/UNU, 2001. Human energy requirements. Rome; FAO; and Dewey KG, Brown KH.

Federal Democratic Republic of Ethiopia Ministry of Health, 2003. Nutrition Extension Package.

Federal Democratic Republic of Ethiopia Ministry of Health, 2006. Complementary feeding recipes for Ethiopian children 6-23 months old a practical cooking and feeding guide august 2006.

Fernandes, F. A. N., Rodrigues,S.,2006. "Optimization of osmotic dehydration of papaya followed by air-drying." *Food Research International*,39(4): 492-498.

Folake O. Samuel , Bolanle O. Otegbayo, Titilope Alalade, 2012.Nutrient and anti-nutrient content of soy-enriched tapioca. *Food and Nutrition Sciences,* 2012, 3, 784-789

Food and Agriculture Organization (FAO) of the United Nation, 2007. Developing food-based dietary guidelines. A manual for the English Speaking Caribbean.

Food and Nutrition Board, Institute of MedicineNational Academies;1997,2001 and 2002/200. dietary reference intakes (DRIs): recommended dietary allowances and adequate intakes.

Food and Nutrition Technical Assistance Project (FANTA), 2006. Developing and validating simple indicators of dietary quality and energy intake of infants and young children in developing countries.

Fottrell E, Enquselassie F and P Byass, 2009. The distribution and effect of child mortality risk factors in Ethiopia: a comparison of estimates from DSS and DHS. *Ethiopian J Health Develop* 23: 163-168.

Fouzia Muhsin, 2009. Effect of extrusion cooking on some quality attributes of full-fat soy flour and soy protein concentrate from locally grown Soybean (Glycine Max L.) varieties.

Gafar MK,Itodo AU, 2011. Proximate and mineral composition of hairy indigo leaves. In *Electronic Journal of Environmental, Agricultural and Food Chemistry* (EJEAFChe); vol. 10 (3): 2007-2018.

Garrow JS, James WPT, Ralph A. ,1993. Human Nutrition and Dietetics. Ninth Edition. Churchill Livingstone. Edinburgh, London, Madrid, Melbourne, New York, and Tokyo.

Gebremariam, M. M., Zarnkow, M., and Becker, T. , 2012. Teff (Eragrostis tef) as a raw material for malting, brewing and manufacturing of gluten-free foods and beverages: a review. *Journal of Food Science and Technology*, 1-15.

Gilligan, D. O., Hoddinott, J. and Taffesse, A. S. ,2009. The Impact of Ethiopia's Productive Safety Net Program and its Linkages. Journal of Development Studies, 45 (10): 1684-1706.

Golden, 2009. Proposed nutrient densities for moderately malnourished children *Food and Nutrition Bulletin*, vol. 30, no. 3 (supplement).

Gomez M, Lajolo F, Cordenunsi B ,2002. Evolution of soluble sugars during ripening of papaya fruit and its relation to sweet taste. *J. Food Sci.* 67:442-447.

Gomez, M., Ronda, F., P. Caballero., A. Apesteguia, 2003. Effect of dietary fiber on dough rheology and bread quality. Eur. Food Res.Technol. 216 51-56.

Groff JL, Gropper SS, Hunt SM,1995. Advanced Nutrition and Human Metabolism. New York:West Publishing Co. 575 pp.

Hager, A. S., Wolter, A., Jacob, F., Zannini, E., and Arendt, E. K., 2012. Nutritional properties and ultra-structure of commercial gluten free flours from different botanical sources compared to wheat flours. Journal of Cereal Science, 56(2), 239-247.

Hahn DH, Rooney LW, Earp CF, 1984. Tannins and phenols of sorghum. Cereal Foods World ; *29:776–779.*

Handelman GJ, 1996. Carotenoids as scavengers of active oxygen species. In Cadenas E, Packer L (eds). Handbook of Antioxidants. New York: Marcel Dekker, *p 259-314.*

Hatlùy A, LE Torheim and A Oshaug ,1998. Food variety a good indicator of nutritional adequacy of the diet. A case study from an urban area in Mali, West Africa Institute for Nutrition Research, University of Oslo, Norway.

Hernandez OM, Fraga JMG, Jimenez AI, Jimenez F and Arias JJ, 2004. Characterization of honey from the Canary Islands: determination of the mineral content by atomic absorption spectrophotometer. *Food Chemistry,* 93:449-458

Hodge, J.C. and E.M. Osman, 1976. Carbohydrates. In: Fennema, R.O., (Ed.), Principles of food science, *Part I. Food Chemistry. Marcel Dekker, New York, pp: 97-200.*

Hopman, Erica, Liesbeth Dekking, Marie-Loes Blokland, Maud Wuisman, Walter Zuijderduin, Frits Koning, and Joachim Schweizer,2008. "Teff in the diet of celiac patients in the Netherlands." *Scandinavian Journal of Gastroenterology.* 43 (3): 277-282.

Hoppe C, Andersen GS, Jacobsen S, Molgaard C, Friis H, Sangild PT ,2008.The use of whey or skimmed milk powder in fortified blended foods for vulnerable groups. *J Nutr138:145S-61S.*

Hotz C, Gibson RS, 2001. Assessment of home-based processing methods to reduce the phytate content and phytate/zinc molar ratio of white maize (Zea mays). *J Agric Food Chem;49:692-8.*

Idris, W.H., S.M. Abdel, H.B. Rahman, El Maki, E.E. Babiker and A.H. El Tinay, 2007. Effect of malt pretreatment on HCl-extractability of calcium, phosphorus and iron of sorghum (sorghum biocolor) cultivars. Inter. *J. Food Sci. Tech., 42:194-199.*

Iheagawara, M.C. ,2012. Wheat Milling: Types of Wheat Flour (Personal Communication.Italy. 2008.

Jane A. Scott , Tsz Ying Chih and Wendy H. Oddy , 2012. Food variety at 2 years of age is related to duration of breastfeeding.

Joana Vanessa Ramos Galante, 2013. Vegetable protein functionality. *NIZO Food Research B. V.*

Joel Ndife, L. O. Abdulraheem and U. M. Zakari , 2011. Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends Department of Food Technology, Kaduna Polytechnic, Kaduna State, Nigeria.

Joseph, G.V.R, 2002. ”Papaya for your digestion”, *Herald of Health, May, Vol.9,No.5,Pp.9-10.*

Kaleab Baye, 2014. Teff: nutrient composition and health benefits. *Center for Food Science and Nutrition, College of Natural Sciences, Addis Ababa University.*

Kant AK, Schatzkin A and RG Ziegler,1995. Dietary diversity and subsequent case-specific mortality in the NHANES epidemiologic follow-up study. *Journal of the American College of Nutrition ;14: 233-38.*

Kant AK., 2004. Dietary patterns and health outcomes. *Am Diet Assoc., 104:615-35.*

Kanyago M., Bisabirye Murnga F., Nabu, Goomu F., J.M Ntambi,J.T. Kakitahi and E.K Kiboneka ,2007. The Effect of incorporation soybean and sesame into instant matooke flour porridge with respect to sensory quality attributes and viscosity,Uganda.

Kebede, L., S. Worku, G. Bultosa, and S. Yetneberek, 2010. Effect of extrusion operating conditions on the physical and sensory properties of teff (Eragrostis tef [Zucc.] Trotter) flourextrudates. *Ethiopian Journal of Applied Science and Technology, 1(1): 27-38.*

Kellet, E.; Smith, A.; Schmerlaib, Y., 1998. *Australian Guide to Healthy Eating*; Commonwealth Department of Health and Family Services: Canberra, Australia.

Kennedy, G., Fanou, N., Seghieri, C., and Brouwer, I.D., 2009. “Dietary diversity as a measure of the micronutrient adequacy of women’s diets: results from Bamako, Mali site”, Food and Nutrition Technical Assistance II Project (FANTA-2).

Khader V ,2001. Textbook of food science and technology. ICAR, New Delhi.

Khan, Y., and Bhutta, Z. A. ,2010. Nutritional deficiencies in the developing world: current status and opportunities for intervention. Pediatric Clinics of North America, 57(6), 1409-1441.

König, A., Cockburn, A., Crevel, R. W. R., Debruyne, E., Grafstroem, R., Hammerling, U., and Wal, J. M. ,2004. Assessment of the safety of foods derived from genetically modified (GM) crops. *Food and Chemical Toxicology, 42(7), 1047-1088.*

Krishna, K., M. Paridhavi, 2008. "Review on nutritional, medicinal and pharmacological properties of papaya (Carica papaya Linn.)*." Nat Prod Radian, 7: 364-373.*

Kumar R.1992. Antinutritional factors, the potential risks of toxicity and methods to alleviate them. Proceedings of the FAO Expert Consultation held at the Malaysian Agricultural Research and Development Institute (MARDI) in Kuala Lumpur, Malaysia, 14-18.

Labadarios, D., Steyn, N.P., and Nel, J., 2011. “How diverse is the diet of adult South African?”, *Nutrition Journal*, Vol. 10, No. 33.

Lakshmi AJ, Khyrunnisa B, Saraswathi G, Jamuna P , 2005. Dietary adequacy of Indian rural preschool children–influencing factors. *J Trop Pediatr*, *51:39–44.*

Laswai, H.S., Mpanalile, J.J., Silayo, V.C. K., Ballegu, W.R. ,2005. Use of soybeans in food formulation in Tanzania‟.

Liebman, B., 1992, 2008. "A papaya a day nutrition action healthletter." Nutrition ActionHealthletter .

Liu K., 2004: Soybeans as a powerhouse of nutrients and phytochemicals. In: Liu K, editor.Soybeans as functional foods and ingredients.*AOCS PRESS1-22.*

Lokuruka, M. N. I. ,2010. Soybean nutritional properties: The good and the bad about soy foods consumption-A review. *African Journal of Food, Agriculture, Nutrition and Development, 10(*4).

López-Azpiazu I, Sanchez-Villegas A, Johansson L, Petkeviciene J, Prattalaw R, Martinez-Gonzalez, 2003. Disparities in food habits in Europe: systematic review of educational and occupational differences in the intake of fat. J Hum Nutr Diet. Oct;16 (5):349-64.

Mahgoub 1999; SEO Production and evaluation of weaning foods based on sorghum and legumes. *Plant Foods for Human Nutrition 54: 29–42*.

Malomo , Olu., Ogunmoyela , A.O.B. and Kukoyi, Iretimipo , 2012. Effect of germinated and ungerminated soybean flour on the rheological properties of wheat bread dough *Bells University of Technology, Km 9 Idiroko road, Ota, Ogun State, Nigeria*.

Maneju H, Udobi CE, Ndife J ,2011. Effect of added brewers dry grain on the physico-chemical, microbial and sensory quality of wheat bread. *Am. J. Food Nutr., 1(1): 39-43.*

Maqbool, A.R.A., N.B. Aurangzeb, N. Habib and I. Khan,1987. Nutritional and organoleptic evaluation of wheat rotis supplemented with soybean flour. *Pakistan Journal of Science and Indian Research*, 30(8): 615 – 648

Mariam I.O. Mohammed,Abdelmoneim I. Mustafa and Gammaa A.M. Osman ,*2009.*Evaluation of wheat breads supplemented with Teff (*Eragrostis tef* (ZUCC.) Trotter) Grain flour .*Faculty of Agriculture, University of Khartoum, Sudan.*

Marriott BP, White A, Hadden L, Davies JC, Wallingford JC, 2012. World Health Organization (WHO) infant and young child feeding indicators: associations with growth measures in 14 low-income countries. Matern Child *Nutr, 8:354–370.*

Martin H, Laswai H and K Kulwa ,2010. Nutrient content andacceptability of soybean based complementary food.Sokoine University of Agriculture, Department of Food Science and Technology,P.O. Box 3006, Chuo Kikuu, Morogoro, Tanzania.

Mashayekh M, Mahmoodi MR, Enterazzi MH ,2008. Effect of fortification of defatted soy flour on sensory and rheological properties of wheat bread. *Int. J. Food Sci. Technol, 43: 1693-1698.*

Maxson, E.D. and Rooney, L.W.,1972. Evaluation of methods for tannin analysis in sorghum grain. *American association of Cereal Chemists, 49:719-729.*

McLeod M N., 1974. Plant tannins-their role in forage quality. Nutr. Abstr. *Rev; 44:803-815.*

Mengesha, M. H., 1966. Chemical composition of Teff (Eragrostis tef) compared with that of wheat, barley and grain sorghum. Econonomic Botany *20(3): 268-273.*

Mensah P, Tomkins A, 2003. Household-level technologies to improve the availability and preparation of adequate and safe complementary foods. *Food Nutr Bull 24:104-25.*

Meseret Bekele, 2011.Effect of fermentation on Quality Protein Maize-soybean blends for the production of weaning food. Addis AbabaUniversity, Institute of Technology.

Michaelsen, Kim F, Kathryn G Dewey, Ana B Perez-Exposito, Mulia Nurhasan, Lotte Lauritzen, and Nanna Roos, 2011. "Food sources and intake of n-6 and n-3 fatty acids in low-income countries with emphasis on infants, young children (6–24 months), and pregnant and lactating women." *Maternal* and *child nutrition. 7 (S2): 124-40*.

Mohamed, N., A.A., Isam, A.M., Babiker, E.E. and A.Y. Abu El Gasim, 2010. Investigations on winter season Sudanese sorghum cultivars: Effect of sprouting on the nutritional value. *Inter. J. Food Sci. Tech. 45:884–890*.

Mohammed, I., Ahmed, A. R., and Senge, B., 2012. Dough rheology and bread quality of wheat–chickpea flour blends. Industrial Crops and Products, *36(1), 196-202.*

Mohiedeen, I.E., Abdullahi, H.E., Abd Elmoneim, O.E., Babiker, E.E. and Mallasy, L.O., 2010. Effect of fermentation and cooking on protein quality of maize (Zea Mays Linnaus) cultivars. *Inter. J. Food Sci. Tech., 45:1284-1290*.

Moure, A.; Sineiro, J.; Domínguez and Parajó, J. C. 2006. Functionality of oilseed protein products: *A review. Food Research International, 39:945-963.*

Moursi MM, Arimond M, Dewey KG, Trèche S, Ruel MT, Delpeuch F,2008. Dietary diversity is a good predictor of the micronutrient density of the diet of 6- to 23-month-old children in Madagascar. *J Nutr. ; 138: 2448-2453.*

Mugendi J. B., E. N. M. Njagi E.N. Kuria, M. A. Mwasaru, J. G.Mureithi, and Z. Apostolides, 2010. Effects of processing technique on the nutritional composition and anti-nutrient content of mucuna bean (Mucuna pruriens L.). *African Journal of Food Science, 4(4): 156-166*.

Musinguzi E, Maundu P, Grum M and KS Nokoe, 2012. A systematic approach to food variety classification as a tool in dietary assessment: a case study of kitui district.

Muzquiz M., 2004. Recent advances of research in anti-nutritional factors in legume seeds and oil seeds. EAAP publications No.110. Toledo, Spain.

Muzquiz, M. and J.A. Wood, 2007. Anti-nutritional factors. In chickpea. *Inter. J. of food sci. and nutr., 55:143-158.*

Myaka, F, A. 2005. Soybean research in the eastern zone Tanzania‟. In: Myaka, F. A., Kirenga G, and B. Malema (eds). 2006. Proceedings of the First National Soybean Stakeholders Workshop, 10th – 11th November 2005, Morogoro- Tanzania. *Pp. 21–27*.

Myaka, F. A., Kirenga G, and B. Malema (eds), 2006. Proceedings of the First National Soybean Stakeholders Workshop, 10th – 11th November 2005, Morogoro- Tanzania *Pp. 52–59*.

Nair Biji,Jogleker Abhaya, Verma Sandhya , 2013. Sensory and nutritional quality of soya fortified traditional products, India.

National Health and Medical Research Council, 2003. Dietary guidelines for children and adolescents in Australia incorporating the infant feeding guidelines for health workers.

National Health and Medical Research Council, 2003. *Dietary Guidelines for Australian Adults*; Commonwealth Department of Health and Ageing: Canberra, Australia.

National Research Council, 1989. Recommended Dietary Allowances. Washington (DC): National Academy Press.284 pp.

Nejat Kiyak Tsegaye, Tefera Belachew, Oliver Hensel and Sirawdink Fikreyesus, 2015. Assessment of anthropometric status and dietary diversity of under-two children in selected districts of Jimma zone, south west Ethiopia, March-May, 2014: a cross-sectional study. College of Agriculture and Veterinary Medicine, Jimma University, Ethiopia.

Nelson TS, Ferrara LW, Storer NL., 1968. Phytate phosphorus content of feed ingredients derived from plants. *Poult. Sci,; 47: 1372-1374.*

Nicklaus, S., 2009. Development of food variety in children. *Appetite*, *52,* 253–255

Nicolau, A., Turtoi, M., 2006. Factorii care influenţează dezvoltarea microorganismelor, Academica, Galaţi, *264p.*

Nicole, M., H. Yu-Fei and C. Pierre, 2010. Characterization of ready-to-eat composite porridge flours made by soy-maize-sorghum-wheat extrusion cooking process. *Pakistan Journal of Nutrition. 9(2):171-178*.

Nnamani, C.V., Oselebe, H.O and Agbatutu A ,2009. Assessment of nutritional values of thre underutilize indigenous leafy vegetable of Eboyi State Nigeria. *African Journal of food science.*

North K, Emmett P., 2000. Multivariate analysis of diet among three year-old children and associations with socio-demographic characteristics. The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Study Team. Eur J Clin Nutr 54:73–80.

Novasima A.G., 2005.The meaning of water activity. Novasima. www. novassima.com.
nutrition and development *10: 2928-2942.*

Nwosu, Justina N. Owuamanam C. I, Omeire G. C. and Eke C. C., 2014. Quality parameters of bread produced from substitution of wheat flour with cassava flour using soybean as an improver , Nigeria.

Nyakabau, T., Wokadala, O. C., and Emmambux, M. N., 2013. Effect of steeping additives on tef starch extraction and its quality. *Starch‐Stärke, 65(9‐10), 738-746.*

Oboh, H.A., M. Muzquiz, C. Burbano, Cuadrado, C. Pedrosa, M.M. Ayet and A.U. Osagie, 2000. Effect of soaking, cooking and germination on the oligosaccharide content of selected Nigerian legume seeds. *Plt Foods Hum. nutr., 55:97-110.*

Okoye, J.I, Nkwocha, A.C1 and Ogbonnaya, A.E., 2008. Production, proximate composition and consumer acceptability of biscuits from wheat/ soybean flour blends. *Continental Journal of Food Science and Technology, 2: 6 – 13*.

Olson JA. Vitamin A. In Ziegler EE, Filer LJ, 1996. Present Knowledge in Nutrition. Washinton (DC):ILSI. *Press. p 109-19.*

Omotoso, O.T ,2005. Nutritional quality, functional properties and anti nutrient composition of the larva of crina forda (Westwood). *Journal Zhejiang University of Science 7 (1), 51-55.*

Omueti O, Otegbayo B, Jaiyeola O, Afolabi O, 2009. Functional Properties of Complementary diets developed from Soybean (*Glycine max*), Groundnut (*Arachis hypogea*) and Crayfish (*Macrobrachim spp*).*Electronic Journal of Environmental Agricultural and Food Chemistry. 563 –573.*

Onabanjo, O. O., C.R.B. Oguntona, B. Maziya-Dixon, I.O. Olayiwola, E.B. Oguntona and Dixon, A. G. O. ,2008. Nutritional evaluation of four optimized cassava-based complementary foods.African. *J.Food Sci. 2: 136-142.*

Onibon VO, Abulude FO, Lawal LO , 2007. Nutritional and anti-nutritional composition of some nigerian fruits. *J. Food Tech. 5:120-122.*

Onyeike, E.N.; Olungwe, T., Uwakwe, A. A., 1995. Effect of heat treatment and defatting on the proximate composition of some nigerian local soup thickeners. Food Chemistry 53: 173-175. *Nig J. Biotech. Vol. 23 (2011) 5 – 12.*

Osborne, D.R. and Voogt, P.,1978. The analysis of nutrients in food. Academic press Inc. London

Osho, S.M. 1995. Soybean processing and utilization research at International Institute of Tropical Agriculture.Processing from SOYAFRICA‟95: Johannesburg, South Africa, 4-5.

Association des Produits a Marche (APROMA) CEE/ACP, 52, avenue Louis Lepoutre B1060 Bruxelles, Belgigue.

Oshodi, A. A., and Adeladun, M. O. A., 1993. Proximate composition, some nutritionally valuable minerals and functional properties of three varieties of Lima bean (Phaseolus lunatus Linn.) flour. *International journal of food sciences and nutrition, 43(4), 181-186.*

Osman, N.M., A.M. Isam and E.E. Babiker, 2010. Fermentation and cooking of Sicklepod (Cassia obtusifolia) leaves: Changes in chemical and amino acid composition, anti-nutrients and protein fractions and digestibility. *Inter. J. Food Sci. Tech. 45:124-132.*

Otegbayo BO, Aina JO, Asiedu R, Bokanga M, 2006. Pasting characteristics of fresh yams (Discorea spp) as indicators of textural quality in major food product "Pounded – yam" Food Chemistry. *99:663 – 669.*

Owino VO, Kasonka LM, Sinkala MM, Wells JK, Eaton S, Darch T, 2007. Fortified complementary foods with or without alpha-amylase treatment increase hemoglobin but do not reduce breast milk intake of 9-mo-old Zambian infants Am J Clin *Nutr;86:1094- 103.*

Oyarekua, M.A. and E.I. Adeyeye, 2008. Comparative evaluation of the nutritional quality, functional properties and amino acid profile of co-fermented maize/cowpea and sorghum/cowpea *Ogi* as infant complementary food. *Asian J. Clin. Nutr. 1: 31-39.*

Padmapriya T., 2013. Nutrition content of the papaya powder obtained by different methods of drying. *Research Fellow, Women Studies Centre, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore- 641043, Tamil Nadu, India page -314.*

Pan American Health Organization, World Health Organization, 2003. *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington DC.

Pinnavaia G, Pizzirani S ,1998. Evaluation of the degree of gelatinization of starchy products by water holding capacity. Starch/Starke 50: S 64-67.

Potts S. C and Potts AC, 2014. An assessment of dietary diversity and nutritional status of preschool children.

Raji A. O. and J. A. V. Famurewa, 2008. Effect of hull on the physico-chemical properties of soyflour vol. x.

Raji, A. O. and D. I. Akaaimo ,2005. Development and evaluation of a threshing machine for prosopis africana seed. *Journal of Applied Science, Engineering and Technology, Volume 5, Nos 1 and 2: 56 - 62.*

Ramakrishna, V., P. Jhansirani, and P.R. Ramakrishna, 2006. Nutritional quality of storage proteins during germination of Indian bean (Dolichos lablab var. lignosus) Seeds. *World J. of Dairy and Food Scien. 1(1): 06-11.*

Riaz, M. N. ,2006. Soy applications in foods. London: CRC Taylor and Francis pp. 39-226.

Rita Elsie Sanful and Sophia Darko, 2010. Utilization of Soybean Flour in the Production of Bread.Department of Hotel, Catering and Institutional Management, Ghana.

Roeder E., 1995. Medicinal plants in China containing pyrrolizidine alkaloids. Pharmazie;*50: 83-98.*

Ruel M, Graham J, Murphy S, Allen L, 2004. Validating simple indicators of dietary diversity and animal source food intake that accurately reflect nutrient adequacy in developing countries. Report for Global Livestock CRSP, University of California at Davis.

Ruel, M., 2002. "Is Dietary Diversity as Indicator of Food Security or Dietary Quality? A review of measurement and research needs", FCND Discussion Paper No. 140. International Food Policy Research Institute, Washington D.C.

Ruel MT, 2003.Operationalising dietary diversity: A review of measurement issues and research priorities. *The Journal of Nutrition; 113: 3911S.*

Rusydi, M. R. M., and A. Azrina, 2012. Effect of germination on total phenolic, tannin and phytic acid contents in soy beanand peanut. International Food Research, 19(2): 673-677.

Rynek Rzepaku,2010. Stan i perspektywy. IERiG, *ISSN 1231-269X.*

Sadler, G., Davis, J., and Dezman, D.,1990. Rapid extraction of lycopene and β-carotene from reconstituted tomato paste and pink grapefruit homogenates. *J. Food Sci*. *55,* 1460–1461.

Santiago-Silva, P., R. A. Labanca, 2011. "Functional potential of tropical fruits with respect to free bioactive amines." *Food Research International 44(5): 1264-1268.*

Savage King F, Burgess A., 1993. Nutrition for developing countries. Second edition.oxford medical publications. Oxford University Press. Oxford, New York.

Save the Children UK ,2009. 'Ethiopia National Nutrition Strategy: Review and Analysis of Progress and Gaps, One Year On'. London: Save the Children UK.

Save the Children, 2012. A Life free from hunger: Tackling child malnutrition. Save the Children, London, UK.

Savy M, Martin-Prevel Y., 2002. Dietary divessty as house hold food security indicator. Washington, D.C.: FANTA Project, Acadaemy for educational Development.

Shurtleff, W. and A. Aoyagi, 2007. History of soybeans and soyfoods in Africa. Soyfoods Center. Lafayate, California.

Singh, N., K.S. Sandhu and M. Kaur, 2004. Caractérisation des amidons de pois chiches Indien (*Cicer arietinum L*.) cultivars. J. *Food Eng. 63: 441-449.*

Singh,C.Bhagat,B.K.and Ray,R.N. ,1998. "Effect of nitrogen, phosphorus and potassium on growth, yield and quality of papaya (carica papaya)", *The Orissa Journal of Horticulture, Vol.26 (2),Pp.61-65.*

Sirawdink Fikreyesus F. and Hosahalli S. Ramaswamy, *2011*. Protein rich extruded products from tef, corn and soy protein isolate blends. *Ethiop .J. Appl. Sci. Technol. 2(2) 75 - 90*

Sirawdink, F. F., and H. S. Ramaswamy, 2011. Protein rich extruded products from teff, corn and soy protein isolate blends.

Sokrab, A.M., A.M. Isam and E.E. Babiker, 2012. Effect of malting and fermentation on anti-nutrients, and total and extractable minerals of high and low phytate corn genotypes. *Inter. J. Food Sci. Tech., 47:1037-1043*.

Solomon, W. K. ,2007.Hydration kinetics of lupin (Lupinusalbus) seeds. *Food Process Engineering, 30(1): 119-130.*

Steve O. Ijarotimi, Funmilayo Aroge ,2005. Evaluation of the nutritional composition, sensory and physical properties of a potential weaning food from locally available food materials – breadfruit(*artocarpus altilis*) and soybean (*glycine max*).

Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D, 2006. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy. *Public Health Nutr. ; 9: 644-650.*

Tatarov P. ,2007. Chimia alimentară, ciclul de prelegeri, partea , *UTM,125p.*

Tewodros Girma, Geremew Bultosa and Negussie Bussa, 2013. Effect of grain tef (*Eragrostis tef* (Zucc.) Trotter) flour substitutions with flaxseed on mineral content, antioxidant activity,phytic acid content and microbial quality of injera food, *Medicine and Healthcare Administrative and Control Authority of Ethiopia.*

Tewodros, T. ,2009. Survey and serological detection of sweet potato (Ipomoea Batatas (L.) Lam.) Infecting viruses in Ethiopia. The larva of crina forda (Westwood) *Journal Zhejiang University of Science 7 (1), 51-55.*

Tizazu S, Urga K, Abuye C, Retta N., 2010. Improvement of energy and nutrient density of sorghum based complementary foods using germination. *African journal of food agriculture* Tokyo.

Turrell G, Kavanagh AM, 2006. Socio-economic pathways to diet: modeling the association between socio-economic position and food purchasing behaviour. Public Health Nutr. May;9(3):375-83.

Ugwuona, F. U., 2009. Chemical and sensory evaluation of soy-fortified cassavawheat biscuit, Nigeria.

Umeta, M. and R.M. Faulks, 1988.The effect of fermentation on the carbohydrates in tef (Eragrostis tef).*Food Chem., 27: 181-189.*

Underwood BA, 2000. Dietary approaches to the control of vitamin a deficiency: An introduction and overview. *Food and Nutrition Bulletin*; 21(2): 117-22.

United States Department of Agriculture, 2009. Food and nutrition service, special supplemental nutrition program for women, infant and children (WIC): A Guide for use in the WIC and CSF programs.

Urbano, G., M. Lo´pez-Jurado, J. Herna´ndez, M. Ferna´ndez, M.C. Moreu, J., Frias, C. M. Diaz-Polla´n, Prodanov and C. Vidal- Valverde, 1995. Nutritional assessment of raw, heated and germinated lentils. *J. Agric. Food Chem, 43:1871-1877.*

USDA (United States Department of Agriculture), 2009. Agricultural research service, national nutrient database for standard reference*, release 22, nutrient data laboratory home page, http://www.ars.usda.gov/ba/bhnrc/ndl.*

USDA ,2011. "National Nutrient Database for Standard Reference Release 25." Nutrient data for 09226, Papayas, raw. *Retrieved 25.10US.*

Vaintraub and Lapteva. 1988. Colorimetric determination of phytate in unpurified extracts of seeds, and the products of their processing. *Analytical Biochemistry, 175:227-230.*

Van Eys, J. E., Offner, A., and Bach, A., 2004. Manual of quality analyses for soybean products in the feed industry. *American Soybean Association, Saint Louis, MO*., USA.

Vandana.Mishra,Vinita Puranik, Nazra Akhtar and G.K.Rai, 2012. Development and compositional analysis of protien rich soyabean-maize flour blended cookies.Vinita Puranik, *Centre of Food Technology, University of Allahabad, Uttar Pradesh, India.*

Vidal, V,C., J. Frias, I. Estrella, M.J. Gorospe, R. Ruiz and J. Bacon, 1994. Effect of processing on some anti-nutritive factors of lentils. *J. Agric. Food Chem, 42:2291-2295*.

Walker SP, Wachs TD, Gardner JM, Lozoff B, Wasserman GA, Pollitt E , 2007. Child development: risk factors for adverse outcomes in developing countries. *Lancet;369:145-57.*

Wechsler, L. J.,2010. Effect of sensory properties and health information on consumer acceptance and purchase of colorful fresh market potatoes.

WHO, 2004. Principes directeurs pour l'alimentation complémentaire de l'enfant allaité au sein. *Alimentation et nutrition.36.*

WHO/FAO (World Health Organization/Food and Agriculture Organization of the United Nations). 1996). "Preparation and use of food-based dietary guidelines", Geneva: Nutrition Programme, World Health Organization.

WHO, 2004.WHO technical background paper: feeding of non breastfed children from 6 to 24 months of age in developing countries. *Food Nutr Bull 25:377-402.*

WHO/UNICEF, 1998. Complementary feeding of young children in developing countries: a review of current scientific knowledge. *(WHO/NUT/98.1).* Geneva.

Woldemariam G and T Genebo ,2002. Determinants of nutritional status of women and children in Ethiopia. Calverton, Maryland, USA: ORC Macro.

Wolf WJ, 1977. Legumes: Seed composition and structure, Processing into protein products and protein properties. In: Food Proteins, Whitaker, J.R. and S.R. Tannenbaum (Eds.). *AVI Publishing, Westport CT., USA., pp: 291-314*

Yetneberk, S., L. W. Rooney, and J. R. N. Taylor, 2005. Improving the quality of sorghum injera by decortication and compositing with teff. *Journal of the Science of Food Agriculture, 85(8): 1252-1258.*

Young VR ,2001. Protein and amino acids. In: *Present Knowledge in Nutrition*. 8th Edition. Bowman BA and Russel RM (eds). *International Life Sciences Institute, Washington DC. chapter 5, pp. 43-58.*

Zewdu, A. D., and W. K. Solomon ,2007. Moisture-dependent physical properties of teff seed. *Biosystems Engineering, 96(1): 57-63.*

Zulu, W., 2005. Use of soybean in poultry feed: Perspective from Zambia, Malawi and Botswana‟. In: Myaka, F. A., Kirenga G, and B. Malema (eds). 2006. Proceedings of the First National Soybean Stakeholders Workshop, 10th – 11th November 2005, Morogoro- Tanzania *Pp. 47–51.*

Zuluaga MF, BaenaY, Mora CE, D'Leon LFP, 2007. Physicochemical characterization and application of yam (Dioscorea cayenensis-rotundata) Starch as a pharmaceutical excipient. Starch/Stärke *59: 307-317.*

Xie B, Gilliland FD, Li YF, Rockett HR, 2003. Effects of ethnicity, family income, and education on dietary intake among adolescents. Prev Med 36:30–40.

9. APPENDICES

Appendix Table 1: Estimated regression coefficients of proximate compositions of individual and mixed products.

Term	**MC (%)**		**Ash (%)**		**CFA (%)**		**CFI (%)**		**CP (%)**		**CHO**		**Energy Kcal/100g**	
	RC	SE	RC	SE	RC	SE	RC	SE	RC	SE	RC	SE	RC	SE
A	7.976	2.356	8.1	0.9553	6.96	1.387	6.1	1.751	39	11.02	32.1	10.76	345.9	14.29
B	-7.625	17.854	31.2	7.2398	66.77	10.513	45.6	13.268	704	83.52	-740.0	81.53	456.9	108.29
C	11.844	24.777	78.5	10.0469	13.50	14.589	94.9	18.413	-303	115.90	204.0	113.15	-273.3	150.28
A*B	8.447	32.668	-47.8	13.2466	-82.08	19.236	-63.6	24.277	-1029	152.81	1214.2	149.18	1.5	198..14
A*C	1.935	32.668	-111.4	13.2466	-10.85	19.236	-118.5	24.277	570	152.81	-330.9	149.18	857.8	198.14
B*C	1.216	32.947	-101.0	13.3597	-96.44	19.400	168.0	24.484	-989	154.12	1353.0	150.46	588.9	199.83
R^2	98.28		99.37		99.71		98.82		99.27		99.56		98.01	

A= Red teff, B=Soybean, C=Papaya, RC= Regression coefficient; SE= standard error, R_2 =determination coefficient

Appenidx Table 2: Estimated regression coefficients of β- Carotene of individual and mixed products

Term	β- Carotene (mg/g)	
	RC	SE
A	-0.9	5.664
B	-9.0	42.924
C	346.3	59.567
A*B	18.3	78.538
A*C	-387	78.538

B*C	-312.8	79.208
R^2	99.34	

A= Red teff, B=Soybean, C=Papaya, RC= Regression coefficient; SE= standard error, R2 =determination coefficient

Appenidx Table 3: Estimated regression coefficients of minerals of individual and mixed products

Term	**Fe (mg/100g)**		**Ca (mg/100g)**		**Zn (mg/100g)**	
	RC	SE	RC	SE	RC	SE
A	279	7.755	355	36.87	1.70	2.303
B	951	58.777	1863	279.43	-11.52	17.455
C	408	81.566	3213	387.77	-98.71	24.223
A*B	-2070	107.543	-2003	511.27	36.23	31.937
A*C	-1226	107.543	-4073	511.27	114.65	31.937
B*C	-1064	108.462	-8914	515.63	137.67	32.210
R^2	99.94		99.95		98.48	

A= Red teff, B=Soybean, C=Papaya, RC= Regression coefficient; SE= standard error, R2 =determination coefficient

Appenidx Table 4: Estimated regression coefficients of functional properties of individual ingredient and their mixed products.

Term	**aw at 26 ^oC**		**WAC (%)**		**BD (g/cm^3)**	
	RC	SE	RC	SE	RC	SE
A	0.774	0.06585	136	50.04	-0.320	0.6270
B	1.236	0.49905	-58	379.26	-9.929	4.7520
C	0.034	0.69254	3827	526.31	-3.895	6.5945
A*B	-2.537	0.91310	142	693.93	18.741	8.6948
A*C	-1.207	0.91310	-4119	693.93	4.896	8.6948
B*C	1.326	0.92090	-3728	699.85	23.576	8.7690
R^2	98.24		99.43		70.86	

A= Red teff, B=Soybean, C=Papaya, RC= Regression coefficient; SE= standard error, R2 =determination coefficient

Appenidx Table 5: Estimated regression coefficients of anti-nutrition factors of individual and mixed products.

Term	**Phytate (µg/g)**		**Tannin (mg/g)**	
	RC	SE	RC	SE
A	128	68.44	-0.997	0.1808
B	-2106	518.68	-4.334	1.3703
C	1118	719.79	9.718	1.9016
A*B	3764	949.03	10.371	2.5072
A*C	-1063	949.03	-8.223	2.5.72
B*C	2595	957.13	-8.395	2.5287
R^2	98.33		98.96	

A= Red teff, B=Soybean, C=Papaya, RC= Regression coefficient; SE= standard error, R_2 =determination coefficient

Appenidx Table 6: Estimated regression coefficients of sensory evaluations parameters of individual ingredient and their mixed products.

Term	Appearance		Aroma		Taste		Mouth feel		Over all acceptability	
	RC	SE	RC	SE	RC	SE	RC	SE	RC	SE
A	-24.7	3.927	0.5	4.381	5.82	1.321	4.34	1.369	-3.6	0.9422
B	-109.5	29.765	-18.9	33.204	15.51	10.010	-1.89	10.377	-46.8	7.1409
C	227.4	41.306	-114.7	46.079	60.28	13.892	69.26	14.401	105.5	9.9096
A*B	268.3	54.461	26.2	60.754	-22.57	18.316	7.07	18.987	98.6	13.0656
A*C	-197.2	54.461	158.6	60.754	-56.99	18.316	-73.12	18.987	-105.6	13.0656

B*C	-241.9	54.926	223.2	61.273	-82.20	18.472	-56.91	19.149	-56.2	13.1772
R^2	97.73		97.96		98.83		98.80		99.58	

Appenidx Table 7: The response optimizer analysis of the best treatment combination value for all parameters

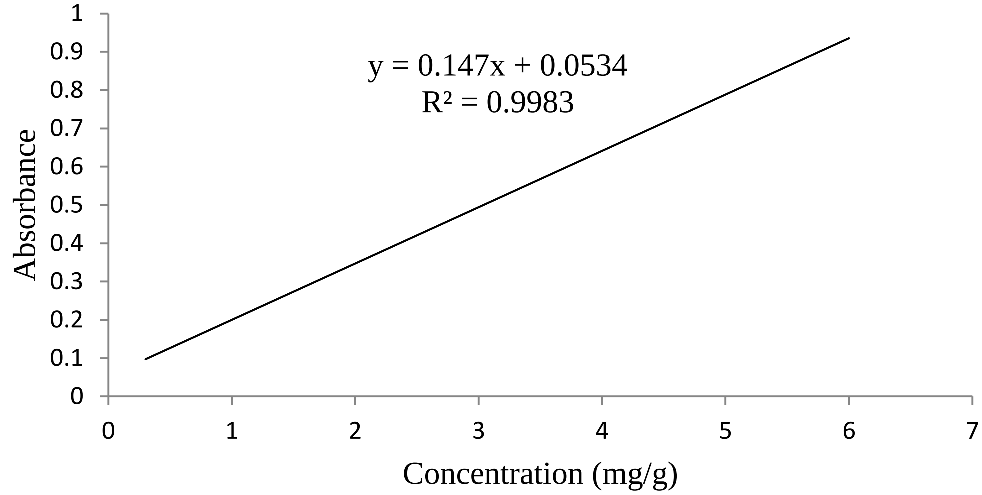
Parameters	Predicted responses
Fat (%)	6.551
Fiber (%)	2.886
Protein (%)	18.616
Carbohydrate (%)	62.678
Energy (kcal /100g)	384.136
Fe (mg/100g)	17.838
Ca(mg/100g)	222.438
Zn(mg/100g)	5.303
β- Carotene (mg/g)	1.440
Overall acceptability (in scale of 5)	4.156

Appenidx Table 8: Dietary reference intakes (DRIs), recommended dietary allowances, and adequate intakes of young childrens

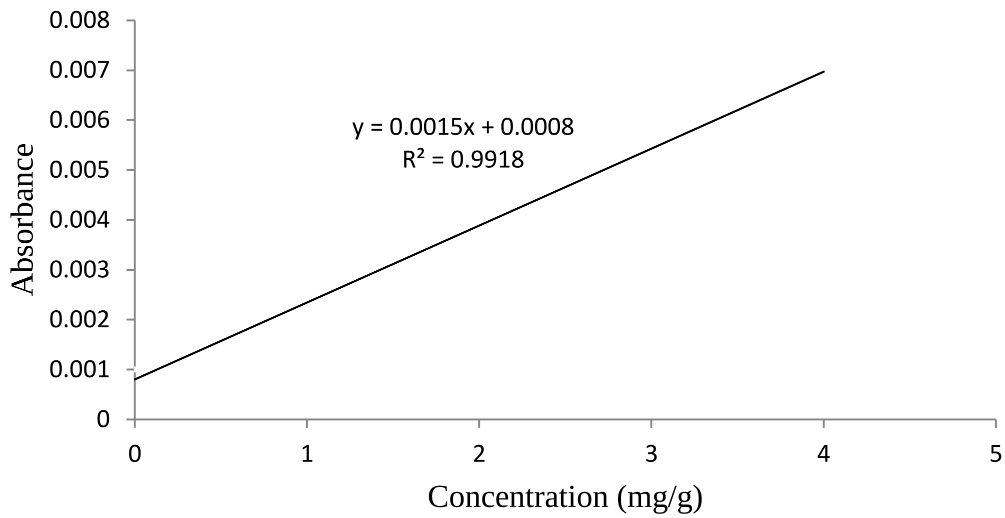
Nutrient	Life stage group	
	Infants 6-12 month	Children 1-3y
Vitamin A (μg/d)*a*	500*	**300**
Calcium (mg/d)	260*	**700**
Iron (mg/d)	**11**	**7**
Zinc (mg/d)	**3**	**3**
Carbohydrate (g/d)	95*	**130**
Total fiber(g/d)	ND	19*
Total Fat(g/d)	30*	ND
Protein (g/d)	**11**	**13**

This table presents Recommended Dietary Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*).An RDA is the average daily dietary intake level; sufficient to meet the nutrient requirements of nearly all (97-98 percent) healthy individuals in a group. It is calculated from an Estimated Average Requirement (EAR). If sufficient scientific evidence is not available to establish an EAR, and thus calculate an RDA, an AI is usually developed. For healthy breastfed infants, an AI is the mean intake. ND: Not determined.

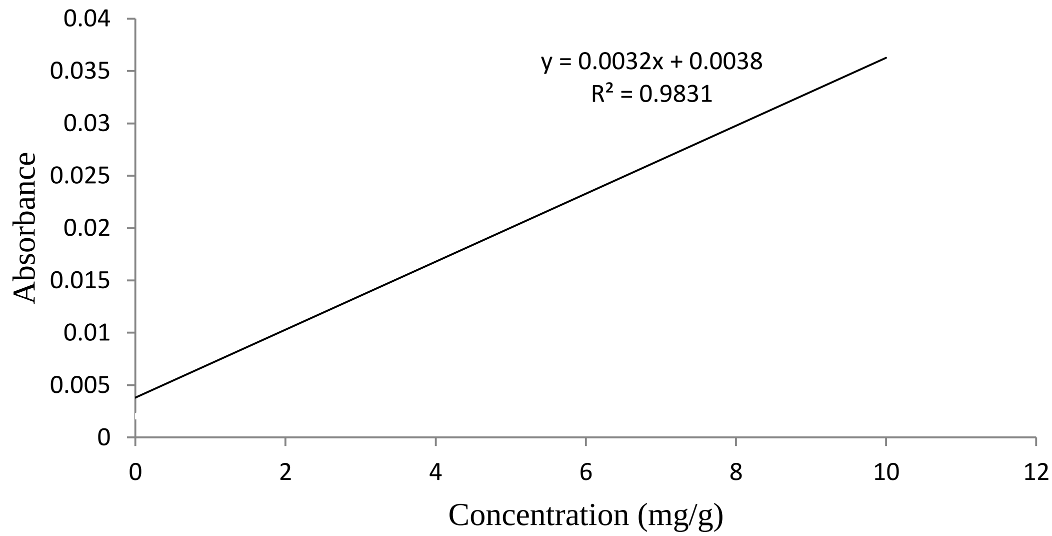
I. β- Carotene standard calibration curve



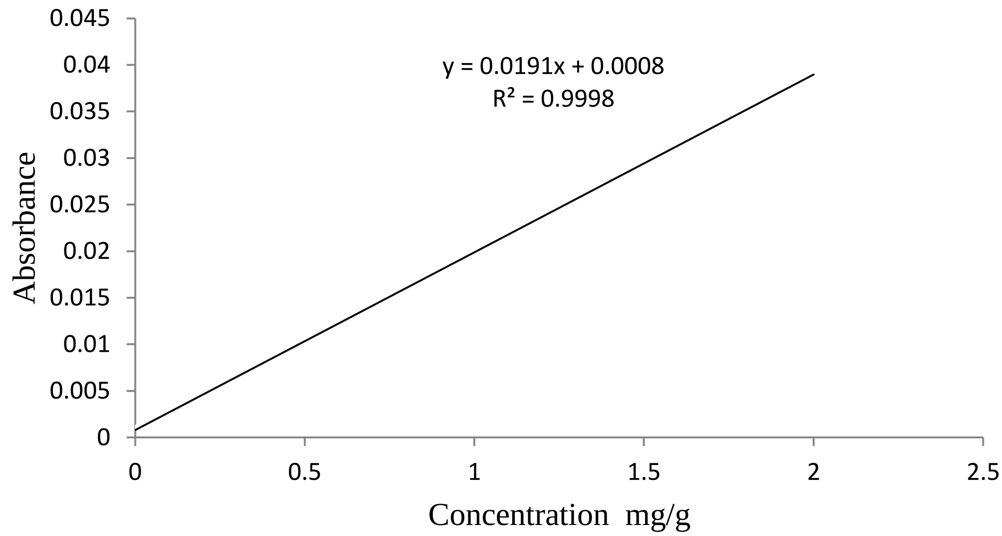
II. Iron standard calibration curve



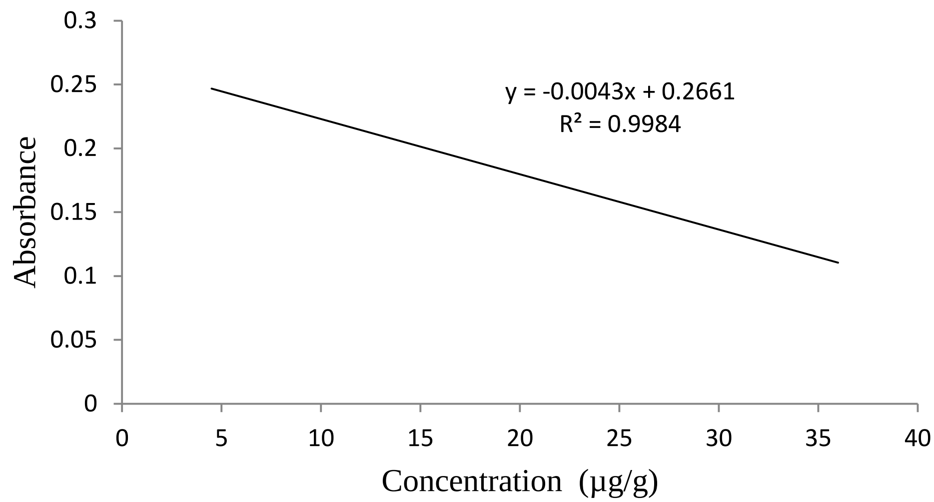
III. Calcium standard calibration curve



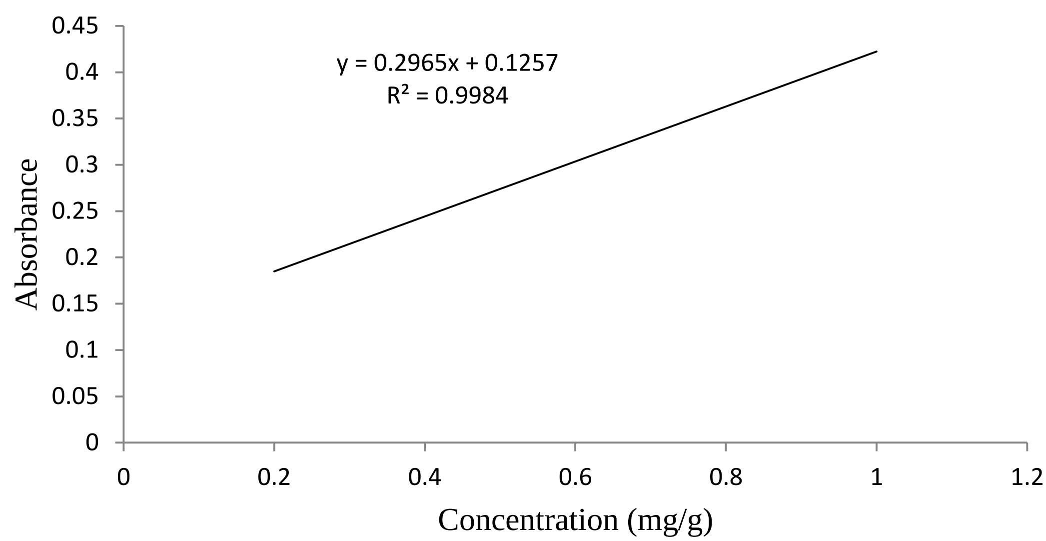
IV. Zinc Standard calibration curve



V. Phytate standard curve



VI. Tannin standard curve



VII. Sensory evaluation questioner form

Please look at and taste each sample of porridge in order from left to right as shown on the ballot. Indicate how much you like or dislike each sample by checking the appropriate phrase of category which is listed below and mark your choice with the number that corresponds to your preference on each parameter.

1. Dislike Very Much
2. Dislike
3. Neither Like or Dislike
4. Like
5. Like Very Much

Sample code	Appearance	Aroma	Taste	Mouth feel	Overall acceptability

VIII. **Questioners**

Date__________

A. Identification Code No.________

Name of the respondent _________________________

Time of questioning______________
Place of questioning (“*Kebel”*): _________________________
Interviewer______________________

Supervised by Name_________________ Date _____________ Signature _____________

B .Demographic Information

1. Types of the household: (tick where appropriate) 1. Male headed ☐ 2. Female headed ☐

2. What is the household size? 1. Male __________2. Female ___________ 3. Total ____________

Socio –demographic data of the care givers

No.	Family relation ship	Marital Status	Sex	Age	Education Level	Occupation	Monthly Income
	1.Mother 2.Father 3.Brother 4.Sister	1.Unmarried 2.Married 3.Separated 4.Divorced	1.Female 2.Male		1. Can read and write 2. Grade 1-6 3. Grade 7-	1.Farming 2. Handicraft 3. Daily labor 4. Student	

	5.Adopter 6.other	5.Widowed			12 4. Illiterate 5.Diploma holder 6. Degree and above	5. Soldier 6. Trade 7. Gvt sector 8.Others (Specify)	

C. Socio-Economic Information

- ✓ **Environment**

a) What is your water source? (tick where appropriate)

1) Piped water ☐ 2) River ☐ 3) Borehole ☐ 4) others (specify) ____

b) Do you have access to latrine/toilet?

Ye s = 1 ☐ No =0 ☐

c) If yes, what type?

1) Pit 2) WC 3) Bush 4) other (specify)________________________________

d) What is the roofing material for the main house?

1) Thatched 2) Corrugated sheets 3) Tiles 4) others (specify)

e) What is the wall material for the main house?

1) Mud 2) wooden 3) Iron sheet 4) others (specify)

- ✓ **Economic Issues**

a) Who is the main income earner?

1) Husband 2)Wife 3) Family members (__________________)

b) How does this person make an income?

1) Salary 2) Merchant 3) Pension 4) others (specify)

c) Has type of work changed in the last month?

Ye s = 1 ☐ No =0 ☐

d) In what way has it changed?____

e) How much money on average do you spent on food purchase daily?_______________Birr

f) Do you practice farming?

Ye s = 1 ☐ No =0 ☐

g) If yes, what type and number of animals and crops you keep?

Animal	No. of animals	Crops	Area in M^2	

h) Do you earn any income from agriculture?

Ye s = 1 ☐ No =0 ☐

i) If yes, from which agriculture sources and how much per year?

Animals	Birr	Crop	Birr

D. DDS (Children) Food Groups (Score: 0-8)

1. Grains, roots or tubers
2. Vitamin A-rich plant foods
3. Other fruits or vegetables
4. Meat, poultry, fish, seafood
5. Eggs
6. Pulses/legumes/nuts
7. Milk and milk products
8. Foods cooked in oil/fat

Under line the foods (meals and snacks) that ate or drank in 24 hour during the day and night, whether at home or outside the home. Start with the first food or drink eaten in the morning.

Food group	Food list
1	White teff , Red teff ,Wheat ,Barely, Sorghum, Rice, Oate ,Maize ,Rye, Triticale ,Yam, Potato, Sweat potato, Cassava, Enset , and Taro root
2	Ripe mango, Carrot, Papaya , Moringa , Pumpkin ,Orange flesh sweet potato, Apricots
3	Cabbages, Spinach, Amaranthus, Carrots, Tomatoes , Lettuce, Spinach, Cabbage, Cucumbers, Lettuce, Zucchini, Apple, Blackberry, Grapefruit, Guava, Lemon, Mangoes ,Pineapple, Strawberry, Watermelon, Oranges, Banana ,Squash, Passion fruit, Papaya and Avocado
4	Fish, Chicken, Beef, Organ Meat, Flesh Meat, Fresh or dried fish, Canned fish (anchovies, tuna, sardines)
5	Egg
6	Beans, Peas, Soybean, Chickpea, Guaya (vetch), lentil , Pigeon pea, peanut
7	Milk
8	Biscuits (sweet) or cookies