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PROXIMATE COMPOSITION ANALYSIS OF DIFFERENT MAIZE VARIETIES ADAPTED UNDER SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)




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SoRPARI _____

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Executive Summary

The study was conducted in Somali Regional state with objective to analyze macronutrient and mineral content of different maize varieties adapted under Somali Region pastoral and Agro-pastoral research institute (SoRPARI). Four different types of samples such as Melkasa-6Q, MH-138, BH661 and BH-549 sample were collected. The collected maize samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, different minerals like Calcium, Iron, zinc and total phosphorous were determined by AOAC. Based on the result obtained, the ash content of the four maize varieties is in the range 4.06(Bh-549)-5.88% (Melksa-6Q), while the protein content from 12.82 (BH-549)-15.24% (Melkasa-6Q). The fat content is in the range 11.89 (BH661)-21.02%(Melkasa-6Q) while the carbohydrate content is in the range of 45.48% (Melkasa-6Q)-59.07% (BH-549). Significant difference was observed in most of these macronutrient content at $p<0.05$. Significant difference was also observed at $p<0.05$ in minerals content such as Calcium, Zinc, iron and Total Phosphorous where Melkasa-6Q had highest in almost all minerals content. Overall, from the finding we conclude that, all adapted maize varieties have good in both macronutrient and minerals especially Melkasa-6Q. Therefore, all actors of maize should contribute to the promotion of nutrient dense varieties of maize to the local community which in turn important for the fight against malnutrition.

Key words: *Maize, maize varieties, macronutrient, mineral content.*

CHAPTER ONE

1. INTRODUCTION

1.2. Background

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and Maize. Maize literally means that which "sustains life". Pieces of evidence from Botany, Genetics and Cytology have pointed towards a common origin for every existing type of maize (2n = 20). Maize belongs to Family Poaceae and Genus *Zea*. Maize is a highly cross-pollinated species. It was also one of the first plant species identified to photosynthesize by C4 pathway with high yield potential. The suitability of maize to diverse environments is unmatched by any other crop as the expansion of maize to new areas and environment still continues, as it has a range of plasticity. By origin, it is a tropical crop and has adapted magnificently to temperate environments with much higher productivity. It is grown from latitude 580 N to 400 S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 5000 mm (Dowswell *et al.,* 1996; Premlatha and Kalamani, 2010). The United States of America has the largest cultivated area of corn. Major maize producers are the USA (30%), China (15%), European Union (14%), Brazil (4%) and India (3%). These five countries have around 60% of the world's corn harvested area (Annonymous, 2007; Tao Ye *et al.,* 2015).

Maize is used as a basic food ingredient, either in its original or modified form. Maize grains are a rich source of starch (72%), ash (17%), protein (10.4%), fiber (2.5%), oil (4.8%), vitamins and minerals (Farhad *et al.,* 2009; Zhiqiang *et al.,* 2018). The oil and protein contents have commercial value and are used in food products manufacturing (Paliwal, 2000). Maize is used primarily as a food for humans in most areas of the world, in contrast to the United States where about 85 percent of the crop is used as cattle feed. Maize is used for livestock feeds in a variety of ways. Byproducts of processing are gluten feed, gluten meal, oil cake meal, germ meal, distiller's and brewer's grains.

In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and it remains the most important agricultural crop for over 70 million farm families worldwide. Of the 22 countries in the world where maize forms the highest percentage of energy in the national

diet, 16 are in Africa (Nuss and Tanumihardjo, 2011). Maize is used as human food in the form of tortillas, porridge, popcorn and barbecues and as forage and silage for animals. It is also a good source of industrial products such as starch (Zhang *et al*., 2012), vitamin (Warman and Havard, 1998), fiber, oil, weaning porridges (Mburu et al., 2012) and ethanol (Lamsal et al., 2011). Maize kernels are the largest cereal seed weighing 250 -300 mg each, they are flat seed due to pressure during growth from adjacent kernels on the cob.

Ethiopia is among the major maize producers in Africa and ranked third next to South Africa and Nigeria (FAO,2012). In Ethiopia the crop is widely cultivated at altitudes ranging from 1500–2200 meters above sea level of Western, Southwestern, and Southern parts of the country. Maize production takes significant share of cereals and grain in any production year Among cereals, maize ranked second to tef in area coverage (21.7% for maize and 27.4% for tef), and first in total production (28.5% for maize and 19.9% for tef) and productivity (Mosisa et,al, 2011).

Yellow maize, in addition to being dietary source of energy, lipids, protein, minerals and vitamins, it is a source of carotenoids (Adam & Liu. 2012, Dewanto & Liu. 2002, Menkir et.al, 2008). Food composition data is important in nutritional planning and provides data for epidemiological studies (Ali et.al, 2008).

1.2. Statement of the problem

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and Maize. By origin, it is a tropical crop and has adapted magnificently to temperate environments with much higher productivity. It is grown from latitude 580 N to 400 S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 5000 mm (Dowswell *et al.,* 1996; Premlatha and Kalamani, 2010). Maize is used as a basic food ingredient, either in its original or modified form. Maize grains are a rich source of starch (72%), ash (17%), protein (10.4%), fiber (2.5%), oil (4.8%), vitamins and minerals (Farhad *et al.,* 2009; Zhiqiang *et al.,* 2018). The oil and protein contents have commercial value and are used in food products manufacturing (Paliwal, 2000).

In general, it has a great worldwide significance as human food, animal feed and a source of a large number of industrial products. It has the highest potential of per day carbohydrate

productivity. Thus, the father of the green revolution, the renowned Noble Laureate, Dr. Norman E. Borlaug, stated that "After the last two decades saw the revolution in Maize and wheat, the next few decades will be known as maize era". A number of genotypes e.g. single crosses, double crosses, three-way crosses, vertical hybrids, multiple hybrids composites, synthetics, pools, populations etc. are feasible to maize growing farmers for commercial cultivation by virtue of the crop being highly cross-pollinated (Tao Ye *et al.*, 2015; Zhiqiang *et al.*, 2018). In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and it remains the most important agricultural crop for over 70 million farm families worldwide. Of the 22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa (Nuss and Tanumihardjo, 2011).

Ethiopia is among the major maize producers in Africa and ranked third next to South Africa and Nigeria [10]. In Ethiopia the crop is widely cultivated at altitudes ranging from 1500–2200 meters above sea level of Western, Southwestern, and Southern parts of the country. Maize production takes significant share of cereals and grain in any production year Among cereals, maize ranked second to tef in area coverage (21.7% for maize and 27.4% for tef), and first in total production (28.5% for maize and 19.9% for tef) and productivity [17]. In Ethiopia, maize is a staple food in major maize producing areas which is also true for Somali region community. The per capita consumption of maize in Ethiopia is about 60 kg per annum [17]. However, there is no or limited study about the nutritional content of the different maize varieties growing in Ethiopia particularly in Somali region. This study is designed to provide information on nutritional composition of different maize varieties grown under SoRPARI potential areas and Somali Region in Ethiopia.

1.3. Objective

1.3.1. General Objective:

The general objective of the study is to evaluate the nutritional, functional and physico-chemical quality of different maize varieties grown under SoRPARI and other local or marketed one.

1.3.2. Specific objective

The specific objectives of the research were;

- To assess the proximate composition of different maize varieties grown in study area

- To evaluate the minerals contents of different maize varieties grown in study area.

1.4. Significance of the study

This study so important as it is the 1st in its nature to conduct such study on different maize varieties macro-nutrient composition and mineral of different variety grown in SRS. The output of the study will important to get up to date data on the macro-nutrient and minerals content of the different maize varieties adapted by SoRAPRI. The result obtained from this study will further be important for future researcher as baseline information to conduct their research. Based on the recommendation come out from this study, policy maker, government, Non-Government organization and other interested institutions working on the area will expected to get up to date information form the study.

CHAPTER TWO

2. LITRATURE REVIEW

2.1. History of maize

In the Western world, the term maize is used interchangeably with corn. Although the origin of the word maize is also controversial, it is generally accepted that the word has its origin in Arawac tribes of the indigenous people of the Caribbean. On the basis of this common name, Linnaeus included the name as species epithet in the botanical classification Zea (Zea mays L.) (Smith, 2001). It is considered that maize was one of the first plants cultivated by farmers between 7000 and 10,000 years ago, with evidence of maize as food coming from some archaeological sites in Mexico where some small corn cobs, estimated at more than 5000 years old, were found in caves. The discovery of fossil pollen and cave corncobs in archaeological areas support the position that maize originated in Mexico. Other theories describe maize as originating in the region of the Himalayas in Asia, the product of a cross between Coix spp. and some Andropogoneas (probably of the Sorghum species), both parental chromosomes with five pairs, or in the high Andes of Bolivia, Ecuador, and Peru, as evidenced by the presence of popcorn in South America and the wide genetic diversity present in the Andean maize, especially in the highlands of Peru (Piperno, D.R. & K.V. Flannery. 2001).

The spread of maize from its center of origin in Mexico to various parts of the world has been remarkable and rapid with respect to its evolution as a cultivated plant and as a variety of food products. The inhabitants of several indigenous tribes in Central America and Mexico brought the plant to other regions of Latin America, the Caribbean, and then to the United States and Canada. European explorers took maize to Europe and later traders took maize to Asia and Africa (Vollbrecht, E. & B. Sigmon. 2005, Brown, W. & L. Darrah. 1985, Gibson, L. & G. Benson. 2002.).

2.2. Types of maize

Different types of maize are grown throughout the world, with one important difference being color. Maize kernels can be different colors ranging from white to yellow to red to black. Most of the maize grown in the United States is yellow, whereas people in Africa, Central America,

and the southern United States prefer white maize. Yellow maize is not popular in Africa for reasons associated with the perception of social status: apparently it is associated with food-aid programs and is perceived as being consumed only by poor people. Also, the feed industry consumes mostly yellow maize in the manufacture of animal feed (National Chamber of Milling, South Africa. 2008). But the main reason for the preference for white maize is simply one of tradition: people are used to eating a white product in these countries, usually the whiter the better. This preference means a lower consumption of β-carotene and β -cryptoxanthin, vitamin A precursors, present in higher concentrations in yellow and orange maize. This also shows up in the preference for meal and flour made with higher extraction rates, which are whiter than the whole-grain products, but also with lower contents of fiber, vitamins, and minerals (Doebley, J. 2004). The quality of white maize is important since it affects the milling performance, grading, and yield of high-quality products.

There is a classification of maize on the basis of the size and composition of the endosperm, resulting in an artificial definition by kernel type as follows: dent, flint, waxy, flour, sweet, pop, Indian, and pod corn. Another difference or classification criterion is the sweetness or amount of sugar. The amount of residual sugar depends on the variety of maize and when it is harvested from the field. Sweet maize stores poorly and must be eaten fresh, canned, or frozen before the kernels age, becoming small, tough, and starchy. Sweet varieties cannot be fortified (Brown, W. & L. Darrah. 1985, Gibson, L. & G. Benson. 2002).

Genetically modified (GM) herbicide-resistant maize (e.g., Bt corn, a variant of maize that has been genetically altered to express one or more proteins from the bacteria, Bacillus thuringeiensis) has become the major type of maize grown in many countries, including the United States where 85% of the crop is GM. European and African countries originally banned GM maize, but while still very controversial, this position may be changing as the benefits of Bt corn become accepted. In fact, as of 2011, herbicide-resistant GM maize was grown in 14 countries (James, C. 2011). By 2012, 26 varieties of herbicide resistant GM maize were authorized for import into the European Union, and in 2012, the European Union was reported to import 30 million tons of GM crops. The GM maize MON810 was cultivated on almost 89,000 hectares in five European countries, particularly in regions with high infestation levels of maize borer (a pest affecting both the quality and quantity of the harvest) (GMO Compass, 2014).

There does not appear to be any nutritional difference with Bt maize; therefore, its presence or absence should have no effect on fortification technology or policy.23–26 Other recent papers address maize milling and the different types of milled products made from maize. The main products, all of which can and are being fortified, are meal, flour, precooked meal, dry masa or hominy flour, and breakfast cereals. In addition, there are mixtures with other ingredients, such as Corn Soy Blend, used for infant and food-aid feeding. Some products, such as corn chips and masa dough, may not be suitable for fortification (Dale, E. & F.F. Niernberger. 1982).

2.3. Maize production, utilization, and economics

Maize is grown throughout the world, although there are large differences in yields (Table 2.1). The Food and Agriculture Organization (FAO) of the United Nations indices of agricultural production include commodities that are considered edible and contain nutrients, and show the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 1999–2001. It is estimated that in 2012, the total world production of maize was 875,226,630 tons,(FAO, 2012) with the United States, China, and Brazil harvesting 31%, 24%, and 8% of the total production of maize, respectively.

Table 2.1: Corn production in 2012 by country, FAOSTAT (FAO, 2012)

Country	**Maize production (Million MT/Year)**
United States of America	274
China	208
Brazil	71
Mexico	22
Argentina	21
India	21
Ukraine	21
Indonesia	19
France	16
Canada	12
South Africa	12

market-oriented supply response to short U.S. crops. Several countries, including Brazil, Ukraine, Romania, and South Africa, have had significant maize exports when crops were large or international prices were attractive (United States Department of Agriculture (USDA), 2014). China has been a significant source of uncertainty in world maize trade, swinging from being the second largest exporter in some years to occasionally importing significant quantities. While a

large maize producer, Mexico processes much of its production of white maize into human food products, but has turned to imported yellow maize for livestock feed to support increased meat production (United States Department of Agriculture (USDA), 2014).

The analysis of the use of maize in the United States for the last 30 years shows that it has been used mainly for animal feeding, followed by human consumption and alcohol production (Table 2.2). However, in the last 10 years, the use of maize for fuel production significantly increased (Wallington, T et.al., 2012). As the ethanol industry absorbs a larger share of the maize crop, higher prices for maize will intensify demand competition among domestic industries and external buyers. This could also affect maize prices for animal and human consumption, although maize has historically been one of the least expensive foods and food ingredient available. It is estimated that nearly 40% has been used in recent years to make ethanol for fuel. Of this, 27% becomes ethanol and 12% is the distillers' dry grain residue that goes to animal feed, making the total animal feed use at 50% (Wallington, T et.al., 2012). Exports accounted for 13% and 4% are used to make high-glucose corn syrup. Part of the remaining 7% is used to make corn oil, cornstarch, corn syrups, and other industrial applications, while some is used to make whiskey and other alcoholic beverages.

Table 2.2: Domestic corn use in the USA from 1980 to 2013 in billions of bushels

Corn Use	**1980**	**1990**	**2000**	**2010**	**2013**
Animal feed and residual	4.16	4.75	5,73	4.79	5.00
Food, seed and industrial	0.81	1.08	1.15	1.25	1.46
Ethanol production	0.02	0.42	0.83	5.00	5.00
Total	**4.99**	**6.25**	**7.71**	**11.04**	**11.46**

2.4. Maize consumption by country and World Health Organization region

Estimated maize consumption in grams per person per day in countries where maize is considered an important food source (i.e., above 50 g/person/day) were corrected for an average 80% extraction rate, using the FAOSTAT food balance sheets with 2009 data by World Health Organization (WHO) region (Table 2.3). It is clear that maize is a staple in the African region where the consumption ranges from 52 to 328 g/person/day and the region of the Americas

where the highest consumption was 267 g/person/day in Mexico. The results may vary according to the extraction rate, which varies in each country by type of flour milled as well as by the maize type used (Dary, O. & B. Imhoff-Kunsch. 2012).

Other data sources to estimate maize flour consumption have been proposed. Household Consumption and Expenditures Surveys, which include Household Income and Expenditure Surveys, Living Standards Monitoring Surveys, and National Household Budget Surveys, can help to address the food consumption information gap. Some countries such as Zambia have introduced specific food item categories in order to be able to obtain more precise data with which to assess the feasibility of or to design fortification programs. In 2006, the Zambia Living Standards Measurement Study asked about households' consumption of maize with a focus on breakfast mealie meal, roller mealie meal, and hammer-milled meal, in addition to maize grain, in order to be able to distinguish those maize meal consumers who purchase their product from large scale, modern roller mills flour milled as well as by the maize type used. No consumption above 50 g/person/day was estimated in the Western Pacific Region (Dary, O. & B. Imhoff-Kunsch. 2012).

Table 2.3 African Countries with the highest maize consumption (g/person/day) by WHO region

Country (Mainly African Region)	Maize consumption (g/person/day)
Lesotho	328
Malawi	293
Zambia	243
Zimbabwe	241
South Africa	222
Kenya	171
Togo	160
Swaziland	152
Tanzania	128
Namibia	127
Benin	119
Mozambique	116
Burkina Faso	107
Ethiopia	94

Major importers of maize in 2009 were Japan, South Korea, and Mexico (FAO. 2012). Experts from the U.S. World production of maize has shown a slight but steady increase over the years, but human consumption of the grain has remained steady. It is thought that the majority of the increase in production has corresponded to an increase in the use of maize for animal feed. However, maize is still a staple food for many people, especially in Africa. Maize has food, feed, and industrial uses. It is a major component of livestock feed. The amount of maize used for feed also depends on the crop's supply and price, the amount of supplemental ingredients used in feed rations, and the supplies and prices of competing ingredients (United States Department of Agriculture (USDA), 2014).

2.5. Maize expansion in sub-Saharan Africa

In a relatively short period of time, maize has become the main staple crop in many parts of sub-Saharan Africa. After epidemics of common staple foods (like millet) in the early 1900s, colonial governments introduced and promoted white maize as a subsistence and cash crop, because it is easy to grow and process (Byerlee, D.; Heisey, P.W., 1997). This is not to say that the quick adoption of maize on the African continent happened only because of state intervention. Carefully selecting the appropriate crops and varieties each season, farmers rapidly incorporated the high-yielding crop into their farming practices (McCann, J., 2007). As a result, today, maize is one of the most important staple crops, mostly grown by smallholder farmers for food. In Eastern and Southern Africa (excluding South Africa), maize accounts for 19% of the average calorie intake per capita and the demand for the crop as food will only be increasing (FAOSTAT. 2019, Nolte, K et.al, 2016), also as a consequence of population growth. In recent years, more and more maize were produced across the world and according to the latest statistics published by the Food and Agriculture Organization (FAO), maize has become the second most produced crop after sugar cane (OECD et.al., 2019).

2.6. A Growing Demand for Maize

The increase in maize production and the expansion of land on which it is grown goes hand-in-hand with the growing global demand for the crop, for food, livestock feed, and as biofuel feedstock. Unlike high-income countries, where more than 70% of maize is grown for livestock feed, in sub-Saharan Africa, more than two-thirds of produced maize is grown for human consumption (Shiferaw, B., et.al., 2011, Smale, M.; et.al., 2011). The annual Global Agricultural

Outlook, published by the Organization for Economic Co-operation and Development (OECD) and the OECD (2019), point out two main drivers for an increase in demand for agricultural products: population dynamics and per-capita demand growth. In other contexts, because maize is often used as animal feed, an increase in demand is often associated with an increase in the demand for meat. Over the years, this has been the main reason for rapid maize expansion, for example, in China. Although meat consumption is expected to increase in SSA by 25% in the next decades, incomes are not expected to increase significantly and make meat consumption more widely accessible. On the contrary, per-capita, meat consumption is expected to decline slightly (OECD, 2019). According to the OECD/FAO (2019), population dynamics in Africa drive most growth of projected food use, attributing 90% of the expansion of cereals to population growth. Therefore, because maize is mostly produced for food, the growing demand for maize is closely linked to the growing population in SSA. Processes of late, but rapid urbanization in SSA have also contributed to the increased need for cereals, including maize (OECD et.al, 2018, FAO 2018, McCann, 2007., Smale et al, 2011). In 2007, McCann [13] (p. 214) points out the appearance of maize in urban agriculture and the potential benefits of this new form of artisanal farming. (Shannon, M.; Santpoort, R, ND).

New uses of the crop, besides food and feed have emerged over the past decades that have been driven by the contemporary narrative around climate change. Across the world, maize has been increasingly used for 'new' purposes as a so-called 'flex crop'. Borras, Franco, Isakson, (Borras,et.al., 2015) define flex crops as crops that have dimensions of 'multiple-ness' and 'flexible-ness'. Multiple-ness, according to the authors, refers to the multiple uses of the crop (e.g., for food and livestock feed). 'Flexible-ness' means that the use of a crop can be easily changed for different products (like corn oil or flour). The combination of multiple-ness and flexible-ness make a product more valuable and attractive for large investments (Borras,et.al., 2015). Especially in high-income countries, maize is used as biofuel feedstock, mainly for ethanol production, driven by policies. With policy agendas across the world being more focused on energy use from renewable sources, the growing demand for biofuels in the US, Europe, and China led to an increasing demand for cereals of more than 120 million tons of mostly maize. This contributed to historical worldwide production levels of the crop in 2017 (OECD et al., 2018). In many countries in SSA, maize is prohibited to be exported outside the region or to be

used for other purposes than food or feed. Uganda's Biofuels Bill, for example, states several times that biofuel production licenses will only be granted if feedstock production does not endanger the country's food security, although maize is appointed as a potential feedstock (Government of Uganda, 2016). In South Africa, maize, being an important food crop, is banned from being used as biofuel feedstock.

2.7. The maize story in Ethiopia

Maize is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socioeconomic conditions typically under rain-fed production. The maize agro-ecologies in Ethiopia can be broadly divided into six major categories (MOA, 2005), including Moist and Semi-moist mid-altitudes (1700–2000 m above sea level; 1000–1200 mm rainfall), Moist upper mid-altitudes (2000– 2400 m; >1200 mm), Dry mid-altitudes (1000–1600 m; 650–900 mm), Moist lower mid-altitudes (900–1500 m; 900–1200 mm), Moist lowlands (<900 m, 900-1200 mm), and dry lowlands (<1000 m, 700 mm). The moist and semi-moist mid-altitude zones comprise the bulk of the national maize area in Ethiopia. These are mostly located in the SW and W Oromia, W and NW Amhara, parts of the Southern Nations Nationalities and Peoples Region (SNNPR), and Ben Shangul-Gumuz (BSG). Taken together, the Semi-moist and Moist ecologies cover about 75 % of the national maize production area whereas the dry ecologies cover the remaining 25 %.

Smallholder farms account for more than 95 % of the total maize area and production in Ethiopia. The farmers use animal traction for land preparation and cultivation; almost all production is rainfed, irrigated areas accounting for only about 1 % of the total. Smallholders across all 70 administrative units of Ethiopia, which include 59 zones and 11 special weredas3 grow maize (. The top five maize producing zones of Ethiopia, according to the 2011 CSA data, are West Gojjam, Jimma, East Welega, West Welega and East Gojjam. Most of these fall into the mid-altitude (1500–2000 m asl) range.

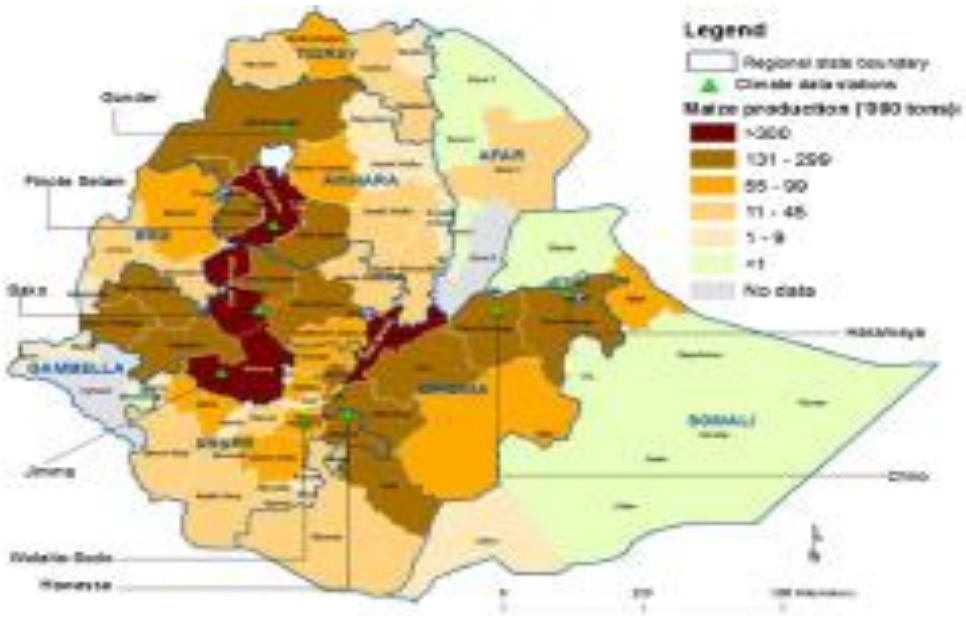


Figure 2.1: Distribution maize production in Ethiopia. (Source: CSA 2011)

More than 9 million households, grow maize in Ethiopia (CSA, 2011–13 data). The annual rate of growth for the number of households cultivating maize grew at 3.5 % each year between 2004 and 2013, compared to 3.0 % for sorghum, 3.1 % for teff, 2.1 % for wheat, and 1.8 % for barley. At present, as a sub-Saharan country, Ethiopia has the fifth largest area devoted to maize but is second, only to South Africa, in yield and third, after South Africa and Nigeria, in production.

Maize currently occupies about 2 million ha with an average yield of upwards of 3 MT/ha. National maize yields have doubled from about 1.50 MT/ha during the early 1990s to 3.23 MT/ha in 2013. Analysis of FAO data revealed that a highly significant ($p<0.0001$) annual yield gain of 68 kg/ha was recorded for maize in Ethiopia for the period 1990 to 2013. Only South Africa exceeded this figure (119 kg/ ha/yr) in SSA whereas some countries such as Tanzania and Kenya registered negative growth. Ethiopia's figure is superior to Mexico (55 kg/ha/yr), China (55 kg/ha), and India (47 kg/ha/yr). Yield gains grew even faster (120 kg/ha/yr) between 2000 and 2013.

Despite the pockets of change across Africa, such change at the national level is a significant transformation in a region where a green revolution seemed largely unattainable (Howard and Mungoma 1997; De Groote et al. 2002; Smale et al. 2011; Smale and Olwande 2014). On

average, maize area and productivity increased by 4.0 and 6.3 % pr annum, respectively, during the 10 years between 2004 and 2013. Similarly, the annual rate of growth for production during the same period was 10.5 %.

It is interesting to see that the increases in maize production in Ethiopia resulted more from increases in productivity rather than area expansion - i.e., the yield grew faster than the area. The current performance of maize in Ethiopia compares favorably with the main maize producing countries in SSA. Ethiopia is the only country in SSA outside South Africa that has attained >3 MT/ha yield; only Zambia and Uganda have achieved >2.5 MT/ha, followed by Malawi, with >2 MT/ha. The SSA average is about 1.8 MT/ha.

Largely because of the increasing demand (Rosegrant et al. 2001) driven by population growth and competitiveness of the crop, maize area in Ethiopia also doubled during the past two decades from 1 to 2 million ha. This increase in area came mainly from two sources. First, the traditionally sorghum growing smallholder farmers in the rift valley shifted to maize because of the weaver bird (Quelea quelea) invasion that resulted in the total destruction of sorghum in the early 1980s. The second driver of maize area increase was the adoption of maize by the traditional teff-growing farmers in north-central Ethiopia – particularly in West Gojjam, North Gondar, and other surrounding agro-ecologies – because of its high productivity achieved through new hybrids (starting with the hybrid BH140) and diversity in end-uses of maize. Unlike in the central rift valley, farmers here did not necessarily shift from teff to maize but rather expanded the area of the latter.

In general, the growth in the proportion of maize area was higher than all other major cereals over the last three decades. For example, maize occupied roughly 16 % of the total cereals area in 1981–83 compared to 30 % for teff, 20 % for sorghum, 14 % for wheat, and 19 % for barley; the area occupied by maize, teff, sorghum, wheat and barley in 2001– 03 was 24, 31, 17, 15, and 13 %, respectively. Currently teff, maize, sorghum, wheat and barley occupy 30, 22, 20, 17, and 11 %, respectively, of the total cereal acreage of Ethiopia. It should be noted here that production of major cereals in Ethiopia remained stagnant in the 1960s and showed dramatic declines in the 1970s and 1980s due to major droughts and political conflicts.

2.8. Maize transformation and research and development in Ethiopia

The expansion and productivity change in maize production in Ethiopia is attributable to multiple factors. These include a) increased availability of modern varieties, b) increased commitment to enhance farmer access to and use of modern inputs through better research-extension linkages, c) wider adaptability of the crop and modern varieties, d) better production conditions and low production risks and e) growing consumption demand and market access for producers to support market-based production to absorb surplus supply. We discuss some of these factors and draw lessons on the key drivers of change in the following section to show the relevance of similar processes of transformation in African agriculture.

Maize research and development in Ethiopia has gone through a number of changes over the last several decades, which marked critical periods in terms of driving the current change in production and productivity. Some of the key events that warrant specific mention include the 1984 major drought and famine that helped to increase the profile of maize in attaining national food security; the introduction of nationally developed hybrids adapted to the local production conditions in the late 1980s and early 1990s; the launching in 1993 of the government campaign, NEIP (National Extension Intervention Program) in partnership with Sasakawa Global 2000 (or SG2000) to increase food security; the introduction of a maize grain floor price in the early 2000s; the introduction of an integrated systems approach for research and development by the Ethiopian Institute of Agricultural Research (EIAR) in the early 2000s (Abate 2006, 2007); and inclusion of maize in the commodity exchange in recent years. Earlier attempts made to introduce hybrids from Kenya were unsuccessful due to poor adaptation to the prevalent production systems and high seed price.

2.9. Modern varieties (MVs)

Undoubtedly, the maize story in Ethiopia is largely homegrown and improved maize germplasm has played a key part in catalyzing change in production practices by replacing traditional varieties with input-responsive, stable and high yielding MVs. The Ethiopian NARS has released a total of 61 maize varieties between 1973 and 2013. The first locally developed hybrid (BH140, in the early- to intermediate-maturity group) was released in 1988, followed by a late- maturing hybrid (BH660) in 1993, and BH540 and the Pioneer Hi-bred Seed Ethiopia hybrid PHB3253 (marketed as Jabi) in 1995.

There was a total of 16 hybrids and 4 Open Pollinated Varieties (OPVs) under production in 2013 (Table 3). Hybrids accounted for 97 % while OPVs represented only 3 % of the total seed market. Furthermore, the Ethiopian seed market has been dominated by BH660 and BH540; the average age of 80 % of the currently grown varieties is more than 20 years. There are also hybrids that came into production between 2005 and 2008, but their amounts remain limited, with the exception of the Pioneer hybrids Shone and Agar.

BH661, promoted under the auspices of the Drought Tolerant Maize for Africa (DTMA) project, is of particular significance because of its drought tolerance, resistance to major diseases, higher yield potential and wide adaptability. This variety is expected to replace both BH660 and BH540. The demand for foundation seed by seed companies of this new hybrid is rapidly growing. In 2012 Ethiopian Seed Enterprise (ESE) produced 6 MT of certified seed; by 2014 five companies, including Amhara Seed Enterprise (ASE), Avallo, ESE, Oromia Seed Enterprise (OSE), and Southern Seed Enterprise (SSE) produced nearly 2,900 MT.

Only four OPVs are at all common but their use is limited to the more drought-prone areas such as the central rift valley. The OPVs Melkassa2 and Melkassa4 have been used extensively in the last several years; two new ones (Melkassa6 and Gibe2) were recently introduced into the market and their use is expected to expand before getting replaced by higher yielding hybrids that are in the process of development.

CHAPTER THREE

3. Materials and Method

3.1. Structure of the experiment work

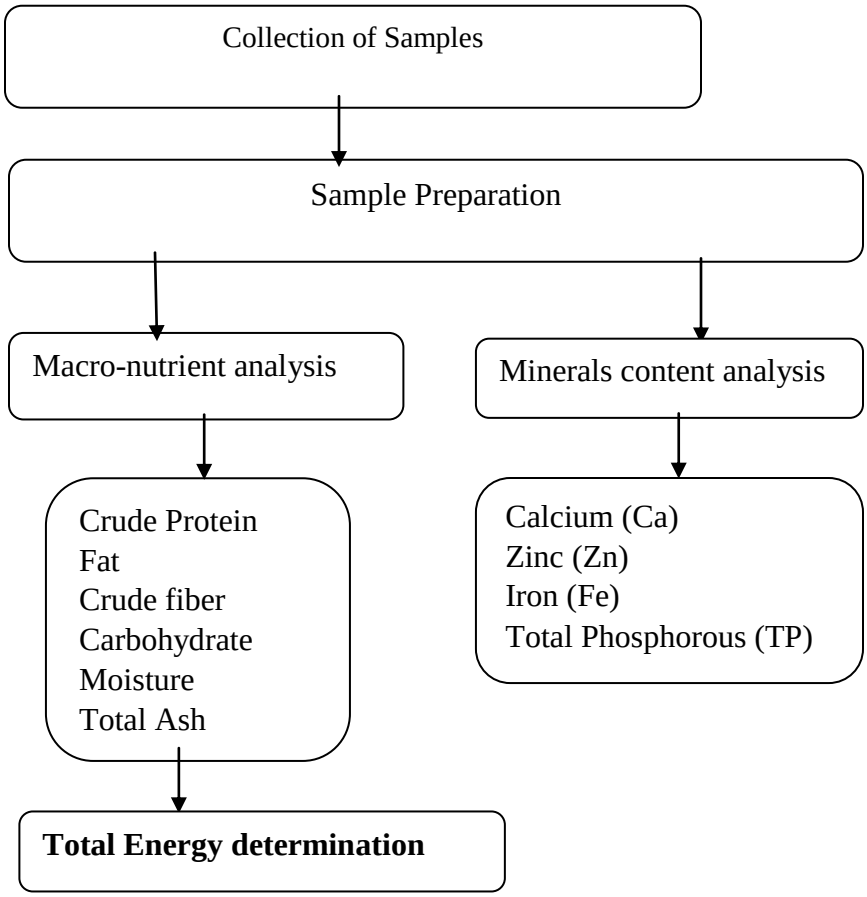


Figure 3.1: Structure of experimental work

3.2. Materials and Equipment Used

Four different maize varieties produced/adapted under SoRPARI were collected from Kelafo agricultural research sub center. The four varieties produced or adapted under SoRPARI that will going to use for this study includes BH661, BH-549, Melkasa 6 Q and MH 138. Only whole maize grains without any physical damage or insect infestation were selected for analysis. All equipment used in sample preparation were obtained from SoRPARI laboratories and missed equipment can be used from local institutes Further, after bringing to the laboratory, Maize

samples was individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

3.3. Proximate Composition

3.3.1 Moisture content

The moisture content of the samples was determined by drying 10g of sample in an air oven at 105^{o}C to constant weight (16 -18 h).

3.3.2. Protein content of the flours

Protein content was determined according to AOAC (2000) using the official method 979.09, which comprised three major steps: digestions, distillation and titration, and quantification.

Digestion

Fresh samples (in duplicate) of each 0.5g was added into Tecator tubes and 6ml of acid mixture (5parts of concentrated ortho-phosphoric acid and 95 parts of concentrated sulfuric acid) was added into each tubes and mixed, and 3.5ml of 30% hydrogen peroxide was added step by step, resulting in violent reaction. Following the cessation of violet reaction, the tubes should be shaken and placed back to the rack. Catalyst mixture (ground 0.5g of selenium metal with 100g of potassium sulfate) of 3g was added into each tube and were allowed to stand for about 10 minutes before digestion. Following the attainment of digester temperature at 370^{o}C, the tubes was low ill bed into the digester. The digestion was continued until a clear solution was obtained (~ after 4 hours). The tubes in the rack should be cooled in a fumehood. 25 ml of de-ionized water was added and the mixture should be shaken to avoid precipitation of sulfate in the solution.

Distillation and titration

The digested and diluted sample solution was distilled using boric acid and the distillate was subjected to titration using 0.1N hydrochloric acid until reddish color appeared.

Quantification of crude protein concentration

$$\text{Nitrogen } \% = \frac{\text{VHCl} * [\text{HCl}]}{\text{Wo}} * 14 * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{Protein \%} = 6.25 * \text{\% Nitrogen} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where; V is the volume of HCl consumed in liter, N is the normality of HCl (0.1N), W_O is the sample weight on dry mass basis and 14 is the molecular weight of nitrogen.

3.3.3. Experimental analysis of fat

The fat content of the complementary food samples (flours) was determined using a semi-continuous solvent extraction method (Soxhlet method) following the procedures of AOAC 960.39 (2000). In this method, the solvent builds up in the extraction chamber for 5-10 minutes and completely surrounds the sample and then siphons back to the boiling flask.

The crude fat content (percent weight by weight) was calculated as follows:

$$F = \left(\frac{W2 - W1}{W}\right) * 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where;

F= Crude fat content in percent weight by weight
W_1 = Weight of the extraction flask in gram (g)
W_2 = Weight of the extraction flask and the dried crude fat in gram (g)
W = Weight of sample in gram (g)

3.3.4. Experimental analysis of ash content

The ash content was determined based on AOAC (2000) using the official method 923.03. Briefly, porcelain crucible that was behind using distilled water was placed in a muffle furnace at 550^{o}C for 30 minutes. Then, the crucibles were cooled by placing it in desiccators for 30 minutes at room temperature. Following this step, they were weighed to the nearest milligram (M_1) using the dried, cooled and weighed crucible, 2.5g of fresh sample together (M_2). Then the sample was thoroughly char in fume-hood by placing it on a hot plate, and increasing the temperature slowly until smoking ceases. After the completion of charring, the sample was placed into the muffle furnace at 550^{o}C for 5 hours. The ignition was continued by cooling for 1hour and weighing until a clean and white ash was obtained, which was then measured to the nearest milligram (M_3).

$$\text{Total ash(in \% weight by weight)} = \left(\frac{M3 - M1}{M2 - M1}\right) * 100 \ldots\ldots\ldots\ldots\ldots (5)$$ Where:

(M_2-M_1) is the weight of sample in gram (g) on dry basis
(M_3-M_1) is the weight of ash in gram (g)

3.3.5. Experimental analysis of carbohydrates

The total available carbohydrate concentration was determined by difference according to AOAC official method, (922.02, 925. 05).

% Carbohydrate = 100% - (%moisture + %protein + %fat + %ash + % crude fiber)…. (6)

2.5.6. Experimental analysis of the crude fiber content

The crude fiber content of the complementary foods (flour) was determined by using the official method of AOAC (2000). The method involved the digestion of a fresh sample, filtration, will behing, drying and combustion. Following these steps, the crude fiber was calculated using the following formula:

$$\text{Crude fiber in } \left(\frac{g}{100g}\right) = \frac{[(W2-W3)*100]}{W1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where;

W_1 = weight of the fresh sample
W_2 = weight of crucible with the sample after oven draying
W3 = weight of the crucible with the sample after ashing

3.3.6. Gross energy (total calorie)

Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories.

3.4 Mineral analysis

Mineral composition of the samples was determined according to methods recommended by Association of Official Analytical Chemists (AOAC, 2000). Fe, and Zn content of complementary food samples was determined by atomic absorption spectrophotometer (AAS) following standard procedures.

Sample preparation for Fe and Zn

The complementary food samples were ashed following the procedure described above in the total ash analysis section. 7 mL of 6N HCl solution was added to the ash of each sample and heated on a low temperature hot plate until it dried. Then, 15 mL of 3N HCl solution was added

and the mixture was heated on the hot plate till it just boils. After the solution cooled down, it was filtered through a filter paper into a volumetric flask (50 mL). Ten mL of 3N HCl was added and the crucible was heated until the solution boiled. The solution was allowed to cool and filtered through a filter paper into the volumetric flask. The crucible and filter paper was will behed thoroughly and the will behings was collected into the flask. Finally, 2.5 mL of lanthanum chloride was added into the solution and the volume was made up to the 50 mL mark with deionized water. Blank sample will also run by taking the same amount of reagents. The solutions was transferred to polyethylene bottles and stored in cool place until analysis.

Calibration curve and AAS reading

In order to fit calibration curves, a series of standard solutions of the minerals was prepared from stock solutions of 20 ppm for Fe (0, 0.5, 1, 2, 3, and 4) and Zn (0, 0.5, 1, 2,3 and 4 ppm). The flame AAS was calibrated with the prepared standards for the respective minerals and the sample solutions and also the blank was run to correct the obtained values. Finally, the mineral content of the samples was calculated by using the following formula.

$$\text{Mineral content } (mg/100g) = \frac{[(cs-cb)x\,v\,x\,D]}{10\,x\,W}$$

Where,

Cs = concentration sample, Cb = Concentration of the blank, V = volume (mL) of the extract and W = weight of samples, D= dilution factors.

$$\text{Fe content } (mg/100g) = \frac{(c-D)x\,200}{w\,x\,10}$$

$$\text{Zn content } (mg/100g) = \frac{(E-F)x\,2000}{wx\,10}$$

W = weight (g) of sample

C and E = Concentration of the sample

D and F = Concentration of blank

The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc was determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate. After removal of organic material by dry ashing, the residue was dissolved in dilute acid. The solution was sprayed into the flame of

Atomic Absorption Spectrophotometer (Varian SpectraAA-20Plus, Varian Australia Pty., Ltd., Australia) and the absorption of the metal to be analyzed was measured at a specific wavelength. The stock standard solutions of minerals (iron, zinc and calcium) was diluted with 0.3 N HCl to concentrations that fall within the working range (0, 0.6, 1.0, 1.4, 1.8, μg/ml for zinc analysis; 1.0, 1.5, 2.5, and 3.0 μg/ml for calcium analysis and 0, 2.0, 6.0, 10.0 12.0 μg/ml for iron analysis). The Atomic Absorption Spectrophotometer (AAS) used for mineral determination was calibrated using standard solutions and the reagent blank solution was run with the sample.

Ashes were obtained from dry ashing. The ash was wetted completely with 5ml of 6N HCl, and dried on a low temperature hot plate. A 7ml of 3N HCl was added to the dried ash and heated on the hot plate until the solution just boils. The ash solution was cooled to room temperature at open air in a hood and filtered through a filter paper (Whatman 42, 125mm) into a 50ml graduated flask. A 5ml of 3N HCl was added into each crucible dishes and heated until the solution just boil, cooled, and filtered into the flask. The crucible dishes was again will behed three times with de-ionized water; the will behings was filtered into the flask. A 2.5mL of 10% Lanthanum chloride solution was added into each graduated flask. Then the solution was cooled and diluted to the mark (50ml) with deionized

water. A blank was prepared by taking the same procedure as the sample.

Calculation:

Mineral content (mg/100g) = [(a-b) x V]/10W

Mineral content (mg/Kg) = [(a-b) x V]/W

Where,

W = weight in grams of samples

V = Volume in ml of extract

A = concentration in micro gm/ml of sample solution

B = concentration in micro gm/ml of blank solution.

Phosphorous determination

Phosphorous was determined by the colorimetric method using ammonium molybdate (AOAC, 2000). It was converted to phosphomolybdate, which was reduced to a blue molybdenum

compound by aminonaphtholsulphonic acid to give a blue molybdenum compound. A sample solution was obtained from mineral analysis (determination of Fe, Zn and Ca). 1 ml of the clear extract was taken from the sample solution and diluted to 100 ml with distilled water in a 100 ml volumetric flask.

A 5ml of the sample dilution was added into test tubes. A 0.5ml of molybdate and a 0.20ml aminonaphtholsulphonic acid was added into the test tube (sample solution) and mixed thoroughly step by step. A 0.20ml aminonaphtholsulphonic acid was added into the test tube repeatedly each time until the solution becomes clear. The solution was allowed to stand for 10 minute. The absorbance (reading A) of the solution was measured at 660 nm against distilled water. Simultaneously with sample phosphorous, standard and blank analysis was carried out. Standard and blank solutions was prepared as above but 5 ml of working standard (reading AS) and 5 ml of distilled water (reading AB) in place of the sample dilution was used respectively. A standard curve was made from absorbance versus concentration and the slope was used for calculation.

Calculation:

First A_B was subtracted from all other readings

P mg/100g = $(A-A_B) \times 50 \times 100 \times /slope \times W_F \times 10$

Where: A = Reading of the sample solution

A_B = Reading of the blank solution

W_F = Weight of fresh sample.

Determination of phytate and non-phytate phosphorus

Phytate and phosphorous was determined by the above methods. Phytate phosphorus was calculated with the following formula (Khetarpaul and Sharma, 1997).

Phytate phosphorous (mg/*100g) = (A*28.18)/100*

Where; A = phytate content (mg/100g)

Non-phytate phosphorous was calculated as a difference between the total phosphorus and phytate phosphorous.

Determination of molar ratio of phytate/mineral (Bioavailability)

The mole of phytate and minerals was determined by dividing the weight of phytate and minerals with its atomic weight (phytate: 660g/mol; Fe: 56g/mol; Zn: 65g/mol; Ca: 40 /mol). The molar

ratio between phytate and mineral was obtained after dividing the mole of phytate with the mole of minerals.

3.5. Statistical analysis

All the analysis was performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance was considered at $P < 0.05$.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1: RESULT

4.1.1: Macronutrient content

Table 4. 1: Proximate composition of different Maize Varieties

Varieties	Results in (%)/(100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
BH661	10.68±0.00^{c}	4.07±0.00^{a}	3.11±0.11^{c}	13.49±0.80^{a}	11.89±0.38^{a}	56.77±1.26^{b}	400.5±1.96^{a}
BH-549	10.00±0.02^{a}	4.06±0.02^{a}	1.85±0.04^{b}	12.82±0.23^{ab}	12.20±0.29^{a}	59.07±0.01^{b}	404.7±1.51^{a}
MH-138	10.36±0.015^{b}	4.74±0.22^{a}	1.77±0.11^{b}	14.57±0.23^{ab}	11.96± 0.11^{a}	56.60±0.21^{b}	399.5±1.45^{a}
Melkasa-6Q	10.94±0.035^{d}	5.88±0.37^{b}	1.44±0.015^{a}	15.24±0.21^{b}	21.02±1.04^{b}	45.48±2.20^{a}	437.8±3.86^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these maize varieties

The proximate composition of different maize varieties is depicted in table 4.1 above. There is significant difference when it comes the moisture content between all the four varieties of maize under study at $p<0.05$. The ash content of Melkasa-6Q is highest as compared to the other three varieties (BH661, BH-549 and MH-138) and significantly different as compared to the other varieties at $p<0.05$. There is no significant different with ash content among the three maize varieties except Melkasa-6Q at $p<0.05$. With respect to crude fiber content, BH661 has the highest while Melkasa-6Q has the lowest. There is no significance difference in crude fiber content for BH-549 and MH-138 maize varieties at $p<0.05$. But there is significant difference between the other maize varieties as shown in table above at $p<0.05$. The comparison also shown in figure 4.1 below.

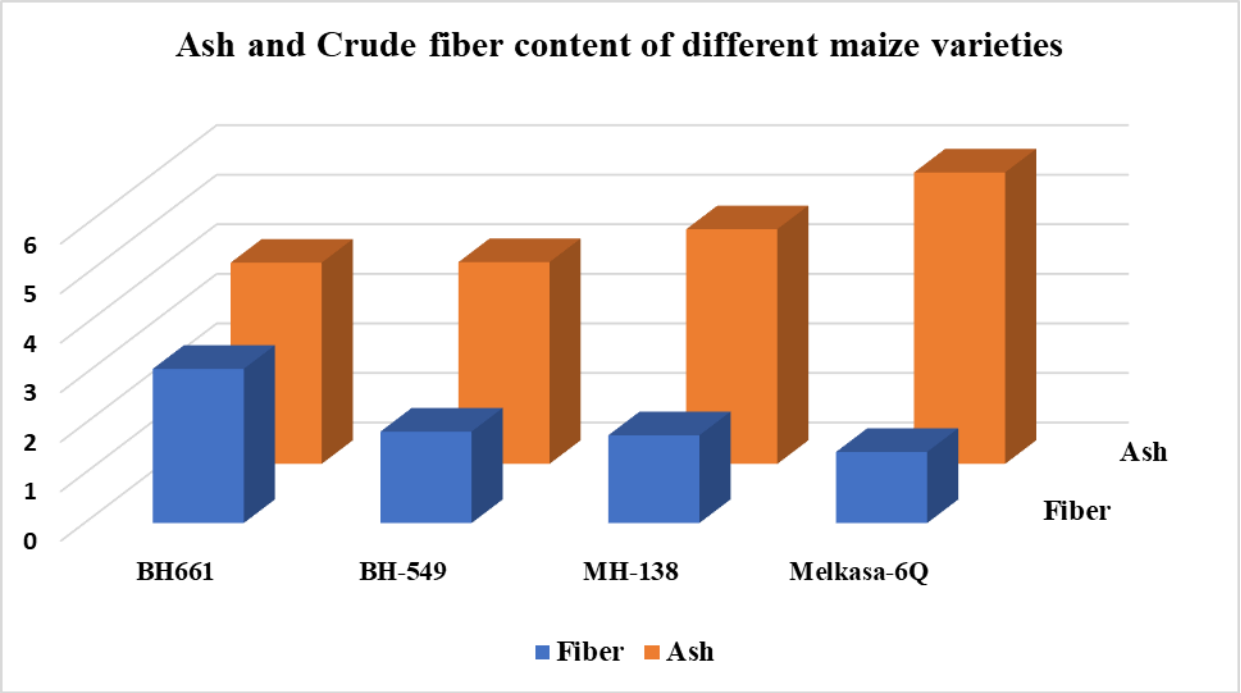


Figure 4.1: Comparizon for Ash and Fiber content

Melkasa -6Q has the highest protein content while BH-549 maize variety has the lowest in protein content as shown in table 4.1 above and figure 4.2 below. Almost there is no significances difference in protein content among all varieties especially between maize varieties BH-549 and MH-138 at $p<0.05$. There is significant difference between maize varieties BH661 and Melkasa-6Q at $p<0.05$ in protein content. When it comes to fat content, Melkasa -6Q has the highest while BH661 has the lowest in crude fat content as shown in table 4.1 above in figure 4.2 below. There is no significant different between BH661, BH-549 and MH-138 maize varieties for crude fat content at $P<0.05$. The crude fat content of melkasa-6Q varieties significantly different as compared to the other three maize varieties under study at $p<0.05$.

BH-549 maize variety has the highest while Melkasa-6Q has lowest in carbohydrate content as shown in table 4.1 and figure 4.2 below. There is no significant different between BH661, BH-549 and MH-138 maize varieties for carbohydrate content at $P<0.05$. The carbohydrate content of melkasa-6Q varieties lowest and significantly different as compared to the other three maize varieties under study at $p<0.05$.

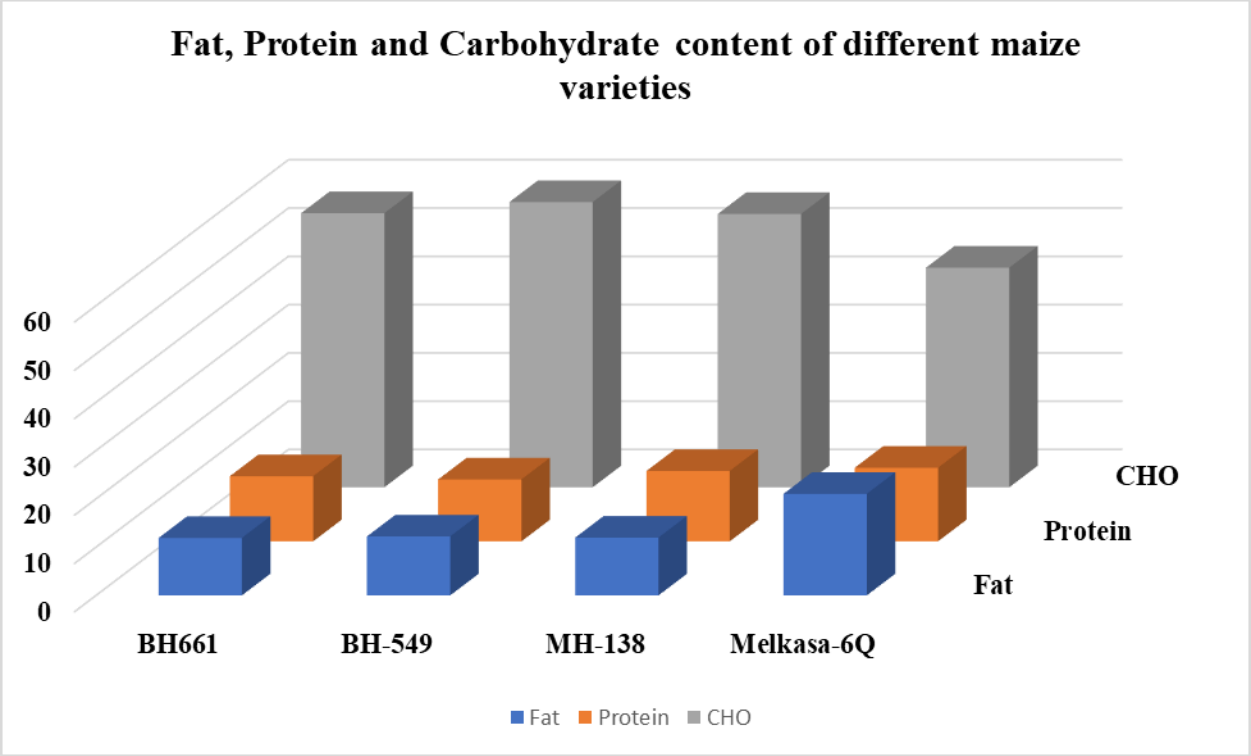


Figure 4.2: fat, protein and CHO Content of different maize varieties

When it comes to energy content, MH-138 has the lowest while melkasa-6Q has the highest in energy content as shown in table 4.1 and figure 4.3 below. There is no significant different between BH661, BH-549 and MH-138 maize varieties for energy content at $P<0.05$. The energy content of melkasa-6Q varieties significantly different as compared to the other three maize varieties under study at $p<0.05$.

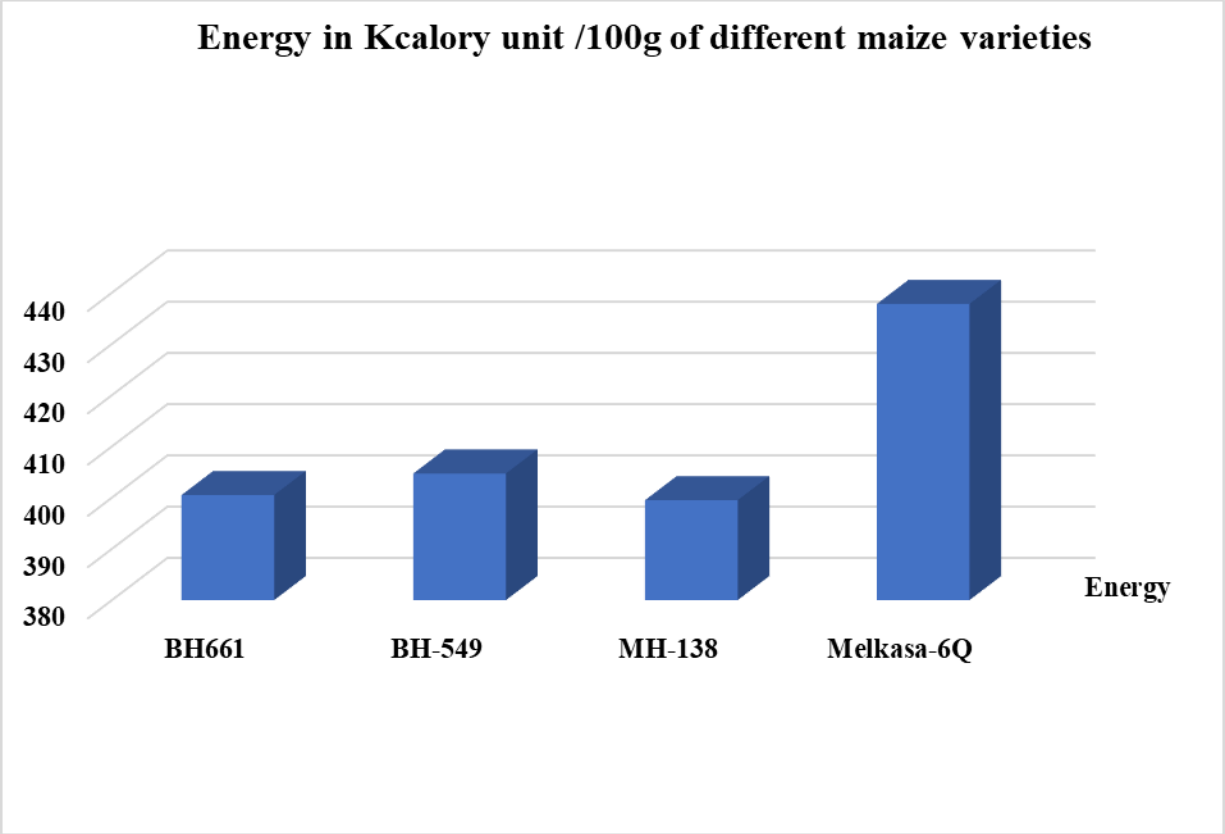


Figure 4.3: The energy in Kcalory unit content of different maize varieties

4.1.2: Mineral content of maize

Table 4.2. Mineral's content of different Maize varieties

Maize varieties	Result in (mg/Kg)			
	Calcium (Ca)	Zink (Zn)	Iron (Fe)	Total phosphorous (TP)
BH661	670.7±41.54^{a}	59.62±1.59^{a}	135.1±7.85^{a}	669.9±21.38^{a}
BH-549	852.6±53.32^{b}	61.84±1.22^{a}	129.4±6.6^{a}	759.7±11.98^{a}
MH-138	1068.3±2.31^{c}	66.84±3.43^{a}	150.6±6.49^{ab}	976.5±19.82^{b}
Melkasa-6Q	1001.0±31.84^{c}	85.42±0.31^{b}	186.9±12.7^{b}	901.4±26.59^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$

Table 4.2 indicate the mineral content of different maize varieties. For clear comparison, the minerals content of different maize varieties also indicated in figure 4.4 below. MH-138 has the highest in calcium content while BH661 maize varieties has the lowest calcium content. There is no significant difference in calcium content between MH-138 and Melkasa-6Q at $p<0.05$. But there is significant difference between BH661 and BH-549 and there is also significant difference between (BH661 & BH-549) and (MH-138 & Melkasa-6Q) at $p<0.05$. When it comes to zinc content, BH661 has the lowest while Melkasa-6Q has the highest in zinc content. There is no significant difference with zinc content between the three varies of maize namely BH661, BH-549 and MH-138 at $P<0.05$. But there is significant difference between Melkasa-6Q and the other three maize varieties (BH661, BH-549 and MH-138) in zinc content at $p<0.05$.

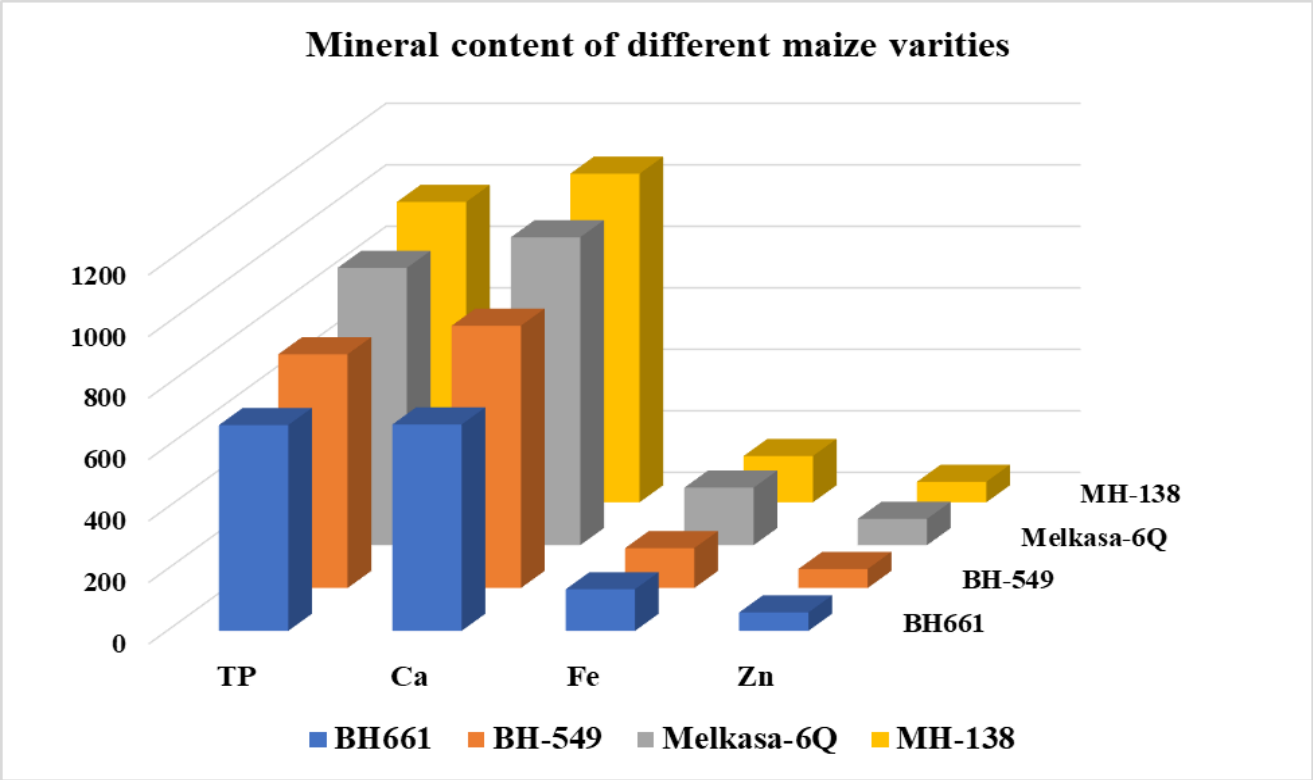


Figure 4.4: Mineral content of different maize varieties

The iron content of different maize varieties is also indicated in table 4.2 above. BH-549 has the lowest while Melkasa-6Q has the highest in iron content. There is no significant difference

between BH661 and BH-549 maize varieties for iron content at P<0.05. There is also no significant difference for iron content between (BH661 and BH-549) and MH-138 maize varieties. Significant difference was observed between Melkasa-6Q and (BH661 and BH-549) maize varieties at p<0.05. When it comes total phosphorous content, BH661 has the lowest while MH-138 has the highest in phosphorous content. There is no significant difference between BH661 and BH-549 and as well as between MH-138 and Melkasa-6Q in total phosphorous content at p<0.05. Significant difference was observed between BH661 and (MH-138 & Melkasa-6Q) and between BH-549 and (MH-138 & Melkasa-6Q) at P<0.05.

4.2: Discussion

4.2.1: Macro nutrient content of different maize varieties

The macronutrient content of different maize varieties has been indicated in table 4.1. As indicated, the moisture content significantly different among different maize varieties. The variation of moisture contents in maize flours may be attributed by different factors such as agronomic, environmental factors and the maize variety. The result in moisture content is in agreement with research done on seven different maize varieties by Kidist (2018) with is in between 9.42-11.45%. It is inconsistent with research done by (Kumar U. and Kweera B., 2014) which is in between 4.3 to 6.7%. On the other hand, the result of moisture content indicates all maize are in very good range for their shelf stability.

As shown in table 4.1, all maize varieties have high amount ash. The ash content beyond normal values of most common maize varieties of anywhere. Ash content in a food substance indicates inorganic remains after the organic matter has been burnt away and provides an estimate of the total mineral content of a food. This indicates all maize varieties have good source of different minerals. The ash content is a little bit different in amount among the four varieties of maize under study. This might be the fact that, there are different in variety, there response against different harsh condition might be different, the way they are managed during their farming time and some other reasons. Ash content of BH661, BH-549 and MH-138 maize flour was also in relatively good agreement with the literature 1.4–3.3% (Shaista Qamar et al.2016), whereas it is higher in melkasa -6Q maize. All maize ash content is inconsistent with result obtained by Kidist

(2018) which is in between 1.37 to 1.74%. The difference might be due being in different agro ecology, different farming system and environmental factors.

Fiber has been postulated to have beneficial effects on diabetes, atherosclerosis, cancer, and appendicitis and prevention of duodenal ulcer formation and varicose veins (Yeung D. L. and Laquatra I. 2003). The fiber of different maize varieties under this study shows some significant difference as shown in table 4.1. This might be due being different in variety, the resistance against different environmental factors. The result crude fiber content is in agreement with the research done by Kidist (2018) which are in the range of 1.62 to 3.46%.

Protein is the building block of all cells. All maize varieties have highest in protein content especially Melkasa-6Q which 15.24% as shown in table 4.1. But there is Signiant difference among maize varieties under study at $P<0.05$. This might be the fact that, because of being different in their variety, their difference in their resistance and utility of naturally occurring nutrient, soil difference. The result of protein content is in agreement with the research done by Kidist (2018) on seven different varieties which are in the range of 9.69 to 15.30%. In a similar fashion, the present study range of crude protein contents were within the range reported by (Fageer et.al., 2004) for twelve genotype 11.3 to 16.9% and (Ullah I., Ali M. and Farooqi A. (2010)) for 10 varieties 7.7 to 14.6%.

Fat is one the macronutrient which provide more than twice of energy than carbohydrate and protein. Exceptionally, melkasa-6Q has the highest crude fat content than any other maize varieties under study as shown in table 4.1. This might be the fact that, melkasa-6Q is one the new varieties released for its high in protein and some other useful nutrient content in fighting malnutrition. The result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which are in the range of 5.13 to 7.22%.

Carbohydrate is one the macronutrient which provide energy. The carbohydrate content of three maize varieties (BH661, BH-549, MH-138) are under normal range. But there is Significant difference in carbohydrate content when it comes to Melkasa-6Q as shown in table 4.1. This difference mainly come as result of melkasa -6Q has high amount fat content. And it is also the fact that being different variety, their response against different environmental factors. The

result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which are in the range of 67.10 to 69.99%.

Energy is obtained from the main macronutrients such as carbohydrate, protein and fat. There is no significant difference in energy between all maize varieties except melkasa-6Q as shown in table 4.1 above. But there is a little difference in energy content among the three maize varieties under study except Melkasa-6Q. This is because of their difference in protein, carbohydrate and fat content. The result obtained is a little bit different from the research done by (Ullah I., Ali M. and Farooqi A. (2010)) on ten different maize varieties which are in the range of 365.95 to 385.83Kcal/100g.

4.2.2. Mineral content of different maize varieties

Minerals are essential for body functions. They are classified as macro minerals or micro minerals (trace elements) depend on their dietary requirement. Calcium is part of macro minerals whereas iron and zinc are micro minerals [Yeung D. L. and Laquatra I. (2003)]. The calcium content is in the range of 670.7 to 1068.3mg/Kg as shown in table 4.2 above. Except MH-138 and Melkasa-6Q there is significant difference in calcium content among the maize varieties under study at $p<0.05$. This might be due to difference in variety, environmental factors, their utilities toward minerals in the soil. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 219.8 to 481.0mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 1290.27 to 1327.56mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

When it comes Zinc, the values are in the range of 59.62 to 85.42mg/Kg. There is no significant difference in zinc content except Melkasa-6Q as shown in table 4.2. This little difference come as result of being difference in variety, their response against different harsh condition, soil types. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.1 to 29.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 6.1 to

33.89mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

The iron (Fe) content of different maize varieties under study is in the range of 129.4-186.9mg/Kg. There is some significance difference among maize varieties under study as shown in table 4.2 above. This is because of being different in their variety type, utility of minerals with in a soil, difference in soil minerals continent . The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.4 to 37.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 80.73 to 115.13mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons. Finally, the total phosphorous content of the four maize under study is in the range of 669.9 to 976.5mg/Kg. There is some significant difference among maize varieties under study as shown in table 4.2 above. This difference come as a result of being different in variety, soil mineral content, their utility toward this mineral.

4.3. Limitation of the study

The scope of the research is limited to conduct macronutrient and minerals (only four) content of only four maize varieties because of financial constraint. The research should cover more than these analysis by including more varieties of maize. It should also include other parameters of grain such as the anti-nutrient content analysis as well as carotenoid content analysis. Finance is not the only limitation to this and other previous researches, laboratory facility is also the main challenges to such kind of research in SoRPARI and the whole region.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1: Conclusion

From the research done I conclude that, the macro nutrient content of the all-maize varieties is very good especially fat, protein and ash content. The ash content in a food substance indicates inorganic remains after the organic matter has been burnt away and provides an estimate of the total mineral content of a food. The fat content of all maize varieties is very high especially melkasa-6Q. The same is true when it comes to protein content especially melkasa-6Q. This indicate all maize varieties are better in responding to the malnutrition problem in the region especially if mixed with some nutrient dense legumes such as cowpea. Because of being high in macro nutrient content, all of the maize varieties have high energy calory which almost more than 400Kcal/100g.

As indicated above, the high in ash indicate the better content of different mineral content. All maize varieties have high total phosphorous content as well as calcium content. The same is true when it comes to iron and zinc. From this it shows that, our region soil is reach in minerals and virgin. This is indicative that, all these maize varieties are better in fighting against hidden hunger especially if fortified or mixed with some other grain with high minerals content. Melkasa-6Q is exceptional when it comes both macro-nutrients and mineral content.

5.2: Recommendation

From the research, I recommend the following based on the gaps identified;

- Further research should be done on more maize varieties by adding extra maize varieties for better comparison
- Further research should be done on carotenoid and anti-nutrient content of all maize varieties to strength full package information on maize varieties.
- With the limited research result, the data indicate all maize varieties have good content both macro nutrient and minerals contents. If mixed with some other grains such

legumes, nutrient dense food can be prepared which is better to fight the malnutrition problem.

- Especial emphasis should be given to melkasa-6Q as it is nutrient dense both with macro-nutrient and mineral content. Therefore, melkasa-6Q and other melkasa maize varieties or Quality protein maize (QPM) should be used in fighting malnutrition.

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Picture of during sample preparation.




BH-661
MH-138
BH-549
MELKASA
6Q