Addis Ababa University

College of Natural and Computational Science

Center for Food Science and Nutrition

Effect of processing on proximate composition and functional properties of Mung bean [*Vigna radiata* (L.)Wilczek] commercial varieties in Ethiopia

By: Wondwossen Alemu

February, 2022

Addis Ababa, Ethiopia

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A thesis submitted to, Addis Ababa University College of Natural and Computational Science Center for Food Science and Nutrition in Partial Fulfillment for the Masters of food Science and Nutrition

February, 2022

Addis Ababa, Ethiopia

Declaration

I the under signed, declare that this is original work and has never been presented in this or other universities as well as research center previously and all the source of material used for this master thesis study have been fully acknowledged.

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Date of Submission: ……

The research paper has been submitted for examination with my approval as University advisors.

Advisor

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirement for the Degree of Master of Science in Food Science and Nutrition.

By:

Wondwossen Alemu

Advisor: Prof.Kelbessa Urga

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Acknowledgements

I would like to thank Ministry of trade and Industry, European Union and Addis Ababa University for giving and sponsoring me to study my Master degree in food Science and Nutrition.

I would like to express my deepest gratitude and thanks to my advisor, Kelbesa Urga (prof) for support and guidance in the manuscript writing as well as for their encouragement, advice, and concrete support during conducting this thesis work.

I would like to thank the staff member of Ethiopian Commodity Exchange Authority for their cooperation to give information about Mung bean production area for my study population for writing this Thesis.

I also extend my profound gratitude to department of Center for Food Science and Nutrition Department for providing facilities to conduct this research. I am also very thankful to the technical staffs of the center especially, Mr. Debeb Hailu, for providing all the necessary laboratory facilities needed for my analysis.

Finally I would like to thank our staff members of Ethiopian Commodity Exchange Authority Economic Analysis Directorate for giving me their feedback, suggestion, and editing this Thesis.

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Acronyms

ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
CSA	Central Statistical Agency
DPPH	2, 2-Diphenyl–1-picrylhydrazyl
ECX	Ethiopian Commodity Exchange
FAO	Food and Agriculture Organization
ROS	Reactive Oxygen Species
RNS	Reactive Nitrogen Species
SOD	Superoxide Dismutase
SPSS	Statistical Product and Service Solution
WHO	World Health Organization

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Abstract

Mung bean [Vigna radiata (L.)Wilczek] is one of the important legume crops grown from the tropical to sub-tropical areas around the world. Effect of processing method on the proximate composition and functional properties of mung bean in Ethiopia was not well addressed because the crop is not indigenous and well known throughout in the country .In this study effect of processing methods, dehulling, germinating, dry roasting, soaking and boiling on proximity composition, antinutritional factor, antioxidant activity, and functional properties of mung bean [Vigna radiata (L.)Wilczek] collected from Bale, Gonder and North showa part of Ethiopia were investigated on dry basis. The proximity composition of both the processed and raw mung bean were determined by AOAC 2016. The total phenolic extract by methanol were determined using Folin-Ciocalteu methods while total flavonoid content was estimated by using aluminum trichloride(AlCl3), Free radical scavenging activity was determined by 2,2-diphenylpicryl-1-picrylhydrazyl activity using ascorbic acid as standards. The moisture content, ash, crude protein, crude fat, crude fiber ,utilizable carbohydrate and energy of processed and raw mung bean flour were ranged from 3.73%-9.40%, 2.13-3.47%, 27.65%-30.92%, 1.33%-2.00%, 0.48%-7.57%, 50.43%-59.97% and 328.41-374.27%Kcal/100g respectively for raw and processed sample. The antinutritional factors, level of phytate and tannin were, 133.86-190.75µg/100g, and13.69- 23.71mg/100g respectively for the raw and processed sample. Among the processing methods used, Germination had significant effect ($p<0.05$) on reducing antinutritional factors. Germination significantly ($p<0.05$) increases the total phenolic and total flavonoid from (14.28 to 125.72) mg Gallic acid equivalent/g and (42.38 to 190.99) mg D-Catechin equivalent/g respectively. Dry roasting increased the total flavonoid and reduced total phenolic amount from the raw mung bean flour. The five processing methods had also significant effect on functional properties of mung bean. Therefore among the five traditional applied processing methods germination and dry roasting was recommended process. Finally among the three types of commercial mung bean varieties Bale type mung bean was better than Gonder type and North showa type mung bean in most of the parameter determined in this study.

***Keywords**: Mung bean, Proximity Composition, Processing method, Antinutritional factors, Functional property, Antioxidant Activity, Total phenol, Flavonoid.*

CHAPTER ONE

1. INTRODUCTION

1.1 Background and justification

Mung bean [*Vigna radiata* (L.)Wilczek] is one of the important legume crops grown from the tropical to sub-tropical areas around the world (Kumari *et al*., 2012; Khan *et al*., 2012). From the 6 million ha of world mung bean production, about 90% is in Asia and among that, India is the biggest producer where about 2.99 million ha are cultivated (Nair *et al*, 2013). It is a minor crop in Australia, China, Iran, Kenya, Korea, Malaysia, the Middle East, Peru, Taiwan and United States. Apparently, it has been introduced in different regions of Ethiopia like Shewa, Hararge, Illubabor, Bale, Gamogofa, Tigray, Asosa and Gondar, Farmers in some moisture stress areas (Gofa, Konso, South Omo zone and Konta) have been producing mung bean to supplement their protein needs and also effectively use scanty rainfall. It is an important wide spreading, herbaceous and annual legume pulse crop cultivated mostly by traditional farmers (Ali *et al.*, 2010). The crop is characterized by fast growth under warm conditions, low water requirement and excellent soil fertility enhancement via nitrogen fixation (Yagoob, 2014). Fertilization of this crop occurs through self-pollination without requirement of other pollinators like insects, water and wind (Rashid *et al*., 2013). According to Asfaw *et al*. (2012), the optimum temperature range for good production of mung bean ranges from 27^0 C- 30^0 C. The temperature necessities always stay above 15^0 C and the crop requires from 90–120 days for maturity.

The Ethiopian Commodity Exchange (ECX) installed mung beans as the sixth commodity to be traded on its floor on Wednesday, January 22, 2014 (ecx.gov.et).The decision was made at the end of July, 2013, after the Board of the Ethiopian Commodity Exchange Authority (ECEA) gave its approval. The ECEA is the supervisory body of the ECX and has the final say on whether or not new commodities can enter the trading floor (ecea.gov.et). The ECX commenced trading operations in April 2008, with coffee, sesame, maize, wheat and pea beans (ecx.gov.et). There are four quality grades (grade 1,2,3 and 4) for mung beans, different contract based on origin such as green mung bean Bale type, green mung bean Gonder type, green mung bean North showa type, etc. and different delivery sites, located in – Addis Abeba; Kombolcha in South Wollo Zone (376km from Addis Abeba) and Gonder (656 km from Addis Abeba) of the

Amhara Region ,Assosa, the capital of the Benishangul Gumuz Region (657 km from Addis Abeba) (ecx.gov.et).

Although Mung bean is widely known for its fiber, mineral and protein, at present it is considered not only as a rich source of nutrients but also a source of other bioactive compounds with many beneficial physiological effects such as antioxidant, antidiabetic, anticholesteromic and anticancer effect in controlling and preventing various metabolic diseases. Previous studies done by Bhatty *et al*. (2000), Mubarak (2005), Huang *et al*. (2014) and Chandrasiri *et al*. (2016) have shown that processing alters the proximate composition and functional properties of food. Some processing methods can increase and some can decrease the nutritional and functional properties of food. Therefore a great attention should be paid not only on what is eaten but also on the way of preparing it. Mung bean is processed into various forms such as sprouted, cooked and boiled before consumption. However, the effect of processing on nutritional and functional properties of Mung bean has not been widely studied in Ethiopia. Thus, the objective of this study is to investigate the effect of dry roasting, dehulling, soaking, germination and boiling on proximate composition and functional properties of mung bean varieties in Ethiopia.

1.2 Statement of the problem

Effect of processing method on the proximate composition and functional properties of mung bean in Ethiopia was not well addressed because the crop is not indigenous and well known throughout in the country. In addition the crop was introduced in Ethiopia ten years ago so that it is one of the crops that was traded in Ethiopia Commodity Exchange and exported to other countries (ecx.gov.et). Furthermore, Mung bean was consumed by local population in different forms.

Some of the previous studies done by Bhatty *et al*. (2000), Mubarak (2005) Huang *et al*. (2014) and Chandrasiri *et al*. (2016) and available data on the nutrient and anti-nutrient composition of mung bean do not cover the entire nutrient and anti-nutrient factor where available. This was because of the possible effects of variety/genetic origin, climate, soil, processing methods, pesticides and fertilizers on the chemical composition of the mung bean. In addition there was no information on the nutrient composition and antinutritional factors of mung bean grown in Ethiopia.

Consequently several considerations justify the continued surveillance, knowledge and research on anti-nutritional factors and toxic substances naturally present in plants used as foods like mung bean and ways of reducing them to safe level of consumption. Moreover the determination of minerals and trace elements in foodstuffs was also an important part of nutritional and toxicological analyses.

1.3 Objectives of the proposed study

1.3.1 General objectives

The general objective of the study was to investigate the effect of processing on proximate composition antinutritional factor, antioxidant activity and functional properties of mung bean commercial varieties in Ethiopia.

1.3.2 Specific objectives

The specific objectives of this study were:-

- To determine the proximate composition (moisture content, total ash, crude protein, crude fiber, and crude fat and utilizable carbohydrate) of raw and processed mung bean.
- To investigate the effect of dry roasting, dehulling, soaking, germination and boiling of mung bean on proximate composition and functional properties of flours prepared by these treatments.
- To investigate the effect of processing on antioxidant activity and antinutritional factor of mung bean.

1.4 Significance of the study

In Ethiopia mung bean grains was used in different form such as green vegetables, ‘Kollo’ (soaked and roasted) and ‘Nifro’ (boiled seed) and added in soup etc. Furthermore in all forms, it may be consumed alone or mixed with other cereals. The processing method used to convert mung bean in to consumable forms including dehulling, soaking, roasting, boiling, germinating, oven cooking etc. The results of this study can be used to promote the consumption of the legume seeds of mung bean by enhancing the bioavailability of minerals to prevent micronutrient malnutrition.

- The finding helps to promote in which processing method is best to get the good quality nutrient that are found in mung bean.
- The report helps to promote the inclusion of mung bean in children formula food in Ethiopia.
- The finding may be used as source of information for the public, researchers etc.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Over view of mung bean

2.1.1. World production of mung bean

The center of origin of cultivated mung bean is Asia. As Sangsiri *et al.* (2007, 2009) reported, mung bean originated in the India-Burma region of Asia because evidence provided by archaebotanical findings and literary records showed that mung bean was domesticated in India where wild mung bean is widely distributed. Specifically, it has been found at Neolithic sites in southern India where wild mung bean exists. The findings also point to both south-eastern and western Himalayan foothills as likely places where domestication could have taken place. Altaf (2009) also suggested that the primary gene diversity center for mung bean was the central Asian Region with India having the widest diversity of domesticated varieties of the crop. Mung bean is one of the important legume crops grown from the tropical to sub-tropical areas around the world (Kumari *et al*., 2012; Khan *et al*., 2012). From the 6 million ha of world mung bean production, about 90% is in Asia and among that, India is the biggest producer where about 2.99 million ha are cultivated (Nair *et al*, 2013). It is a minor crop in Australia, China, Iran, Kenya, Korea, Malaysia, the Middle East, Peru, Taiwan and United States.

2.1.2 Production of mung bean in Ethiopia

Mung bean production in Ethiopia was introduced recently so that Ethiopian Statistical Agency (CSA) included to report in its annual agricultural sample survey since 2006 E.C. From the CSA annual agricultural sample survey report since 2006E.C-2010 E.C for the five-year report indicated that area in hectare increased from 10700ha to 41633.3ha and production increased from 80600 quintal to 514220 quintal. In addition productivity increased from 7.54qu/ha to 12.35qu/ha. Furthermore small holder farmer in 2006 E.C was estimated to 90437 but in 2010 E.C estimated to be 325788(Fig 2).

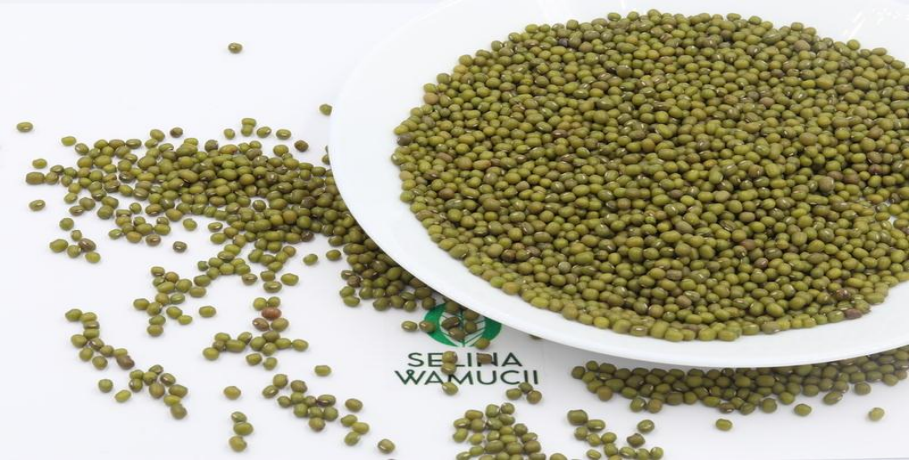
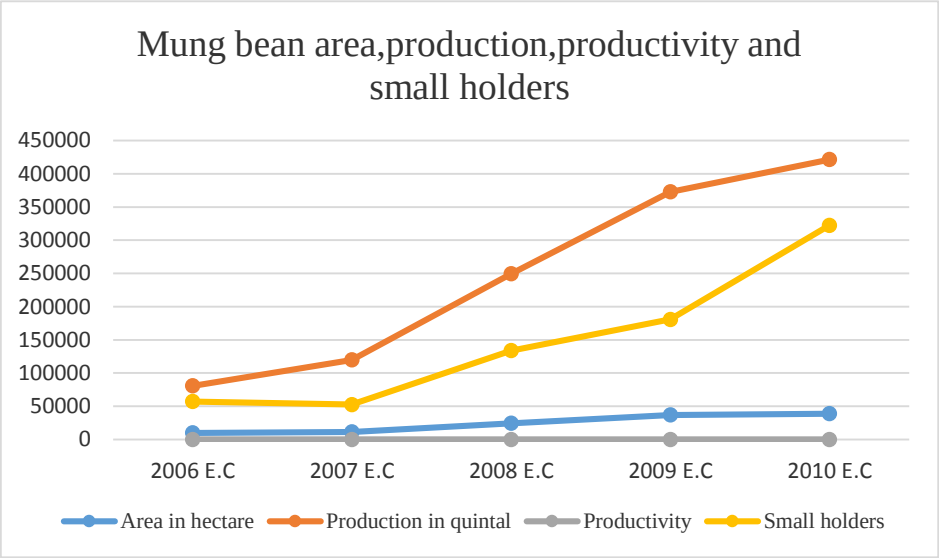


Fig 1: Mung bean (Masho) or green mung bean in Ethiopia



source CSA anuall agricultural survey

Fig2: Mung bean area,production, productivity and small holders

From fig 2 we can seen that the area,production, productivity and small holders increased through out the last five year production year.Furthermore, in Ethiopia mung bean has produced in some of the regions according to Ethiopian Central Statistical Agency annual agricultural sample survey report since 2006 E.C-2010 E.C was listed by region in Table 2.1.From this we can seen that most of the prodcution of mung bean is produced in Amahara region its area,production and small holders was 88.25%,96.74% and 82.03% respectively.In addition in oromia region their was no report in area,production and small holders in 2006 E.C,2007 E.C

and 2008 E.C respectively but there was report in area and small holders in 2009 E.C and 2010 E.C so that their contribution in area was 9.6% and in small holders was 11.19%

Table 1: Mung bean area,production, and small holders by region from 2006 E.C-2010 E.C

Region		**Mung bean production by year**					**Total**	**%**
		2006 E.C	**2007 E.C**	**2008 E.C**	**2009 E.C**	**2010 E.C**		
Oromia	Area in hectare	*	*	*	5711.12	5813.65	11524.77	9.6%
	Production in quintal	*	*	*	*	*	0	0.00%
	Small holders	3158.00	*	9022.00	*32766.00*	38583	83529.00	11.19%
Amhara	Area in hectare	9808.22	11281.69	24038.85	28992.86	31670.70	105792.32	88.25%
	Production in quintal	80640.10	119828.48	247422.26	352972.50	403014.67	1203878.21	96.74%
	Small holders	52802.00	52473.00	120341.00	131991.00	254765.00	612375.00	82.03%
Tigray	Area in hectare	*	*	*	*	*	*	
	Production in quintal	*	*	*	*	*	*	
	Small holders	1112.00	*	*	*	*	1112.00	0.15%
SNNP	Area in hectare	*	*	224.40	907.61		1132.01	0.94%
	Production in quintal	*	*	2090.10	4722.85		6812.95	0.55%
	Small holders	*	*	4426.00	8827.00	18536.00	31789.00	4.21%
Benshagul	Area in hectare	*	*	*	1255.43	1427.64	2683.07	2.24%
	Production in quintal	*	*	*	15155.87	18540.93	33696.80	2.71%
	Small holders	*	*	*	7099.00	10612.00	17711.00	2.31%
Total	Area in hectare						**119876.74**	***100%***
	Production in quintal						**1244387.96**	***100%***
	Small holders						**746516.00**	***100%***

Source CSA annual agricultural survey report

2.2 Mungbean and health

Mung bean is an important grain legume in South, East and Southeast Asia, which produce up to three million metric tons of seed consumed directly as dhal, porridge and bean sprouts, or processed into high value noodles (Nair *et al*, 2012). To meet global mung bean demand and to address widespread malnutrition, it is imperative to improve the current average global

productivity as well as to expand its reach into new regions, including Central Asia and Africa (Nair *et al*,2013). Mung bean is a substantive source of dietary protein (24% - 28%) and carbohydrates (59% - 65%) on a dry weight basis, and provides about 3400 kJ energy/kg grain (USDA, 2010). In comparison to other legumes, such as chickpea (Cicer arietinum), pigeon pea (Cajanus Cajan), and lentils (Lens culinaris), mung bean starch is easier to digest (Sandhu *et al*, 2008). Mung bean also induces less flatulence and is well tolerated by children (Pal *et al*, 2010). In addition, mung bean is lower in phytic acid (72% of the total Phosphors content) than pea, soybean (Glycine max), and cereals. Phytic acid is commonly found in cereal and legume crops and has a negative impact on iron and zinc bioavailability in plant-based human diets. Owing to its palatable taste and nutritional quality, mung bean has been used as an iron-rich whole food source for baby food (Imtiaz *et al*, 2011).

The seeds and sprouts of mung bean contain abundant nutrients with biological activities. The review by Tang *et al*, 2014 provides insights into the nutritional value of mung beans. Constituents that have been isolated in the past few decades, such as flavonoids, phenolic acids, organic acids, amino acids, carbohydrates, and lipids have been discussed. In addition, dynamic changes in metabolites during the sprouting process and related biological activities, including antioxidant, and health promoting effects, are evidence of its use as a medicine.

2.3 Antinutritional factors in Mung bean

An antinutrient is a substance occurring in the diet which acts antagonistically towards one or multiple nutrients, reducing bioavailability. This is usually done through complex formation which reduces nutrient absorption (Graham *et al*., 2000).

2.3.1Antinutritional effects of phytate

Phytic acid (phytate; myo-inositol 1, 2, 3, 4, 5, 6-hexakisphosphate) is the primary source of inositol and storage phosphorus in plant seeds contributing ~ 70% of total phosphorus. The abundance of phytic acid in cereal grains is a concern in the foods and animal feeds industries because the phosphorus in this form is unavailable to monogastric animals due to a lack of endogenous phytases; enzymes specific for the dephosphorylation of phytic acid. In addition, the strong chelating characteristic of phytic acid reduces the bioavailability of other essential dietary nutrients such as minerals (e.g. $Ca^{2+,}$ Zn^{2+}, Mg^{2+}, Mn^{2+}, $Fe^{2+/3+),}$ proteins and amino acids(Walter

et al., 2002). High phytic acid content feeds are generally supplemented with inorganic phosphate; however this causes increased fecal phosphate levels and subsequent eutrophication of waterways. Alternatively, supplementation with commercial phytases is becoming increasingly popular and reduces the requirement for inorganic phosphate supplementation as well as the associated environmental issues. The daily intake of phytate was estimated to be 2000–2600 mg for vegetarian diets as well as diets of inhabitants of rural areas of developing countries and 150–1400mg for mixed diets.

2.3.2 Antinutritional effects of tannins

Tannins are polyphenols components prevalent in food legumes. Tannins are mainly located in seed coat of pulses, hence physical removal of seed coat by either dehulling or milling and separating hulls decreases the tannin content of pulses and improves their nutritional quality. Dehulling eliminates about 68 to 99% of tannins in seed. Soaking of seeds before cooking is a common household practice and, used to soften the texture and hasten the process of cooking.

Studies have shown that tannins interact with proteins, enzymes or nonenzymes, and form tannin-protein complexes, which decrease protein digestibility and protein solubility. This decrease in protein digestibility may be caused by either the inactivation of digestive enzyme or the reduction of the susceptibility of the substrate proteins after forming the complex. Polyphenols are found to interact with proteins and cause either inactivation of enzyme such as trypsin and chymotrypsin or make protein insoluble. Polyphenols inhibit several enzymes including α-amylase, lipases, pectin esterase, cellulase and β-galactosidase (Salunkhe *et al*., 1985). The total acceptable tannin daily intake for human being is 560mg/100g ml (Shimelis and Rakshit, 2007).

2.4 Antioxidants

Antioxidants are scavenging molecules that convert reactive oxygen species (ROS) to water (H2O) to prevent overproduction of reactive oxygen species. There are two types of antioxidants in the human body: enzymatic antioxidants and non-enzymatic antioxidants (Domej *et al*, 2014). Enzymatic antioxidants – are also known as natural or endogenous antioxidants as stated above. They neutralize excessive ROS and RNS and so prevent them from damaging the cellular structure

Enzymatic antioxidants, which help to prevent the excessive accumulation or upsurge of free radicals are composed of superoxide dismutase (SOD), catalase, glutathione peroxidase and glutathione reductase, which also causes reduction of hydrogen peroxide to water. As stated above hydrogen peroxide is not a free radical but it is a potentially toxic oxidant and so must be eliminated from the body. The hydrogen peroxide is eliminated by the action of catalase to give water and oxygen from two molecules of hydrogen peroxide. Hydrogen peroxide can also be eliminated by the action of the enzyme glutathione peroxidase in which hydrogen peroxide reacts with NADPH + H^+ to form NADP and water (Halliwell &Gutteridge, 2002).

Non-enzymatic antioxidants – are also known as synthetic antioxidants or dietary or natural-occurring antioxidant vitamins. The body's complex antioxidant system is influenced by dietary intake of antioxidant vitamins and minerals such as ascorbic acid or vitamin C, tocopherols and tocotrienols or vitamin E, selenium, zinc, taurine, hypotaurine, glutathione, beta carotene and carotene (provitamin A). Vitamin C or ascorbic acid is a chain breaking antioxidant that stops the propagation of the peroxidative process and also helps to recycle oxidized vitamin E and glutathione (lobo *et al*, 2010).

Phytochemicals are compounds which are found in vegetables together with fruits and legumes (i.e. they are rich in plant-based foods). Though these phytochemicals are found in very small or minute amounts they act as very potent or effective antioxidants. They advance or promote health and help in the prevention of coronary heart disease (keep cholesterol from depositing on the walls of the arteries and thus, lower the progress of arteriosclerosis) and cancer (Podmore *et al*, 1998).

2.5 Effect of processing methods on mung bean

The effects of some domestic traditional processes, such as dehulling, soaking, germination, boiling, autoclaving and microwave cooking, on the nutritional composition and anti-nutritional factors of mung bean seeds were studied. Germination and cooking processes caused significant ($p < 0:05$) decreases in fat, carbohydrate fractions, anti-nutritional factors and total ash contents. All processes decreased the concentrations of lysine, tryptophan, threonine and sulfur-containing amino acids. However, all treatments were higher in total aromatic amino acids, leucine, isoleucine and valine contents than the FAO/WHO reference (El-Adawy, 2002). Dehulling, soaking and germination processes were less effective than cooking processes in reducing trypsin

inhibitor, tannins and hemagglutinin activity contents. Also, germination was more effective in reducing phytic acid, stachyose and raffinose. Germination resulted in a greater retention of all minerals compared to other processes. In vitro protein digestibility and protein efficiency ratio were improved by all processes. The chemical score and limiting amino acids of mung bean subjected to the various processes varied considerably, depending on the type of process (El-Beltagy, 1996).

2.5.1 Boiling

Boiling/cooking and roasting are important food processing methods. As a thermal process, boiling/cooking could enhance the palatability and nutritional value by inactivating endogenous toxic factors. Roasting is similar to cooking/boiling but involves higher temperature and reduced time. Boiling is effective method in reducing water soluble antinutrient. Boiling is also found to decrease some amount of soluble phytate. Thus, providing plants with heat-stable phytases or addition of exogenous heat-stable phytases are seen as possibilities to improve phytate dephosphorylation during cooking (Greiner and Konietzny, 1998).

2.5.2 Soaking

Soaking is often used as a pretreatment to facilitate processing of legume grains and cereal seeds. Soaking may last for a short period, about 15 to 20 minutes, or for a very long period, usually 12 to 16 hours. In household situations cereals and legumes are typically soaked in water at room temperatures overnight. Because phytate is water soluble, a significant phytate reduction can be realized by discarding the soak water. In addition, action of endogenous phytases contributes to phytate reduction. Temperature and pH value have been shown to have a significant effect on enzymatic phytate hydrolysis during soaking. If the soaking step is carried out at temperatures between 45 and 65 °C and pH values between pH=5.0 and 6.0, which are close to the optimal conditions for phytate dephosphorylation by the intrinsic plant phytases, a significant percentage of phytate (26–100 %) was enzymatically hydrolyzed (Greiner and Konietzny, 2006).

Moreover, soaking removes some of the non-nutritional compounds, which can be partly or totally solubilized and eliminated with the discarded soaking solution (Frias *et al*., 2000). Some previous studies reported in the literature have analyzed the effect of the soaking conditions on the main quality parameters in the final product (Frias *et al*., 2000; Sayar *et al*., 2001). Frias *et al* (2000) concluded that the seed coat controls water absorption up to a certain level of moisture.

Frias *et al.* (2000) also concluded that the differences in water absorption might be due to the differential solubilization of the starch during soaking which is caused mainly by differences in starch structure, seed size and membrane permeability.

2.5.3 Germination

Germination is a process widely used in legumes and cereals to increase their palatability and nutritional value, particularly through the breakdown of certain antinutrient, such as phytate and protease inhibitors. In non-germinated legume grains and cereal seeds, with the exception of rye and to some extent wheat, triticale and barley, only little intrinsic phytate-degrading activity is found, but during germination a marked increase in phytate-degrading activity with a concomitant decline in phytate content was observed (Graham *et al*., 2000).

Phytate is hydrolyzed during germination in a stepwise manner by phytases or a concerted action of phytases and phosphatases which do not accept phytate as a substrate to supply the nutritional needs of the plant without an accumulation of less phosphorylated myo-inositol intermediates.

2.6 Functional properties

Functional properties are very important in determining the level of utilization in ingredient formulation and new food product development (Fasasi, 2007). Before consideration is given to mung bean as potential sources of flour and starch to produce foods, it is necessary to characterize their chemical composition, physical, physicochemical, and functional properties (Elevina *et al*., 2010). The chemical composition of flours and starches exhibits differences especially in amylose and phosphorous content, as a function of the botanical origin. It is significant because of the influence of amylose and phosphorous content in the functional properties of flours and starches. It is a general consensus that the influence of both amylose and phosphorous content affects the gelatinization and pasting behavior of starches and flours. These two parameters determine the functional properties of flours and starches such as: texture, consistency, binding, coating, adhesiveness, cohesiveness, thickening, viscosity, and palatability (Elevina *et al*., 2010).

2.6.1 Water absorption capacity

The ability to absorb water is a very important property of flours used in food preparation. The ability of food materials to absorb water is sometimes attributed to the protein content (Mbofung, 2006). Water absorption capacity is an important functional property required in food

formulations especially those involving dough handling (Udensi and Okoronkwo, 2006). WAC plays a major role in the functionality of dough. In particular, WAC has been shown to be related to dough consistency (Njintang, *et al., 2008*). It is known that water binding by starches and flours is a function of several parameters including size, shape, conformational characteristics, steric factors, hydrophilic hydrophobic balance in the starch molecule, lipids and carbohydrates associated with the proteins, thermodynamic properties of the system (energy of bonding, interfacial tension, etc.), physicochemical environment (pH, ionic strength, vapor pressure, temperature, presence/absence of surfactant etc.), solubility of starch molecules and others (Shimelis,2006).

2.6.2 Oil absorption capacity

Oil absorption capacity (OAC) is defined as the difference in the flour weight before and after its oil absorption (Giami *et al*., 1994). It is great importance, since fat acts as flavor retainer and also increases soft texture to mouth feel of foods, especially bread and other baked foods (Ubbor and Akobundu, 2009). They are also important because of their storage stability and particularly in the rancidity development.

2.6.3 Bulk density

Bulk density gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding (Udensi and Okoronkwo, 2006).

2.6.4 Swelling power and solubility

Swelling power provides evidence of non-covalent bonding between starch molecules. Factors like amylose-amylopectin ratio, chain length and molecular weight distribution, degree/length of branching and confirmation determine the degree of swelling and solubility. Solubility of flours depends on a number of factors such as sucrose, interassociative forces, swelling power, presence of other factors, etc. (Subramony, 2002).

CHAPTER THREE

3. MATERIALS AND METHOD

3.1 Origin of the mung bean

The origin of the mung bean used in the study were North Showa, Gonder, and Bale in this area more than 96 % of the mung bean production produced and exported in Ethiopia.

3.2 Experimental Design

Completely randomized design were used to study the effect of processing (dehulling, soaking, dry roasting, boiling and germination) on proximate composition, anti-nutrients (phytate, tannin),antioxidant activity(DPPH, flavonoid and phenol) and functional properties (BD, WAC and OAC) of mung bean flours were studied.

3.3 Sample Collection

Six kilogram of each North Showa type, Bale type and Gonder type were collected from Ethiopian Commodity Exchange of Gonder and Saris warehouses. The seeds were cleaned manually by removing any foreign material, damaged and broken seeds, shriveled and insect attacked seeds. The seeds were processed by direct grinding of raw (used as control), dehulling, soaking, germination, boiling and dry roasting. The processed samples except the roasted one were dried in an oven at 50°C for 24 h. All the samples including the control were ground by a laboratory mill to pass through a 0.05μm sieve and was kept in moisture proof plastic bag placed in air tight tin container at 40 ^{0}C. The seed flours of both the control and processed samples were evaluated for nutritional composition, anti-nutritional and functional properties.

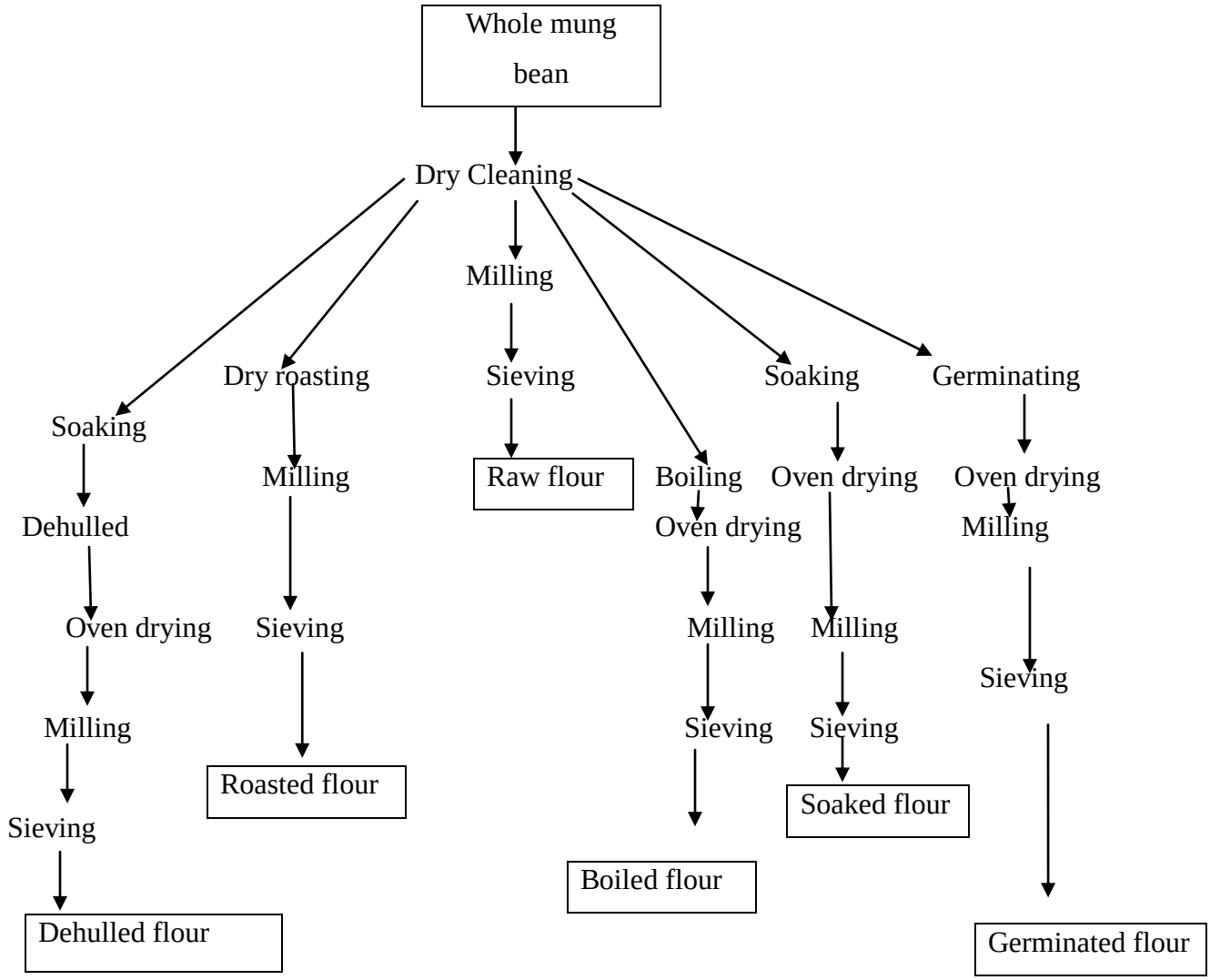


Fig 3: Flow Chart of the undehulled and dehulled mung bean sample flour

3.4. Processing methods

3.4.1. Raw (control)

Cleaned seed of 500 g of each of the four mung bean type samples were directly ground by a mill (Teklehaimanot *et al*., 1993).

Fig 4: Milled and sieved mung bean flour

3.4.2. Dehulling

Hulls were removed manually after soaking 600 g cleaned seeds of the three mung bean types for 6 h in distilled water at room temperature. Seeds were completely covered by water using seed to water ratio of 1:3 (w/v) (Nestares *et al*., 2003). The dehulled seeds were then dried and milled to flour.

3.4.3. Soaking

Cleaned 500 g each of the three mung bean types were soaked for 12 h in distilled water at room temperature. Seeds were completely covered by water using seed-to-water ratio of 1:3 (w/v) (Nestares *et al*., 2003)

3.4.4. Dry roasting

Cleaned 500 g seeds each of the three mung bean types were roasted by hot air oven for 30 minutes at 150°C.The cooled samples were then milled in to flour, (Suvendu and prakash, 1997).

3.4.5. Germination

Cleaned 500 g each of the three mung bean types were washed and cleaned with tap water. Germination was done according to the method used by Shimelis and Rakshit, (2005). It was performed at room temperature in a dark room. Washed mung bean type were soaked for 12 h in distilled water using seed to water as 1:5(w/v). Soaked seeds were spread on moist filter paper on large plastic screen. The seeds were then cover with filter paper to reduce evaporation. The screen was placed in perforated plastic container and keep in the dark at room temperature for 72 h to germinate. The seeds were splashed every 24 h with running sodium hypochlorite at concentration of 0.01% (w/v) for 10 min to avoid mold contamination. At the end of germination period, non-germinated seeds were discarded and the germinated ones were dried at 50^{o}C for 24 h. The dry germinated seeds were milled to flour.

Fig 5: Germinated mung bean

3.4.6. Boiling

Cleaned 500 g seeds of the three mung bean types were washed under tap water, were rinsed with distilled water, and placed in 2 L of distilled boiling water at 96°C and was cooked for 60 min. (until soft) (Teklehaimanot *et al*., 1993). The boiled samples were dried and milled.

Fig 6: Boiled mung bean

3.5. Determination of proximate composition

Moisture, crude protein, crude fat, ash, crude carbohydrate, crude fiber and total energy content of the three processed mung bean types were determined by using AOAC official 2016.

3.5.1 Moisture

Moisture was determined according to AOAC official 2016. A clean dried and covered flat aluminum dishes were weighed and about 5gm of the sample was transferred to the dish. The dish then was placed in an oven set at 105^0C for 3hrs and then cooled in desiccators and re-weighed. Then, the moisture content was estimated by the formula:-

$$\text{Moisture content in percent (\%)} = \frac{(W2-W3)}{(W2-W1)} * 100$$

Where W1= weight of crucible

W2= weight of crucible and sample

W3=weight of crucible and sample after dried

3.5.2 Crude Protein

3.5.2.1 Sample Preparation

The samples were weighed of 0.5gm of processed and whole mung bean of the three types in a Tecator tube and we placed it in the Tecator rack. Then we added 6ml of concentrated Sulfuric acid from Bird or oxford pipette then after immediately mixed the sample and acid carefully. Then we were added 3.5ml of Hydrogen peroxide step by step then watched for violent reactions

as soon as the most violent reaction had ceased we shacked the tube a few time by hand and we put it back in the rack. Finally we added 3 gram of mixture of copper sulphate and potassium sulphate catalyst and waited for 5-15 minutes before digestion.

3.5.2.2 Digestion

We placed sample (accurately weighed) in Kjeldahl flask and with temperature of the digester at 370 ^{0}C lower the tubes (in the rack) in to the digester and we continued the digestion until clear solution was obtained about 4 hours .Then transfer the tubes in the rack in to fume hood cooled and finally we added 50 ml of water and shacked to avoid precipitation of sulphate in the solution.

$$\text{Protein} \xrightarrow[\text{Heat, catalyst}]{\text{Sulfuric acid}} (NH_4)_2SO_4 \qquad (1)$$

3.5.2.3 Distillation

We added 25 ml of the 35% of sodium hydroxide solution in to the digested and diluted solution then we placed 250 ml conical flask containing 25 ml of the boric acid, 25 ml of distilled water and indicator solution under the condenser of the distiller with its tip immersed in to the solution. Finally distillation would continue until total volume became between 200ml and 250ml and rinsed the tip with a few ml of water before the receiver is removed.

$$(NH_4)_2SO_4 + 2\,NaOH \longrightarrow 2\,NH_3 + Na_2SO_4 + 2\,H_2O \qquad (2)$$

$$NH_3 + H_3BO_3 \text{ (boric acid)} \longrightarrow NH_4 + H_2BO_3^- \text{ (borate ion)} \qquad (3)$$

3.5.2.4 Titration

First we prepared 0.1N HCl in 1000 ml of volumetric flask by using dilution formula as followed:

M=%concentration *specific density *10 / Molecular weight of HCl = 37%*1.18*10 / 36.5 =12N

Normality = molarity in HCl

By using dilution formula C1V1=C2V2

V1=C2V2 / C1 = 0.1N*1000ml / 12N = 8.3ml

We had taken 8.3 ml of concentrated HCl and diluted with distilled water in 1000ml of volumetric flask .Then titrate with 0.1 N HCl until we seen a reddish color.

$$H_2BO_3^- + H^+ \longrightarrow H_3BO_3 \qquad (4)$$

Mole of HCl =Moles of NH_3=Moles of N in the sample

Then the crude protein content was determined using the following equation

Nitrogen (%) = V_{HCl} in L *0.1 N HCl*corrected acid volume *14*100 / W (weight of sample)

The conversion factor is 6.25, which is obtained from food composition table of EPHI.

Crude protein content (%) = total nitrogen (%) × 6.25

3.5.3 Crude Fat

First we washed extraction cylinder with hot water to remove any impurity and put it into an oven for about 1 hour at a temperature of 105 ^{o}C and we took out it and put them into a desiccator and weighed (W1) and we put it again in the desiccator. Then we covered the bottom of an extraction thimble with a layer of fat free cotton or defatted cotton and weighed about 2 gm of the sample in the thimble (W) accurately and covered with a layer of fat free cotton or defatted cotton after that we were put the thimble in the extraction chamber. An extraction cylinder from the desiccator has been taken out and put it on the bracket, to check the number and 50 ml of petroleum ether has been added in to the extraction cylinder and move in to the heating plank to late the extraction go on for 4 hours. Then the extraction cylinder was disconnected and put it in the drying oven at 70 ^{0}C for 30 minute and we put it in the desiccator to cool for half an hour.

Finally the sample was weighed the extraction cylinder immediately after it was taken out of the desiccator (W2).

Then the crude fat, percent content was determined using the following equation

$$\text{Crude fat, percent by weight (\%)} = \frac{(W2-W1)*100}{W}$$

Where : W1= weight of the extraction flask (g)

W2= weight of the extraction flask plus the dried crude fat(g)

W= weight of sample (g)

3.5.4 Total ash

We had cleaned a Porcelain crucible and dried it in a muffle furnace for 30 min at 550 ^{0}C and cooled the crucible in a desiccators (with granular silica gel) for about 30 minutes or more at room temperature and weighed it (W1) then we weighed about 2.5 g of fresh sample to an accuracy of 4 decimal places in the crucible (W2) chare the sample on a hot plate under a fume – hood and slowly increased the temperature until smoking ceases. Next we were ash the sample in the muffle furnace at 550 ^{0}C for 5 hours and the ash should be clean and white in appearance and finally cooled to room temperature and reweighed (W3) each crucible with ash. Then the ash content was determined using the following equation

$$\text{Total ash \%} = \frac{W3-W1}{W2-W1}*100$$

Where :W1=weight of the crucible

W2=weight of crucible and sample

W3= weight of crucible and sample after ashing

(W2-W1) is sample mass in g on dry base and (W3-W1) Mass of ash in g

3.5.5 Crude Fiber

Crude fiber analysis was conducted using the method of AOAC official 2016.About 1.6g weighed sample was transferred into a 600 ml beaker and about 200 ml 1.25% sulfuric acid was added and boiled for 30 minutes. Recording took place by placing a watch glass over the mouth of the beaker. After 30 minutes heating by gently keeping the level constant with distilled water, 20 ml 28% KOH was added and boiled gently again for another 30 minutes. Subsequently,

washing was conducted with 1% sulfuric acid and NaOH solution. After, filtering it was then dried in an electric oven for 2hrs. Furthermore, it was cooled at room temperature for 30 minutes in a desiccators and weighed, then transferred the crucibles to muffle furnace for 30 minute ashing at 550^0C. Finally, it was cooled again in desiccators and reweighed. The crude fiber content was determined by using the formula:-

$$\%\text{Crude Fiber} = \frac{W2-W3}{W1} * 100$$

Where W1=Crucible weight after drying

W2=crucible weight after ash,

W3=dry weight

3.5.6 Utilizable carbohydrate determination

The total utilizable carbohydrate was calculated by difference with the exclusion of crude fiber.

Total carbohydrate (%) = 100 - (crude fat + crude fiber + crude protein + ash + moisture)

3.5.7 Total energy in kilo calories

The gross energy (GE) content in each sample was determined mathematically using the following formulae:

Gross energy (Kcal) = (9 x crude fat) + (4 x crude protein) + (4 x utilizable carbohydrate).

3.6.2 Functional properties of mung bean flour

3.6.2.1. Bulk density

Bulk density was determined by the method of Narayana and Narasinga-Rao (1984). An empty calibrated centrifuge tube was weighed. The tube was filled with a sample to 5 ml by constant tapping until there was no further change in volume. The weight of the tube and its contents was taken and recorded. The weight of the sample was determined by difference. Bulk density was calculated as weight per unit volume of the sample.

Bulk density, $g/cm^3 = \frac{W_2 - W_1}{\text{Vol.of sample after tapping}}$

W_1= weight of tube in g

W_2= weight of tube with sample in g

3.6.2.2. Solubility and swelling power

The method used by Tester and Morrison (1990) and Anderson et al. (1969) was used to determine the solubility and swelling power. About 1g ground sample (< 60 mesh) was suspended in 10 mL of water and was incubated in a thermostatically controlled water bath at 95^{o}C in a tared screw cap tube of 15 mL The suspension was stirred intermittently over 30 min period to keep the starch granules suspended. The tubes were rapidly be cooled to 20^{o}C. The cool paste was centrifuged, at 2200 x g for 15 min to separate jell and supernatant. Then, the aqueous supernatant was removed and poured in to dish for subsequent analysis of solubility pattern. After this, the weight of the swollen sediment was determined. Supernatant liquid (dissolved starch) was poured into a tarred evaporating dish and put in air oven at 100^{o}C for 4 h. Water solubility index was determined from the amount of dried solids obtained the following equation.

$$\text{Solubility (\%)} = \frac{W_1 * 100}{W_s (1-Mc)}$$

Swelling power was calculated by the following equation

$$\text{Swelling power (\%)} = \frac{W_2 * 100}{W_{dm} (100-\text{solublity})}$$

Dry matter weight = w_s (1-Mc)

Where:

W_1= Weight of dissolved solids in supernatant, g

W_2= Weight of centrifuged swollen granules, g

W_s= Weight of sample, g

Mc= Moisture content of sample, dry basis (decimal), g

W_{dm}= Weight of dry matter, g

3.6.2.3. Water absorption capacity (WAC)

Water absorption capacity was determined using the method of Beuchat (1977). One gram of the sample was mixed with 10 ml distilled water for 30 s. The sample was allowed to stand at room temperature for 30 min and then centrifuged at 5000 x g for 30 min, and the freed water was taken into a 10 ml graduated cylinder and the volume was recorded. Water absorption capacity was estimated as the amount of water retained by 100 g materials on dry basis. Density of water was assumed to be 1 g/ml. The mean of triplicate determinations was reported on a dry weight basis.

$$WAC = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry basis)}}$$

3.6.2.4. Oil absorption capacity (OAC)

An oil absorption capacity was determined using the method of Beuchat (1977). About one gram of the sample was mixed with 10 ml oil for 30 sec in a mixer. The samples was allowed to stand at room temperature for 30min, centrifuged at 5000 x G for 30 min. The freed oil was decanted into a 10 ml graduated cylinder and the volume was recorded. Oil absorption capacity was expressed as the amount of oil bound by 100 grams dry matter. Density of oil was determined to be 0.893 g/ml. The mean of triplicate determinations results was reported on a dry weight basis.

$$OAC = \frac{\text{Weight of oil bound}}{\text{Weight of sample (dry basis)}}$$

3.7.3 Determination of Antinutritional Factors

3.7.3.1 Determination of Phytate content

Phytate was determined by the method of Latta and Eskin (1980) and later modified by Vantraub and Lapteva (1988). About 0.2g of fresh samples were extracted with 10ml 0.2 % HCl in a mechanical shaker (Eberbach) for 1hour at an ambient temperature and centrifuged at 3000rpm for 30 minute. The clear supernatant was used for Phytate estimation. A 2ml of Wade reagent (containing 0.03% solution of $FeCl_3.6H_2O$ and 0.3% of sulfosalicilic acid in water) was added to 3ml of the sample solution (supernatant) and the mixture was mixed on a Vortex for 5 seconds.

The absorbance of the sample solutions was measured at 500 nm using UVVIS spectrophotometer.

A series of standard solution was prepared containing 4, 8, 16, 24 and 32 ppm of phytic acid (analytical grade sodium phytate) in 0.2N HCl. A 3ml of standard was added into 15ml of centrifuge tubes with 3ml of water which were used as a blank. A 2ml of the Wade reagent was added to each test tube and the solution was mixed on a Vortex mixer for 5 seconds. The mixtures were centrifuged for 10 minutes and then absorbance of the solutions (both the sample and standard) were measured at 500nm by using deionized water as a blank. A standard curve was made from absorbance versus concentration and the slope and intercept were used for calculation.

$$\text{Phytic acid in } \mu g/g = \frac{[(A_s - A_b) - \text{Intercept}] * 10}{\text{Slope} * w * 3}$$

Where;

$A_{s=}$ sample absorbance

A_b= blank absorbance

W=Weight of sample

3.7.3.1 Determination of Tannin content

Tannin content was determined by the method of Burns (1971) as modified by Maxson and Rooney (1972). About 2.0 gram of mung bean flour was weighed in a screw cap test tube. The mung bean flour was extracted with 10ml of 1% HCl in methanol for 24 hours at room temperature with mechanical shaking. After 24 hours shaking, the solution was centrifuged at 1000rpm for 5 minutes. A 1ml of supernatant were taken and mixed with 5 ml of vanillin-HCl reagent (prepared by combining equal volume of 8% concentrated HCl in methanol and 4% Vanillin in methanol). D-catechin was used as standard for condensed tannin determination. A 40mg of D-catechin were weighed and dissolved in 1000 ml of 1% HCl in methanol, which were used as stock solution. A 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of stock solution were taken in test tube and the volume of each test tube was adjusted to 1ml with 1% HCl in methanol. A 5ml of vanillin-HCl reagent were added into each test tube. After 20 minutes, the absorbance of sample solutions and the standard solution were measured at 500nm by using water to zero the

spectrophotometer, and the calibration curve were constructed from the series of standard solution using SPSS-22. A standard curve was made from absorbance versus concentration and the slope and intercept were used for calculation.

Calculation:

Concentration of tannin was read in mg of D-catechin per 100g of sample

Tannin in mg/100g = ((absorbance-intercept)*10)/ (slope x density x weight of sample)

3.8.4 Determination of antioxidant activity

3.8.4.1 Sample extraction

Samples were extracted based on the procedures as outline by Latta and Eskin**.**The Mung bean flour samples were homogenized and weight in 5g was then extracted by 25ml of methanol at 25^0C at 150rpm for 24hour using an incubator shaker (ZHWY-103) and then filtered through what man No.1 filter paper. The residue was then extracted with additional 25ml of methanol as described above. The combined methanolic extracts were evaporated at 40^0c dryness using rotary evaporator and redissolved in methanol at concentration of 50mg/ml and stored at 40^0c for further use.

3.8.4.2 Determination of DPPH radical scavenging capacity

DPPH scavenging activity of the tuber methanolic extract was measured according to the method of Latta and Eskin .IC50 values of the extracts and concentration of the extracts necessary to decrease the initial concentration of DPPH by 50% were calculated. The hydrogen donation ability of the corresponding extracts and some pure compound was measured from the bleaching purpled colored methanol solution of DPPH. The effect of methanolic extract on DPPH radical was estimated according to Kirby A.J and Schmidt R.J 4ml 0.004% solution of DPPH radical solution in methanol was mixed with 1ml of various concentrations (2-12mg/ml) of extracts in methanol with vortex mixer. Incubate the sample for 30min in dark at room temperature Ascorbic acid standards prepared by dissolving 0.3mg into 1ml of methanol (or 3mg in 10ml methanol).Scavenging capacity was read Spectrophotometrically by monitoring the decrease in

absorbance at 517 nm by (UV-7804C, UV-Vis spectrophotometer. Inhibition of free radical DPPH in percent (I %) was calculated in following way:

$$I\% = \frac{Ac - As}{Ac} * 100$$

Where:

Ac=is the absorbance of control reaction without test sample

As =is the absorbance of the test sample (containing all reagents except the test sample) Ascorbic acid

%I= Percent of inhibition

The concentration of scavenging activities at IC50 was calculated using the %I from the absorbance of control and absorbance sample solution.

3.8.4.3 Total polyphenol content

The total phenol content was determined by the method described by Siddhuraju, P. and Becker, K. Aliquots (100 µl) of each extracts were taken in test tubes and made up to the volume of 1 ml with distilled water. Then 0.5ml of Folin-Ciocalteu phenol reagent (1:1 with water) and 2.5ml of sodium carbonate solution (20%) were added sequentially in each tube. Rapidly after vortexing the reaction mixture, the test tubes were placed in dark for 40 minutes and the absorbance was recorded at 765nm against reagent blank using UV-Vis (UV-7804C ultraviolet visible spectrometer. Gallic acid was used to construct the standard curve, and the result was expressed mean± standard deviation expressed as milligram of Gallic acid (GAE) equivalent of extract. All determinations were carried out in triplicate. 0.05g of Gallic acid in 1ml methanol and then dilute to 10ml with deionized water (5g/L) final stock. Dissolve 0.1, 0.2, 0.5and 1ml with water to create standards with 20, 40, 60, 80,100,120 and 140mg/L (ppm) concentration respectively.

The total phenolic compound in the extract in Gallic acid equivalent (GAE) was calculated using the formulae:

$$\text{Total phenolic content}(C) = \frac{GAEc * V}{W}$$

Where, GAEc=concentration of Gallic acid equivalent (milligram/ml) from curve

V= Total volume of the extract (ml)

W= sample weight (gm)

3.8.4.4 Total flavonoid

Flavonoid contents were determined according to the method of Zhishen et al. An aliquot (150 µl) of each extract or standard solution was mixed with 1.25 ml of deionized water and 75 µl of 5% NaNO2 solution. After 6 min, 150µl of 10% $AlCl_3.H_2O$ solution was added. After 5 min, 0.5 ml of 1 M NaOH solution was added and then the total volume was made up to 2.5 ml with double distilled water. Prepare 10-1000µL quercetin standard in methanol from 1mg/ ml stock by dissolving (10mg/10ml). Following thorough mixing of the solution, the absorbance against blank was determined at 510 nm using (UV-7804C, ultraviolet visible spectrometer). The results were expressed in mg Catechin equivalent (CE).

$$\text{Flavonoid Content} = \frac{DE*V}{W}$$

Where DE= D-Catechin equivalent (mg/ml)

V= total volume of the sample (ml)

W= sample weight (mg)

3.9. Statistical Analysis

The data which were obtain in this experiment subjected to two ways analysis of variance (ANOVA) using SPSS version 22 software because in this study we were considered effect of processing and origin of mung bean as a factor. The mean separation values were determined using Least significance (LSD) and Duncan multiple range test (DMRT) and significant differences were defined at $p<0.05$. The results were presented as mean ± Standard deviation of three separate determinations.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1.Proximate composition of mung bean flour

The proximate composition of raw and processed mung bean sample is presented in Table 2.

4.1.1. Moisture

The moisture contents of raw and processed mung bean flour samples collected from Bale, Gonder and North showa ranged from 3.73% to 9.40% (Table 2). The maximum moisture content observed for boiled Gonder type mung bean flour and minimum moisture content observed for dry roasted Gonder type mung bean flour. The moisture contents for the Bale Type, Gonder type and North showa type mung bean of the four processing methods, dry roasting, dehulling and germination, and soaking respectively had significantly decreased moisture content of mung bean sample as compared to the raw sample($p<0.05$). In addition there was no significant difference of the boiled Bale type, Gonder type and North showa type mung bean as compared to the raw mung bean($p>0.05$). Consequently there were no significant difference among the moisture content of the Bale type, Gonder type and North showa type mung bean flour($p>0.05$). The interaction of processing methods and origin of mung bean had significant effect on the moisture content of mung bean flour sample ($p<0.05$). The relative decrease of moisture content by processing methods except boiling may be attributed due to a variation in the treatment during the drying processes of the samples. All the treatments except raw sample were subjected to drying operation in order to prepare flour for analysis at low moisture content, the flours possessed low water activity hindering any microbial growth. Moreover, dried flours are devoid of moisture required for the spore growth and physiological activity. However; other researchers had earlier reported that raw mung bean had 8.25-10% moisture content (Bhatty et al., 2000).

4.1.2. Crude protein

The protein content of raw and processed mung bean flour samples ranged from 27.65% to 30.92% (Table 2). The dehulled North showa type samples had highest protein value (30.92 %)

and the minimum corresponds to raw Gonder type samples of mung bean (27.65%). The determinations of crude protein for the Bale Type, Gonder type and North showa type mung bean of the five processing methods, dehulling, dry roasting and germination, boiling and soaking respectively had a significantly increased the crude protein content of mung bean sample as compared to the raw sample($p<0.05$). In addition, there was significant difference among the crude protein content of Bale type, Gonder type and North showa type mung bean flour samples respectively ($p<0.05$) but there was no significant difference between the crude protein content of Gonder type and North showa type mung bean ($p>0.05$).Consequently the interaction of processing methods and origin of mung bean had significant effect on the crude protein content of mung bean flour sample ($p<0.05$). The results of this study reveal that, dehulling, germination, dry roasting, boiling and soaking respectively increases crude protein content in mung bean it is probably due to increasing non-protein nitrogen content during processing by releasing the bound nitrogenous compounds (e.g.-tannin-protein complexes) (Chandrasiri *et al*, 2016). The results obtained were in agreement with those obtained with processed kidney beans (Alonso *et al*., 2000) and mung bean (Mubarak, 2005).

4.1.3 Crude Fat

The crude fat content of raw and processed mung bean flour samples were in the range from 1.33% to 2.00% (Table 2). The dry roasted Gonder type samples mung bean flour had highest crude fat value (2.00 %) and the minimum corresponds to dry roasted Bale type samples of mung bean flour (1.33%). Furthermore, dry roasting had a significantly increased the fat content of mung bean flour samples ($P < 0.05$). In addition soaking, dehulling and boiling had a significantly reduced the crude fat content of mung bean flour samples ($P < 0.05$).Moreover, there was no significant difference between the crude fat content of germinated and raw mung bean flour samples ($p>0.05$). Consequently there had a significantly difference between fat content of Bale, Gonder and North showa type mung bean flours sample($P < 0.05$). Finally there was no significantly difference between the fat content of Gonder and North showa type mung bean flours ($P > 0.05$). The interaction of processing methods and origin of mung bean had significant effect on the crude fat content of mung bean flour sample ($p<0.05$). The result of this study shows that a slight decrease in crude fat content of soaked, dehulled and boiled mung bean flour samples as compared to the raw mung bean flour sample this might be due to their

diffusion in water. The fat content of the raw sample (1.5%) was close from the result (1.85%-2.83%) reported by Bhatty *et al*. (2000) and Mubarak (2005).

4.1.4 Total ash

The total ash content of raw and processed mung bean flour samples were ranged from 2.13% to 3.47% (Table 2). The maximum ash content observed for dry roasted Gonder type and North showa type mung bean flour and minimum ash content observed for boiled Bale type mung bean flour. Moreover, boiling and dehulling had significantly decreased the total ash content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, there were no significant difference among the total ash content of germinated, raw, dry roasted and soaked mung bean flour samples($p>0.05$). Consequently there were no significant differences among the total ash content of the Bale type, Gonder type and North showa type mung bean flour samples ($p>0.05$). The interaction of processing methods and origin of mung bean had significant effect on the total ash content of mung bean flour sample ($p<0.05$). The result of this study disclose that there was decreasing in the total ash content of boiled and dehulled mung bean flour samples as compared to the raw mung bean flour sample. The leaching of minerals from the seeds during boiling and dehulling could be the reason. It was observed that legumes contained a large portion of water soluble ash which has the tendency to leach out during hydro processing of seeds. The raw sample had ash content (3.2%-3.33%) close to the value reported by Mubarak (2005) for undehulled mung bean seeds flour (3.76%).

4.1.5 Crude fiber

The crude fiber content of raw and processed mung bean flour samples were ranged from 0.48% to 7.57% (Table 2). The maximum crude fiber content observed for raw Bale type mung bean flour sample and minimum crude fiber observed for boiled Gonder type mung bean flour sample. Furthermore, soaking and dehulling, boiling, germination and dry roasting had significantly decreased the crude fiber content of mung bean flour samples as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were significant differences ($p<0.05$) among the crude fiber content of the North showa type, Bale type and Gonder type mung bean flour samples ($p<0.05$). Finally there was no significantly difference between the crude fiber content of Bale and Gonder type mung bean flour sample ($P > 0.05$). The interaction of processing methods and origin of mung bean had significant effect on the crude fiber content of mung bean

flour sample ($p<0.05$). The result of this study reveal that all the five processing methods (soaking, dehulling, boiling, germination and dry roasting) decreased the crude fiber content of mung bean flour samples as compared to the raw mung bean flour sample this might be due to solubilization of cellulose and hemi cellulosic material by the processing methods. The crude fiber content of the raw sample (5.47%-7.57%) was slightly higher than that reported by Mubarak (2005)-4.63%.

4.1.6 Utilizable carbohydrate

The utilizable carbohydrate content of raw and processed mung bean flour samples were ranged from 50.43% to 59.97% (Table 2). The maximum utilizable carbohydrate content observed for dry roasted Bale type mung bean flour sample and minimum utilizable carbohydrate content observed for raw Bale type mung bean flour sample. In addition, dry roasting, dehulling, germination and soaking, and boiling had significantly increased the utilizable carbohydrate content of mung bean flour samples as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were significant differences among the utilizable carbohydrate content of the North showa type, Bale type and Gonder type mung bean flour($p<0.05$). Finally there was no significantly difference between the utilizable carbohydrate content of Bale and Gonder type mung bean flour sample ($P > 0.05$). The interaction of processing methods and origin of mung bean had significant effect on the utilizable carbohydrate content of mung bean flour sample ($p<0.05$). The result of this study reveal that all the five processing methods (soaking, dehulling, boiling, germination and dry roasting) increased the utilizable carbohydrate content of mung bean flour samples as compared to the raw mung bean flour sample this might be due to the retro gradation of starch after gelatinization by the processing methods. This result was in agreement with the finding of Chandrasiri *et al*., (2016) which showed that sprouting and boiling increased in the utilizable carbohydrate content of mung bean flour sample.

Table 2: Proximate composition of raw and processed mung bean flour

Method of processing	Origin of mung bean	%Moisture	%Ash	%Crude protein	%crude Fat	%Crude Fiber	%Crude Carbohydrate	Total energy(Kcal/100gm)
Raw	Bale type mung bean	9.00 ± 0.00^{d}	3.20 ± 0.00^{cd}	$28.30\pm0.20^{a*}$	$1.50\pm0.00^{b*}$	7.57 ± 0.30^{d}	50.43 ± 0.50^{a}	328.41 ± 1.20^{a}
	Gonder type mung bean	7.47 ± 0.23^{d}	3.33 ± 0.23^{cd}	27.65 ± 0.31^{a}	1.50 ± 0.00^{b}	5.47 ± 0.35^{d}	54.58 ± 0.85^{a}	342.42 ± 2.88^{a}
	North showa type mung bean	8.53 ± 0.50^{d}	3.33 ± 0.23^{cd}	28.18 ± 0.31^{a}	1.50 ± 0.00^{b}	$6.92\pm0.05^{d*}$	$51.54\pm0.46^{a*}$	$332.37\pm2.66^{a*}$
Dehulled	Bale type mung bean	5.07 ± 0.23^{b}	3.07 ± 0.23^{b}	$30.57\pm0.20^{d*}$	$1.50\pm0.00^{a*}$	1.28 ± 0.11^{ab}	58.52 ± 0.20^{cd}	369.86 ± 1.20^{d}
	Gonder type mung bean	5.33 ± 0.46^{b}	3.07 ± 0.23^{b}	30.09 ± 0.92^{d}	1.00 ± 0.00^{a}	2.06 ± 0.32^{ab}	58.45 ± 1.30^{cd}	367.65 ± 2.04^{d}
	North showa type mung bean	5.47 ± 0.50^{b}	3.07 ± 0.23^{b}	30.92 ± 0.40^{d}	1.50 ± 0.00^{a}	$1.03\pm0.16^{ab*}$	$58.02\pm0.52^{cd*}$	$369.25\pm3.34^{d*}$
Dry roasted	Bale type mung bean	4.20 ± 0.20^{a}	3.20 ± 0.00^{d}	$30.22\pm0.71^{c*}$	$1.33\pm0.28^{c*}$	1.07 ± 0.06^{c}	59.97 ± 0.80^{d}	374.27 ± 0.38^{d}
	Gonder type mung bean	3.73 ± 0.12^{a}	3.47 ± 0.23^{d}	30.15 ± 0.51^{c}	2.00 ± 0.00^{c}	2.29 ± 0.32^{c}	58.36 ± 0.52^{d}	367.54 ± 0.81^{d}
	North showa type mung bean	4.47 ± 0.42^{a}	3.47 ± 0.23^{d}	29.69 ± 0.11^{c}	1.50 ± 0.00^{c}	$2.74\pm0.46^{c*}$	$58.14\pm0.76^{d*}$	$364.79\pm3.46^{d*}$
Germinated	Bale type mung bean	5.07 ± 0.12^{b}	3.33 ± 0.23^{d}	$30.28\pm0.00^{cd*}$	$1.50\pm0.00^{b*}$	1.23 ± 0.08^{b}	58.59 ± 0.39^{c}	368.97 ± 1.57^{c}
	Gonder type mung bean	5.53 ± 0.23^{b}	3.47 ± 0.23^{d}	30.19 ± 0.08^{cd}	1.50 ± 0.00^{b}	1.29 ± 0.06^{b}	58.01 ± 0.30^{c}	366.33 ± 1.82^{c}
	North showa type mung bean	5.40 ± 0.35^{b}	3.60 ± 0.00^{d}	30.69 ± 0.10^{cd}	1.50 ± 0.00^{b}	$1.99\pm0.24^{b*}$	$57.81\pm0.86^{c*}$	$363.54\pm1.23^{c*}$
Soaked	Bale type mung bean	7.47 ± 0.23^{c}	3.33 ± 0.23^{bc}	$29.52\pm0.20^{b*}$	$1.00\pm0.00^{a*}$	0.63 ± 0.10^{a}	58.05 ± 0.10^{c}	363.77 ± 0.39^{b}
	Gonder type mung bean	6.93 ± 0.23^{c}	3.07 ± 0.23^{bc}	29.29 ± 0.10^{b}	1.50 ± 0.00^{a}	1.45 ± 0.17^{a}	57.76 ± 0.15^{c}	361.70 ± 0.69^{b}
	North showa type mung bean	6.73 ± 0.23^{c}	3.07 ± 0.23^{bc}	29.40 ± 0.00^{b}	1.50 ± 0.00^{a}	$1.74\pm0.25^{a*}$	$57.56\pm0.25^{c*}$	$361.33\pm0.99^{b*}$
Boiled	Bale type mung bean	7.67 ± 0.12^{d}	2.13 ± 0.23^{a}	$30.63\pm0.31^{c*}$	$1.00\pm0.00^{a*}$	1.19 ± 0.10^{ab}	57.38 ± 0.30^{b}	365.54 ± 1.63^{b}
	Gonder type mung bean	9.40 ± 0.20^{d}	2.27 ± 0.23^{a}	29.98 ± 1.01^{c}	1.50 ± 0.00^{a}	0.48 ± 0.02^{ab}	56.37 ± 1.29^{b}	358.91 ± 1.16^{b}
	North showa type mung bean	7.13 ± 0.31^{d}	2.27 ± 0.23^{a}	29.51 ± 0.09^{c}	1.50 ± 0.00^{a}	$2.73\pm0.02^{ab*}$	$56.87\pm0.83^{b*}$	$358.99\pm2.09^{b*}$

All values are the means of triplicates ± standard deviation n=3

Means with the same superscript letters within a column are not significantly different at ($P>0.05$)

a, b, c, d are superscript to show significance difference between means a<b<c<d

Means with superscript * indicated there is significant different between origin of mung bean ($p<0.05$)

4.2 Functional Properties of Mung bean flour

Table 3. Functional properties of mung bean flour

Method of processing	Origin of mung bean	bulk density	Water Absorption Capacity	Oil Absorption Capacity	Swelling power	Solubility Index
Raw	Bale type mung bean	1.08 ± 0.00^{e}	1.95 ± 0.05^{b}	$1.67\pm0.00^{a*}$	$19.00\pm0.00^{c*}$	$13.04\pm0.06^{b*}$
	Gonder type mung bean	1.07 ± 0.00^{e}	2.07 ± 0.03^{b}	$1.81\pm0.01^{a**}$	$20.67\pm0.58^{c**}$	$11.34\pm0.27^{b**}$
	North showa type mung bean	$1.06\pm0.00^{e*}$	2.04 ± 0.02^{b}	$1.88\pm0.01^{a***}$	$12.00\pm0.00^{c***}$	$20.47\pm0.09^{b***}$
Dehulled	Bale type mung bean	1.00 ± 0.01^{b}	1.84 ± 0.01^{a}	$1.85\pm0.01^{b*}$	$17.67\pm0.58^{c*}$	$12.67\pm0.49^{a*}$
	Gonder type mung bean	1.01 ± 0.00^{b}	1.77 ± 0.01^{a}	$1.73\pm0.01^{b**}$	$19.33\pm1.15^{c**}$	$11.16\pm0.63^{a**}$
	North showa type mung bean	$1.00\pm0.00^{b*}$	1.90 ± 0.02^{a}	$1.84\pm0.01^{b***}$	$14.33\pm0.58^{c***}$	$15.31\pm0.44^{a***}$
Dry roasted	Bale type mung bean	1.01 ± 0.00^{c}	2.55 ± 0.04^{d}	$1.88\pm0.01^{e*}$	$8.67\pm0.58^{a*}$	$31.79\pm2.34^{e*}$
	Gonder type mung bean	1.00 ± 0.00^{c}	2.54 ± 0.05^{d}	$1.77\pm0.01^{e**}$	$7.33\pm0.58^{a**}$	$37.65\pm2.83^{e**}$
	North showa type mung bean	$1.02\pm0.00^{c*}$	2.58 ± 0.00^{d}	$1.98\pm0.00^{e***}$	$7.33\pm0.58^{a***}$	$37.55\pm2.75^{e***}$
Germinated	Bale type mung bean	1.01 ± 0.00^{d}	2.10 ± 0.01^{c}	$1.86\pm0.01^{c*}$	$15.33\pm0.58^{d*}$	$21.85\pm0.75^{c*}$
	Gonder type mung bean	1.02 ± 0.00^{d}	2.10 ± 0.01^{c}	$1.80\pm0.00^{c**}$	$19.00\pm0.00^{d**}$	$13.72\pm0.06^{c**}$
	North showa type mung bean	$1.03\pm0.00^{d*}$	2.20 ± 0.02^{c}	$1.88\pm0.01^{c***}$	$19.33\pm0.58^{d***}$	$15.20\pm0.39^{c***}$
Soaked	Bale type mung bean	1.02 ± 0.00^{d}	2.04 ± 0.02^{c}	$1.97\pm0.01^{d*}$	$11.00\pm0.00^{b*}$	$22.42\pm0.11^{d*}$
	Gonder type mung bean	1.01 ± 0.00^{d}	2.22 ± 0.02^{c}	$1.73\pm0.00^{d**}$	$19.67\pm0.58^{b**}$	$12.48\pm0.40^{d**}$
	North showa type mung bean	$1.03\pm0.00^{d*}$	2.04 ± 0.00^{c}	$1.90\pm0.01^{d***}$	$13.67\pm1.15^{b***}$	$20.65\pm1.54^{d***}$
Boiled	Bale type mung bean	0.93 ± 0.00^{a}	3.22 ± 0.02^{e}	$1.80\pm0.01^{b*}$	$6.00\pm0.00^{a*}$	$51.89\pm0.19^{f*}$
	Gonder type mung bean	0.93 ± 0.00^{a}	3.14 ± 0.02^{e}	$1.78\pm0.01^{b**}$	$11.67\pm1.15^{a**}$	$26.98\pm2.71^{f**}$
	North showa type mung bean	$0.94\pm0.00^{a*}$	3.16 ± 0.01^{e}	$1.84\pm0.01^{b***}$	$6.00\pm0.00^{a***}$	$52.61\pm0.19^{f***}$

All values are the means of triplicates ± standard deviation n=3
Means with the same superscript letters within a column are not significantly different at ($P>0.05$)
a, b, c, d, e, f are superscript to show significance difference between means a<b<c<d<e<f
Means with superscript * indicated there is significant different between origin of mung bean ($p<0.05$)

4.2.1 Bulk density

The bulk density of raw and processed mung bean flour samples collected from Bale, Gonder and North showa were ranged from 0.93% to 1.08% (Table 3). The highest bulk density observed for raw Bale type mung bean flour and lowest bulk density observed for boiled Bale type and Gonder type mung bean flour sample. In addition, germination and soaking, dry roasting, dehulling, and boiling had decreased the bulk density of mung bean flour samples as compared to the raw mung bean flour sample significantly ($P < 0.05$). Furthermore, there were significant difference) among the bulk density of the North showa type, Bale type and Gonder type mung bean flour sample ($p<0.05$). Consequently there was no significant difference between the bulk density of Bale type and Gonder type mung bean flour sample ($p>0.05$). The interaction of processing methods and origin of mung bean had significant effect on the bulk

density of mung bean flour sample ($p<0.05$). The result of this study disclose that all the five processing methods (soaking, dehulling, boiling, germination and dry roasting) decreased the bulk density of mung bean flour samples as compared to the raw mung bean flour sample. Bulk density is influenced by the structure of the starch polymers and the loose structure of the starch polymers by processing methods could result in low bulk density. The advantage of flour that has high bulk density is that it does not take up too much space when distributing and decreases packaging costs (Karuna *et al*., 1996).

4.2.2 Solubility index

The solubility index of raw and processed mung bean flour samples were ranged from 11.16% to 52.61% (Table 3). The maximum solubility index observed for boiled North showa type mung bean flour and minimum solubility index observed for dehulled Gonder type mung bean flour. Moreover, boiling, dry roasting, soaking and germination had significantly increased the solubility index of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, dehulling had significantly decreased the solubility index of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were significant difference among the solubility index of the North showa type, Bale type and Gonder type Mung bean flour samples ($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the solubility index of mung bean flour sample ($p<0.05$). The result of the study shows that boiling, dry roasting, soaking and germination increased the solubility index of mung bean flour samples as compared to raw mung bean flour sample. As a direct result of flour swelling, there is a parallel increase in the solubility of flour. High solubility implies high leaching. The high water solubility of any sample analyzed may be attributed to the degree of swelling power and swelling power and solubility of the flour provide evidence of non-covalent bonding between molecules within the flour (Onitilo *et al*., 2007).But dehulling decreased the solubility index of mung bean flour sample as compared to raw mung bean flour sample and it is probably due to the removal of seeds cover.

4.2.3 Swelling power

The swelling power of raw and processed mung bean flour samples were ranged from 7.33% to 20.67% (Table 3). The maximum swelling power observed for raw North showa type mung bean

flour and minimum swelling power observed for boiled Bale and North showa type mung bean flour. In addition, germination had significantly increased the swelling power of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Moreover, boiling, dry roasting, and soaking had significantly decreased the swelling power of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, there was no significant difference between the swelling power of dehulling mung bean flour sample and raw mung bean flower sample($p>0.05$). Consequently there were significant difference among the swelling power of the North showa type, Bale type and Gonder type mung bean flour samples ($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the swelling power of mung bean flour sample ($p<0.05$). The result of the study disclose that boiling, dry roasting, and soaking decreased the swelling power of mung bean flour samples as compared to raw mung bean flour sample. But germination increased the solubility index of mung bean flour sample as compared to raw mung bean flour sample. The swelling power of flour samples is often related to their protein and starch contents (Woolfe, 1992). A higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restricts the swelling power. In addition to protein content, a higher concentration of phosphorous may increase hydration and swelling power by weakening the extent of bonding within the crystalline domain (Singh *et al*., 2003).Furthermore, the amylopectin is primarily responsible for granule swelling, thus higher amylose content would reduce the swelling factor of starch (Tester and Morrison, 1990).The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water (Ruales,1993). The result of this study similar with previous study was conducted by Pangastuti *et al*. (2013).

4.2.4 Water Absorption Capacity

The water absorption capacity of raw and processed mung bean flour samples were ranged from 1.77% to 3.22% (Table 3). The maximum water absorption capacity observed for boiled Bale type mung bean flour and minimum water absorption capacity observed for dehulled Gonder type mung bean flour. Furthermore, boiling, dry roasting, and germination had significantly increased the water absorption capacity of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). An increase in water absorption capacity by germination could be

attributed to the breakdown of polysaccharide and an increase in protein content, which probably increased the sites for interaction of water molecules Elkhalifa and Bernhardt (2010).Moreover, dehulling had significantly decreased the water absorption capacity of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were no significant differences among the water absorption capacity of the North showa type, Bale type and Gonder type mung bean flour sample($p>0.05$). The interaction of processing methods and origin of mung bean had significant effect on water absorption capacity of mung bean flour sample ($p<0.05$).

4.2.5 Oil Absorption Capacity

The oil absorption capacity of raw and processed mung bean flour samples were ranged from 1.67% to 1.98% (Table 3). The maximum oil absorption capacity observed for dry roasted North showa type mung bean flour and minimum oil absorption capacity observed for raw Bale type mung bean flour sample. Moreover, dry roasting, soaking, germination, dehulling, and boiling had significantly increased the oil absorption capacity of mung bean flour samples as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were significant difference among the oil absorption capacity of the North showa type, Gonder type and Bale type mung bean flour samples ($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the oil absorption capacity of mung bean flour sample ($p<0.05$). The result of this study show that all the five processing methods (soaking, dehulling, boiling, germination and dry roasting) increased the oil absorption capacity of mung bean flour samples as compared to the raw mung bean flour sample. Earlier studies also showed that the oil absorption capacity of sorghum and brown rice flour increased as the germination time progressed Chinma *et al*. (2015). Oil absorption capacity is an important property in food formulations because fats improve the flavor and mouth feel of foods (Plaami, 1997).

4.3 Determination of Antinutritional Factors of Mung bean flour

4.3.1 Phytate

The phytate content of raw and processed mung bean flour samples collected from Bale, Gonder and North showa ranged from 133.86% to 190.75% (Table 4). The maximum phytate content

observed for dehulled Bale type mung bean flour and minimum phytate content observed for raw Gonder type mung bean flour. Furthermore, soaking, dehulling, boiling, and germination had significantly decreased the phytate content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Moreover, dry roasting had significantly increased the phytate content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Consequently there were significant difference among the phytate content of the Bale type, North showa type and Gonder type mung bean flour sample ($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the phytate content of mung bean flour sample ($p<0.05$). The result of this study reveal that soaking, dehulling, boiling and germination decreased the phytate content of mung bean flour sample as compared to the raw mung bean flour sample. But dry roasting increased the phytate content of mung bean flour sample as compared to the raw mung bean flour sample. The differences in the loss of phytic acid contents during processing could probably be explained on the basis that phytases activity at a temperature of 40–55C^0 may degraded inositol hexaphosphate to the pentaphosphate or lower molecular weight forms (De Boland *et al.*,1975). Phytic acid content decreased because insoluble complexes between phytate and other components were formed during processing (Kumar *et al.*, 1978).

4.3.2 Tannin

The Tannin content of raw and processed mung bean flour samples were ranged from 13.69% to 23.71% (Table 4). The maximum tannin content observed for soaked Gonder type mung bean flour and minimum tannin content observed for germinated Gonder type mung bean flour. In addition, germination and dehulling had significantly decreased the tannin content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, dry roasting and soaking significantly increased the tannin content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Moreover, there were no significant difference between the tannin content of boiled and raw mung bean flour sample ($P >0.05$). Consequently there were significant difference among the tannin content of the Bale type, Gonder type and North showa type mung bean flour sample($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the tannin content of mung bean flour sample ($p<0.05$). The result of this study disclose that soaking, dehulling, boiling and

germination decreased the tannin content of mung bean flour sample as compared to the raw mung bean flour sample. But dry roasting and soaking increased the tannin content of mung bean flour sample as compared to the raw mung bean flour sample. The decreased during processing might be due to thermal degradation and denaturation of the antinutrients as well as the formation of insoluble complexes and leaching out of hydrolysable tannin in the boiling water (Osman,2004).

Table 4. Antinutritional contents of raw and processed mung bean flour

Method of processing	Origin of mung bean	Phytate content(µg/100 gm)	Tannin(mg/100gm)
Raw	Bale type mung bean	$182.59\pm0.08^{e*}$	$19.29\pm0.18^{c*}$
	Gonder type mung bean	$133.86\pm0.91^{e**}$	$17.25\pm0.15^{c**}$
	North showa type mung bean	$176.14\pm0.01^{e***}$	$18.71\pm0.31^{c***}$
Dehulled	Bale type mung bean	$190.75\pm0.02^{b*}$	$18.41\pm0.05^{b*}$
	Gonder type mung bean	$134.51\pm0.70^{b**}$	$17.15\pm0.08^{b**}$
	North showa type mung bean	$148.04\pm0.22^{b***}$	$17.98\pm0.09^{b***}$
Dry roasting	Bale type mung bean	$179.46\pm0.09^{f*}$	$20.43\pm0.20^{e*}$
	Gonder type mung bean	$184.23\pm0.31^{f**}$	$20.60\pm0.19^{e**}$
	North showa type mung bean	$183.94\pm0.82^{f***}$	$22.22\pm0.07^{e***}$
Germinating	Bale type mung bean	$181.54\pm0.01^{d*}$	$17.95\pm0.50^{a*}$
	Gonder type mung bean	$134.31\pm0.91^{d**}$	$13.69\pm0.10^{a**}$
	North showa type mung bean	$169.06\pm0.28^{d***}$	$12.93\pm0.91^{a***}$
Soaked	Bale type mung bean	$138.05\pm0.30^{a*}$	$17.30\pm0.29^{d*}$
	Gonder type mung bean	$145.72\pm0.16^{a**}$	$23.71\pm0.13^{d**}$
	North showa type mung bean	$145.43\pm0.39^{a***}$	$19.25\pm0.33^{d***}$
Boiled	Bale type mung bean	$163.23\pm0.36^{c*}$	$19.77\pm0.12^{c*}$
	Gonder type mung bean	$134.31\pm0.91^{c**}$	$17.93\pm0.08^{c**}$
	North showa type mung bean	$183.06\pm0.69^{c***}$	$17.27\pm0.08^{c***}$

All values are the means of triplicates ± standard deviation n=3
Means with the same superscript letters within a column are not significantly different at (P>0.05)
a, b, c, d, e, f are superscript to show significance difference between means a<b<c<d<e<f
Values are expressed in µg/100gm and mg/100g of dry weight basis
Means with superscript * indicated there is significant different between origin of mung bean (p<0.05)

4.4 Antioxidant activities of mung bean flour

4.4.1 Yield of extract

The percentage of yields of extract raw and processed mung bean flour samples collected from Bale, Gonder and North showa by methanol were ranged from 13.4% to 2.8% (Table 5). From

the yield of extract the free radical scavenging capacity by DPPH, total phenol and flavonoid was determined.

Table 5 Percentage of yields of extract by methanol from raw and processed mung bean

Sample type	Raw	Dehulled	Soaked	Germinated	Boiled	Dry roasted
Bale type	5	5	4.8	11.6	3	4.8
Gonder type	5.4	2.8	9	12	2.8	5.4
North showa type	7.6	8.6	4.4	11.8	3.8	13.4

4.4.2 Determination of radicals scavenging activity of mung bean by DPPH

Radical scavenging activity of the sample extracts was measured by determining the inhibition rate of DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical. DPPH is stable free radical at room temperature and accepts an electron / hydrogen radical to become a stable diamagnetic molecule (J.M, 2004). The reduction capability of DPPH radical is determined by the decrease in its absorbance at 5l7 nm, induced by antioxidants. The decreased in absorbance of DPPH radical is caused by antioxidants, because of the reaction between antioxidant molecules and radicals, progresses, which results in the scavenging of the radical by hydrogen donation. It is visually noticeable as a change in color from purple to yellow. Hence, DPPH is usually used as a substrate to evaluate the antioxidative activity (R.Edamatsu, 1989).The ability of mung bean extracts to quench reactive species by hydrogen donation was determined by the DPPH radical scavenging activity. The antioxidant of the sample can react with DPPH free radical, a violet color is converted in to yellow color of α, α-diphenil-β-picryllhydrazine. The discoloration of the reaction mixture can be quantified by measuring the absorbance at 517nm, which indicates the radical scavenging ability of the antioxidant. The concentration antioxidant of the sample at IC50 was determined from the graph of %inhibition vs concentration.

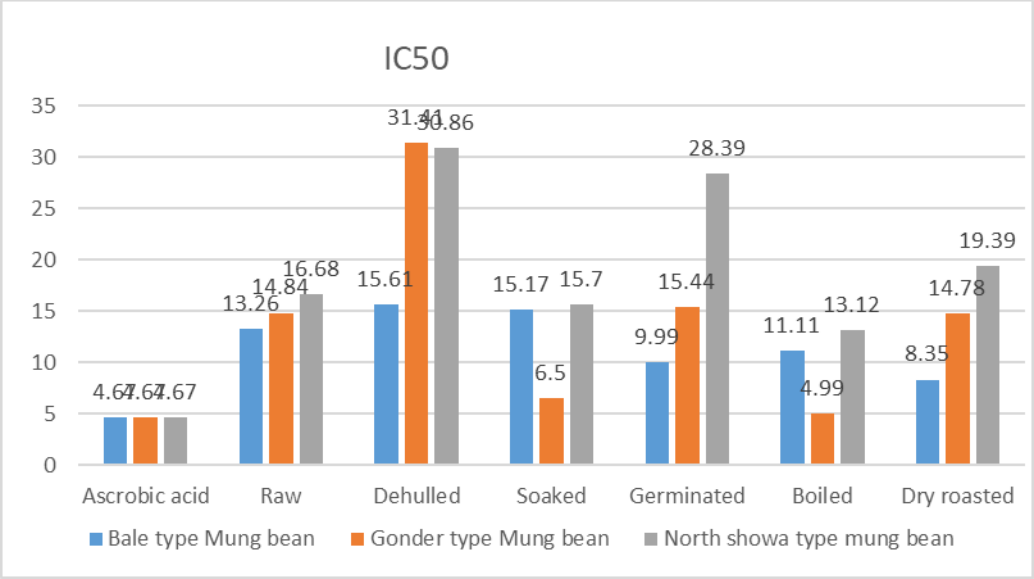


Fig7: Percentage inhibition verse concentration of samples and ascorbic acid at IC50 by DPPH

At the concentration 50mg/ml, the scavenging effect of ascorbic acid and mung bean extract which is collected from Bale, Gonder and North showa on the DPPH radical scavenging decreased in the order of ascorbic acid>boiled >raw>soaked>germinated>dehulled. From the above figure the concentration of the raw and processed mung bean that scavenged free radical ranged from 4.67mg/ml to 31.41mg/ml, which means the minimum value was for ascorbic acid that had the largest antioxidizing activity and the maximum value was for dehulled Gonder type mung bean which had less oxidizing activity. The reduction of antioxidant of the dehulled Gonder and North showa type mung bean sample was due to the removal of the seed cover of mung bean. As concentration increased from 4.67mg/ml to 31.41 mg/ml, the antioxidant activities decreased.

Table 6 Concentration of ascorbic acid and samples at IC50

Variety	Ascorbic acid	Raw	Dehulled	Soaked	Germinated	Boiled	Dry roasted
Bale type Mung bean	4.67	13.26	15.61	15.17	9.99	11.11	8.35
Gonder type Mung bean	4.67	14.84	31.41	6.5	15.44	4.99	14.78
North showa type mung bean	4.67	16.68	30.86	15.7	28.39	13.12	19.39

4.4.3 Determination of Total Phenol

The total phenol content of raw and processed mung bean flour samples were ranged from 14.28 to 125.72 mg GAE/g extract (Table 6). The maximum total phenol content observed for germinated Bale type mung bean flour and minimum total phenol content observed for dry roasted North showa type mung bean flour. Germination had significantly increased the total phenol content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, dry roasting, boiling, soaking and dehulling had significantly decreased the total phenol content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Moreover, there were significant difference among the total phenol content of the Bale type, Gonder type and North showa type mung bean flour sample($p<0.05$). Consequently, there was no significant difference between Gonder type and North showa type mung bean flour sample ($p>0.05$). The interaction of processing methods and origin of mung bean had significant effect on the total phenol content of mung bean flour sample ($p<0.05$). The result of this study reveal that germination increased the total phenol content of mung bean flour sample as compared to the raw mung bean flour sample. But dry roasting, soaking, boiling and dehulling decreased the total phenol content of mung bean flour sample as compared to the raw mung bean flour sample. This shows an increased in phenolic content during germination. Germination process causes release of microbial enzyme which in turn produces more freely available form of plant chemicals like flavonoid, alkaloid and phenyl propanoids (Messens and Vuyst 2002).

4.4.4 Determination of total flavonoid

The total flavonoid content of raw and processed mung bean flour samples were ranged from 42.38 to 190.99 mg DE/g. (Table 6). The maximum total flavonoid content observed for germinated Bale type mung bean flour and minimum total flavonoid content observed for dehulled Gonder type mung bean flour. Moreover, germination and dry roasting had significantly increased the total flavonoid content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Furthermore, dehulling, boiling, and soaking had significantly decreased the total flavonoid content of mung bean flour sample as compared to the raw mung bean flour sample ($P < 0.05$). Consequently, there were significant difference among the total flavonoid content of the North showa type, Bale type and Gonder type mung bean flour sample ($p<0.05$). The interaction of processing methods and origin of mung bean had significant effect on the flavonoid content of mung bean flour sample ($p<0.05$). The result of this study reveal that germination and dry roasting increased the total flavonoid content of mung bean flour sample as compared to the raw mung bean flour sample. But soaking, boiling and dehulling decreased the total flavonoid content of mung bean flour sample as compared to the raw mung bean flour sample. Germination increased the flavonoid content might be due to microbial enzymes, such as glucosidase, amylase, cellulase, tannase, esterase, invertase or lipase produced during germination can hydrolyse glucosides, and break down plant cell walls or starch. These enzymes play a role in disintegrating the plant cell wall matrix and consequently facilitating the flavonoids extraction (Hur *et al*., 2014). Another mechanism is along germination the β- glucosidase of microbial origin could also be used to hydrolyze the phenolic and flavonoids.

Table 7 Total phenol and flavonoid contents of raw and processed mung bean

Method of processing	Variety	Total Phenol(mg GAE/g extract)	Total Flavonoid(mg DE/g)
Raw	Bale type mung bean	$25.71\pm0.87^{c*}$	$66.39\pm0.73^{d*}$
	Gonder type mung bean	$45.14\pm0.40^{c,}$	$77.72\pm0.62^{d**}$
	North showa type mung bean	37.27 ± 0.46^{c}	$87.29\pm0.67^{d***}$
Dehulled	Bale type mung bean	$23.28\pm0.97^{b*}$	$58.45\pm0.91^{a*}$
	Gonder type mung bean	19.04 ± 0.68^{b}	$42.38\pm0.79^{a**}$
	North showa type mung bean	43.85 ± 0.15^{b}	$44.19\pm0.56^{a***}$
Dry roasting	Bale type mung bean	$36.88\pm1.06^{a*}$	$114.24\pm0.58^{e*}$
	Gonder type mung bean	23.62 ± 0.36^{a}	$97.23\pm0.18^{e**}$
	North showa type mung bean	14.28 ± 0.92^{a}	$151.10\pm0.17^{e***}$
Germinating	Bale type mung bean	$125.72\pm13.26^{d*}$	$190.99\pm0.80^{f*}$
	Gonder type mung bean	54.98 ± 0.60^{d}	$143.94\pm0.65^{f**}$
	North showa type mung bean	65.23 ± 0.53^{d}	$173.40\pm0.65^{f***}$
Soaked	Bale type mung bean	$26.46\pm2.29^{b*}$	$71.53\pm0.58^{c*}$
	Gonder type mung bean	39.69 ± 0.97^{b}	$78.32\pm0.70^{c**}$
	North showa type mung bean	29.75 ± 1.13^{b}	$66.08\pm0.29^{c***}$
Boiled	Bale type mung bean	$18.37\pm0.63^{b*}$	$49.51\pm0.09^{b*}$
	Gonder type mung bean	35.60 ± 0.47^{b}	$44.92\pm0.37^{b**}$
	North showa type mung bean	32.99 ± 0.54^{b}	$60.79\pm0.34^{b***}$

All values are the means of triplicates ± standard deviation n=3

Means with the same superscript letters within a column are not significantly different at ($P>0.05$)

a, b, c, d, e, f are superscript to show significance difference between means a<b<c<d<e<f

Means with superscript * indicated there is significant different between origin of mung bean ($p<0.05$)

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Mung bean is one of the exported commodity in Ethiopian Commodity Exchange and consumed pules in Ethiopia. This study attempted to investigate the effect of five processing methods (boiling, dehulling, dry roasting, germination and soaking) on nutritional composition, functional properties, antinutritional factors, and antioxidant activities of raw and processed mung bean flour collected from Bale, Gonder and North showa. From the results of the present study it was understood that mung bean contains adequate amount of carbohydrate, crude fiber, and crude protein. Furthermore, the results of this study also showed that mung bean contains low levels of antinutrients (phytate and tannin) when compared to other pulses and cereals. Moreover, there were further reductions of the antinutritional factors during processing. In addition, it was observed in the study that functional properties of mung bean flour was remarkably higher. Moreover, high water absorption capacity and swelling power than other pulses flour was recorded. However, the solubility index and oil absorption capacity was in the range. Consequently, evaluation of the five processing methods in terms of antinutrients reduction and nutrients enrichment indicated that all the five processing methods were found to be effective in the reduction of antinutrients but effect of germination was found to be highest in the reduction of antinutritional factors. In relation to nutritional profile, the low protein content of mung bean flour sample was observed to be increased by germination and total phenol and flavonoid contents also increased by germination and dehulling. Germination of mung bean flour was a more acceptable process as it was inexpensive, fuel efficient method and environmentally friendly by which people can obtain good quality food and this process can only be performed at their own homes. However, boiling was found to decreased most of the functional properties of mung bean flour. Germination and dry roasting increased oil absorption and reduced most of antinutritional factor of mung bean samples. Therefore among the five traditional applied processing methods germination and dry roasting was recommended process. Finally among the three types of export mung bean varieties (Bale type mung bean, Gonder type mung bean and North Showa type mung bean) in terms of proximity composition, functional properties,

antinutritional factor and antioxidant activities Bale type mung bean was better than Gonder type and North showa type mung bean.

5.2 Recommendations

Due to the low attention given to mung bean in Ethiopia and limitation of mung bean in specific regions and yet no research on it, mung bean cannot known as functional food in Ethiopia

- Encourage public awareness on the importance of mung bean and community based management of these pulse through avoiding antinutritional factors by processing.
- Encourage research on this plant, especially for its potential as a nutraceutical, or pharmaceutical product for use in the treatment of obesity, obesity-related dyslipidemia diabetes, hyperlipidemia and hypercholesterolemia.
- Encourage farmers to cultivate and conserve mung bean that grow in their farmlands to be used in times of drought.
- Analysis should be done for the vitamins and minerals content of mung bean.
- Investigation on more specific properties, such as baking property, of these composite flours should be undertaken in the future to fully investigate their specific application.
- Functional property of mung bean is relatively higher than other pulses, therefore it is a good input for product formulation with other crop.
- The starch characteristic of mung bean should be studied to know how much amylose/amylopectin and gelatinization properties.
- Sensory evaluation of the product should be developed.

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Appendix-1

1. ANOVA and Duncan table of proximity analysis

1.1 ANOVA table of moisture content

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	144.327[a]	17	8.49	98.80	0.000
Intercept	2188.86	1	2188.86	25473.80	0.000
Processing method	129.91	5	25.98	302.374	0.000
Origin	0.164	2	0.082	.957	0.394
Processing method * Origin	14.25	10	1.425	16.588	0.000
Error	3.09	36	0.086		
Total	2336.28	54			
Corrected Total	147.42	53			

1.2 Duncan table of moisture content

Method of processing		N	Subset 1	2	3	4
Duncan[a,b]	dry roasted	9	4.1333			
	dehulled	9		5.2889		
	germinated	9		5.3333		
	soaked	9			7.0444	
	boiled	9				8.0667
	raw	9				8.3333
	Sig.		1.000	.750	1.000	.062

Means for groups in homogeneous subsets are displayed.
Based on observed means. The error term is Mean Square (Error) = .086.
a. Uses Harmonic Mean Sample Size = 9.000.
b. Alpha = .05.

1.3 ANOVA table of Crude protein

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	42.419[a]	17	2.495	13.845	0.000
Intercept	47746.976	1	47746.976	264928.456	0.000
Processing method	37.786	5	7.557	41.932	0.000
Origin	1.153	2	0.577	3.199	0.053
Processing method * Origin	3.480	10	0.348	1.931	0.073
Error	6.488	36	0.180		
Total	47795.883	54			
Corrected Total	48.907	53			

1.4 Duncan table of Crude protein

Method of processing		N	Subset 1	2	3	4
Duncan[a,b]	raw	9	28.0422			
	soaked	9		29.4011		
	dry roasted	9			30.0200	
	boiled	9			30.0389	
	germinated	9			30.3867	30.3867
	dehulled	9				30.5244
	Sig.		1.000	1.000	.091	.496

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .180.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

1.5 Duncan table Export type mung bean origin of Crude protein

Export type mung bean Origin		N	Subset 1	2
Duncan[a,b]	Bale type mung bean	18	29.5600	
	Gonder type mung bean	18	29.7289	29.7289
	North showa type mung bean	18		29.9178
	Sig.		.240	.190

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .180.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

1.6 ANOVA table of Crude fat

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	2.856[a]	17	0.168	36.294	0.000
Intercept	111.227	1	111.227	24025.000	0.000
Processing method	0.634	5	0.127	27.400	0.000
Origin	0.454	2	0.227	49.000	0.000
Processing method * Origin	1.769	10	0.177	38.200	0.000
Error	0.167	36	0.005		
Total	114.250	54			
Corrected Total	3.023	53			

1.7 Duncan table method of processing of Crude fat

Method of processing		N	Subset		
			1	2	3
Duncan[a,b]	dehulled	9	1.3333		
	soaked	9	1.3333		
	boiled	9	1.3333		
	raw	9		1.5000	
	germinated	9		1.5000	
	dry roasted	9			1.6111
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .005.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

1.8 Duncan table Export type mung bean variety of Crude fat

Export type mung bean Origin		N	Subset	
			1	2
Duncan[a,b]	Bale type mung bean	18	1.3056	
	Gonder type mung bean	18		1.5000
	North showa type mung bean	18		1.5000
	Sig.		1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .005.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

1.9 ANOVA table of Total ash

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	9.659[a]	17	0.568	12.784	0.000
Intercept	517.701	1	517.701	11648.267	0.000
Processing method	9.197	5	1.839	41.387	0.000
Origin	0.077	2	0.039	0.867	0.429
Processing method * Origin	0.385	10	0.039	0.867	0.571
Error	1.600	36	0.044		
Total	528.960	54			
Corrected Total	11.259	53			

1.10 Duncan table of method of processing of total ash

Method of processing		N	Subset			
			1	2	3	4
Duncan[a,b]	boiled	9	2.2222			
	dehulled	9		3.0667		
	soaked	9		3.1556	3.1556	
	raw	9			3.2889	3.2889
	dry roasted	9				3.3778
	germinated	9				3.4667
	Sig.		1.000	.377	.188	.099

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .044.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

1.11 ANOVA table of Crude fiber

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	222.590[a]	17	13.094	316.368	0.000
Intercept	310.704	1	310.704	7507.280	0.000
Processing method	198.460	5	39.692	959.045	0.000
Origin	5.705	2	2.853	68.924	0.000
Processing method * Origin	18.425	10	1.842	44.518	0.000
Error	1.490	36	0.041		
Total	534.784	54			
Corrected Total	224.080	53			

1.12 Duncan table of method of processing of Crude fiber

Method of processing		N	Subset			
			1	2	3	4
Duncan[a,b]	soaked	9	1.2756			
	dehulled	9	1.4567	1.4567		
	boiled	9	1.4656	1.4656		
	germinated	9		1.5056		
	dry roasted	9			2.0356	
	raw	9				6.6533
	Sig.		.068	.635	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .041.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

1.13 Duncan table of Export type mung bean variety Crude fiber

Export type mung bean Origin		N	Subset 1	Subset 2
Duncan[a,b]	Bale type mung bean	18	2.1633	
	Gonder type mung bean	18	2.1744	
	North showa type mung bean	18		2.8583
	Sig.		.871	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .041.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

1.14 ANOVA table of Utilizable carbohydrate

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	307.168[a]	17	18.069	44.792	0.000
Intercept	175246.557	1	175246.557	434433.761	0.000
Processing method	266.281	5	53.256	132.021	0.000
Origin	6.228	2	3.114	7.720	0.002
Processing method * Origin	34.659	10	3.466	8.592	0.000
Error	14.522	36	0.403		
Total	175568.247	54			
Corrected Total	321.690	53			

1.15 Duncan table of method of processing of Utilizable carbohydrate

Method of processing		N	Subset 1	Subset 2	Subset 3	Subset 4
Duncan[a,b]	raw	9	52.1822			
	boiled	9		56.8733		
	soaked	9			57.7900	
	germinated	9			57.8078	
	dehulled	9			58.3300	58.3300
	dry roasted	9				58.8222
	Sig.		1.000	1.000	.096	.109

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .403.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

1.16 Duncan table of Export type mung bean variety Utilizable carbohydrate

Export type mung bean Origin		N	Subset 1	Subset 2
Duncan[a,b]	North showa type mung bean	18	56.4906	
	Bale type mung bean	18		57.1578
	Gonder type mung bean	18		57.2544
	Sig.		1.000	.651

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .403.

a. Uses Harmonic Mean Sample Size = 18.000.

b. Alpha = .05.

Appendix-2

2. ANOVA and Duncan table of functional properties

2.1 ANOVA table of Bulk density

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	0.090[a]	17	0.005	756.174	0.000
Intercept	54.888	1	54.888	7799819.379	0.000
Processing method	0.088	5	0.018	2492.726	0.000
Origin	0.000	2	0.000	28.337	0.000
Processing method * Origin	0.002	10	0.000	33.465	0.000
Error	7.04E-006	36	7.04E-006		
Total	54.978	54			
Corrected Total	0.091	53			

2.2 Duncan table of method of processing of Bulk density

Method of processing		N	Subset				
			1	2	3	4	5
Duncan[a,b]	boiled	9	.9318				
	dehulled	9		1.0022			
	dry roasted	9			1.0111		
	soaked	9				1.0164	
	germinated	9				1.0187	
	raw	9					1.0689
	Sig.		1.000	1.000	1.000	.084	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 7.04E-006.

a. Uses Harmonic Mean Sample Size = 9.00

b. Alpha = .05.

2.3 Duncan table of Export type mung bean variety of Bulk density

Export type mung bean Origin		N	Subset	
			1	2
Duncan[a,b]	Bale type mung bean	18	1.0054	
	Gonder type mung bean	18	1.0072	
	North showa type mung bean	18		1.0119
	Sig.		.052	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 7.04E-006.

a. Uses Harmonic Mean Sample Size = 18.000.

b. Alpha = .05.

2.4 ANOVA table of Solubility

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	9093.415[a]	17	534.907	294.628	0.000
Intercept	30645.383	1	30645.383	16879.549	0.000
Processing method	7299.149	5	1459.830	804.078	0.000
Origin	673.263	2	336.632	185.417	0.000
Processing method * Origin	1121.004	10	112.100	61.745	0.000
Error	65.359	36	1.816		
Total	39804.158	54			
Corrected Total	9158.775	53			

2.5 Duncan table of method of processing of Solubility

Method of processing		N	Subset					
			1	2	3	4	5	6
Duncan[a,b]	dehulled	9	13.0500					
	raw	9		14.9511				
	germinated	9			16.9200			
	soaked	9				18.5189		
	dry roasted	9					35.6667	
	boiled	9						43.8278
	Sig.		1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 1.816.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

2.6 Duncan table of Export type mung bean variety of Solubility

Export type mung bean Origin		N	Subset		
			1	2	3
Duncan[a,b]	Gonder type mung bean	18	18.8906		
	Bale type mung bean	18		25.6106	
	North showa type mung bean	18			26.9661
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 1.816.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

2.7 ANOVA table of swelling power

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	1385.333[a]	17	81.490	209.546	0.000
Intercept	10250.667	1	10250.667	26358.857	0.000
Processing method	1004.000	5	200.800	516.343	0.000
Origin	175.000	2	87.500	225.000	0.000
Processing method * Origin	206.333	10	20.633	53.057	0.000
Error	14.000	36	0.389		
Total	11650.000	54			
Corrected Total	1399.333	53			

2.8 Duncan table of method of processing of swelling power

Method of processing		N	Subset			
			1	2	3	4
Duncan[a,b]	dry roasted	9	7.7778			
	boiled	9	7.8889			
	soaked	9		14.7778		
	dehulled	9			17.1111	
	raw	9			17.2222	
	germinated	9				17.8889
	Sig.		.708	1.000	.708	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .389.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

2.9 Duncan table of Export type mung bean variety of swelling power

Export type mung bean Origin		N	Subset		
			1	2	3
Duncan[a,b]	North showa type mung bean	18	12.1111		
	Bale type mung bean	18		12.9444	
	Gonder type mung bean	18			16.2778
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .389.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

2.10 ANOVA table of Water Absorption Capacity

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	10.843[a]	17	0.638	162.312	0.000
Intercept	286.719	1	286.719	72963.360	0.000
Processing method	10.694	5	2.139	544.263	0.000
Origin	0.013	2	0.007	1.664	0.204
Processing method * Origin	0.136	10	0.014	3.466	0.003
Error	0.141	36	0.004		
Total	297.703	54			
Corrected Total	10.985	53			

2.11 Duncan table of method of processing Water Absorption Capacity

Method of processing		N	Subset 1	2	3	4	5
Duncan[a,b]	dehulled	9	1.8400				
	raw	9		2.0200			
	soaked	9			2.1011		
	germinated	9			2.1344		
	dry roasted	9				2.5544	
	boiled	9					3.1756
	Sig.		1.000	1.000	.267	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .004.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

2.12 ANOVA table of Oil Absorption Capacity

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	0.327[a]	17	0.019	259.300	0.000
Intercept	180.914	1	180.914	2442336.400	0.000
Processing method	0.064	5	0.013	172.600	0.000
Origin	0.124	2	0.062	834.100	0.000
Processing method * Origin	0.139	10	0.014	187.690	0.000
Error	0.003	36	0.000074		
Total	181.243	54			
Corrected Total	0.329	53			

2.13 Duncan table of method of processing of Oil Absorption Capacity

Method of processing		N	Subset 1	2	3	4	5
Duncan[a,b]	raw	9	1.7844				
	dehulled	9		1.8033			
	boiled	9		1.8056			
	germinated	9			1.8467		
	soaked	9				1.8656	
	dry roasted	9					1.8767
	Sig.		1.000	.587	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 7.41E-005.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

2.14 Duncan table of Export type mung bean variety of Oil Absorption Capacity

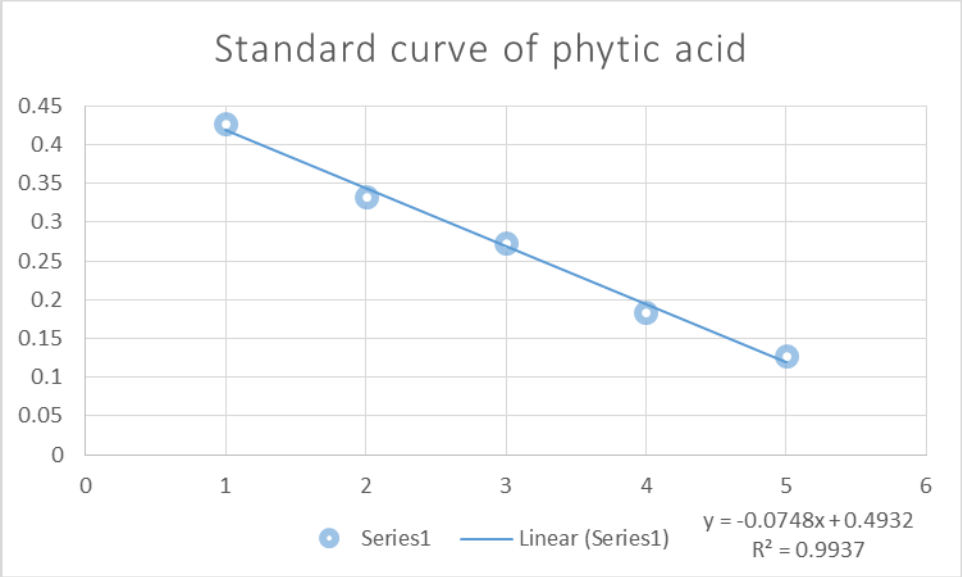
Export type mung bean Origin		N	Subset 1	2	3
Duncan[a,b]	Gonder type mung bean	18	1.7689		
	Bale type mung bean	18		1.8367	
	North showa type mung bean	18			1.8856
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 7.41E-005.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

Appendix-3

3. Standard Curve, ANOVA and Duncan table of Antinutritional factor

3.1 Standard Curve of phytate



3.2 ANOVA table of phytate

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	23983.973[a]	17	1410.822	5320.324	0.000
Intercept	1409620.697	1	1409620.697	5315794.380	0.000
Processing method	7251.338	5	1450.268	5469.077	0.000
Origin	8100.693	2	4050.346	15274.186	0.000
Processing method * Origin	8631.942	10	863.194	3255.176	0.000
Error	9.546	36	0.265		
Total	1433614.216	54			
Corrected Total	23993.520	53			

3.3 Duncan table of method of processing of phytate

Method of processing		N	Subset					
			1	2	3	4	5	6
Duncan[a,b]	soaked	9	143.0644					
	dehulled	9		157.7644				
	boiled	9			160.1978			
	germinated	9				161.6356		
	raw	9					164.1978	
	dry roasted	9						182.5456
	Sig.		1.000	1.000	1.000	1.000	1.000	1.000

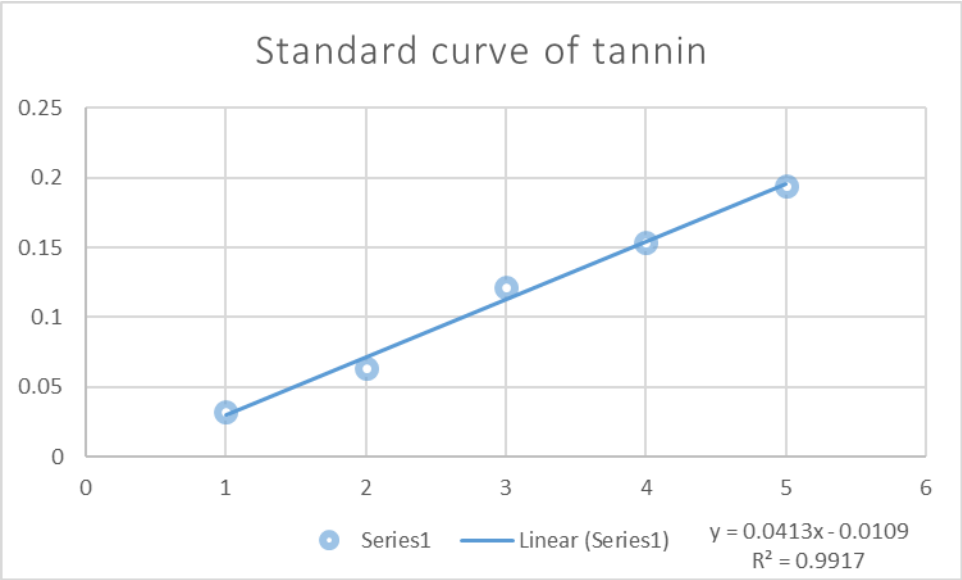
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .265.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

3.4 Duncan table of Export type mung bean variety of phytate

Export type mung bean Origin		N	Subset		
			1	2	3
Duncan[a,b]	Gonder type mung bean	18	144.4878		
	North showa type mung bean	18		167.6117	
	Bale type mung bean	18			172.6033
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .265.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

3.5 Standard Curve of Tannin



3.6 ANOVA table of Tannin

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	340.178[a]	17	20.010	228.386	0.000
Intercept	18352.964	1	18352.964	209468.871	0.000
Processing method	206.242	5	41.248	470.782	0.000
Origin	5.819	2	2.909	33.206	0.000
Processing method * Origin	128.117	10	12.812	146.224	0.000
Error	3.154	36	0.088		
Total	18696.296	54			
Corrected Total	343.332	53			

3.7 Duncan table of method of processing of Tannin

Method of processing		N	Subset 1	2	3	4	5
Duncan[a,b]	germinated	9	14.8556				
	dehulled	9		17.8456			
	boiled	9			18.3233		
	whole	9			18.4178		
	soaked	9				20.0889	
	dry roasted	9					21.0822
	Sig.		1.000	1.000	.503	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .088.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

3.8 Duncan table of Export type mung bean variety of Tannin

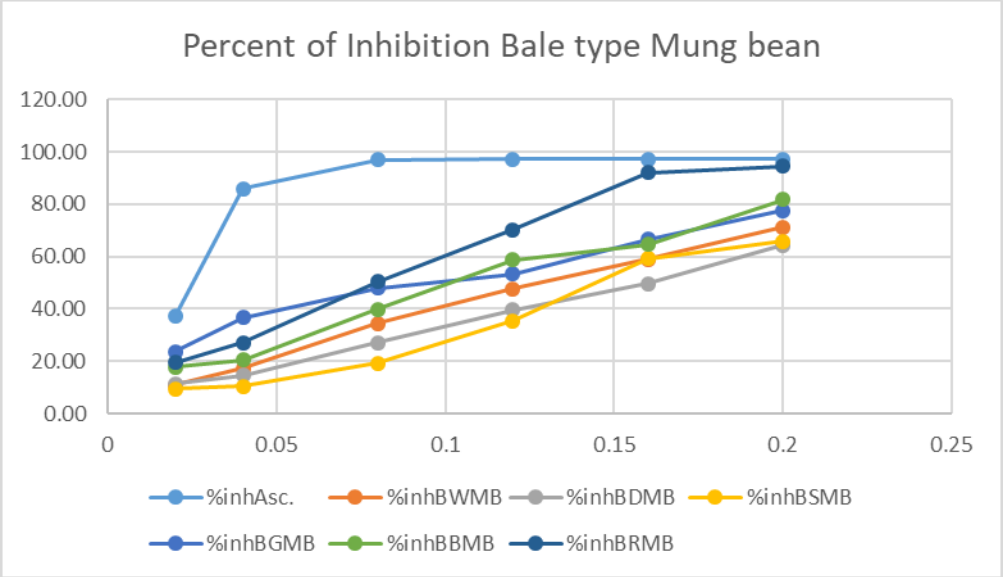
Export type mung bean Origin		N	Subset 1	2	3
Duncan[a,b]	North showa type mung bean	18	18.0589		
	Gonder type mung bean	18		18.3889	
	Bale type mung bean	18			18.8589
	Sig.		1.000	1.000	1.000

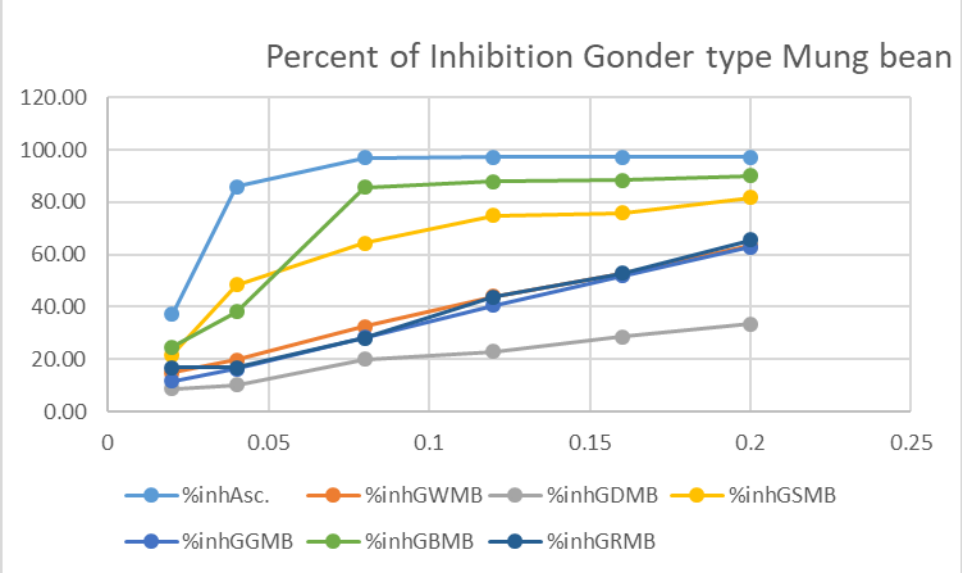
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .088.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

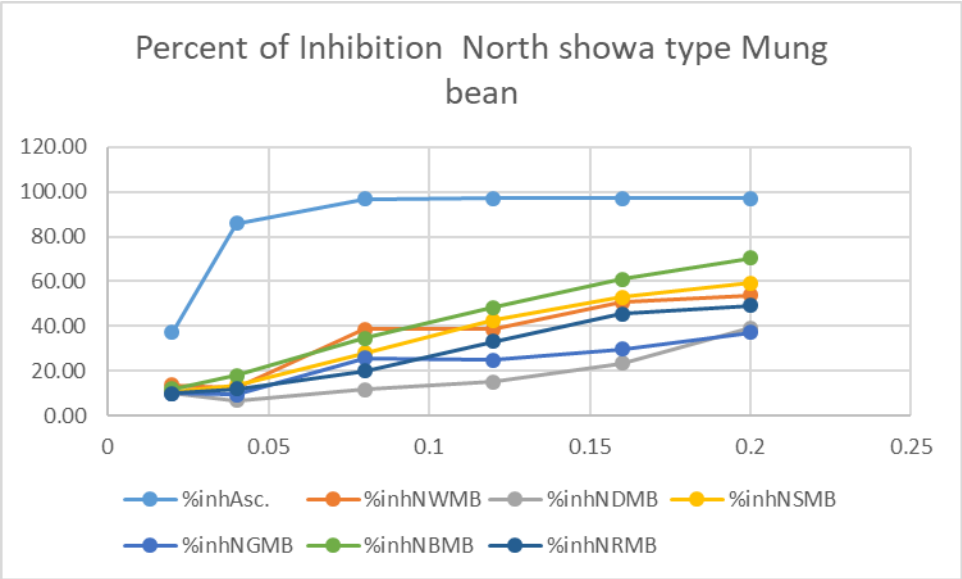
Appendix-4

4 Graph of percent of inhibition for three type Mung bean of DPPH, Standard curve, ANOVA and Duncan table of Antioxidant Activity

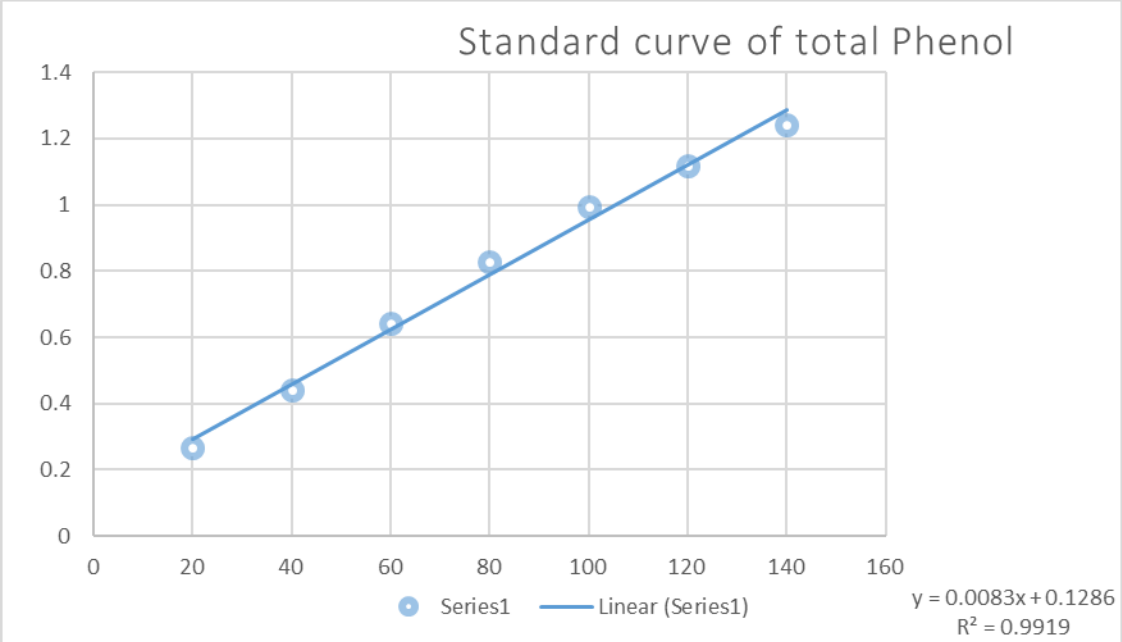
4.1 Graph of percent of inhibition for three type Mung bean of DPPH







4.2 Standard curve of Total Phenol



4.3 ANOVA table of total Phenol

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	32752.587[a]	17	1926.623	183.038	0.000
Intercept	81165.770	1	81165.770	7711.10	0.000
Processing method	20778.126	5	4155.625	394.803	0.000
Origin	431.672	2	215.836	20.505	0.000
Processing method * Origin	11542.790	10	1154.279	109.662	0.000
Error	378.930	36	10.526		
Total	114297.287	54			
Corrected Total	33131.517	53			

4.4 Duncan table of method of processing of total Phenol

Method of processing		N	Subset			
			1	2	3	4
Duncan[a,b]	dry roasted	9	24.9267			
	dehulled	9		28.7222		
	boiled	9		28.9867		
	soaked	9		31.9656		
	raw	9			36.0411	
	germinated	9				81.9744
	Sig.		1.000	.051	1.000	1.000

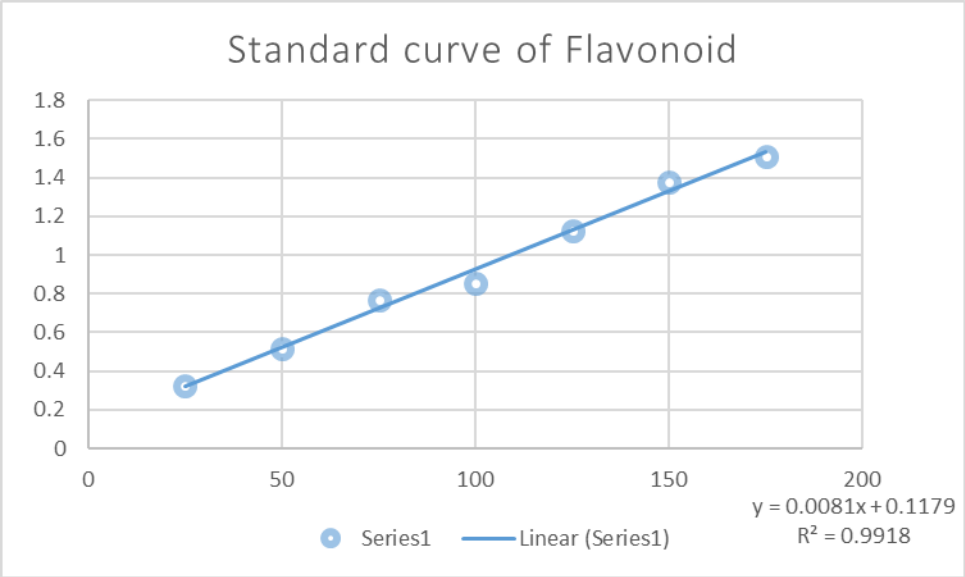
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 10.526.
a. Uses Harmonic Mean Sample Size = 9.00
b. Alpha = .05.

4.5 Duncan table of Export type mung bean variety of total Phenol

Export type mung bean Origin		N	Subset	
			1	2
Duncan[a,b]	Gonder type mung bean	18	36.3467	
	North showa type mung bean	18	37.2261	
	Bale type mung bean	18		42.7356
	Sig.		.421	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 10.526.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05

4.6 Standard curve of Flavonoid



4.7 ANOVA table of Flavonoid

Source	Sum of Squares	df	Mean square	F	Sig.
Corrected Model	108268.596[a]	17	6568.388	18567.731	0.000
Intercept	436572.392	1	436572.392	1272874.529	0.000
Processing method	98575.374	5	19715.075	57481.456	0.000
Origin	2519.479	2	1259.739	3672.908	0.000
Processing method * Origin	7167.743	10	716.774	2089.834	0.000
Error	12.347	36	0.343		
Total	544847.335	54			
Corrected Total	108274.943	53			

4.8 Duncan table of method of processing of Flavonoid

Method of processing		N	Subset					
			1	2	3	4	5	6
Duncan[a,b]	dehulled	9	48.3389					
	boiled	9		51.7411				
	soaked	9			71.9789			
	raw	9				77.1322		
	dry roasted	9					120.8556	
	germinated	9						169.4422
	Sig.		1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .343.

a. Uses Harmonic Mean Sample Size = 9.00

b. Alpha = .05.

4.9 Duncan table of Export type mung bean variety

Export type mung bean Origin		N	Subset 1	Subset 2	Subset 3
Duncan[a,b]	Gonder type mung bean	18	80.7500		
	Bale type mung bean	18		91.8533	
	North showa type mung bean	18			97.1411
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .343.

a. Uses Harmonic Mean Sample Size = 18.000.

b. Alpha = .05