EFFECTS OF VARIETY AND MOISTURE CONTENT PRIOR TO ARTIFICIAL DRYING ON RAW AND CUP QUALITY OF COFFEE *(Coffea arabica.*L*)* AT GEMADRO COFFEE PLANTATION

MSC THESIS

BY

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JIMMA, ETHIOPIA

EFFECTS OF VARIETY AND MOISTURE CONTENT PRIOR TO ARTIFICIAL DRYING ON RAW AND CUP QUALITY OF COFFEE *(Coffea arabica.*L*)* AT GEMADRO COFFEE PLANTATION

A Thesis submitted to the School of Graduate Studies of Jimma University, College of Agriculture and Veterinary Medicine in Partial Fulfillment of the Requirements for the Degree of Master of Science in Post-Harvest Management (Perishable Crops)

By

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August, 2015

DEDICATION

This thesis is dedicated to my beloved family especially, my father Gebre Haile for all the sacrifices, requirements and creditable to my success in all my activities.

STATEMENT OF THE AUTHOR

I declare that this thesis, submitted in partial fulfillment of the requirement for MSc. Degree in Post-Harvest Management to Jimma University College of Agriculture and Veterinary Medicine, is my own original work and has not been submitted to any institution anywhere for the award of any academic degree or diploma. All sources of materials and financial support used for this thesis work have been appropriately acknowledged. This thesis can be deposited in the university library to be made available to readers or borrowers come to pass under rules of the university library. Brief quotation from this thesis is allowable without special permission provided that accurate acknowledgement of source is made. In all other instances, however, permission must be obtained from the author.

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BIOGRAPHICAL SKETCH

ElsabethGebre was born in Mettu town on January 17, 1986. She attended her Elementary, Junior Secondary and High School education at 04 kebele Elementary School, kidusGebrielJunior Secondary and Mettu High School, respectively. She joined then Jimma University Ambo College (now Ambo University) in 2004 and graduated on 2006 with B.Sc degree in crop production and protection.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CLU	coffee liquoring unit
CQI	Coffee quality Institute
CTA	Coffee and Tea Authority
EAFCA	East African Fine Coffee Association
ECQIAC	Ethiopian Coffee Quality Inspection and Auction Center
ECX	Ethiopian Commodity Exchange
ha	hectare
FAO	Food and Agriculture Organization
ICO	International Coffee Organization
ISO	International Standard Organization
ITC	International Trade Center
LSD	Least of significance difference
MoARD	Ministry of Agriculture and Rural Development
OTA	Ochratoxin A
'Q'	Quality
QSAE	Quality and Standard Authority of Ethiopia
SAS	Statically Analysis Software
SCAA	Specialty Coffee Association of America
SNNPR	Southern Nations, Nationalities and Peoples Region
UG	under Grade

Abstract

With respect to the maintenance of coffee quality, drying is the most critical post-harvest processing step. This step is crucial since it will dictate quality performance of coffee. The objective of this study was to evaluate variations in terms of quality of coffee subjected to mechanical drying with different initial moisture contents (21, 40 and 60 percent) and determine appropriate initial moisture content of parchment coffee for mechanical drying of different coffeevarieties. Red ripe cherries of six different varieties (744, 7454, 74110, 74112, 74165, 75227) and one control treatment (local method of working at Gemadro coffee plantation by mixing all varieties) were harvested and processed from Gemadro coffee plantation and examined for physical and sensory attributes with factorial complete randomized design. Accordingly, findings of the study revealed significant variations for all coffee raw quality attributes. Moisture content and variety had significant effect on primary defect, secondary defect and shape and make while Color, odor and raw qualities were significantly affected by the interaction of the two. ANOVA result for Cup quality showed all cup quality attributes except cup cleanness were affected by variety and moisture content and interaction effect was significant for acidity and specialty value. The result pertaining to raw quality depicted that coffees pre-dried to as low as 21 percent moisture content had higher raw quality value for most varieties whereas,the poorest raw quality value was recorded for coffees dried directly by mechanical drier without any pre-drying. The cup quality value also indicated that higher coffee quality with sweet balanced cup was recorded for most coffee varieties pre-dried to 21 and 40 percent moisture content before mechanical drying and coffee varieties dried mechanically without sun drying recorded poor or fair cup values. From the present findings, it could be concluded that pre-drying coffee to reduce initial moisture content will help to preserve the inherent quality of coffee.

Key: Mechanical drier, moisture content, Arabica coffee, varieties, quality, wet processing

1. INTRODUCTION

Coffee is an edible commodity that belongs to the family *Rubiaceae*and genus *Coffea*. It is widely used as a beverage and is composed of hundreds of components, now a day's it's also used as input in some food processing industries (ECQIAC, 2007). For instance, it is used as a flavoring agent to various pastries, ice-creams, chocolate, etc.

In genus *Coffea* there are around 124, species (Davis *et al*. 2011), but two of them *Coffea Arabica* and *Coffeacanephora*are the dominantly cultivated for commercial production (Willson, 1`999). Coffee made from Arabica beans has an intense, intricate aroma that can be reminiscent of flowers, fruit, honey, chocolate, caramel or roasted bread with less than 1.5 percent by weight caffeine content. Because of its superior quality and taste, Arabica coffee sells at higher price (Illy, 2002). Ethiopia is well known not only for being the home of Arabica coffee, but also for its very fine quality coffee acclaimed for its aroma and flavor characteristics. The coffee that is distinguished for such unique characteristics include Sidamo, Yirgachafe, Harar, Gimbi, Jimma and Limmu coffee types (Anwar, 2010).

Coffee is the most important agricultural commodity that ranks second only to petroleum in terms of dollar traded accounting for exports worth an estimated US$ 15.4 billion in2009/10 More than 80 countries including Ethiopia, cultivate coffee, which is exported as the raw, roasted, or soluble product to more than 165 countries worldwide. Coffee is exported and/or re- exported by more than 121 countries. More than 50 developing countries in the world, 25 of them in Africa, depend on coffee as an export with 17 countries 25 % of their foreign exchange from coffee (CTA, 1999; ICO 2012).

Ethiopia holds a unique position in the world as *Coffeaarabica* L. has its primary centre of diversity in the south-western highlands of the country (Jean-pierre et al., 2008) and also Ethiopia is the world fifth largest Arabica coffee producer (ICO, 2014). Coffee is one of themost important commodities to the Ethiopian economy. It has been the country's most important cash crop and largest export commodity.

The Ethiopian economy is highly reliant on coffee as it contributes more than 25% of the country's foreign exchange earnings (Ministry of trade, 2012). The largest volume of coffee is grown in the two large regions of Ethiopia, Oromia (in the central part of the country) and the Southern Nations, Nationalities and Peoples Region (SNNPR). Only five percent of coffee production is grown on modern plantations, which are owned by private investors or by the government. The rest is grown by smallholder farmers, and about half of that production is in backyards or gardens (USDA, 2012).

Coffee fruits are processed using several different steps for beverage production; these steps have a pronounced effect on the final quality of the resulting beverage (Mazzafera and Purcino, 2004; Bytof*et al*., 2005). Processing coffee is the method of converting the raw coffee cherry into the commodity green coffee (coffee bean). The fundamental purpose of green coffee processing is the recovery of the beans, by removing the various covering layers and drying to produce green.

Coffee beans have to be dried down to a safe moisture content level, at least 11-12%. Mold development will be minimized at this level. It is also reported that breakage during the hulling process will also decrease under this level of moisture content (GTZ, 2002). During the coffee drying process, variations in the structure of the beans (color, aspect, defects, bouquet and flavor, etc.) can occur, affecting the quality of the beverage. Sun drying of coffee is the preferred drying technique. It is cheap and in addition, the ultraviolet rays of sun considered to bleach out chlorophyll from the beans, which will reduce the green and grassy flavor components from coffee bean. However, the rainfall distribution at Gemadro coffee plantation is almost nine months. As a result, the farm is forced to use artificial driers for both washed and unwashed coffees. The initial moisture content of the parchment coffee is about 40%, by mixing different varieties of coffee. There is hardly any effort made so far to determine optimum initial moisture content of parchment coffee for mechanical drying ofdifferent varieties of coffee. Therefore, the present study was carried out with the following objectives

General objective

- To evaluate the effect of initial moisture content and variety on the raw and cup quality of mechanically dried parchment coffee

Specific objectives

- To assess the raw and cup quality of coffee varieties at Gemadro coffee plantation
- To determine the optimum initial moisture content of different coffee varieties for mechanical drying
- To evaluate the interaction effect between initial moisture content and variety on the green and cup quality of coffee

2. LITERATURE REVIEW

2.1 Coffee diversity

Coffee is an evergreen Coffee is an evergreen shrub or small tree belonging to the *Rubiaceae* family, which comprises around 124, species of the genus *Coffea* (Davis *et al*., 2011). The two species that are commercially exploited are *Coffeaarabica L,* which accounts for two thirds of world production, and *C. canephora,* often-called Robusta coffee, with one third of global output (Llly, 2002). The size of the plant varies depending on the species. It ranges from small woody shrubs to a large forest tree. Robusta is a high yielding and disease resistant tree standing up to 12 meters tall. But C. *arabica L* is a medium to low yielding tree from 5 to 6 meters tall (Llly, 2002). Phenotypic variation between species is enormous. Some are deciduous while others are evergreen. Leaves range in colour from yellow and dark green to bronze and purple-green; their size vary from 1 to 40 cm in length, *Coffealiberica*L. having the largest leaves. Species differ considerably in the type of fruit they bear, ranging from being good and sweet flavored to being distinctly inedible. Fruit size ranges from that of a small pea to a good-sized plum. Flowers range from being small, unattractive and scentless to being large and densely clustered with abundant fragrance. Some species have white flowers, some pink or almost purplish and some creamy to yellowish (Wellman, 1961).

The genus *Coffea*is not only endowed with enormous morphological variation, but also with adaptation to a wide range of environments. It grows between the latitudes of 25^{o}N and 25^{o}S but requires very specific environmental conditions for commercial cultivation. Temperature, rainfall, sunlight, wind, and soils are all important, but requirements vary according to the varieties grown. Ideal average temperatures range between 15 and 24^{o}C for *Arabica* and 24 - 30^{o}C for *Robusta* at altitudes around 2,000 m. In general, coffee needs an annual rainfall of 1,500 to 3,000 mm, Arabica coffee needing less than other species. The pattern of rainy and dry periods is important for growth, budding, and flowering (Hicks 2001).

2.2 Coffee in Ethiopia

The Ethiopian economy is highly dependent on coffee as it contributes more than 25% of the country's foreign exchange earnings and it contributes more than 60 % of the country's foreign exchange earnings. No other product or service in Ethiopia has earned as much (Coffee and Tea Authority, 1999; Ministry of Trade, 2012). The labor intensive tree crop also provides much employment in rural areas and is the livelihood for over 15 million people in Ethiopia (Coffee and Tea Authority, 1999).

There are four types of production system in Ethiopia: forest coffee, semi forest coffee, garden coffee and plantation coffee. Forest coffee is found in south and south- western Ethiopia (Bale, Kaffa, West Wollega, Shekka, Metu and Jimma Zones (Coffee and Tea Authority, 1999). It accounts 10 % of Ethiopia's total coffee production. Semi - forest coffee production system is also found in the south and south - western parts of the country. It accounts 35 % of Ethiopia's total coffee productions. Garden coffee is grown in the vicinity of farmers' residences, mainly in the southern and eastern parts of the country. It accounts for about 35 % of Ethiopia's total coffee production. Plantation coffee includes that grown plantation owned by the former state and some well managed smallholder coffee farms (Coffee and Tea Authority, 1999). The former state plantation accounts about 5% of total production and well-managed smallholder coffee farms account 15 % of the Ethiopia's total production.

Processing coffee is the method of converting the raw coffee fruit (cherry) into the commodity green coffee (coffee bean). In Ethiopia, there are two ways of coffee processing. They are wet method (washed coffee) and dry method (natural coffee). The wet method is used in regions where there is plentiful supply of water. It involves more capital outlay and more care than the dry method. The dry method is simple. It is all done with exposure to the sun. In general, the coffee produced by wet method is usually of better quality but commands higher prices (ECQIAC, 2007).

From the total coffee production of Ethiopia, the highest proportion accounts for natural coffee. That is, dry processed coffee is supplied to the market (ICO, 2000, Endale, 2007). Relatively, a small portion of coffee production is washed coffee. The coffee supplying areas for washed and unwashed coffee include Yirgacheffe, Sidamo, Limu and Bebeka. Mainly unwashed coffees are from Harar, Jimma, Bale, Wellega and Illubabor. Coffee in each specific area has particular physical and chemical properties which attributes to distinct characteristics of the region. Coffee is graded for export with the objective of producing the best cup quality and there by securing the best price possible. However, there is no universal grading system. Each producing country has its own national standard which fulfills the minimum export quality requirement suggested by the market (ITC, 2002; ICO, 2000; Endale, 2007).

Coffee grading in Ethiopia is conducted by Ethiopian commodity exchange through the combination of two methods (Endale, 2007). They are green coffee (raw bean) analysis and cup tests (liquoring)(ECX, 2012). Green coffee analysis involves visual inspection of physical characteristics of coffee bean. This includes screen analysis which makes size assessment, defect count, appearance or color test and shape which usually refers to the structure of beans. Cup test is based on roasted coffee analysis (chemical process) by which aroma, acidity, and other flavor components are tested, from the overall grading of coffee, green analysis accounts 40% and cup test accounts 60% in the quality inspection process (ECX, 2012).

2.3 Origin, growing areas & characteristics of Arabica coffee

Arabica coffee is the only species found in Ethiopia. Its centre of origin is geographically isolated from the center of origin of other species of the genus *Coffea*. It is confined to the highland of southwestern Ethiopia and on the Boma plateau of Sudan (Anthony *et al*., 2001]). Arabica coffee is the earliest known and most widely distributed coffee species. It is grown throughout the tropical belt and in some areas even beyond the two tropics as in Brazil and Mozambique in the southern and in China in the northern hemisphere. Arabica coffee has its origins in Ethiopia, which remains Africa's largest producer of Arabica beans. Due to the dominance of traditional techniques, yields are low and although there is a good growing condition, Ethiopia is one of the world’s lowest cost Arabica producers. National annual production is approximately 280,000 metric tons (EAFCA, 2008). In Ethiopia, coffee grows almost everywhere, under diverse environmental conditions ranging in altitude from 550-2600m above sea level and annual rainfall of 1000-2000mm (Wrigley, 1988). Although the major production areas are more concentrated in the south western and south eastern parts, coffee grows all over the country.

The size and shape of the beans differ depending upon the variety, environmental conditions and management practices. On average, beans are 10mm long, 6-7mm wide, 3-4mm thick and weigh between 0.15 and 0.20g (CLU, 2008). Bean color can be yellowish-grey to slate-grey, bluish or grey-green, depending upon the variety, method of preparation and storage condition. Bean shape may be sub-globular, ovoid, oblong, linear-oblong, either rounded at both ends or pointed at one end and rounded at the other (FAO, 2005).

Farmers use organic materials and environmentally sound processing practices in order to produces a truly organic product. The reach genetic wealth, the vast and highly suitable environmental conditions offer the greatest opportunity to produce superior quality coffee. Ethiopian significant coffee producing regions have a particular taste and characteristic therefore, these coffee types are internationally well known. According to the International Trade Centre (ITC), ‘Ethiopia produces some of the world’s finest “original” coffees such as Yirgacheffe, Limu and Harar. Other varieties of distinctively flavored coffee beans produced in Ethiopia, based on their contribution to the country’s export are Jimma, Gimbi, Lekempti and Sidamo. These coffee types are internationally recognized and marketed either in blend or as 100% Ethiopian products, and they command high prices.

2.4 Green coffee production

Good harvesting methods are important to produce good quality coffee. Therefore, awareness about quality is important throughout the entire agricultural process (Farah, 2012). Coffee fruits are typically harvested in one of three ways: picking, stripping, or mechanical harvest. In the first method, the ripe fruits, known as cherries, are picked one at a time. Because coffee fruits do not usually ripen simultaneously, this method is time-consuming and therefore expensive where the size of the workforce is not sufficient. However, picking tends to produce better-quality coffee seeds, in terms of both taste and health, than other methods. Manual stripping of the twigs collects immature, ripe, and overripe seeds along with leaves.

Mechanical harvesting is performed by shaking the trees or by stripping the branches with an apparatus similar to a flexible comb. Stripping and mechanical harvesting yield defects derived from fruits in different degrees of maturation and fermented fruits. Extrinsic defects include stones, husks, and twigs that are mixed with the fruits during harvesting. Intrinsic defects, which are usually more relevant for cup quality and health, are defective seeds such as immature, black, sour, black-immature, bored or insect-damaged, and broken. Immature seeds, which originate mainly from unripe fruits, increase beverage astringency. Sour seeds can be due to lack of water during fruit development or abnormal fermentation of immature or mature seeds. Sour seeds may also precede the formation of black seeds, which usually originate from overripe cherries that fall to the ground by the action of rain or during harvest and contact with the soil promotes microbial fermentation. Black seeds can also originate from carbohydrate deficiency caused by poor agricultural practices or microbial fermentation of seeds while still on the tree or during postharvest processing. The silver skin of the black immature seed is dark or black–green due to the action of high temperatures on the immature seed. Black-immature seeds can also be produced by inadequate drying of immature seeds.

After harvest, coffee fruits undergo pulp extraction to produce green coffee seeds. The most common methods of pulp extraction are known as wet and dry methods. With the dry processing method, seeds are exposed to the sun or air dryers until the moisture content is approximately 10%–12% . If air dryers are not available, low rainfall during harvest is needed to ensure a good-quality coffee. After drying, the fruits are cleaned and dehulled, and then the dried skin and pulp are removed, leaving a mucilaginous material (silver skin) adhering to the seed surface. To obtain a good-quality beverage, the seeds (two seeds per fruit) are mechanically and electronically sorted to separate defective seeds from the high quality seeds. This method is commonly used in Brazil and Africa, where sun and space are abundant and fruits are often harvested by stripping.

2.4.1 Harvesting and its effect on quality

Coffee fruits are harvested when the fruits are in the 'cherry' stage (the fruit turns red as it ripens). Each fruit consists of a peel (exocarp), the pulp (mesocarp) and the parchment (endocarp), which is surrounding the beans (seeds). Within the pulp, the seeds are covered by a thin parchment-like hull (silver skin). Both the pulp and hull are removed before the coffee beans are roasted (Arya and Rao, 2007).

The most common defect in coffee comes from harvesting green coffee. Dependingon the magnitude of care during harvesting and post harvesting processes, strong consequences on coffee quality can be observed (TirufatDejene, 2011). Achieving coffee quality by harvesting ripe cherries or harvesting a mixed product and complementing with proper post-harvest treatment is a cost benefit decision that coffee growers have to face. If only ripe cherries are picked, the volume of quality is higher, but harvesting cost is higher, too. If a mixed product is picked, the volumes of quality coffee are smaller, but harvesting cost falls. The decision facing the grower is whether the saving in harvesting cost offset the loss of income from less quality coffee. If they do, the growers should move away from selective hand picking to stripping and modern mechanical harvesting systems to maximize their profits. Selective coffee picking is not the only to ensure that quality in the tree is transferred to the cup rather it should be combined with proper processing techniques (Mburu, 1999). The fact is that selective picking is no more than an indicator of only sound, red, ripe cherries should be used as raw material to produce the finest bean from which a perfect cup is brewed.

High quality coffee is demanded and well paid for by international traders and coffee roasters. Thefinal quality of the green bean depends to a large extend on the processing practice, field management also has influence. Here, farmers have an important role to play. Although a bad quality of green bean may not seem a problem for farmers, but when the exported coffee is rejected, the competitive power of the exporting company will become less, which will make it more difficult to export coffee and obtain a good price. In the end, this will affect negatively the price that the farmers received (Kuit*et al.*, 2006).

The decision facing the grower is whether the saving in harvesting cost offset the loss of income from less quality coffee. If they do, the grower should move away from selective hand picking and in to stripping and modern mechanical harvesting systems to maximize his profits (Wintgens, 2004). Selective coffee picking is not the only way to ensure that quality in the tree is transferred to the cup. The fact is that selective picking is no more than an indicator that only sound, red, ripe coffee cherries should be used as raw material to produce the finest bean from which a perfect cup is brewed. Sound, fresh, red, ripe cherries may be obtained from a variety of picking practices combined with processing techniques (Sivetz and Desrosier, 1979; Wintgens, 2004).

2.4.2 Postharvest coffee processing

Processing is a very important activity in coffee production and plays a crucial role in quality determination (TirufatDejene, 2011). Post-harvest practices in coffee play an important role in preserving and enhancing the intrinsic quality of coffee. Poor coffee harvest and post-harvest practices can lead to poor quality and contaminated coffee. In particular, poor drying, re-wetting and bad storage practices in the post-production handling of coffee commonly lead to mould growth which can result in ochratoxin A (OTA) contamination and to off flavors in the final product.

Coffee processing must begin immediately after the fruit is harvested, to prevent the pulp from fermentation and deteriorating (Hicks, 2001). Coffee processing is a method of converting the raw fruit of the coffee into commodity green coffee. Coffee is either processed by wet processing method (washed) or dry processing method (natural or unwashed), which vary in complexity and expected quality of the coffee (Wintegens, 2004; ECQIAC, 2007). The method chosen to prepare green coffee in producing countries depends on the species grown, and on the conditions and resources in each production region (Oscar Gonzalez *et al.*, 2006).

2.4.2.1 Dry processing method

The dry method also called the natural method it is the oldest, simplest, and cheapest method. It produces ‘natural’ coffees and is adopted mostly in Brazil and Africa and requires little machinery (TirufatDejene, 2011). In the dry processing, the fruit are allowed to remain on the tree until the fully ripe stage. After harvesting, coffee berries are laid out in the solar to dry until 12% of moisture content in the final beans. The dry method is simpler and cheaper, but the coffee product is usually lower quality than the product from wet processing (Sivetz, 1963; Clarke, 1985; Varnam and Sutherland, 1994).

The coffee during the drying period, which lasts 8-10 days in favorable conditions, solar drying is subject to the vagaries of atmospheric conditions, together with the possibilities of growth of both desirable and undesirable microorganisms generating substances from the drying pulp, affecting subsequent flavor of the coffee brew made from the coffee after roasting hot air drying is widely used in large scale operations in Brazil and also in Africa. Hot air can be used for the entire drying process, which is reduced in length to3 days. The time which the coffee is maintained at a given temperature during drying process is just as important in its effect on quality. Overheating during drying produces sour or cooked flavors in the brewed coffee (Sivetz, 1963).

2.4.2.2 Wet processing method

It is another method of preparation. It produces so-called ‘washed’ or ‘mild’ coffees and the aroma of coffee in wet processing is superior to that of dry processed coffee, because, firstly the method gets rid of low quality berries by flotation cleaning and secondly, parchment coffee is easier to dry than whole berries (Jacquet*et al*., 2008). The drying takes less time and the risk of mould and other hazards is consequently reduced. This involves more capital outlay, more water, and more care than the dry method. It does help to preserve the intrinsic qualities of the bean better, producing a green coffee which is homogeneous and has few defective beans. The coffee produced by this method is regarded as being of better quality and commands higher prices (Hicks, 2001).

The main difference between the wet and dry methods is that the wet method removes the pulp from the bean within 12-24 hours of harvesting instead of allowing the berries to air dry. Wet coffee processing consists in removing pulp and skin from the drupes while still fresh. It involves several stages, in which considerable amounts of water are used, notably for microbial mucilage removal. It is now possible to carry out that stage in a recently invented mechanical mucilage remover, which uses less water and is more ecological (Quintero, 1999). This process is more sophisticated than the dry process, and by general consent leads to better quality coffee and commands a higher price (Clarke, 1985). Only ripe berries should be used for wet processing, classification by flotation in water is most convenient and involves at least two stages, first to remove stones and dirt, and second to separate cherries (Clarke, 1985).Wet processing goes through pulping, fermentation, washing, soaking, drying and cleaning.

Pulping: It is a process in which cherry is fed in to the pulping machine which separates each berries (beans) from their skins then the parchment coffee is fed in to the pre grader and the skin will led to a skin pit. Quality defects can be seen during pulping in three forms these are Beans may be discharged with the skins broken and lost, Beans may be nipped and Beans may be hulled of their parchment cover but otherwise be intact Defects under the first problem are obviously lost, nipped/chipped or cracked beans and the defects under the second problem are ruined and can only be sold as inferior, low grades after being removed by hand and the last grouped in third may appear whole but they always dry to a poor green bean appearance, a dull roast appearance and with a coarse, unattractive flavour.

*Fermentation**:*** It is a process of removing sticky mucilage from the parchment. If the mucilage were not removed, there would be impeded drying and the beans would attract moulds and insects. There is a considerable risk of brown colors developed during fermentation. Therefore the best way of avoiding this is to use the two stage fermentation.

Washing: During washing the coffee seeds floated on the water surface classified to be low quality, because these coffee seeds are not matured to the proper size and density. Some coffee seeds floated at the middle of the bath referred as an average quality. The best quality coffee is achieved from the bottom of the bath. The soaking tank used to reduce the amount of water required to wash the pulped coffee and it ensures the browning substances are removed from the bean and therefore gives the best quality coffee.

2.4.3 Coffee drying and different drying methods

The drying of coffee is a step in coffee processing that is required, as for many other food crops, to stabilize an otherwise unstable product. Drying is simultaneous process of heat and mass transfer between the product to the drying air that consists on excess moisture content removal from the product by means of evaporation process, generally caused by heated air convection forces with the objective for maintain the product quality during the storage (Correa *et al.,* 2006).

Whatever type of processing is employed, the result must be dry coffee. The whole drying process can be carried out by means of exposure to sunlight in the wet season solar drying of produce is difficult. Rain is very unpredictable and frequent. Sun drying will prevent the coffee getting wet. However, due to the low level of sunlight it can take a long time. This can lead to mold growth so an alternative drier or mechanical drier is needed on the large plantations (Tirufat Dejene, 2011).

Drying operation is one of the most important steps in the coffee post harvesting processing. The use of natural sun drying process of coffee is still very common among the coffee producers. However, it requires high labor; it is a time requiring operation and on dependency on the climatic conditions. As coffee production increases, sun drying operation happens to be problematic in terms of coffee production operation and mechanical drying becomes a need due to the possibility of advancing the harvesting operation, allowing to harvest better coffee in terms of quality and quantity and making it possible to destine usable areas for other (Paulo *et al.,* 2006). It is not in any way a trivial processing step, regardless of the degree of technology employed, and quality can easily be lost by drying that is too slow, too fast or otherwise inappropriate. Depending on the processing method employed, the whole fruit, the crushed fruit, parchments (bean enclosed by the inner integument), or naked beans may be dried (FAO, 2013). The agricultural product conservation through the drying process is based on the fact that the microorganisms or enzymes and all metabolic mechanism need water for their activities. Reducing the available water down to the safe storage level the water activities, the chemical reactions and the microorganism development are slowed down (Christensen and Kaufmann, 1974).

2.4.3.1 Sun drying

Whenever climate conditions allow, sun drying is the preferred drying technique. It is cheap and in addition, the ultraviolet light of the sun is considered to bleach out chlorophyll from the beans, reducing green and grassy flavor components. Sun drying needs to be supervised very carefully as site and climate conditions strongly influence coffee quality (GTZ, 2002). The coffee should be sheltered from the rain since rain lengthens the drying process and can cause mildew; it should also be protected against very high temperature during the hottest part of the day. Drying of washed coffee Consists of three drying stages this are quick drying or skin drying, slow drying and final or main drying.

Skin Drying: - the coffee from the soaking tank will be put onto skin drying trays to drip or evaporate the foreign moisture off the parchment as quickly as possible within three hrs. period, this is usually done in the morning since defective coffee beans; pulp or any other extraneous materials are clearly visible at this stage should be removed off completely.

Slow Drying: - after skin drying, the coffee is allowed to dry slowly, thinly spread on to the drying table at a depth of not more than 1" and frequently stirred. Slow drying avoids parchment cracking and taken about three days (Coffee and Tea Development and Marketing Authority, 1995).

Main Drying:-The coffee on drying tables is spread thinly and turned frequently till it attains a moisture content of 11.5 to 10.5%. Protect the parchment coffee from direct midday sunshine by covering the coffee with hessian cloth and from rain by covering with plastic sheeting. The drying beds can be made of chicken wire and hessian cloth or wire mesh. The parchment cover protects the green bean from any contaminates or any bean damage, this helps to preserve the quality of washed coffee. It is therefore important to keep washed coffee with its parchment until it is ready for export or to be used for consumption (Coffee and Tea Development and Marketing Authority, 1995).

2.4.3.2 Mechanical drying

Generically there are three common types of mechanical dryers used in coffee processing Static bed or silo dryers where hot air is forced through a bed of coffee; Contra-flow or vertical dryers where the coffee is cycled from bottom to top and allowed to flow downward through a stream of hot air; and Horizontal dryers where the hot air is introduced through a central shaft and forced outward through a rotating, perforated cylinder oriented horizontally which shares features of contra and concurrent flow. There are several new designs which promise higher drying efficiencies as measured by kJ/kg of coffee required to effect drying.

Mechanical drying requires pre-drying so, with the exception of some arrangements of silo dryers, partial drying in the sun is also required where mechanical drying is applied. Heat exchangers are commonly employed to protect the coffee from acquiring a taint but where clean burning materials such as charcoal or propane are used, direct heating can be applied. In addition to these, wood (often from shade trees or coffee prunings), coffee husk, dried sugar cane, fuel oil and kerosene are used.

2.4.4 Coffee Storage

Coffee storage and handling is one of the crucial processes influencing quality, and thus needs due care. The dried coffee should not be stored in an environment where it can pick up or lose moisture and undesirable smell. Coffee consumption takes place all year round. However, coffee production is seasonal. The goal of coffee storage is to achieve and maintain its commercial value as long as possible by preserving the integrity of the bean with all its characteristics. Green coffee beans are stored for a certain period and under certain conditions until they are finally utilized (Ismail *et al.*, 2013). Adequate storage is crucial since coffee beans are living entities in which their viability depends largely on storage condition and food safety has now become an extremely important issue since the effects of toxic substances, which would develop during storage, can cause significant harm to human health. In general storage facilities should be clean, cool, shaded, dry and well ventilated. In conditions of high relative humidity and temperatures, coffee beans will absorb moisture and develop mold. They may be bleached out in color and lose some desirable flavor. Storage temperature of about 20^{o}c and relative humidity of 50-60% are recommended. Dry cherry coffee can be stored longer in relatively similar conditions than parchment without deteriorating in quality (TirufatDejene, 2011).

In addition, coffee price depends on its sensorial value in which this dedicated aspect can easily be affected if storage is not adequate (Mburu, 1999). Besides this, due to the inherent imbalance between supply and demand in the coffee market, it is sometimes necessary to store coffee for long period of time in which the length of storage affects the quality of coffee (Mekonen, 2007).

Therefore, long term storage of coffee is necessary so that better prices can be achieved. Storage functions to maintain the commercial value of coffee as long as possible by preserving the coffee integrity with all of its characteristics. Since the coffee price is based on its sensorial value, adequate storage considerations such as avoiding close proximity storage of the coffee near to fragrant spices or chemicals with a pervading odor (Rojas, 2009). Potential damages caused during storage which affect cup flavour are baggy, onion, moldy and earthy. In addition of the impact on cup and green coffee color, the defect due to bad storage can be infested and bleached beans (Lingle, 2001). The proper processing of cherry, parchment or market ready coffee gives a dry product with less than 11% moisture content (Barel and Jacquet, 1994; Lingle, 2001). This prevents the formation of mildew and controls insect damage, to some extent. It is obvious that storage must be organized in order to maintain this low humidity level. It is therefore very important to ventilate the premises properly. Air should be able to circulate between the sacks, the floor and the walls. The walls themselves should be thick and smooth, and the roof should provide protection against temperature variations and rain.

2.5 Coffee quality

Quality coffee is a product that has desirable characteristics such as clean raw and roasted appearance, attractive aroma and good cup taste (Behailu*et al*., 2008).The volume of coffee sales depend on the quality of coffee, much attention is paid to quality improvement and maintenance. The quality of coffee depends on a number of processes done by many actors within the value chain which must blend harmoniously. If one of these is unsatisfactory, it will be enough to ruin all the efforts made with regard to the others(Farah *et al.*, 2006). These aspects of quality will determine the satisfactory sale of a country's output on the world market.

The quality of a good cup of coffee, as experienced daily by millions of consumers is not a matter of chance. It is the result of a quality assurance program implemented by all the key players of the coffee production to consumer chain (Prodolliet, 2004). Quality as defined by ISO (2000) and Dessie*et al*. (2008), it is in its more practical definition the ability of a product to satisfy consumer's expectation. They mainly includes: Good sensory characteristics (e.g. aroma, flavor, body, acidity), Absence of off-flavors (e.g. mouldy, earthy, fermented, chemical), Safety (absence of contaminants, like pesticides, mycotoxins), and Environmental aspect (e.g. organic product).

Not all these quality characteristics are a matter of chance. They are the result of planned and systematic activities, prevented measures and precautions taken to ensure that the quality of coffee attained and maintained day after day. This is the meaning of quality assurance (Prodolliet, 2004). The quality of coffee can be predetermined by the genotype, the climatic conditions and the soil characteristics of the area in which it is grown. As a whole, a quality assurance program has to be implemented by all the key players of the coffee production to consumer chain to achieve the common goal: quality and as a consequence, consumer satisfaction. Hence, quality assurance can be described from the level of a soluble coffee manufacturer, focusing on the main controls carried out from the reception of the raw material up to the release of the finished packed product.

Coffee quality is of critical importance to the coffee industry. Coffee quality depends on a combination of many factors, including the botanical characteristics of the variety grown, topographical conditions, weather conditions, and the care taken during growing, harvesting, processing, storage, export preparation and transport. Growing, harvesting, processing, storage and export preparation are the most variable factors that can influence the determination of quality since the varietal and topographical conditions are constant (ITC, 2002).

Researchers are currently looking into which of the approximately 800 chemical compounds present in roasted coffee are linked most strongly to aroma and perceived quality (Farah *et al.*, 2006), and they were find that processing methods are important (Bytof*et al.*, 2000; Knopp*et al.*, 2006).

There are different views of expressing quality. ITC (2002) defines that the quality of a parcel of coffee comes from combination of the botanical variety, topographical conditions, weather conditions, and the care taken during growing, harvesting, storage, export preparation and transport. On the other hand, for coffee, the definition of quality and the attributes considered have probably evolved through the centuries. Now days, according to Lorey*et al*. (2006), this definition varies along the production to consumer chain at the farmer level coffee quality is combination of production level, price and easiness of culture, at the exporter or importer level: coffee quality is linked to bean size, lack of defects, regularity of provisioning, tonnage available, physical characteristics and price, at the roaster level coffee qualities depend on moisture content, stability of the characteristics, origin, price, biochemical compounds and organoleptic quality. It should be noted that each consumer market or country may define its own organoleptic qualities. And finally at the consumer level coffee quality deals with price, taste and flavor, effect on health and alertness, geographical origin, environmental and sociological aspects (organic coffee, fair trade, etc.) (Lorey*et al*., 2006).

2.5.1 Coffee quality characteristics

2.5.1.1 Moisture content

Moisture is an important attribute and indicator of quality. A high moisture content of the beans is a loss of material and leads to physical and sensorial defects. If the beans are too wet (above 12.5 % moisture), they will mold easily during storage, If the beans are too dry (below 8 % moisture), they will lose flavor. The moisture content influences the way coffee roasts and the loss of weight during roasting. Green coffees with low moisture content tend to roast faster than those with high moisture content. The ICO resolution 407 recommends that coffee should not be exported when outside of these limits as assessed by the ISO 6673 method (Lorey*et al*., 2006).

2.5.1.2 Physical quality

The International Coffee Organization (ICO, 2002) implemented a Coffee Quality Improvement Program (CQP) with recommendations to exporting countries. It is not recommended that coffee be exported with the following characteristics: for Arabica, in excess of 86 defects per 300g sample (New York green coffee classification/Brazilian method, or equivalent); and, for Robusta, in excess of 150 defects per 300 grams (Vietnam, Indonesia, or equivalent classification). Also, ISO (2004b) has established a standard (ISO 10470) that describe defects as foreign materials of non-coffee origin which are foreign matters like soil, stone and others, pieces of parchment or husks are also considered as foreign materials of non-bean origin abnormal beans is for shape regularity and for visual appearance, such as black beans, abnormal beans for taste of the cup after proper roasting and brewing.

Bean size, defined as grade from a commercial point of view, is an important factor since price is related to the coffee grade (small beans of the same variety can bring lower prices). Roasting should ideally be carried out with beans of the same size.

2.5.1.3 Organoleptic quality

Cup quality, often referred to as drinking quality or liquor quality, is an important attribute of coffee and acts as yardstick for price determination (Agwanda*et al*., 2003). Its assessment is done organoleptically by panels of experienced coffee tasters (Agwanda, 1999) and is determined on the basis of the level of acidity, body and flavor of the brew.

When assessing organoleptic quality, one has to take into account that consumers have a specific taste according to their nationality which leads to an unreliable definition of organoleptic quality. The assessment of coffee organoleptic quality is a difficult task. The smell of the ground roasted coffee before water is added is sometimes called fragrance, then, one can smell the aroma, evaluate the body and perceive taste and flavors. Organoleptic quality measurement relies overall on sensory evaluation. Two types of analysis are commonly used. The first one, named "hedonic analysis", evaluates the preference of consumers. It has to be performed on a panel of at least 60 spontaneous assessors that represent the population of whose preference is sought. The second method is termed "descriptive analysis". Trained assessors can discriminate coffees using, for example, a triangular test. Three cups of coffee are served, two cups containing the same coffee. The assessor has to determine which cup is unique.

2.5.1.4 Health quality

For consumers, one of the most important components of quality for alimentary goods is food safety. Coffee contains a lot of molecules that can have an effect on health and alertness. Some of them are naturally present in coffee beans or derived from biochemical reactions occurring during roasting, whereas others like OchratoxineA (OTA) and residues of pesticides are external compounds independent of the chemical composition of coffee beans.

The level of pesticide residues is usually low in coffee (FDA, 2002). OchratoxinA (OTA) is a toxic mycotoxin. Mycotoxin can be produced by several mould species and can be found particularly in cereals. In coffee, OTA is produced by *Aspergillusniger, A. carbonarius and A. ochraceus*. It has been shown to cause kidney damage and tumors in test animals. It is classified as possibly carcinogenic to humans. In terms of chemical compounds present in coffee beans, several of them are known to have consequences on health. The one chemical component that has received the most scientific scrutiny is caffeine. Most consumers look for its stimulating effect on brain activity. Despite its positive effect on alertness, caffeine also has some possible implications in diseases like hyper cholesterol and cancers. Coffee also contains chlorogenic acids, melanoidins, and other unknown substances which are identified as strong antioxidants. Diterpens specific to *Coffea* species (Cafestol and Kahweol) have also been shown to present some hyper cholesterol properties associated with possible antioxidant properties. To summarize, despite the knowledge acquired on a few components in terms of consequences on health, very little is known of the other constituents that make up 98 % of roasted coffee beans.

2.6 Coffee quality standard and grading system

In Ethiopia, there are two major components of coffee quality inspection. They are green analysis (visual test) and liquor analysis (cup test). These two methods are universally acceptable methods in both coffee producing and consuming countries tailored to the quality control system of respective countries (ECQIAC, 2007). From the total grading of a coffee, the weight of green analysis is 40% and the remaining 60% is by cup test.

In establishing quality management system, particularly in developing quality control or inspection institutions, there are two key tasks. These are standardization and the technical tools/standards that are associated with it. According to the definition given by QSAE, (Quality and Standard Authority of Ethiopia) standardization is an activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of optimum degree of order in a given context and in this case coffee. However a standard is a document established by consensus and approved by a recognized body that provides the common and repeated use, rules, guidelines, or characteristics for activities for their results, aimed to achieve the optimum degree of order in a given context. Ethiopian commodity exchange (ECX) follows different steps in order to inspect the quality of a sample these are: -

Sampling: - It is one of the main procedures in coffee quality assessment in which a sample drawer is expected to draw a representative/actual sample from each bags based on the sampling rule designed for the institution. In terms of size, a sample drawer is subjected to draw 3Kg per 10 tons of a truck, which usually is the quantity that an average lorry/truck could carry at arrival.

Coding: - It is a process of assigning an arbitrary code (an identity number, an alphabet, or a combination of the two), which is secured and only known by the assigner, used as a mechanism of accountability and transparency in which the experts do not know to whom that coffee belongs.

Screen analysis: - screening is important to make size assessment/grading. It can be conducted manually/electrically. However, ECX laboratory uses the manual system. This activity is carried out by a laboratory assistant taking a 350gm of green sample. Screen size analysis is done by the help of sieve like apparatus to check the size of each coffee bean. The analysis is carried out by adding 300g of coffee bean to the apparatus and after repeatedly shaking the beans on the equipment, the amount of coffee beans passed through the holes are weighted in-order to check the proportion of the coffee bean under the specified screen size. The coffee bean screen size is usually reported as 14 to 20. The numbers indicate the dimension of the holes of the sieve, which is 1/64 of an inch. For example, Screen size 14 means the diameter of the hole is 14/64 of an inch

Moisture content analysis: - The other important aspect in the raw analysis is moisture testing which is very important to know whether the coffee sample tested is within the permissible ranges/standards or not in which one sample is expected to have a maximum of 11.5%.

Defect count system: - This is very decisive and conventionally accepted sub-quality control parameter. It is the principle of counting different kinds of coffee defects using a set of standards developed, taking their rate of effect on the overall quality of coffee.

color: - (bluish, grayish, greenish, faded, whitish, etc) is analyzed by the expertise against the standard. For a better coffee (sample), the blue to grayish signifies the most desirable attribute of appearance/color.

Shape & make: - attribute is an interchangeably used term, which usually refers to the structure or make up of the beans, the region where coffee is growing, type & production system are some of the factors that govern the shape and make quality of the beans (rounded, oval, bourbon, flat etc).

Odour: - The type of odour that a given coffee sample depends on the way the coffee is harvested, processed and transported. Consequently, a coffee with a better attention/management in terms of harvesting, processing, storage and transportation turns out to have a better odour. *Roasting:* - it is a chemical process by which aroma, acid and other flavour components are either created/altered in a way that should augment the flavour, acidity after taste and body of the coffee as desired by roaster/users. The art of roasting is to develop the bean to the exact, where the flavour is brought to its maximum. Roasters undertake this activity on some 100-150gm sample using a sample roasting machine.

Grinding-is a physical change or an alteration in form which will cause particle size reduction using crushing, rubbing, grating, cutting, tearing and any other process. The grind required for cup testing is termed medium that is proper for extraction/brewing of the liquor.

Organoleptic analysis/liquoring: - it is an essential and most decisive step in the coffee quality control system. At ECX, the aim of this testing is to assess the quality of the coffee prior to sell, to be in a position to advice the growers on their drawbacks, and to evaluate the coffee research trails coffee quality based on the standard.

2.6.1 Green coffee analysis

The green analysis is based on human sense of sight (eye) and with the help of other techniques to identify and classify coffee. This method inspects the physical properties of coffee like shape, size, color, uniformity or irregularity and defect count of the coffee bean (HabtamuMinassie, 2008).

The ISO 10470 standard defines defects as “anything divergent from regular nicked sound green beans expected in a coffee lot” and classified them into five categories (ISO, 1993; Wintgens, 2004). These are field damaged bean or processed damaged bean related to the coffee tree, the environment, attack by pests and diseases, and crop management, Harvest-damaged beans or processed damaged beans which is caused by stress due to water or nutrient deficiencies, inadequate cultivation or harvesting practices, unsatisfactory primary processing. Defects occurring during processing which are damaged beans during like pulping, washing, drying, hulling, cleaning, etc. Defects occurring during storage and Defects originated from coffee fruit due to poor cleaning operation following de husking and dehulling.This is the most important criterion of evaluation of green coffee, as their presences alter the final cup quality by generating off flavor.

2.6.2 Sensory evaluation

Sensory evaluation is the conscious effort to identify and judge different sensations and components in an object, be it a piece of food, a beverage, or a perfume. Sensory evaluation encompasses all of the senses. It takes into account several different disciplines but emphasizes the individual's perception. It involves the measurement and evaluation of sensory properties of food and other materials (Willis, 2008). Human judges are used to measure the flavor or sensory characteristics of food. In short, sensory evaluation is a very organized holistic approach to product assessment.

The assessment of sensory evaluation can be done organoleptically by panel of experienced coffee tasters (Van der Vossen, 1985) and is determined based on the level of acidity, body, and flavor of the brew. Coffee cupping is a technique used by cuppers to evaluate the flavor profile of a coffee, to understand minor differences between growing regions, to evaluate coffee for consistence and defects to subsequently make buying decision and to crate coffee blend (EAFCA, 2008). The coffee manufacturers (buyers) main concern is certainly to deliver to the consumer a product with high quality and regular in cup taste and aroma. Therefore, the purpose of checking the sensory profile of green coffee is to ensure the consistent quality of the finished product sensory evaluation is certainly the most reliable way to assess the quality of the raw material (Prodoliet, 2004).

The tasting of coffee is a rigorous and disciplined process, done by an expert to evaluate the brew and determine its characteristics. The taster first assesses the green beans for their appearance. Then 200g of coffee is roasted by the laboratory roaster and tested for its cup cleanness, acidity, body and flavor. After the coffee has been infused in water, the brew is ‘nosed’; after three minutes the brew is lightly stirred and smelled again. The resulting foam is removed and the tasting begins. A small spoonful of coffee is taken into the taster's mouth and it is ‘chewed’ around before being spat out. The procedure is repeated with all of the samples and notes are made as each one is sampled (ECX, 2011).

Acidity This is a desirable characteristic in coffee. A taste sensation related to the presence of sweet tasting compound which are created as acids in coffee, combine with sugars to increase the brews overall sweetness. Taste sensation experienced at the tip of the tongue (Willis, 2008). High acid coffees have a sharp, pleasing snappy flavor, not biting (EAFCA, 2008) and gives better quality and more intense aroma to the beverage (Clifford, 1985). In general taste sense, it is the presence of the aliphatic acid group that gives brightness and best to coffee’s flavor and is the underline reason why coffee with a high acidity (pH value: 4.8-5.1), which is the preferred range and typically sold at premium price (Lingle, 1986). This is a characteristic of high grown coffees such as Ethiopian Yirgacheffee, Sidamo, and Limu as well as coffees from Guatemala, Costa Rica, and Kenya (IPO, 2008; EAFCA, 2008).

Body is the feeling that the coffee has in mouth. The sensation denotes the level of substance in the coffee solution or brew (Willis, 2008). It is the viscosity, heaviness, thickness, or richness that is perceived on the tongue. Body is synonymous with mouth feel and viscosity (Clifford and Wilson, 1985) and/or linked with density viscosity of the brew (Petracco, 2000). However, there is no simple relationship between beverage viscosity measured instrumentally and body judged subjectively (Clifford, 1985).

Aroma is the sensation of gases released from freshly brewed coffee (Willis, 2008). This is a sensation that is hard to separate from flavor. The aroma contributes to the flavors we discern on our palates, such as ‘floral’ or ‘winy’ characteristics, are derived from the aroma of brewed coffee (Hicks, 2001).

Flavor is the overall perception of the coffee . Acidity, aroma and body are all components of flavor. Describing the tastes and flavors of different roasts is as subjective as putting a wine into words. In both cases there's no substitute for your own personal tastes (Hicks, 2001). Flavor is the coffee's principal character, the mid-range notes, in between the first impression given by the coffee's first aroma and acidity to its final after taste. It can be indicated by inhaling the vapor arising from the cup or nasal perception of the volatile substances evolving in the mouth (Petracco, 2000). In this regard, Agwanda (1999) compared four quality traits (acidity, body, flavor and over all standards) for their suitability as a selection criterion for the genetic improvement of overall liquor quality. This trait showed high genetic correlation with preference, was easy to determine organoleptically and had relative high sensitivity discriminating different coffee genotype (Agwanda, 1999). There is also high heritability for the overall standard of cup quality and possibility of good selection progress for this character with the assistance of experienced coffee tasters (Van der Vossen, 1985). In addition, based on correlation, repeatability and sensitivity analysis, flavor rating was recommended as the selection criterion for genetic improvement of cup quality in Arabica coffee (Yigzaw, 2006).

3. MATERIAL AND METHODS

3.1. Description of the study area

Field experiment was carried out at Gemadro Coffee Plantation. Gemadro coffee estate is located 710 km southwest of Addis Ababa in the Southern Regional State (Sheka Zone, GechaWereda, Yoki-Chichi-GemardroKebele). The lowest point on the plantation was at 1500 m above sea level and the highest cultivated point was at 1,900 m. The average precipitation was 1900mm, which falls mostly over nine wet months. The typical annual temperature range was from 14 to 28 degrees(EthioAgri-CEFT, 2012).

The laboratory analysis were conducted at Ethiopian commodity exchange Jimma laboratory which is geographically located 352 km southwest of Addis Ababa.

3.2. Experimental materials

The coffee varieties used in the study were selected based on their reputation with due consideration of area coverage in Ethiopia, high productivity, good quality and resistance to diseases. Accordingly varieties 744, 7454, 74110, 74112, 74165, 75227and mixture of them were used as a control. Trees were selected for uniformity in terms of age and bearing condition.

Table 1.Characteristics of studied coffee varieties

Variety	**Yield (q/ha)**		**Canopy nature**	**Raw quality**	**Cup quality**	**Commercial acceptance**	**Disease resistance**	**Released year**
	Research	Farmer						
744	16.6	8.9	Open	Average/Good	Average	Acceptable	Resistance	1979/80
74110	19.1	9-10	Compact	Average/Good	Good	Acceptable	Resistance	1978/79
74112	18.1	9-10	Compact	Good	Good	Good and Acceptable	Resistance	1978/79
7454	18.3	8-9	Compact	Fair/Good	Fair/Good	Acceptable	Resistance	1978/79
74165	17.3	8-9	Compact	Good	Fair/Good	Acceptable	Resistance	1878/79
75227	17.8	8-9	Open	FAQ	FAQ	Acceptable	Resistance	1980/81

Where FAQ= Fairly Average Quality
Source: CLU report (1996-2004) as cited in Behailu*et al*. (2008)

3.3 Experimental design layout

The treatments consisted of two factors: initial moisture content and varieties. Factor A, comprising three moisture levels (M) which is: M1:- parchment coffees with 60% moisture content; M2:- sun drying until the initial 40% moisture content; M3:-sun drying until the moisture content of 21%. Factor B, was made-up of six coffee varieties and control (V) V1:-744, V2:7454, V3:-74110, V4:-74112, V5:-74165, V6:- 75227and Co:-Control. The experiment was carried out by two factor factorial in complete randomized design arranged in 3*7 with three replications and total of 63 experimental units.

3.4. Experimental procedure

Coffee processing: Red ripe coffee cherries of six coffee varieties (744, 7454, 74110, 74112, 74165, 75227) were handpicked during main harvesting season of year 2013/2014.and before pulping foreign materials, unripe green cherries and over ripe cherries were separated /sorted from fully ripened and healthy berries and The Samples were pulped and a total of 63 samples were prepared using wet processing method by using de-mucilager to remove the mucilage from the parchment and soaked for 36 hours and washed.

Drying: Each variety of wet parchment coffee was divided into three and the first and the second portions was sun dried on mesh wire raised bed until it attains 21 and 40 percent moisture content and the third portion was directly dried on artificial drier. Thisstudy were done by considering the plantations working experience (practice) that is using temperature of 60^{o}c for the first 3 hours and gradually increasing the temperature to 80^{0}c until the moisture content reaches 14% and then decreasing to 60^{0}c until it reaches 11% moisture content for all varieties and control samples.

3.5. Labeling and packing

Each coffee sample was prepared from each variety and separately labeled. The samples were packed and brought to Ethiopian commodity exchange Jimma coffee laboratory for quality analysis. Quality analyses of the coffee samples were conducted through the combination of two methods. They are green coffee (raw bean) analysis and cup tests (liquoring).

3.6. Data collection

During data collection all quality attributes of green bean (screen size and moisture) and quality Factors (primary defect, secondary defect, shape and make, color, odor, cup cleanliness, acidity, body and flavor) were considered as per the standard recommendation (CQIAC, 2008; ECX 2011).

3.6.1 Quality evaluation

Code**:** The samples were randomly coded to avoid individual biasness of the panel.
Moisture content**:** The moisture content of each sample was measured with a standard moisture tester (dickey joy) certified by Quality and Standard Authority of Ethiopia this is done to know whether the coffee sample tested is within the permissible ranges/standards or not in which one sample is expected to have a maximum of 11.5% moisture content.

3.6.2 Coffee raw evaluation

Green coffee analysis involves visual inspection and assessment of physical characteristics of coffee bean. This includes moisture content determination, screen analysis which makes size assessment, defect count (primary and secondary defects), appearance or shape and make, color and odor of the sample. From the overall grading of coffee, green analysis accounts 40% in accordance with Ethiopian Commodity Exchanges working format (ECX, 2011).

3.6.2.1 Green bean defect identification / sorting procedure

First, the parchment of washed coffee samples were hulled / removed before sample preparation then samples were divided into two sub-samples, for cup and raw / green analysis. The amount of sub-sample for physical defect determination / raw analysis were350 gm. The first sub-sample taken from the working sample was used to measure moisture content and then afterwards for screen size determination (analysis of general requirement). After measuring moisture content and screen size the samples were sent to the hand pickers/sorters for green bean defect identification. Sorters/hand pickers spread the sub-sample on the working table to pick defective beans and foreign materials. Primary defects were picked separately and packed in pocket paper; category two (secondary) defects picked and packed together on a paper pocket then the sound beans and defects in the pocket paper was collected on the sample tray and submitted for cuppers for green/raw inspection.

3.4.2.2 Raw analysis procedure

The raw analysis was performed by counting all the primary defects and the corresponding results were given. For secondary defects all the secondary defects was weighed using sensitive scale (weight A) and the result was calculated using the following formula.

Percent by weight of secondary defect $= \frac{A\ X 100}{350}$

Then color and shape and make of the sample were evaluated based on visual inspection by experienced evaluators. Finally, the odor evaluation of the sample was done by deeply sniffing the sample.

3.6.3 Coffee cup analysis

The sensorial analysis of the coffee were carried out at Ethiopian Commodity Exchange Jimma laboratory and performed by Coffee Quality Institute (CQI) Certified Cupping Judges (cuppers). The sensory analysis protocol of the (Ethiopian Commodity Exchange) ECX and SCAA was used. Cup test is based on roasted coffee analysis (chemical process) by which cup cleanness, acidity, body and other flavor components were tested. From the overall grading of coffee, the cup test accounts 60% in the quality inspection process. (SCAA, 2009; ECX, 2011).

3.6.3.1 Roasting and grinding

100gm green bean were used for roasting. Uniformity of roasting was checked by taking out some beans from the roasting machine using a spoon while the machine is working (ECX, 2011). When the samples reaches a moderate\medium roasted stage taken out and immediately air-cooled. The sample were grounded immediately prior to cupping, the grinding machine adjusted as required. Cleansing the Grinder was done for each sample and the samples were grinded each cup's batch individually in to the cupping glass by measuring 13.75gm of roasted whole beans per 250ml size cup. Grinding the beans was done to average (medium) fineness (ECX, 2011).

3.6.3.2 Brew preparation

Hot water was poured on ground coffee in 250 ml capacity cup. Clean, odor free not distilled or not softened water was used. After 4 minutes, the water poured crust was stirred three times with spoon with the same and uniform pattern and sniffed. Then the foam crust from the dissolved coffee were skimmed (ECX, 2011).

3.6.3.3 Cupping procedures

The dissolved coffee was cupped when it reaches to palatable temperature using the round soupspoon raise 6 to 8 cc of liquid to just in front of the mouth and forcefully slurp the liquid. By briskly aspiring, the coffee in this way spread evenly over the entire surface of the tongue. A team of trained, experienced and internationally certified Q grader cuppers made this In this case; three experts participated in a panel for cupping to evaluate the aroma and taste characteristics of each sample of the brew involving olfaction, gestation, and mouth feel sensation. Average results of cuppers were used for the analysis (ECX, 2011).

Cup cleanness: cup cleanness was evaluated as clean (15%), fairly clean (12%), one cup defect (9%), two cup defect (6%), three cup defect (3%) and if there is more than three defective cup we give (0%).

Acidity**:** During cup acidity analysis, evaluated as, pointed (15%), and moderately pointed (12 %), medium (9 %), light (6 %) or lacking (3 %) and the results were recorded accordingly.

Body**:** Cup body evaluated as, full (15 %), moderately full (12 %), medium (9 %), light (6 %), and thin (3 %). The result recorded accordingly.

Flavor**:** The flavor, the overall test of the brew evaluated and recorded as good (15 %), fairly good (12 %), average (9 %), fair (6 %) and commonish (3 %).

Cupping procedure for potential specialty coffee

Coffee samples that has scored from grade 1-3 during the preliminary assessment, were proceeds for specialty assessment. The coffee sample were roasted and stored in air tight container or non-permeable bag for 8 hour. After 8 hours the samples were prepared and analyzed using the Specialty Assessment Form, Judges assign 6-10 points for each of the following attributes: fragrance/aroma, acidity, body, flavor, aftertaste, sweetness, uniformity, clean cup, balance and overall impression. During specialty assessment coffee samples which do not qualify for specialty coffee was considered as commercial grade 3 (SCAA 2009; ECX, 2011).

3.7. Data Analysis

The data obtained from the raw evaluation and sensory analyses were subjected to Analysis of Variance (ANOVA) by using SAS version9.2 computer software (SAS Institute Inc, 2008). Significant treatment means were compared using the Least Significant Difference Test (LSD) at 5% probability level.

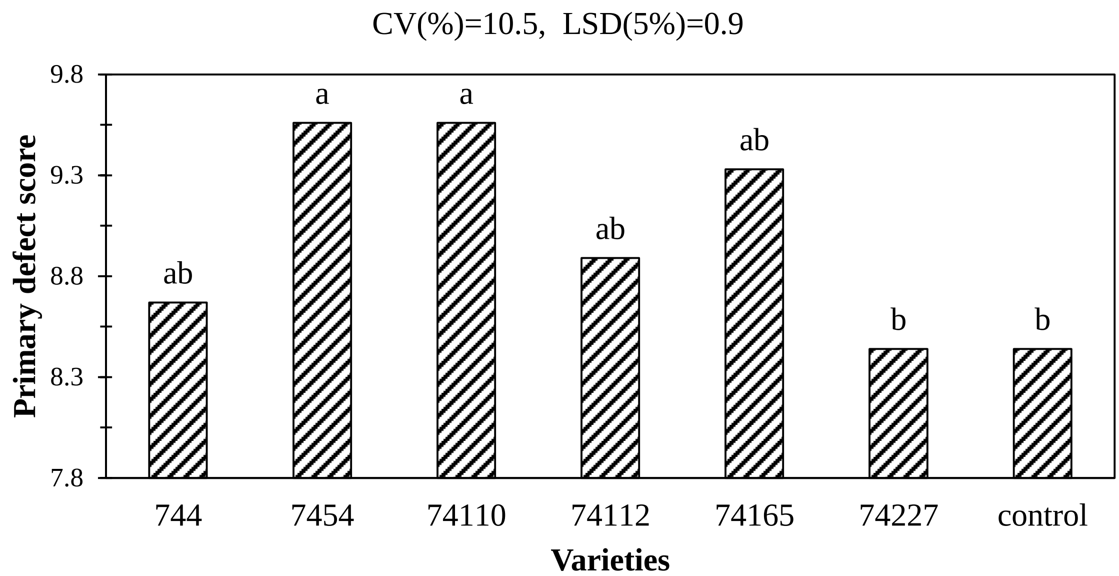
4. RESULTS AND DISCUSSION

4.1. Raw quality attributes

From the overall grading of coffee, green bean analysis or raw quality evaluation accounts 40% in accordance with Ethiopian Commodity Exchanges working format (ECX, 2011) defect count (primary10% and secondary defects 10%), appearance or shape and make10%, color 5%, odor 5% and total raw quality which is the sum of all raw quality attributes of the sample.

4.1.1 Primary defect

The analysis variance result showed significant variations (P< 0.05) among varieties (Appendix Table1) on primary defect of washed Arabica coffee. Variety 7454 and 74110 registered the limited primary defects which is highest score with mean of 9.6 and the more defective and highest primary defect which is lowest score 8.4 was recorded from variety 74227 and the control (Fig. 1). This variation probably due to resistance of varieties for pest damages because most primary defects observed were severe pest damages. This was in line with (Wintgens, 2004) disease and insect attack (such as leaf miner and mites) may also result in lower quality beans.This result agreed with the work done by Tesfaye (2006) who pointed out that properly processed coffee is free from off- flavor and very few defective beans.

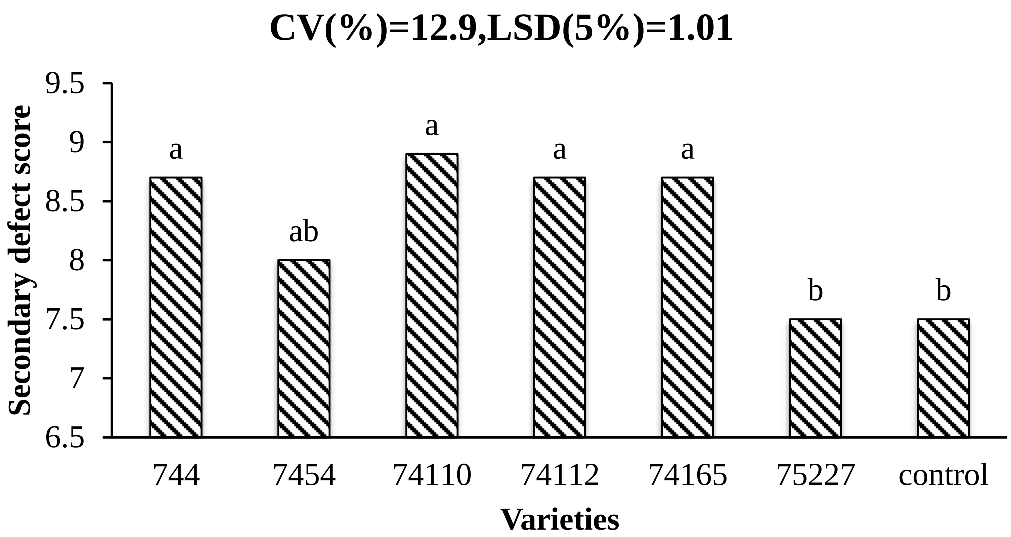


Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 1. Effect of variety on primary defect of washed Arabica coffee varieties

4.1.2 Secondary defect

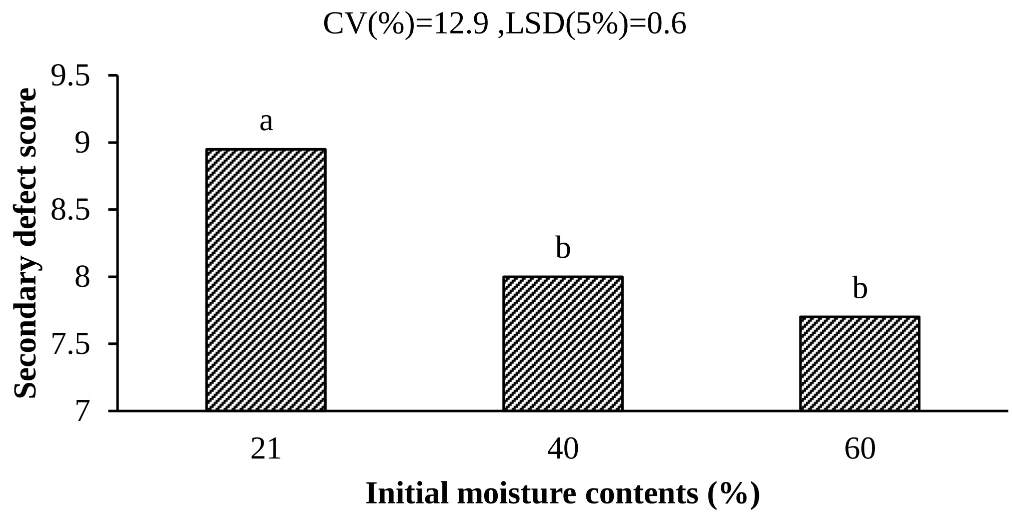
Analysis of variance result of secondary defect showed significant variation ($P < 0.05$) among the main factors effect (initial moisture contents and between varieties (Appendix Table 1). Accordingly, as depicted in Figure 2, significantly higher value (8.9) which is very limited secondary defect was recorded for variety74110 and statistically similar with 74112, 74165, 744 and 7454 on the other hand lower value (7.5) of secondary defect or higher secondary defect distribution were recorded for varieties 75227 and control treatment.Thisis in line with Desse, (2008)reported that, Coffee processed by wet method helps to preserve the intrinsic quality of the bean better, producing a green coffee, which is homogeneous and has few defective beans.



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 2. Effect of variety on secondary defect distribution of washed Arabica coffee

As indicated in Figure 3, effect of Moisture content on secondary defect was also significant (P< 0.01) and coffees dried with 21% moisture content showed higher value with the mean value of (8.95) which shows lower secondary defect and the higher secondary defect or lower score was recorded for coffees dried with 40 and 60 % moisture contents, this variation shows coffees dried by mechanical drier has lost its moisture rapidly and reduces its quality by preventing easy movement of moisture within the bean this finding was in line with Raghu (2010) drying rapidly make coffee over dried and shrinks to prevent easy movement of moisture from within the bean it may become pale and bleached.

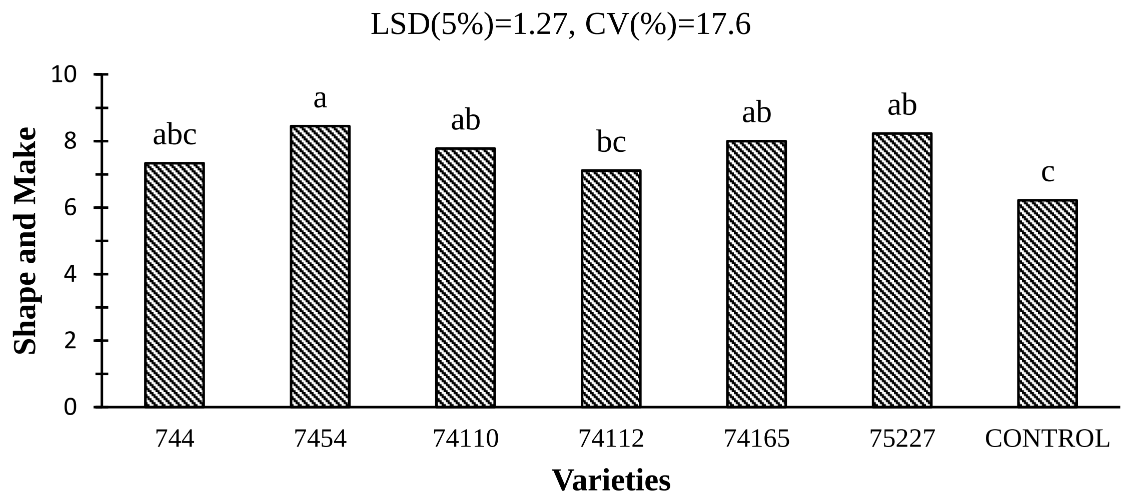


Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 3. Effect of initial moisture content on secondary defect of studied coffee varieties

4.1.3 Shape and make

The result presented for shape and make revealed that there were significant variations (P< 0.05) only among coffee varieties (Appendix Table 1). The highest value was recorded for 7454 variety with an average value of 8.44 which is a very good to good shape and make with more uniform appearance and the lowest value (6.22) of shape and make was recorded by the control which means fair to average shape and make (Fig. 4). This is most likely because the control is a mixture of all studied varieties which had non uniform appearance of coffees which affects the roasting and drying processes which lead to lower cup quality. This finding was in line with the work of Bayetta (2001) andWondimu(1998) who reported presence of morphological variation in coffee genotypes as an indicator of genetic diversity in Ethiopian coffee. According to CLU (2008), the size and shape of the beans differ depending upon the variety. Similarly, this finding agrees with (Mekonen, 2009) who pointed out variability due to botanical variety.



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 4. Effect of variety on shape and make of Arabica coffee

4.1.4 Color

The interaction effect of initial moisture content before mechanical drier and variety showed significant ($P<0.05$) difference on the color of Arabica coffee. Results presented in Table 2 show that significantly the highest bluish to grayish color (4.67) valuewas recorded from 74110 and 74165 coffee varieties dried by initial moisture content of 21 percent. On the other hand, the lowest color value (2.67), coated to greenish color, was noted from 744, 75227and control coffee varieties dried directly by mechanical drier without sun drying. It was statistically similar with all varieties except 74110 dried under this condition and also statistically similar with varieties 744, 74112, 75227 and control variety dried by initial moisture content of 40 percent, this variation in color is due to drying method and variety. This is in line with CLU(2008) Bean color can be yellowish-grey to slate-grey, bluish or grey-green, depending upon the variety and method of preparation.

Table 2. Interaction effect of initial moisture content and variety on the color quality of washed Arabica coffee

Variety	Initial Moisture Content (%)		
	21	40	60
744	4.30^{ab}	2.67^{d}	2.67^{d}
7454	4.30^{ab}	4.00^{abc}	3.00^{cd}
74110	4.00^{abc}	4.30^{ab}	4.00^{abc}
74112	4.67^{a}	3.30^{bcd}	3.30^{bcd}
74165	4.00^{abc}	4.67^{a}	3.00^{cd}
75227	2.67^{d}	3.30^{bcd}	2.67^{d}
Control	3.67^{a-d}	3.30^{bcd}	2.67^{d}
LSD (5%)	1.07		
CV (%)	18.41		

Means followed by same letter(s) among rows and column are not significantly different at P<0.05

4.1.5 Odor

The interaction effect of moisture content and variety showed significant (P<0.05) effect on the odor of coffee (Appendix Table 1). Results in Table 3 depict that significantly higher clean to fairly clean odor values were noted for Varieties 74112 and 74165 with initial moisture content of 21 and 40% respectively. This result was statistically similar with all varieties dried with 21 percent initial moisture content and variety 7454 and 74110) dried at 40 % initial moisture content. Significantly, lower trace to light odor result was revealed from variety 75227, 744, 75227 and control with initial moisture content of 21, 40 and 60 percent respectively. This result was statistically similar with all varieties except variety7454 dried with 60 percent (which is directly dried with mechanical drying).This result was in line with ECQIAC (2007) which reported a coffee with a better attention in terms of harvesting, processing, storage and transportation turns out to have a better odor. Similarly Endale(2008) coffees with a better management in each stage of coffee starting from harvesting till cupping turn out to have a better odor.

Table 3. Interaction effect of moisture content and variety on the odor quality of washed Arabica coffee

Variety	Initial Moisture Content (%)		
	21	40	60
744	5.00[a]	3.00[d]	4.67[ab]
7454	4.67[ab]	4.30[abc]	4.30[abc]
74110	5.00[a]	4.67[ab]	4.00[bc]
74112	4.67[ab]	4.30[abc]	4.30[abc]
74165	5.00[a]	4.67[ab]	4.30[abc]
75227	5.00[a]	4.67[ab]	5.00[a]
Control	4.67[ab]	4.67[ab]	3.67[cd]
LSD (5%)	0.86		
CV (%)	11.5		

Means followed by same letter(s) among rows and columns are not significantly different at P<0.05

4.1.6 Total raw quality

The interaction effect of moisture content and variety were significantly ($P<0.05$) (Appendix Table 1) influenced the total raw quality. The result in Table 4 demonstrates that coffee variety 74165 dried with initial moisture content of 21 had the highest total raw quality with average value of 36.33 but statistically similar with variety 744,7454,74110and 74112 dried with an initial moisture content of 21 percent and variety 7454 and 74110 dried with 40 percent initial moisture content. Whereas the lowest total raw quality value (26.3) was recorded from control variety dried directly by mechanical drier (60 % initial moisture content) without exposing to natural sun but statistically similar with variety 744 dried at 40 percent initial moisture content.

Table 4. Interaction effect of moisture content and variety on the total raw quality of washed Arabica coffee

Variety	Initial Moisture Content (%)		
	21	40	60
744	36.00[a]	29.0[ef]	32.0[cd]
7454	35.00[ab]	35.67[a]	32.3[bcd]
74110	36.33[a]	35.67[a]	32.67[bcd]
74112	36.00[a]	30.33[de]	32.3[bcd]
74165	36.33[a]	32.67[bcd]	32.67[bcd]
75227	32.67[bcd]	32.33[bcd]	30.3[de]
Control	32.33[bcd]	30.67[de]	26.3[f]
LSD(5%)	2.88		
CV(%)	5.3		

Means followed by same letter(s)across rows and columns are not significantly different at P<0.05

4.2 Coffee cup quality analysis

4.2.1Acidity

Interaction effect of moisture content and variety showed significant (P≤0.05) influenced the acidity of coffee (Appendix Table 2). The highest moderately pointed to pointed acidity was recorded for variety 74112 dried with an initial moisture content of 40 and statistically similar with variety 7454 and 74112 dried at 21 percent initial moisture content while the least medium to light acidity was recorded from variety 74165 and 74227 dried directly by mechanical drier (Table 5) this is due to mechanical drying produces lowest sour coffee acidity. This finding was in agreement with of the finding ofMekonen (2009) and Yigzaw (2006) who reported variations in acidity among different coffee genotypesWahyudi and Ismayadi (1995) also stated that full mechanical drying with rapid drying rate produced worse quality with highly sourish, astringent and bitter taste

Table 5. Interaction effect of initial moisture content and variety on the acidity of washed Arabica coffee

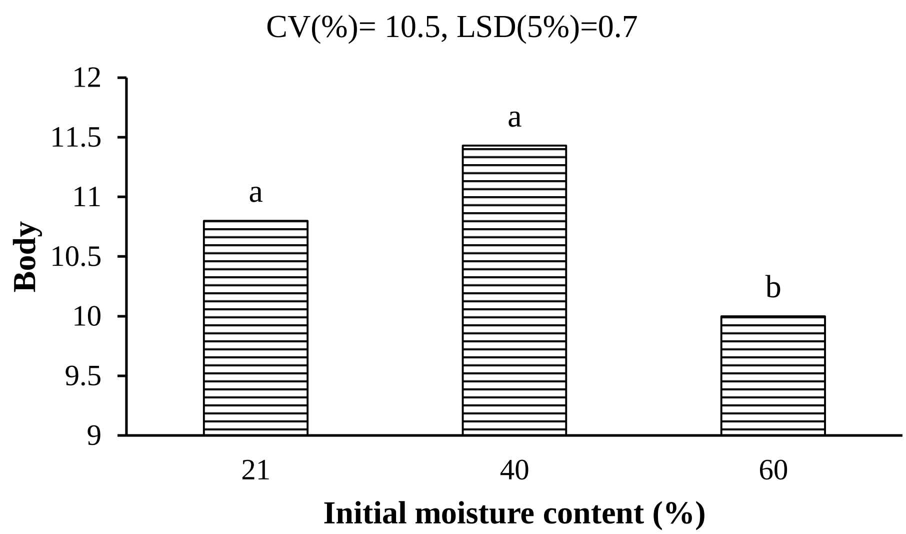
	Initial Moisture Content (%)		
Variety	21	40	60
744	11.0^{bcd}	8.0^{ef}	10.0^{cde}
7454	12.0^{abc}	10.0^{cde}	9.0^{def}
74110	10.0^{cde}	11.0^{bcd}	11.0^{bcd}
74112	13.0^{ab}	14.0^{a}	10.0^{cde}
74165	11.0^{bcd}	11.0^{bcd}	7.0^{f}
75227	10.0^{cde}	9.0^{def}	7.0^{f}
Control	8.0^{ef}	10.0^{cde}	9.0^{def}
CV (5%)	15.5		
LSD (%)	2.6		

Means followed by same letter(s) across rows and columns are not significantly different at P<0.05

4.2.2 Body

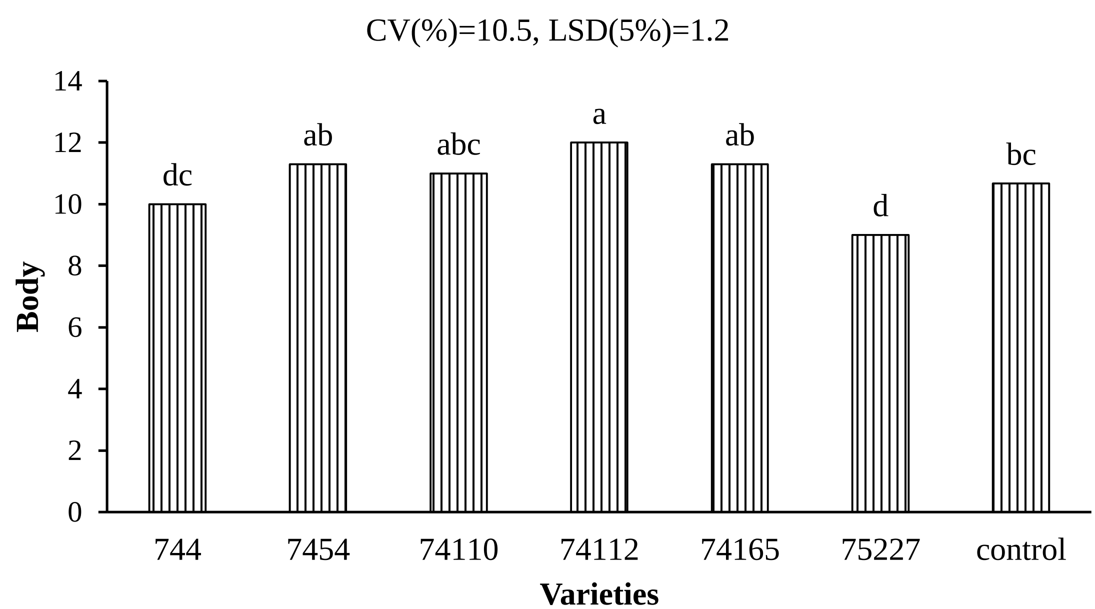
There was highly significant (P≤0.001) effect of the main factors on the body while their interaction effect was non-significant (Appendix Table 2). The highest medium full body with average value of 11.4 was recorded for coffee dried with 21% initial moisture content and this is statistically similar with coffee dried with 40% initial moisture content. While light to medium body with average value of 10.0 was noted for coffees dried directly by mechanical drier with initial moisture content of 60 percent.

Significantly higher full to medium full body with average value of 12 was noted for 74112variety and this is statistically similar with 7454, 74165, and 74165 varieties. The lowest light to medium body with the mean value of 9.0 was recorded for variety 75227 and this value is statistically similar with 744 varieties. This finding was similar with the work of Yigzaw(2006) who reported presence of variation among *Arabica*coffee genotypes on their overall liquor quality and body.Similarly Abyot (2010), indicated the existence of considerable variations among coffee genotypes



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 5. Effect of moisture content on body of wet processed Arabica coffee varieties



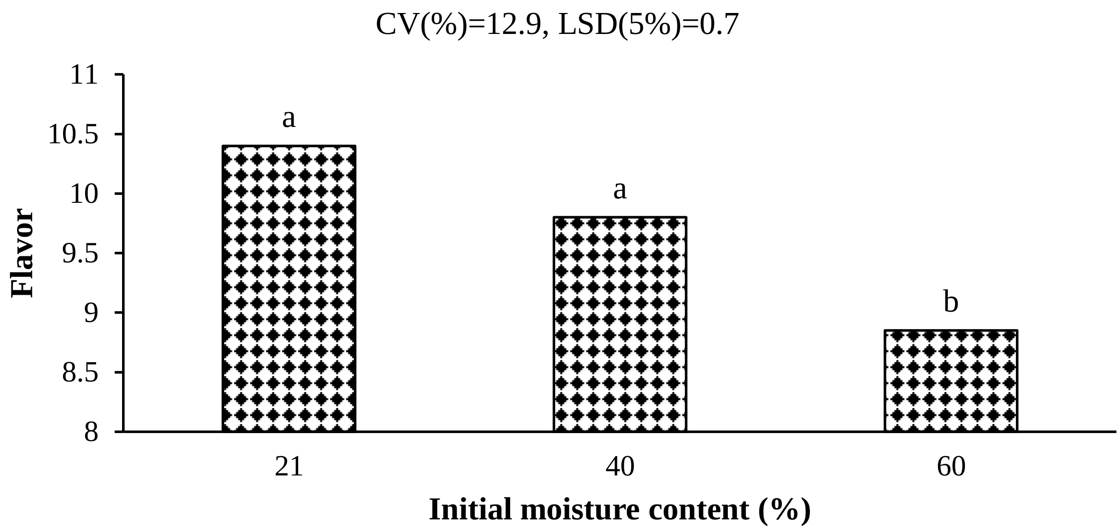
Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 6. Effect of variety on body of wet processed Arabica coffee

4.2.3 Flavor

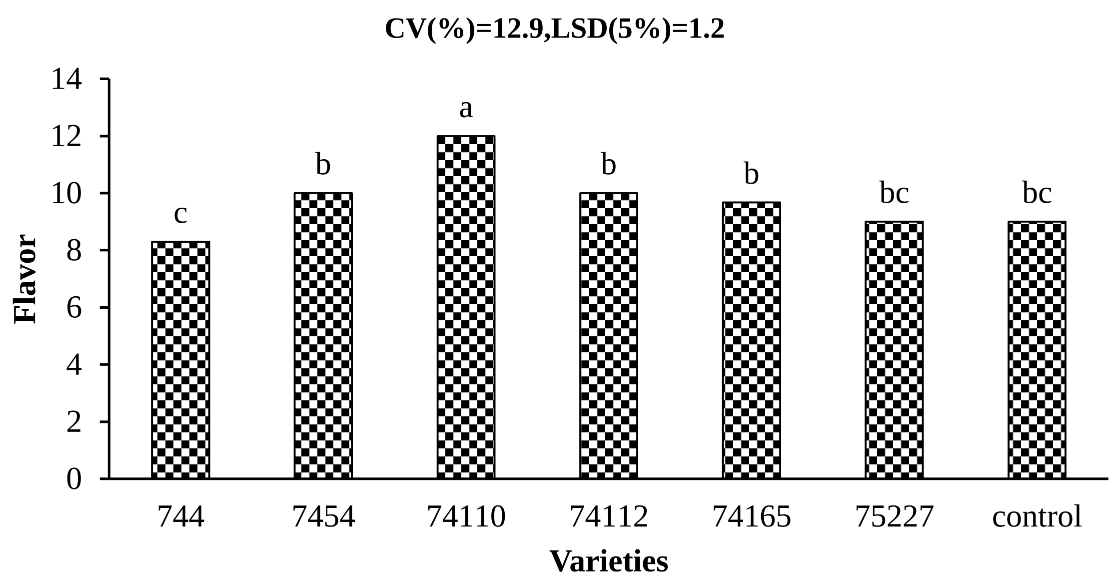
Effect of moisture content and variety on flavor was highly significant (P<0.001) while their interaction effect was non-significant (Appendix Table 2). Effect of moisture content on flavor was significant (P<0.01) (Appendix Table 2). The higher fair good to medium flavor with average value of 10.40 was registered for coffees dried with both moisture contents of 21 and 40 percent. The least fair flavor with average value of 8.85 were noted for coffees (60% moisture content) dried directly by mechanical drier. This result shows coffees with different drying phase will produce different taste and beverage quality. Combination process of sundrying followed by mechanical drying produces green coffee having better flavor than the bean which was full mechanical dried(Wahyudiand Ismayadi, 1995). Coffee fruits processed using several different steps have a pronounced effect on the final quality of the resulting beverage (Mazzafera and Purcino, 2004; Bytof*et al.*, 2005).

Effect of coffee variety on flavor was significant (P<0.01) (Appendix Table 2). The higher good to fair good coffee flavor with average value of 12 was noted for variety 74110 and the lower medium to fair flavor with average value of 8.3 was recorded for variety 744 this is statistically similar with variety 75227 and the control variety this is due to difference in varieties. This result was in line with Wintgens (2004) and coffee genotype is a key factor, since it determines to a great extent important characteristics of chemical composition and flavor.



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 7. Effect of moisture content on flavor of wet processed Arabica coffee varieties



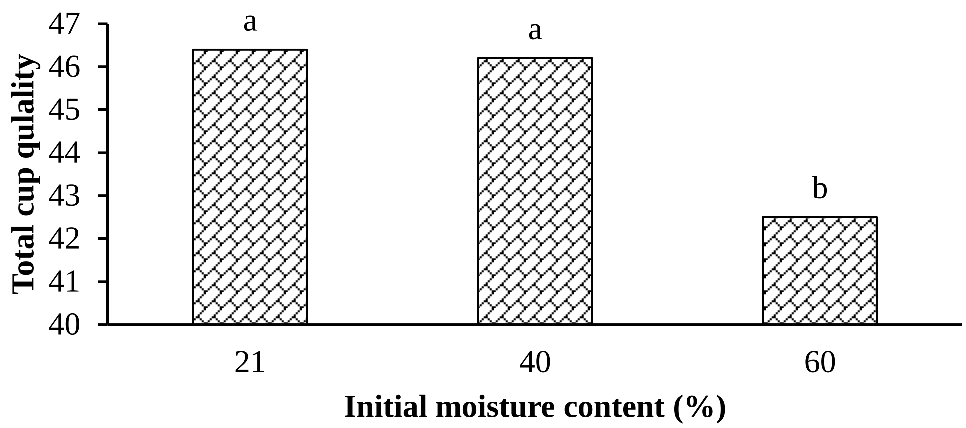
Bars capped with same letter(s) are not significantly difference at P<0.05
Figure 8. Effect of variety on flavor of wet processed Arabica coffee

4.2.4 Total cup quality

Cup quality, often referred as drinking quality or liquor quality, is an important attribute of coffee and acts as yardstick for price determination (Agwanda*et al*., 2003;ECX, 2011).There was highly significant ($P \leq 0.001$) variation of total cup quality among initial moisture content of coffee varieties while their interaction was non-significant. Initial moisture content is highly significant ($P \leq 0.001$) (Appendix Table 2). The higher coffee quality with good sweet quality with average value of 46.4 is noted for coffees dried with both 21 and 40 percent moisture contents. The lowest standard to fair cup were registered for coffees dried with mechanical drier (60 % moisture content) without sun drying this is due to effect of sun light which improves coffees cup quality. This result was supported by Coradi*et al.* (2007) which states drying on a yard by sun had the best coffee quality scores similarly Wahyudi and Ismayadi (1995) states that The mechanical drying process might produce beans with metallic, sourish and fruity tone flavors.

As depicted in Appendix Table 2 there was a significance difference on cup quality ($P < 0.01$)among coffee varieties. The higher sweet balanced cup quality with average value of (49) was observed for variety 74112 and statistically similar with74110. However the lowest average to fair cup quality with average value of 41 was observed on variety 75227 and statistically similar with variety 744,this is due to presence of diversity within coffee varieties and drying methods for the cup quality characteristics. This finding was supported by Mekonen(2009) who confirms the presence of diversity within coffee genotypes, and postharvest processing on the cup quality characteristics.

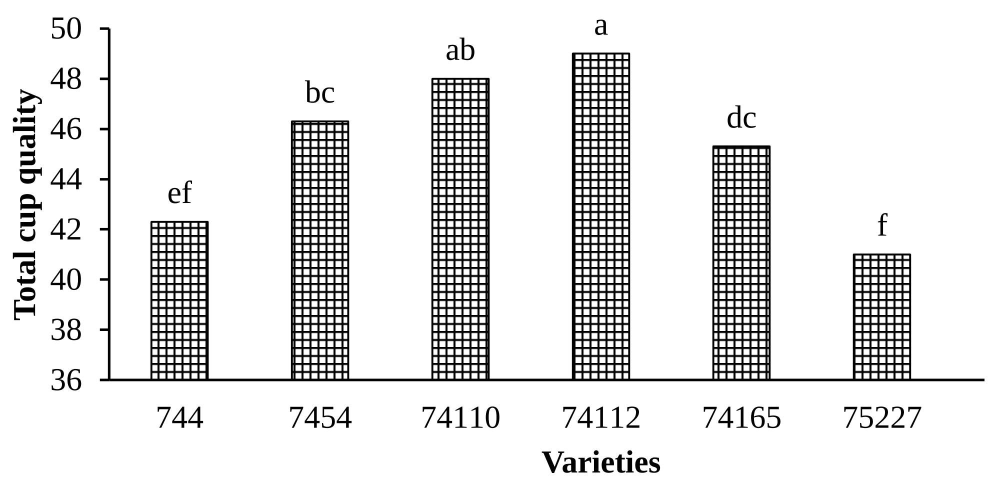
CV(%)=5.9 ,LSD(5%)=1.6



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 9. Effect of moisture content on total cup quality of wet processed Arabica coffee

CV(%)=5.9, LSD(5%)=2.5



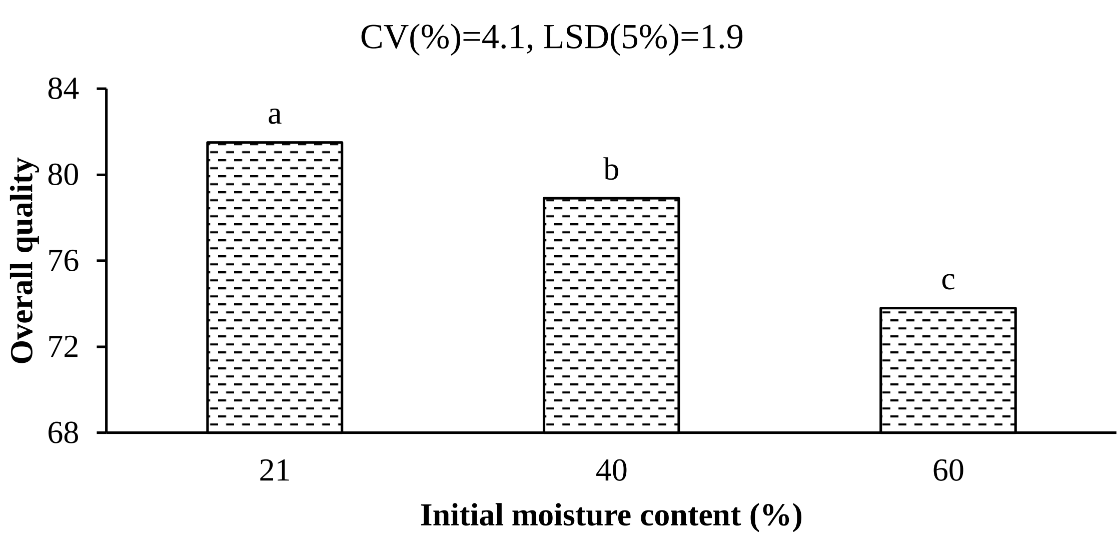
Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 10. Effect of moisture content on total cup quality of wet processed Arabicacoffee

4.2.5 Overall quality

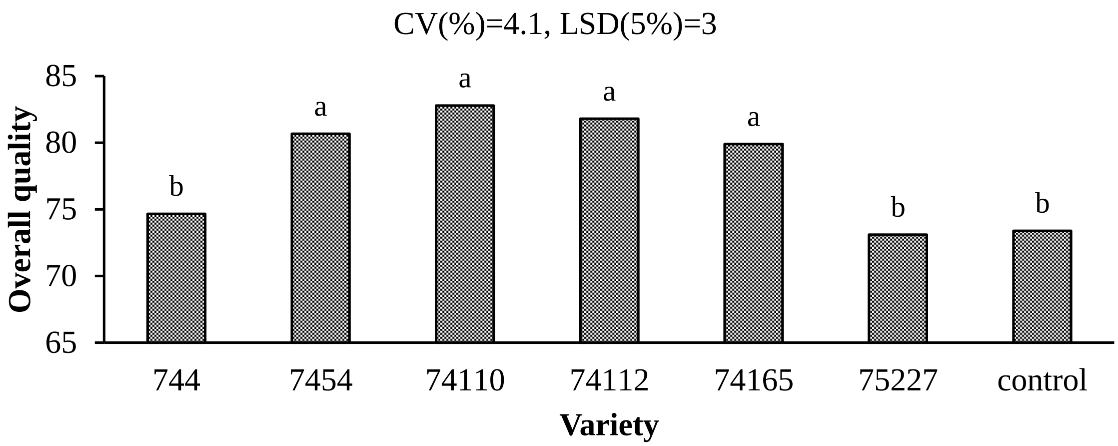
The total quality of a coffee is the overall quality of the coffee which used to determine and evaluate the quality potential of the coffee variety. The analysis of variance indicated that there was significant effect of the main factors on overall quality while their interaction showed non-significant (Appendix Table 2). Therefore, the effect of moisture content on the overall coffee quality shows higher good quality grade 1 to 2 with average value of 81.5 were observed for coffees dried with 21 percent moisture content. However the lowest total quality with average value of 73.8 was noted for coffees dried directly by mechanical dryer with 60 percent moisture content. This result revealed that pre drying coffee by sun before mechanical drying gives higher quality value this finding was supported by Coradi*et al.,*(2007) which states drying on a yard by sun had the best coffee quality scores.

Among coffee varieties evaluated most of the varieties except showed significantly higher Overall quality score. Whereas the other three varieties revealed significantly lower Overall quality this indicates presence of quality difference between different genotypes this finding is supported by Mekonen(2009) and Yigzaw (2006) which confirmed the presence of diversity within coffee genotypes, and postharvest processing on the cup quality characteristics.



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 11. Effect of moisture content on overall quality of wet processed Arabica coffee



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 12. Effect of variety on overall quality of wet processed Arabica coffee

4.2.6 Coffee grades

The result of coffee grades for varieties indicates that most of coffee varieties showed good raw and cup quality values which fall between 1 and 2 grades which were candidate for further evaluation for specialty treatments. On the other hand varieties 744, 75227 and the control treatment showed lower (raw and cup values) grade least 3 and 4 grades especially the control treatment (mixture of all varieties) which is plantations local working practice shows low grade coffee grade 4 this grade variation affects coffee price determination in the world market. This variation is due to the quality difference of different varieties.Similar finding were reported by (Abyot,2010), indicated the existence of considerable variations among coffee genotypes.

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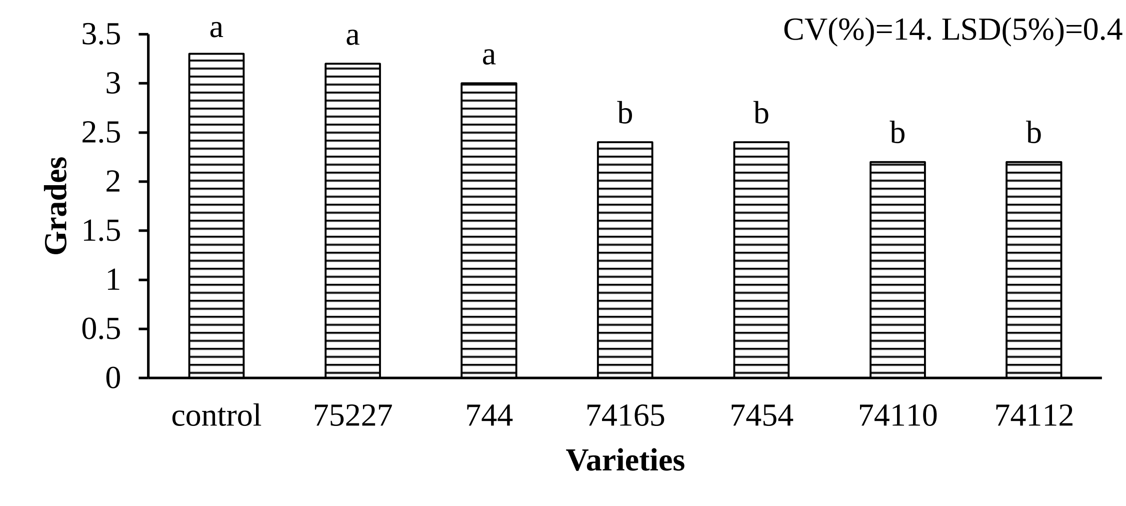
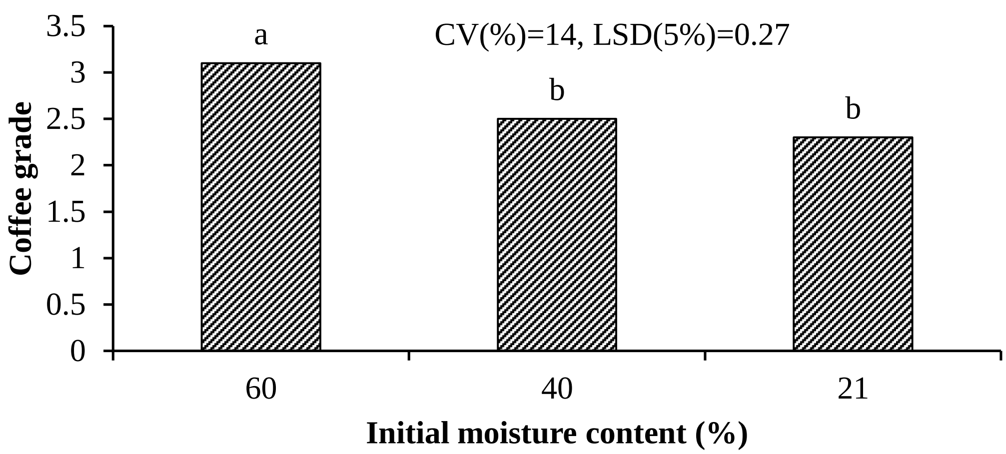
Coffee grade also affected by initial moisture content of coffee before mechanical drying coffee with very good raw and cup result grade 2 was obtained from coffees dried until 21 and 40 percent moisture contents, whereas the lower(raw and cup) commercial 3 and 4 grade result was showed on coffees dried by mechanical drier without pre drying by sun.This result is supported by Wahyudi and Ismayadi (1995)full mechanical drying process produced lower quality than the combination of the two.



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 13. Effect of variety on the gradeswet processed Arabica coffee



Bars capped with same letter(s) are not significantly difference at P<0.05

Figure 14. Effect of initial moisture content on the gradesof wet processed Arabica coffee

4.2.7. Specialty value

The interaction effect of initial moisture content and variety showed significant (P<0.05) effect (Appendix Table 2) on specialty value The result showed that variety 7454 dried at 21percent moisture content had the highest specialty value which is specialty 1(Q_1) with average value of 86.5 and statistically similar with variety 744, 74110 and control dried at 21

% moisture content and variety 74112 dried directly. Whereas the lowest specialty value of 79.3 which is commercial grade was recorded for treatment combination of 60xcontrol.This result shows the presence of diversity in coffee beverage quality among Arabica coffeegenotypes. This was in agreement with previous findings reported by Dessalegn*et al.* (2008) and Kathurima*et al.* (2009).

Table 6.Effect of moisture content and variety on the specialty value of washed Arabica coffee

	Initial Moisture Content (%)		
Variety	21	40	60
744	85.20^{a-e}	81.30^{hi}	81.67^{ghi}
7454	86.50^{a}	83.80^{b-g}	83.30^{c-h}
74110	86.20^{ab}	85.40^{a-d}	84.60^{a-f}
74112	84.50^{a-f}	84.90^{a-f}	85.10^{a-f}
74165	82.67^{fgh}	83.20^{d-h}	83.10^{d-h}
75227	81.20^{hi}	82.67^{fgh}	82.90^{e-h}
Control	85.80^{abc}	84.0^{b-g}	79.30^{i}
LSD (5%)	2.5		
CV (%)	1.8		

Means followed by same letter(s) across rows and columns are not significantly different at P<0.05

5. SUMMARY AND CONCLUSION

High rainfall, high relative humidity and low temperature conditions are considered naturally less suited to effectively dry coffee. Under such circumstances, standard conditions for sundrying cannot be efficient and quality could be compromised. Therefore, mechanical drying is alternative method to overcome such kinds of inconveniences. This calls for evaluationof the existing methods of processingused for the available coffee varieties and scientific study designedto optimize the initial moisture contentand drying stages required in order toproduce green coffee having good quality.

Accordingly, this study was conducted to determine the optimum initial moisture content of different varieties of parchment coffee for mechanical drying to produce coffee of better green and cup qualities. The findings indicate that the effects of variety and moisture content and their interaction effect showed significant effect on green coffee physical and cup quality characteristics.

From initial moisture content of coffee evaluated pre drying coffee to as low as 21 percent moisture content were found to be the best for most raw quality attributes. The cup quality attributes also show highest cup acidity, body, flavor, total cup quality and overall coffee quality values were also identified to be superior at 21% followed by 40 percent initial moisture content. However the lowest raw and cup quality characteristics were observed for most coffees dried directly by mechanical drier with an initial moisture content of 60 percent. Of all three initial moisture contents evaluated 21% had significantly higher desirable cup quality and green bean physicalcharacteristics.

There were also variations among the coffee varieties for green and cup quality characteristics varieties 74112 and 74110 and most of other varieties scored significantly higher quality potential while significantly lower overall qualitywas noted from the control which is the mixture of all varieties this is because irregular raw which leads to irregularity during drying and roasting periods which leads to poor drinking quality.

It is also important to consider buyers cup preference to meet personal choices by supplying different coffees with varied cup (acidity, body flavor) and physical (color and shape and make) quality characteristics. In addition processing coffee varieties differently helps to prepare value added products by blending of coffees with different and better cup qualities. Therefore, coffee quality can be best improved through processing and drying each variety independently.

6. FUTURE LINE OF WORK

Fromthe present findings, it is possible to suggest the followings as high priority research areas.

- Evaluating quality performance present treatments by comparing with other processing methods like full sun drying and unwashed coffee processing
- Determining caffeine content and other biochemical constituents of present treatments
- Evaluating quality of present coffee varieties by using fermentation and demucilager
- Development of cost-effective and environmentally friendly drying and processing methods at each area should be studied.

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APPENDICES

Appendix Table 1.ANOVA for raw quality parameters of washed Arabica coffees at the study

SV	DF	Mean Square					
		PD	SD	SM	CL	OD	RQ
Mc	2	0.15^{ns}	0.002*	0.10^{ns}	0.009*	0.002*	0.0001**
Var	6	0.04*	0.034*	0.02*	0.009*	0.16^{ns}	0.0001**
McxVar	12	0.62^{ns}	0.15^{ns}	0.19^{ns}	0.019*	0.02*	0.008**

*Where *, ** = statistically significant difference at 5% and 1% probability level respectively; ns = non-significant difference; SV = source of variation; DF = degrees of freedom; PD = Primary Defect; SD = Secondary Defect; SM =shape and make; CL= color; OD=odor; RQ=raw quality*

Appendix Table 2. ANOVA for cup quality parameters of Arabica coffee

SV	**DF**	**Mean Square**						
		CC	**AC**	**BO**	**FL**	**CQ**	**TQ**	**SP**
Mc	2	0.72^{ns}	0.002*	0.0008**	0.0008**	0.0001**	0.0001**	0.003*
Var	6	0.84^{ns}	.0003**	0.0001**	0.0001**	0.0001**	0.0001**	0.0002**
McxVar	2	0.72^{ns}	0.01*	0.10^{ns}	0.23^{ns}	0.64^{ns}	0.11^{ns}	0.002*

*Where *, ** = statistically significant difference at 5% and 1% probability level respectively; ns= non-significant difference; SV = source of variation; DF = degrees of freedom; Mc=moisture content Var = variety;CC=cup cleanness CQ = Cup Quality;TQ = Total raw; SP = speciality value*

Appendix Table 3. Standard raw quality parameters and their respective values used for washed coffee quality evaluation (ECX, 2011)

Raw Value (40%)									
Defects (20%)				Shape & Make (10%)		Color (5%)		Odor (5%)	
Primary (count) (10%)	point	Secondary (wt) (10%)	Point	Quality	Point	Quality	Point	Quality	Point
0	10	<5%	10	Very Good	10	Bluish	5	Clean	5
1-4	8	<8%	8	Good	8	Grayish	4	F. Clean	4
5-6	6	<10%	6	F. Good	6	Greenish	3	Trace	3
7-10	4	<12%	4	Average	4	Coated	2	Light	2
11-15	2	<14%	2	Fair	2	Faded	1	Moderate	1
>15	1	>14%	1	Small/Mixed	1	White	0	Strong	0

Appendix Table 4. Standard cup quality parameters and their respective values used for washed coffee quality evaluation (ECX, 2011)

CUP QUALITY VALUE (60%)							
Cup Cleanness (15%)		**Acidity (15%)**		**Body (15%)**		**Flavor (15%)**	
Quality	**Point**	**Quality**	**Point**	**Quality**	**Point**	**Quality**	**Point**
Clean	15	Pointed	15	Full	15	Good	15
Fairly clean	12	Medium pointed	12	Medium full	12	Fairly good	12
1 cup defect	9	Medium	9	Medium	9	Average	9
2 cup defect	6	Light	6	Light	6	Fair	6
3 cup defect	3	Lacking	3	Thin	3	Commonish	3
>3-cup defect	0	Not detected	0	Not detected	0	Not defected	0