ASSESSMENT OF COFFEE QUALITY AND ITS RELATED PROBLEMS IN JIMMA ZONE OF OROMIA REGIONAL STATE

MSc THESIS

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Assessment of Coffee Quality and Its Related Problems in Jimma Zone of Oromia Regional State

By

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As thesis research advisors we hereby certify that we have read and evaluated the thesis prepared under our direction by Anwar Abasanbi, entitled '**Assessment of Coffee Quality and Its Related Problems in Jimma Zone of Oromia Regional State'** and recommend that it be accepted as fulfilling the thesis requirement.

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DEDICATION

I dedicate this thesis to my family for nursing me with affections and love and their dedicated partnership for success in my life

STATEMENT OF THE AUTHOR

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

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BIOGRAPHICAL SKETCH

Anwar Abasanbi Abadiga was born at Abakoyi, Dedo woreda; Jimma zone on September 1 in 1963. He attended his Elementary, Junior Secondary, and High School education at Dedo Elementary School, Jimma Junior Secondary and Agaro High School, respectively. He joined the then Jimma College of Agriculture (now Jimma University, College of Agriculture and Veterinary Medicine) in 1990 and 2002 and graduated on 1997 and 2007 with a diploma and B.Sc degree in general Agriculture and Horticulture, respectively.

He was employed on May 17, 1983 by CIP (Coffee Improvement Project) (now Oromia Agriculture and Rural Development Bureau) to serve as an extension agent at Gomma District of Jimma Zone. Since his employment, he served as extension agent, supervisor, CIP officer and department head posted at different Districts and zone office of Oromia until he joined the School of Graduate Studies of Jimma University on September 30, 2007 to pursue his studies for Master of Science in Agriculture (Horticulture).

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LIST OF ABBREVIATIONS

ARDO	Agricultural and Rural Development Office
CDMIP	Coffee Development and Marketing Improvement Plan in
CFC	Common Fund for Commodities
CIP	Coffee Improvement Project
CLU	Coffee Liquoring Unit
CQPPHMP	Coffee Quality Pre and Post Harvest Management Practices
CSA	Central Statistics Authority
DA	Development Agent
ECEE	Ethiopia Coffee Export Enterprise
ECMC	Ethiopia Coffee Marketing Corporation
ECPSE	Ethiopia Coffee purchase and Sale Enterprise
ECX	Ethiopia Commodity Exchange
EEA	Ethiopian Economic Association
FAO	Food and Agriculture Organization of the United Nations
FAQ	Fairly Average Quality
FTC	Farmers Training Center
HH	Households
HPLC	High Performance Liquid Chromatography
IAR	Institute of Agricultural Research
ICO	International Coffee Organization
ILRI	International live stock Research institution
IPM	Integrated Pest Management
IPMS	Improving Productivity and Marketing Success
ISO	International Standard Organization
ITC	International Trade Centre
JARC	Jimma Agricultural Research Center
JUCAVM	Jimma University, College of Agriculture and Veterinary

JZARDO	Jimma Zone Agricultural and Rural Development Office
NCBE	National Coffee Board of Ethiopia
OTA	Ochratoxin A
PAS	Peasant Associations
QSAE	Quality and Standards Authority of Ethiopia
RWH	Rain Water Harvesting
SCAA	Specialty Coffee Association of America
SAS	Statistical Analysis System
SMS	Subject Matter Specialist
SPSS	Statistical Package for Social Science
WFP	World Food Program

Assessment of Coffee Quality and Its Related Problems in Jimma Zone of Oromia Regional State

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ABSTRACT

Arabica coffee (Coffee arabica L.) is an economically important crop, which is contributing the highest of all export revenues in Ethiopia. It is also the major cash crop of Jimma Zone and produced in eight woredas. Despite the favorable climatic conditions, variety of coffee types and long history of its production in this Zone, quality of coffee is poor due to traditional poor pre and post harvest practices. Efforts were made so far in areas of fermentation time, drying depth, time of storage and extension support, training for coffee expertise and coffee farmers on recommended technologies. But there is lack of profound assessment works to identify the specific coffee quality problems in Jimma zone and lack of adequate information on the effects of post harvest processing and handling techniques on coffee quality. Therefore, the study was conducted with the objectives of assessing the impact of pre and post harvest processing practices on the quality of both wet and dry processed coffee, identifying the inherent quality of coffee in the zone and investigating socio-economic technical and institutional factors related to coffee quality problems in the zone. For field survey, 164 household farmers were randomly selected following sample size determination procedures of probability proportional to size technique and 30 coffee traders were purposefully selected from the two woredas and interviewed in the study area from November to December 2008. The data collected from the field survey were analyzed by employing the statistical procedures of SPSS version 14.0. A binary logit model was employed for the factors affecting adoption of coffee quality pre and post harvest management practices (CQPPHMP). A total of 14 explanatory variables were used for the binary logit model out of which 6 variables were significant to affect the adoption of CQPPHMP practices by the coffee farmers whereas none of the explanatory variables for sampled traders were found to be significant in the chi-square analysis except checking quality for price. In binary logistic regression analysis of field survey obtained from coffee farmers those factors that affect coffee quality were disease prevalent in coffee field, compost application, mixing up of differently harvested coffee during selling, availability of storage, drying materials used for drying and age of coffee in the store. The findings of this study indicate that any effort in promoting and adopting of CQPPHMP practice should recognize the socio-economic, institutional, and technical factors for better adoption of CQPPHMP practices. On the other hand, a total of 32 coffee bean samples (16 from each woreda) were prepared for the laboratory analysis (organoleptic and bean physical quality characteristics) at Jimma Agricultural Research Center (JARC). The laboratory experiment was arranged in split plot design, considering the processing method as main plot and the preparation type as sub-plot in RCBD with three replications and organoleptic quality attributes were assessed by trained coffee panelists. The laboratory data analysis was computed by using general linear model (GLM) procedures of SAS version 9.2. It was observed that wet processing method resulted in high mean values for good cup quality attributes, like acidity, body and flavor, and for bean physical quality attributes, like odor as compared to dry processing method. For most of sensorial quality attributes, recommended preparation procedure outsmarted local preparation (farmers/traders) methods. For physical quality attributes, preparation methods were varied only for color and odor. Nonetheless, of the processing methods investigated in this study, it was observed that the recommended way of preparing coffee promotes the typical quality profile to the final cup quality to meet consumers' choice that finally creates interest for the profile and competence in the international coffee market. From this result, it can be concluded that wet processing method is the best approach to obtain fine and typical flavor in the cup to meet the interest and preference of consumers. Extension intervention could be the best approach to create awareness among coffee producers towards maintaining typical coffee quality profile of their garden through processing that finally adds value to their produces.

1. INTRODUCTION

Coffee *(Coffea arabica L.*) is a non-alcoholic stimulant beverage crop that belongs to the family *Rubiaceae* and genus *Coffea.* It is the only self–fertile with less than 10 per cent cross-pollination, tetraploids species (2n=4x=44) while others are diploids (2n=22) and self-incompatible (Berthaud and Charrier, 1988; Anthony *et al*., 2001). Among 100 *Coffea* species in the genus *Coffea*; *C. arabica* is the only species naturally occurring in Ethiopia (Anthony *et al*., 2001; Yigzaw, 2005).

Ethiopian coffee is an important source of coffee genetic resources for the world coffee industry. As a matter of fact, Ethiopia is the only center of origin and diversity of arabica coffee (*C. arabica*) (Anthony *et al*., 2001). It is cultivated in most parts of the tropics, accounting for 80 per cent of the world coffee market, and about 70 per cent of the production (Tadesse *et al*., 2002). It is also an important source of income and employment in developing countries of Latin America, Africa and Asia (Anthony *et al.,* 2001).

Coffee is the major source of foreign currency for Ethiopia and contributes more than 35% of the total export earnings (FAO/WFP, 2008). Thus, it is a cornerstone in the export economy of the country and it supports directly or indirectly the livelihood of some 15 million people (EEA, 2001). Coffee the defining feature of the national culture and identity, with 44% of the production consumed domestically (Mayne *et al*., 2002). In Ethiopia, coffee is produced in four production systems, namely: forest, semi-forest, garden and plantation coffee in the Western, Southern, and Southwestern parts of the country (CFC, 2004). Coffee grows under diverse environmental conditions ranging from 550 m to 2600 m above sea level, with annual rainfall from 1000-2000 mm, temperature (minimum and maximum from 8-15^{0}C, and 24-31^{0}C, respectively), requires deep, well drained, loamy and slightly acidic soils (Paulos and Tesfaye, 2000). The estimated area of land covered by coffee is about 600,000 hectares, whereas the estimated annual national production of clean coffee is about 350,000 tons (Alemayehu *et al*., 2008).

Jimma Zone is one of coffee growing zones in the Oromia Regional State, which has a total area of 1,093,268 hectares of land (JZARDO, 2008). Currently, the total area of land covered by coffee in the zone is about 105,140 hectares, which includes small-scale farmers' holdings as well as state and private owned plantations. Out of the 40–55 thousand tons of coffee annually produced in the Zone (JZARDO, 2008), about 28-35 thousand tons is sent to the central market, while the remaining is locally consumed (Alemayehu *et al*., 2008). Now a day, Jimma Zone covers a total of 21% of the export share of the country and 43% of the export share of the Oromia Region (JZARDO, 2008).

Coffee is the major cash crop of the Zone, which is produced in the eight woredas namely, Gomma, Manna, Gera, Limmu Kossa, Limmu Seka, Seka Chokorsa, Kersa and Dedo, which serves as a major means of cash income for the livelihood of coffee farming families (JZARDO, 2008). According to the report from the same source, 30-45 % of the people in Jimma Zone are directly or indirectly benefited from the coffee industry.

Despite the favorable climatic conditions, variety of local coffee types for quality improvement and long history of its production in Jimma Zone, coffee quality is declining from time to time due to several improper pre-and post-harvest management practices. This is still practiced by the majority of coffee farmers/traders, from which the larger portion of the produce is obtained. These quality problems are mainly associated with poor agronomic practices like uncontrolled shade level, lack of stumping, pruning and weeding; poor harvesting practices, such as stripping and collecting dropped fruits from the ground; improper post harvest processing and handling practices such as drying on bare ground, improper storage and transportation (Desse, 2008). In addition to this, natural impediment such as prolonged rainy weather, particularly during harvesting and drying season can also contribute to reduced coffee quality (Desse, 2008).

For instance, Desse (2008) reported that out of Jimma coffee sent to the coffee quality inspection center laboratory from 2003 to 2007, more than 60% of dry processed coffee classified into grade 3 as compared to 80% of wet processed into grade 2 and grade 3. The author indicated the problem of post harvest processing and handling in the area resulted in poor quality as the main contributing factor. The poor quality and the subsequent drop in earnings had severely affected coffee farmers in woredas like Gomma, Limmu Kossa, and Manna, where coffee provides a larger portion of their annual income. On the contrary, Jimma Zone is known for some quality coffee types such as Limmu Enaria (Limmu) coffee, which is known for its best quality in the world market.

Though research on coffee has been conducted at the national level for more than four decades by JARC, its target was to develop CBD (Coffee Berry Disease) resistant, high yielding and wide adapting varieties for major coffee growing areas of the country (Getu, 2009). Therefore, so far there was no extensive coffee quality research conducted in the country except on fermentation, drying depth and time of storage (Solomon and Behailu, 2006). However, there was a piece of work done by Getu (2009) and Yigzaw (2005) on organoleptic quality traits variation with respect to genotype by environment interaction. Furthermore, Brownbridge and Eyassu (1968) characterized coffees from Limmu Kossa, Gera and Agaro areas based on the bean shape and other quality assessments using raw, roasted and liquor characteristics.

Despite the favorable climatic conditions, variety of local coffee types for quality improvement and long history of its productions, still there are gaps such as lack of profound assessment works to identify the specific coffee quality problems in Jimma zone and lack of adequate information on the effects of post harvest processing and handling techniques on coffee quality. Hence, this study was designed to address the above mentioned problems thereby forward ways and means that will help growers and processors to produce better quality coffee in the zone.

Therefore, the objectives of this study were:

1. To assess the impact of pre and post harvest processing practices on the quality of both wet and dry processed coffee
2. To assess the inherent quality of coffee in the zone
3. To identify socio-economic, technical and institutional factors related to coffee quality problems in the zone.

2. LITERATURE REVIEW

2.1. Botanical Descriptions

Arabica coffee is an evergreen shrub of variable size. The tree grows up to 8-10 m high and its branches are long, flexible and thin. Branches are semi-erect when young and spreading or pendulous when old (Coste, 1992). The architecture of the coffee tree is characteristic of a tree growing in tropical forests: a vertical (orthotropic) stem, with horizontal (plagiotriopic) branches arising in pairs opposite to each other. The growth is by a typical form of monopodial branching where the branches (primaries) remain subsidiary to the main stem, which continues to grow indefinitely by extension of the apical buds (Wrigley, 1988). The coffee plant takes approximately 3 years to develop from seed germination to first flowering and fruit production. A well- managed coffee tree can be productive for up to 80 years or more, but the economic life span of a coffee plantation is rarely more than 30 years (Wintgens, 2004).

The root consists of a stout central root, often multiple, tapering more or less abruptly, rarely extending as a recognizable until more than 30 to 40 cm from the soil surface. The leaves born in opposite pairs on the sides of the branches are between 10-15 cm long, 4-6 cm wide, and oval-shaped and acuminate. It has white, Jasmine-scented flowers grouped together in the axils of the paired leaves, with two to three cymes making up whorls of 8-15 flowers. Its fruit is sub-globular, ovoid, oblong or squat-shaped. Fruits are orange-red to red on ripening, 16-18 mm long and 10-15 mm wide. Fruits have a colored exocarp (skin), a fleshy yellow-white mesocarp (pulp) and two beans joined together along their flat sides. The calyx may or may not be pronounced as well as persistent until fruit maturity, depending on different varieties.

The size and shape of the beans differ depending upon the variety, environmental conditions and management practices. On average, beans are 10 mm long, 6-7 mm wide, 3-4 mm thick and weigh between 0.15 and 0.20 g. Bean color can be yellowish-grey to slate-grey, bluish or grey-green, depending upon the variety, method of preparation and storage condition (Coste, 1992). 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, 1968).

2.2. Coffee Quality

In recent years, different coffee producing countries have tremendously expanded their production and export volume (Behailu *et al.,* 2008). According to the current context of overproduction and low prices of the coffee market, improvement and valorization of coffee quality could provide the coffee chain with a new impetus (Leroy *et al*., 2006). Production and supply of coffee with excellent quality seems more crucial than ever before for coffee exporting countries. Consequently, some countries consider assessment of coffee quality as important as disease resistance and productivity in their coffee variety development program (ITC, 2004). In view of the present situation, making effort to overcome challenges and threats only through expansion of production does not seem visible for countries like Ethiopia. Thus, it has been repeatedly mentioned at various forum that providing good quality coffee is the only way out and viable option to get into the world market and to remain competitive (Behailu *et al.,* 2008).

Coffee is the most important crop in the national economy of Ethiopia and the leading export commodity. Ethiopia is well known not only for being the home of arabica coffee, but also for it is very fine quality coffee acclaimed for its aroma and flavor characteristics. The coffee types that are distinguished for such unique characteristics include Sidamo, Yirga Chefe, Harerge, Gimbi and Limu types (Workafes and Kassu, 2000). However, coffee produced in some parts of Ethiopia, especially from Harrar, and Yirgachefe, is always sold at a premium price both at domestic and international coffee markets because of its distinctive fine quality (Chifra *et al*., 1998; ITC, 2002) and appropriate processing approach.

On the other hand, sun dried Jimma coffee is one of the lowest priced coffees in the international market due to inappropriate processing as opposed to Limmu washed grade 2 which, fetches better premium price though it is produced in the same agro-ecological zone (Desse, 2008). Limmu coffee is characterized as having excellent balanced flavor with good acidity and medium body. It shares the winy characteristics of Harar (Getu, 2009). Furthermore, Desse (2008) reported that although the inherent flavor of Jimma coffee is pleasantly winy, some of the common cup defects are earthy, musty with secondary cup defects of taints in the liquor, which are mainly due to post harvest management problems.

According to the International Organization for Standardization (ISO) (2000), Quality is described as "the ability of a set of inherent characteristics of a product, system or process to fulfill requirement of customers and other interested parties". These inherent characteristics can also be called "attributes". For coffee, the definition of quality and the attributes considered have probably evolved through the centuries. But nowadays, this definition varies along the production-to-consumer chain (Leroy *et al*., 2006). *i.e.*; at the farmer level, coffee quality is a 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 and regularity of provision, tonnage available, physical characteristics and price; at the roaster level, coffee quality depends on moisture content, stability of the characteristics, origin, price, biochemical compounds and organoleptic quality (Leroy *et al*., 2006). It should be noted that each consumer market or country may define its own organoleptic qualities; at the consumer level: coffee quality deals with price, taste and flavor, effects on health and alertness, geographical origin, environmental and sociological aspects (organic coffee, fair trade, etc (ISO, 2000).

More specifically, ISO (2004a) defined a standard for green coffee quality (ISO 9116 standard) as, it requires several pieces of information, like the geographical and botanic origins of the coffee, the harvest year, the moisture content, the total defects, the proportion of insect-damaged beans and the bean size. These ISO standards define methods of measurements for several of these qualities such as, defects, moisture content, bean size, some chemical compounds and preparation of samples to perform cup tasting. According to the definition of quality and standards authority of Ethiopia (QSAE) (2000) a quality is conformance with requirements or fitness for use in which the parties involved in the industry (customer, processor, supplier, etc) should agree on the requirements and the requirements should be clear to all stake holders involved in the process. On the other hand, Coffee Quality control and auction Center was established with a key objective of maintaining coffee quality control, which in turn facilitates the coffee marketing system to be standard based, and for the betterment /proper functioning of the long coffee supply chain of Ethiopia (Endale, 2008).

Coffee has only one value to give the consumer pleasure and satisfaction through flavor, aroma and desirable physiological and psychological effects (Yigzaw, 2005). Therefore coffee quality, especially liquor or cup quality, determines both the relative price and usefulness of a given quantity of coffee (Agwanda *et al*., 2003). Cup quality, often referred to as drinking quality or liquor quality, is an important attribute of coffee (Muschler, 2001; Agwanda *et al*., 2003) and acts as yardstick for price determination (Agwanda *et al*., 2003).

2.3. Factors Affecting Coffee Quality

Cup quality is a complex characteristic which depends on a series of factors such as the species or variety (genetic factors), environmental conditions (ecological factors), agronomical practices (cultivation factors), processing systems (post harvest factors), storage conditions, industrial processing, preparation of the beverage and taste of the consumer (Moreno *et al*., 1995). Coffee quality is of critical importance to the coffee industry. 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).

However, in Ethiopia the quality of coffee produced by farmers has been deteriorating from time to time. Moreover, factors that determine coffee quality are genotypes, climatic conditions, and soil characteristics of the area, agronomic practices, harvesting methods and timing, post harvest processing techniques, grading, packing, storage conditions and transporting, all contribute either exaltation or deterioration of coffee (Behailu *et al.*, 2008). Similarly, Damanu (2008), reported coffee quality as a combination of the botanical variety, topographical conditions, and climatic conditions and the care taken during growing, harvesting, storage, exports preparation and transport. According to the author botanical variety and topographical conditions are constant and therefore dominate the inherent characters of a coffee where as other factors except climatic conditions can be influenced by human being and are a key factor in determination of the end quality of a green coffee. Furthermore, inadequate systems of harvesting, processing, storage and transportation are responsible for the wide spread failure to maintain the inherent quality of coffee produced in Ethiopia (Alemayehu *et al.*, 2008).

2.3.1 Climatic and soil factors

The environment has also a strong influence on coffee quality (Decasy *et al.*, 2003). Altitude, daily temperature fluctuations, amount and distribution of rainfall and the physical and chemical characteristics of the soil are very important factors. Climate, altitude, and shade play an important role through temperature, availability of light and water during the ripening period (Decasy *et al*., 2003). Rainfall and sunshine distributions have a strong influence on flowering, bean expansion, and ripening (Harding *et al*., 1987). The slowed-down ripening process of coffee berries at higher elevations (lower air temperatures), or under shading, allows more time for complete bean filling (Vaast *et al.,* 2006), yielding beans that are denser and far more intense in flavor than their neighbors grown at lower altitudes (or under full sunlight). The slower maturation process should therefore play a central role in determining high cup quality, possibly by guaranteeing the full manifestation of all biochemical steps required for the development of the beverage quality (Silva *et al.,* 2005). For instance, chlorogenic acids and fat content have been found to increase with elevation in *C. arabica* (Bertrand *et al.,* 2006). Besides the beneficial effect of longer duration of the bean-filling period, a larger leaf area-to-fruit ratio (better bean-filling capacity) may also be linked to superior cup quality (Vaast *et al*., 2006).

The role of soil types has been well studied and it is generally admitted that the most acidic coffee quality is grown on rich volcanic soils (Harding *et al*., 1987). The perceived acidity of coffee brews has always been recognized as an important attribute of coffee quality. Acidity is typically a highly valued quality especially in Central American and some East African coffees (Yigzaw, 2005). Sourness, however, is an extreme of acidity and can be considered as defect. Acidity has been correlated with coffees grown at very high altitudes and in mineral rich volcanic soils. On top of this Yigzaw (2005) reported that if other factors are kept constant, better quality coffee can be found at higher altitudes, while low land coffee were found to be somewhat bland, with considerable body. Moreover, coffee from high altitude areas was more acidic, with better aroma and flavor.

Woelore (1993) reported that for Ethiopian conditions an underwater fermentation technique and the time for fermentation for different agro-ecologies are recommended. According to the author mucilage degradation washed at the first, second, third, or after the third day from pulping in the altitudinal range 1200 m and below, 1200-15000 m, 1500-1800 m and above 1800 m, respectively, for varying fermentation practices. Woelore (1995) reported that factors such as total rainfall, relative humidity, maximum-minimum temperatures with effect on water vapor content of the air and storage duration, greatly influence storability and quality of stored parchment coffee. Periods of prolonged drought may also result in lower quality beans (Wintgens, 2004). Most of the coffee tasters agree now that there is very little or no difference in flavor at all between the Arabica pure breeds cultivated under similar agro-climatic conditions (Wintgens, 2004).

2.3.2. Pre-harvest and harvest factors

Yigzaw (2005) reported that in South America, coffee grown with heavy application of nitrogen fertilizer had poorer, lighter and thinner quality than that from unfertilized fields. An excess of nitrogen increase the caffeine content, resulting in a more bitter taste of the brew. The caffeine and chlorgenic acid contents of the beans are not affected by the levels of phosphorus, calcium, potassium and magnesium in the soil (Wintgens, 2004). A lack of zinc will lead to the production of small light grey-colored beans, which will produce poor liquor (Wintgens, 2004). On the other hand, magnesium deficiency had an adverse effect on cup quality (Mitchell, 1988). High concentration of calcium (>0.11%) and potassium (>1.75%) in the beans is associated with a bitter and "hard" taste (Wintgens, 2004). Taye (1998) reported the use of decomposed coffee husk at a rate of 10 ton ha^{-1} (4 kg $tree^{-1}$ on dry weight basis) was found to be superior in terms of yield performance of coffee trees. A significant improvement in growth and yield of mature coffees was reported in response to coffee pulp and husk compost application (Chane, 1999). On the other hand, there is no correlation between the phosphorus content and the physical and organoleptic quality of the bean (Wintgens, 2004) .On the contrary, repeated application of elephant grass or livestock manure resulted in an increased percentage of undesirable brown-colored bean and, thus, poor roasting characteristics. This effect was associated with a magnesium deficiency induced by the high potassium content of elephant grass as well as high concentration of potassium and calcium in manure (Wintgens, 2004). Good growth conditions (weed control, appropriate planting density and pruning) usually have a positive effect on bean size and flavor (Wintgens, 2004). The relationship between crop management and total coffee quality, however, has not yet been investigated in detail.

Pests and diseases attacks can affect the cherries directly or cause them to deteriorate by debilitating the plants, which will then produce immature or damaged fruits. Disease and insect attack (such as leaf miner and mites) may also result in lower quality beans (Wintgens, 2004). For instance, as reported by Wintgens (2004) the coffee berry borer *Hypothenemus hampii* feeds and reproduces inside the coffee beans and causes their quality to deteriorate. The antestia sting bug as a vector of micro-organisms damages the bean and causes a bitter flavor. Similarly, the fly *Ceratitis capitata* feeds on the mucilage and the cherry becomes infected with micro-organisms; the secondary bacterial infection causes a distinct potato flavor. OTA (Ochratoxin A) is a form of mycotoxin, produced as a metabolic product of *Aspergillus ochraceus*, *A. carbonarius* and strains of *A. niger* reported to exist on coffee dried on bare ground (Eshetu and Girma, 2008).

Carvalho (1988) reported that shade trees did not improve cup quality. On the contrary, Muschler (2001) indicated that shade improved the appearance of green and roasted coffee beans as well as the acidity and body of the brew, especially for those produced in sub-optimal (low altitude) coffee production zones, by promoting slower and balanced filling and uniform ripening of berries. Furthermore, Yemane-Berhan (1998) observed that shade increased sugar concentration, which is an important factor for creating the aroma of coffee.

Apart from agronomic practices, cup quality is influenced by the age of the tree. Accordingly, Yigzaw (2005) reported that samples from young trees are likely to be mild and thin, but fine in flavor. Samples from old trees produce strong taste and a harsh characteristic brew. Medium aged trees, 15 to 20 years old, bear beans with good flavor as well as acidity and body (Yigzaw, 2005).

According to the results of studies by (Bertrand *et al.,* 2006; Vaast *et al*., 2006), tree physiology, plant age, and period of picking all interact to produce the final characteristics of the product. Indeed it was found that tree age, location of the fruits within the tree, and fruits-to-leaves ratio had a strong influence on the chemical content of green beans. Maturation also has a strong influence on coffee quality. The main factor affecting natural coffee quality is harvesting method. It is widely agreed that traditional hand-picking and husbandry labor, as opposed to mechanical harvest, produce the best quality green coffee by decreasing the percentage of defects in coffee batches. Bertrand *et al.* (2006) observed that yellow or green cherries picked at the end of the picking season contain beans with a higher maturity level than red cherries of *C. canephora* picked at the start of the picking season. This can be seen in bean size, chemical contents, and cup quality. On the other hand, for *C. arabica* in Costa Rica, early picking of red cherries gives the best coffee (Bertrand *et al.,* 2006).

On the other hand, Endale *et al.* (2008) pointed out that low caffeine content were found in bean harvested at immature stage (unripe) and in over-ripe coffee beans with conventional analysis using high performance liquid chromatography (HPLC). According to their findings this could be associated with slow metabolism of caffeine and its biodegradation at immature and over-ripe stages of fruit development, respectively.

2.3.3. Post-harvest factors

Depending on the post harvest processes, significant effects on coffee quality can be observed (Barel and Jacquet, 1994). Processing is a very important activity in coffee production and plays a crucial role in quality determination (Mburu, 1999). Coffee is either processed by the wet or dry methods, which vary in complexity and expected quality of the coffee (Wrigley, 1988). Both sun-drying as well as wet-processing methods are operated in Ethiopia, which accounts for 70% and 30% of coffee produced in the country, respectively (Jacquet *et al*., 2008).

According to Clifford (1985) wet processed arabica is aromatic with fine acidity and some astringency, while dry processed arabica is less aromatic and less acidic but with greater body. The perceived acidity of washed coffees is also significantly higher than the acidity found in naturally (dry) processed coffees. This is likely due to an increase in the body of naturally processed coffees relative to wet processed coffees since body masks the coffee's acidity (Yigzaw, 2005). Selmar *et al*. (2001) reported that sensory evaluation of the roast coffees revealed that the dry and washed coffees could be distinguished with high significance (11 of 11 panel members). As their report the differences in quality of differently processed coffees of similar original material is due to the process taking place in the beans during processing.

In the majority of the study area coffee is prepared using a dry processing (natural sun-dried) system, which is the first method by which the fresh cherries are harvested and sun-dried as a whole. Generally, farmers harvest selectively red cherries by picking them by hand; however a premature harvest can be sometimes carried out by strip picking for needs of cash and fear of thefts (Jacquet *et al*., 2008). After drying the cherries are sold to local collectors “Sabsabis”, wholesalers “Akrabis” or cooperatives, which are operating the secondary processing facilities (CFC, 2004).

The second method is the wet processing method in which the fresh red cherries are processed in three stages i.e. removals of the pulp and mucilage, fermentation and washing, and drying of parchment coffee (CFC, 2004). The covering period during drying and depth of parchment layer affects the total time required to dry parchment coffee to an optimum moisture level. Solomon and Behailu (2006) identified parchment coffee dried at the highest drying depth (5 cm) gave the lowest value of cup quality, while the other drying depths (2, 3 and 4 cm) gave better values of cup quality. Then, parchment coffee is dried and ready for transport to where it is sold in the auctions (still in parchment form). Concerning its marketing, as all Ethiopian coffee, Jimma export coffee has to be channeled through the central auctions in Addis Ababa (CFC, 2004).

In washed coffee production, final quality among others is greatly dependent upon the fermentation process (Woelore, 1993). It has been confirmed that under-water soaking following 'dry' fermentation, i.e., two-stage fermentation enhances the appearance of both raw and roast coffees compared to 'dry' fermentation only (Behailu *et al*., 2008). According to their report post fermentation soaking for 24 hours produced better raw and roast appearance than either 8 or 16 hours soaking but extending the soak to 48 hours did not cause any further improvement to the raw and actually reduced the roast quality.

On the other hand, Brownbridge and Michael (1971) have reported that the method of removing the mucilage (dry fermentation, under water fermentation, peptic enzyme accelerated fermentation or chemical cleaning) has no effect on the liquor quality and there is no evidence that any one method can produce significantly better liquors than another. The authors also indicated that high levels of coffee skins in fermenting coffee produces inferior raw, roast and liquor qualities compared to skin-free controls, with the liquors adversely affected by the development of off-flavors variously described as coarse, bitter, fruity, or unclean.

Natural fermentation of coffee is the function of many parameters, such as environmental, P_H, temperature, micro flora and level of pollution in the water used, variety difference in the ripe cherries used for pulping, its geographical and cultural origin, the standard of picking and minor variations in the processing method (Behailu *et al*., 2008). Furthermore, Behailu and Solomon (2006) reported that coffee fermented under shade takes more time, shaded fermentation tanks help to achieve uniform fermentation process and better quality coffee than unshaded one.

However, assessment made on wet-processed Jimma coffee by Brownbridge and Eyassu (1968) revealed that it is very heterogeneous, containing beans of all shapes, sizes and plain liquor, probably because of such a mixture types characterized by small beans of a nice green color and exquisite aroma. As the authors reported neither plant genetics nor the environment can be modified, but effort should be concentrated on the very critical post harvest practices such as harvesting, processing, drying, storing and transporting of coffee cherries, which are liable to be a major influence components of the quality of the cup.

Length and condition of bean storage also affect cup quality (Yigzaw, 2005). Long time storage under high relative humidity and warm conditions increase bean moisture content and consequently reduce quality in terms of raw and roasted appearance as well as liquor (Woelore, 1995).

2.3.4. Genetic factors

As harvesting method, post harvest procedures and the physiology of the plant itself affect coffee quality, its genetic origin (species and genotype) also greatly influence coffee quality (Leroy *et al*., 2006). Agwanda *(*1999) compared four traits (acidity, body, and flavor) and overall standard for their suitability as selection criteria for the genetic improvement of overall liquor quality. According to the author, based on correlation, repeatability and sensitivity analysis, flavor rating was recommended as the best selection criterion for genetic improvement of cup quality in Arabica coffee. The trait showed high genetic correlation with preference, was easy to determine organoleptically and had relatively high sensitivity in discriminating different coffee genotypes. The study of Yigzaw (2005) also revealed that coffee quality depends on genetic make-up and genes control the production of chemical compounds that behave as aroma agents either directly or as aroma precursors expressed during the roasting process. Hence while selecting a cultivar to be planted; cup quality must be the first priority to be considered (Yigzaw (2005).

Furthermore, Owuor (1988) and Moreno *et al*. (1995) improved the cup quality of different coffee genotypes with the assistance of professional coffee tasters. Both researchers observed close similarity among liquorers in ranking various cup quality characteristics of the cultivars, indicating that any one panel could be relied on selection for cup quality. Similarly, Agwanda *et al*. (2003) reported significant genotype x environment interaction effects on coffee bean and liquor quality. Walyaro (1983) reported relatively lower genotype x environment interaction effects on quality characters.

On the contrary, Van der Vossen (1985) reported non-significant genotype x environment interaction effects on quality characters, such as bean size and cup quality. Selvakumar and Sreenivasan (1989) observed coffee cup quality variation ranging from good to excellent among 54 Arabica coffee accessions collected from Keffa, Ethiopia. The genotype is a key factor, since it determines to a great extent important characteristics such as the size and shape of the beans as well as their color, chemical composition and flavor (Wintgens, 2004). The shape and structure of beans (elephant, pea bean and empty beans) are the result of both genotype and environmental factors (Wintgens, 2004).

2.3.5. Institutional factors

The National Coffee Board of Ethiopia (NCBE) was the first institution responsible for coffee which was established in 1957 with the aim of upgrading coffee quality, stimulating cooperative production, establishing marketing associations, conducting research and dissemination of information on coffee production, processing and marketing. Then after, the plantations in the southwestern part of the county were organized under southwestern Agricultural Development organization. Eventually coffee plantations were organized under the Ministry of Coffee and Tea Development (Gari, 2002). From 1979 to 1989, coffee auction market had been operating under the control of the government, i.e. the government set ceiling price, which was not competitive. After the 1990 market policy reform, the auction market was made free and the individual exporters and the Ethiopia Coffee Export Enterprise (ECEE) operate compositely by referring to the most recent world market price for Ethiopia coffee (Admasu, 1998). In 1993, the Ethiopia Coffee Marketing Corporation (ECMC) was restructured in to two enterprises: the Ethiopia Coffee purchase and Sale Enterprise (ECPSE) and the Ethiopia coffee Export Enterprise (ECEE).

Though research on coffee have been conducted nationally for more than four decades by JARC, the target of coffee research in Ethiopia was to develop CBD (Coffee Berry Disease) resistant, high yielding and wide adapting varieties to release for major coffee growing areas of the country (Getu, 2009). Therefore, so far there was no extensive coffee quality research conducted in the country except on fermentation, drying depth and time of storage (Solomon and Behailu, 2006). Coffee Development and Marketing Improvement Plan in Ethiopia (CDMIP) was launched since 2003 to maximize the benefits driven from coffee by optimizing production and marketing systems of the industry (Alemayehu *et al*., 2008). According to their report, the small holding coffee farmers in particular could not able to make use of appropriate inputs and implement tools such as pruning shears, bow saw and drying materials largely due to unavailability, poor purchasing capacity and absence of appropriate credit systems. Effective Agricultural Extension services are of paramount importance for farmers to get timely advices and information on the availability, use and application of new, improved and modern agricultural inputs, technologies and practices. The Gomma and Manna Agricultural and Rural development offices are responsible to offer agricultural extension services. Under these offices, different experts with different professions were organized at all levels and Development

Agents (DAs) at Farmers Training Center (FTC). The Development Agents at the FTC are responsible to give extension services to the farming community and they are accountable to the Woreda Agricultural offices.

According to Jacquet *et al*. (2008), prior to market liberalization washed coffee was subjected to intensive supervision and close monitoring with the aim of keeping its quality in respect to training and technical advices about quality cherries collection, processing, drying and storing to concerned groups. But, currently, the intensity of supervision is reduced because of various factors including limitation of logistics, financial and human resources above all, there are no cherries formal market areas and legally identified coffee purchasers, delay of collected cherries a day before delivered to washing station and narrow price difference between different coffee grades (Jacquet *et al*., 2008).

2.3.6. Socio-economic factors

Factors determining the adoption of technologies are more complex in case of perennial crops like coffee than in the case of annual crops. This is because of the difficulty in securing the benefits associated to the technologies due to the time gaps, and the nature of the commodity trade, which, is influenced by international markets (Admasu, 2008). On the other hand, Mulugeta (1999) reported that access to credit, farm size, supplementary inputs, technical and institutional support like the extension service determine the adoption of technologies. Furthermore, Negussie *et al*. (2008) reported that age, gender, family size, extension contact, attendance of training and experience in coffee farming did not significantly influence farmers' perception in survey made in Manna woreda. According to their report adoption of improved varieties, literacy, visit and proximity to research center positively influenced farmers' perception.

Sex of the Household Head: Many evidences shows that female households have less access to improved technologies, credit and extension service (Ellis and Mudhara, 1995). On the other hand, male-headed households have better access for information than female households that helps for adoption of improved agricultural technologies. According to the findings of Negussie *et al*. (2008), only 26% of the female-headed households had access to improved coffee varieties as compared to 88% for the male-headed and 87% of the male respondents ever used fertilizer as compared to 55% for females in survey made in Gomma woreda.

Education Level of the Household Head: Adoption of improved practices by farmer is necessarily based on his/her capacity to access, process and utilize information related to improved technologies. The finding of several studies (Dasgupta, 1989; Zemedu, 2004) revealed that level of education is strong and significant determinant of farmers' adoption of improved agricultural technologies.

Karki *et al.,* (2004) undertook a study in a mid-hill district of Nepal to assess the impact of foreign-aided project in technology adoption and food security and to identify factors determining adoption of improved technology in case of smallholder peasants. The result using binomial logit model and qualitative analysis revealed the coefficient of years of schooling was positively and significantly influenced farmers' adoption decisions on improved agricultural technologies. As the education level of household head increases, the probability of adopting technology was also found to be increased. Similarly, the finding of Ngigi (2003) in *Kobo,* Ethiopia showed positive and significant association between education level of the household and adopting of RWH technology.

Recently, Admasu (2008) reported that about 80% of the coffee producing farmers believe in the importance of tilling coffee farm land every year, although shortage of labor, farm tools, and fear of risk of tree die back were the reason for not plowing their coffee farm land every year based in survey made in Gomma woreda. Similarly, as indicated by the author about 85% and 93% of sample farmers in the same area respond to have faced cash shortage for the purpose of hiring labor for coffee harvesting and weeding, respectively. Furthermore, the author pointed out that about 87% of sample farmers in Gomma woreda had shortage of farm tools for the purpose of coffee production.

In addition to this Elias (2005) reported that poor quality of coffee supplied by farmers; poor infrastructure and inadequate facilities and lack of institutional credit were the major problems of coffee production and marketing in the Gomma woreda. According to the author lack of credit service was a problem reported by both the coffee growers (22%) and the coffee traders (21%).

Even though several attempts were made and significant achievements were recorded in transferring coffee research outputs to end-users by JARC and different actors. Nevertheless, wider dissemination and utilization of the technologies have been constrained by technical, socio-economic, and institutional factors (Negussie *et al*., 2008).

2.4. Method of Assessing Coffee Quality

2.4.1. Bean physical quality

Internationally, the very low coffee prices that resulted from surplus production in the late 1990s and early 2000s have brought calls for qualities to be eliminated from the market altogether, and the ICO council has passed a resolution to this effect. Since October 1st, 2002, the International Coffee Organization (ICO) (2002) is implementing the Coffee Quality Improvement Program with recommendations to exporting countries. According to the program, it is not recommended to export coffee with the following characteristics: for Arabica, in excess of 86 defects per 300 grams 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).

On the other hand in Ethiopia, the overall standard for raw and liquor quality grades of washed coffee ranges from 1 to 5, where grade 1 = 81-100%, grade 2 = 61-80%, grade 3 = 41-60%, grade 4 = 21-40% or 1-2 defective cups, grade 5 = 20% or more than 2 defective cups whereas, for unwashed coffee, the grades range from 1 to 5, where, grade 1 = 81-100%, grade 2 = 63-80%, grade 3 = 50-62%, grade 4 = 31-49% or 2 cups defect, grade 5 = 15-30% or more than 2 cups defect (CLU, 2007). Recently, ECX (Ethiopia Commodity Exchange) (2009) established a new grading system for washed and unwashed coffee that has nine grades (Appendix XII, XIII, XIV, and XV) though this study focused on the previous grading system of CLU.

The ICO's Coffee Quality Improvement Program also asks members of producing countries not to allow the export of Arabica or Robusta of any grade whose moisture content is below 8% or above 12.5%. ISO (2004b) has established a standard (ISO 10470) that describes defects as: Foreign materials of non-coffee origin: Foreign materials of non-bean origin, such as pieces of parchment or husks: Abnormal beans for shape regularity/integrity; Abnormal beans 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. When uneven sized beans are roasted, the smallest tend to burn and the largest tend to be under-roasted, affecting the visual appearance of the beans and, more importantly, the cup quality (Barel and Jacquet, 1994).

Similarly, Endale (2008) reported that green coffee is graded and classified for export with the ultimate aim of producing the best cup quality and thereby securing the highest price. However, there is no universal grading and classification system, due to this each producing countries has its own minimum standards for export. But generally, grading and classification is usually based on altitude and /or region, botanical variety, preparation (wet or dry process), bean size (screen size, number of defects, bean weight, roast appearance and cup quality (flavor, characteristics, cleanliness) (Endale, 2008).

Moisture is an important attribute and indicator of quality. Quality deterioration occurs due to an increase of moisture content of the bean, the spoiling of the raw appearance of the bean by loss of color fading or tainting, or to the introduction of unpleasant flavors, by infestation of storage insects or by infection with moulds or bacteria (Behailu *et al*., 2008). A market survey conducted in Europe in 1998-1999 for the common fund for commodities concluded that for Arabica coffee beans the most important defect for a trader or a roaster is the moisture content (CFC, 2004). 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 mould easily during storage, whereas, if 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 coffee beans 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 (ICO, 2002). It was recommended that, a cool and dry environment (10-18^{o}C, 50-70% RH) makes a great contribution towards preservation of coffee quality, provided the coffee is initially well dried (Woelore, 1995). As reported by the author coffee could not be stored in parchment form in the primary stores beyond 4 to 5 months.

2.4.2. Organoleptic quality

Cup quality 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 (Yigzaw, 2005). Muschler (2001) also indicated that cup quality or liquor quality is an important attribute of coffee and acts as yardstick for price determination. The Organoleptic quality is affected by the roasting, i.e. according to the profile of temperature and length of roasting the tastes and flavors perceived in the beverage will be different. The smell of the ground roasted coffee before water is added sometimes gives fragrance, then, one can smell the aroma, evaluate the body and perceive the taste and flavors. To asses' organoleptic quality, one has to take into account that consumers have specific taste preferences according to their nationality which leads to an unreliable definition of organoleptic quality (Prodolliet, 2005). For example: Germans and Swedish prefer lighter coffee and more acidic coffee than Italians; in Greece, Lebanon and northern of France, people go for the « rio » taste (a specific taste due to a chemical compound: trichloroanisol). In addition, organoleptic characteristics must be stable, especially for the roaster and the consumer (Prodolliet, 2005).

Overall organoleptic quality measurement relies on sensory evaluation (Barel and Jacquet, 1994). For determination of organoleptic quality; two types of analysis are commonly used. The first one, "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 which the preferences is sought. The second method, termed 'descriptive analysis', is under taken by trained assessors that can discriminate coffee quality using, a triangular test (Prodolliet, 2005). In this method, three cups of coffee are served, two cups containing the same coffee. The assessors determine which cup is unique. Expert assessors can describe a profile. It is a complex procedure, which uses some specific descriptors. There are some existing glossaries (Lingle, 2001; ITC, 2002; ICO, 2004), but ISO elaborated a list of descriptors specific for coffee (Prodolliet, 2005). Expert assessors (at least 5) have to be trained to use the vocabulary. Assessment of coffee organoleptic quality is an extremely demanding exercise; indeed.

Acidity indicates the bitter or acidic balance and the presence of a sweet caramelic after taste (Petracco, 2000). The acid content in a brew is also greatly dependent upon the degree of roast, type of roaster, and brewing method. Uneven roast results in poor quality liquor (ITC, 2002). Dark roast enhance the body while light roast emphasizes acidity (ITC, 2002). High acidity gives better quality and more intense aroma to the beverage (Clifford, 1985). The pH of a coffee has been found to correlate with the perceived acidity of a coffee. A pH of 4.9 to 5.2 is the preferred range for a ‘good cup of coffee (Yigzaw, 2005). Body is synonymous with mouth feel or linked with density and viscosity of the brew (Pertracco, 2000).

Flavor indicates fragrance of the liquor either by direct inhaling of the vapors arising from the cup or nasal perception of the volatile substance evolving in the mouth (Petracco, 2000). The flavor obtained in a coffee cup is the result of multiple aromatic compounds present in the coffee (more than 800 in the roasted coffee). Assessment of Measurement of the composition in 800 aromatic compounds present in roasted coffee is not a viable method to assess coffee organoleptic quality, development of indirect predictors of coffee organoleptic quality is underway (Leroy *et al*., 2006) though it was not the objective of this study. These predictors include quantification of chemical compounds present in green coffee (sugars, lipids, proteins, chlorogenic acids, and methylxanthines) via the traditional wet chemistry method and indirect methods like Near Infrared spectra (Bertrand *et al*., 2005). The development of such easy to use and efficient tools should allow large scale phenotyping; a key component towards the implementation of breeding strategies for organoleptic quality in coffee (Bertrand *et al.,* 2005).

The aroma of a coffee is responsible for all flavor attributes other than the mouth feel and sweet, salt, bitter, and sour taste attributes that are perceived by the tongue. Therefore, it might be said that the aroma is the most important attribute to specialty coffee. Even instant coffee has the components responsible for stimulation of our taste buds. The difference, however, is that instant coffee lacks most of the aromatic volatile compounds causing a dramatic decrease in the overall flavor. Aroma is perceived by two different mechanisms. It can either be sensed nasally via smelling the coffee through the nose or retro nasally. Retro nasal perception occurs when the coffee is either presents in the mouth or has been swallowed and aromatic volatile compounds drift upward into the nasal passage. Yet, the perception of aroma is dependent upon both the concentration of the compound and its odor threshold. It is probable that a relatively small group of compounds that share both a high concentration and a low odor threshold make up the fragrance we know as coffee aroma.

The aroma of coffee is for a large part determined by the roasting of the beans. The four main reactions during the roasting are: Millard reaction; a reaction between nitrogen containing substances (amino acids, proteins, as well as trigonelline and serotonin) and carbohydrates (sugars). Degradation of individual amino acids, particularly, sulphur amino acids, hydroxy-amino acids, and proline. Degradation of sugar resulting in caramel like substances. Degradation of phenolic acids, particularly the quinic acid moiety. Other reactions involve lipid degradation and hundreds of interactions between intermediate decomposition products. Furans are found to be the most predominant group of compounds amongst the coffee aromatics. They typically have caramel-like odors since they result from the pyrolysis of sugars (‘burnt caramel). Furans also produce key aroma notes when secondary reactions take place with sulphur containing compounds.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Manna and Gomma woredas of Jimma zone (Appendix V) The Zone is located in the Southwestern part of Ethiopia between Latitude 6^o and 9^o North and Longitude 34^o and 38^o East, and between altitude ranges of 880 to 3340 meters above sea level (ORG, 2003).

3.1.1. Gomma woreda

Gomma is one of the known coffee growing woreda, among 18 woredas of Jimma Zone. It is located 397 km Southwest of Addis Ababa and about 50 km west of Jimma town (ORG, 2003). Its area is 1,230.2 km^2 (ARDO, 2008). The annual rainfall varies between 800-2000 mm, while the mean minimum and maximum annual temperatures of the woreda vary between 7^{o}C-12^{o}C and 25^{o}C-30^{o}C, respectively (ARDO, 2008). Based on 15 years weather data obtained from Gomma woreda, the average annual rainfall is 1524 mm (Appendix X). Altitudinal range of the woreda is between 1387-2870 m. a.s.l (IPMS, 2007). The three dominant soil types in the woreda are Eutric Vertisols, Humic Alfisols and Humic Nitosols. Nitosols are the most abundant covering about 90% of the woreda, which is dark reddish brown in color, slightly acidic and suitable for coffee production

(IPMS, 2007). Agro-ecologically, this woreda is divided into 8% high land (Dega), 88 %, intermediate high land (Weyina Dega) and 4% low land (Kolla) (IPMS, 2007).

3.1.2. Manna woreda

Manna is one of the major coffee producing woredas in Jimma zone, which is located at 368 km southwest of Addis Ababa and 20 km west of Jimma town. The total area of the woreda is 478.98 km^2 (47,898 ha) of which 12% is highland, 65% intermediate highland and 23% lowland with altitudinal ranges between 1470–2610 m. a.s.l (ARDO, 2008). The mean minimum and maximum temperatures are 13.0^0C and 24.8^0C, respectively (ARDO, 2008). Based on long term (15 years) weather data obtained from the nearby JARC meteorological station, the average annual rainfall is 1523 mm (Appendix XI). Distric Nitosols and Orthic Acrisols are the dominant soil types with slightly acidic PH, which is suitable for coffee production found in Manna woreda (ORG, 2003).

3.2. Field Survey

3.2.1. Sample size determination

For the field survey, sample sizes were determined following the procedures of probability proportional to size technique given by Cochran (1977) using the formula:

$$n = \frac{Z^2_{\frac{\alpha}{2}} p(1-p)}{d^2}$$

Where, n is the sample size, $Z_{\frac{\alpha}{2}}$ is the standard normal distribution at α, p is the population proportion of Peasant associations and farmers, ***d*** is the absolute precision.

Considering limiting factors such as time, money and other facilities and coffee quality problems two woredas (Gomma and Manna) were selected out of the six major coffees growing woredas of Jimma Zone,. In the two selected woredas, eight PAS (peasant associations) were selected randomly from 31 major coffee growing PAS. Then, out of 1124 farmers (721 were from Gomma and 403 were from Manna woreda) major coffee growing farmers in the selected PAS, 164 respondents (household farmers) were randomly selected using simple random sampling method. Besides, 30 coffee traders were purposefully selected from the two woredas. In this study, three stage random sampling technique was found to be appropriate as there exist three level sample units (woredas, PAS and farm household).

3.2.2. Variables studied in the survey

The dependent variable is dichotomous random variable "have acceptable quality/have unacceptable quality status" of coffee produced in the study area. i.e., have acceptable quality =0, have unacceptable quality =1. Independent variables**:** The variables that are hypothesized to influence the prediction of coffee quality status are presented in Table 1 and 2.

3.2.2.1. Demographic factors

1. Sex of household head (SHH11): This is a dummy independent variable, indicating the sex of the household head. Household headed by male coded 1 or 2 for female. Many evidences showed that female households have less access to improved technologies, credit and extension service (Ellis and Mudhara, 1995). On the other hand, male-headed households have better access for information than female households that helps for adoption of improved agricultural technologies. Therefore, it is hypothesized that male status of household head is positively related with adoption of coffee quality pre and post harvest management practices (CQPPHMP).

2. Age of household head (AHH12): Farmers/traders age implies number of years since he/she has embarked on farm/trade operations. Elder farmers/traders with longer farming/trading experience are supposed to have better competence in assessing the characteristics and potential benefits of new technologies than younger farmers/traders with shorter farming/trading experience. It is hypothesized that the number of in farming/trading years to be positively related with the use of CQPPHMP.

3. Family size (FS13): It is independent variable, indicating the number of people of the household. It is hypothesized that household heads with large family size are more likely to improve coffee quality due to more labor during pre and post harvest management. In this study, it is hypothesized that family size is to be positively related with CQPPHMP.

4. Educational status of household head (EDHH14): It refers to the educational status of the household head and is categorized as literate and illiterate. Adoption of improved practices by a farmer is necessarily based on his/her capacity to acquire information about new technologies as well as his/her capacity or knowledge to accept and apply the improved technology. The finding of several studies (Dasgupta, 1989; Zemedu, 2004) revealed that level of education is strong and significant determinant of farmers' adoption of improved agricultural technologies. It is expected that those farmers with higher formal education be disposed to decide to participate in quality maintenance practices. Thus, educational status is hypothesized to influence the adoption decision of farming households positively.

3.2.2.2. Agronomic and physiological factors

1. Age of coffee trees (ACT16): It is independent variable, indicating the age of the coffee tree. Apart from genotype, cup quality is influenced by the age of the tree. Age of coffee trees below 20 years is coded as 1, whereas above 20 years is 2. Yigzaw (2005) reported that samples from young trees are likely to be mild and thin, but fine in flavor. Beans from old trees produced strong taste and a harsh characteristic brew. Medium aged trees, 15 to 20 years old, bear beans with good flavor as well as acidity and body (Yigzaw, 2005). Thus, in this study the variable is hypothesized to have inversely related with coffee quality.

2. Type of coffee weeds (TCW19): This represents the type of weeds prevalent and dominant in the coffee field. It is expected that type of weeds dominant in the field can lead to produce poor quality coffee than the field free of weeds. Hence, in this study if the coffee field is infested with soft weeds coded 1, or coach grass 2, or if both coded 3. It is hypothesized that coffee quality correlate negatively as type of weed infestation increase from soft to both.

3. Diseases observed in coffee farm (DOCF115): This represents the incidence of any type of diseases in the coffee field. It is expected that disease occurrence can lead to poor quality coffee that gives off and disagreeable odor. Hence, in this study the disease occurrence coded 1, or other wise 0. Therefore, it is hypothesized that coffee quality is expected to be inversely related with disease incidence and severity.

4. Coffee tree pruning (CTP17): If coffee tree pruning is exercised it is coded 0, or otherwise 1. Coffee tree pruning is an extremely important pre harvest activity for reducing incidences of diseases, modifying air movement within the plantation, which in turn reduces leaf drying time. Therefore, it is hypothesized that regular coffee pruning can produce sustainable and good quality coffee and is expected to be positively related.

5. Mechanism of weed control (MWC110): It indicates mechanisms used to control weeds in coffee field. If a weed is controlled by slashing it is coded 1, or by hand weeding would be 2 Chemicals 3, cover crops 4, IPM (integrated pest management) 5. Hand weeding can only remove annual weeds but not perennial weeds. Therefore, hand weeding is hypothesized to be negatively correlated with coffee quality.

6. Compost application (CA112): if compost is applied to coffee farm it would be coded 0, or otherwise 1. Application of compost improves the activity of micro organisms and improves macro–and micro- nutrient availability. Compost acts as a good soil conditioner and improves the physical, chemical and biological properties of the soil. Thus, this variable is hypothesized to correlate positively with coffee quality.

3.2.2.3. Harvest and post-harvest factors

1. Fruit maturity stage during harvesting (FMSH121): If coffee is harvested before the beans are ripe or at immature stage, the end product will show color defect and will be cause of uneven roasts, i.e. Grayish or dark grey beans which, leads to bean color and test of coffee classified as undesirable. In this study, this variable was treated as an independent variable coded 1 harvested at full maturity, or 2 harvested at green mature stage or 3 harvested at immature stage. It is hypothesized that coffee quality is to be directly correlated with stage of bean maturity.

2. Method of coffee harvesting (MCH): Different methods of coffee harvesting are exercised by coffee farmers. If farmers harvest their coffee by selective hand picking coded as 1, or 2 for strip method and 3 for farmers harvest their coffee from the ground. It is hypothesized that coffee quality is to be correlated directly with coffee harvesting method coded from 3 to 1.

3. Coffee mixing during selling (CMS120): It is an independent variable, indicating mixing up of differently harvested types of coffee. A value of 1 represents if there is no mixing of coffee while selling or otherwise 2. Apart from the age of coffee tree, cup quality is influenced by mixing of differently harvested coffee while selling**.** It is hypothesized that quality to be correlated inversely with differently harvested coffee mixing.

4. Time of coffee storage (TCS134): During storage due attention must be given to humidity, storage facility, location, and storage duration to prevent from spoiling or losing quality. An acceptable odor quality (fresh and not rancid) was maintained until 7 and 15 storage days at 25 ºC and 4 ºC for coffee brews, respectively. However, taste quality was maintained longer than odor (Dalla Rosa *et al*., 1990). If storage time <4 months coded as 1 and > 4 months coded as 2 As time of storage increases, quality is expected to decrease and vice versa, which implies as storage time increased the cup quality would be decreased as some minor components transform into other components, as a result it tastes woody and harsh after roasting.

5. Drying material of coffee (DMC129): Coffee drying is always a delicate operation which should be carried out carefully. It is expected that using cemented floor, bricks floor and raised bed with mesh wire, wooden and bamboo bed can enable farmers/traders drying their coffee better than farmers/traders drying on the ground**.** If the farmer/traders use cemented, bricks and mesh wire for drying it is coded as 0, wooden bed and bamboo coded as 1, and on the ground 3. It is expected that drying material (coded 3 to 0) correlate positively with quality and vice versa.

6. Type of coffee packing materials used (TCP130): indicating type of packing materials that farmers use for marketing and storage. A value of 1 represents jute bags, 2 plastic bags, and 3 clay pot. Apart from drying materials, cup quality is influenced by packing materials because different packaging materials can have adverse effect on coffee quality. Therefore, quality packaging materials (coded 3 to 1) is expected to correlate positively with coffee quality and vice versa.

7. Storage availability (SA131): indicates availability of storage house. Because it is expected that poor storage can lead to changes in the inherent qualities and appearance of the green coffee as a result of potential development of moulds. The availability of storage facility coded as 1 and 2, otherwise.

8. Sell of coffee at flowering stage (SCF137): refers to those farmers who sell their coffee at flowering stage due to cash shortage. It is expected that selling coffee at flower stage can lead to poor harvesting practices such as striping coffee before it is fully matured that in turn changes in the aroma and flavor of coffee. If the farmers adopt selling their coffee at flowering stage coded as 1 and 0, otherwise.

3.2.2.4. Institutional factors

1. Support from woreda agriculture and rural development office (SARDO138): refers to the governmental support in CQPPHMP. It is a dummy variable, which takes a value 0 if the farmers/traders household has access for any external support and 1, otherwise. Therefore, it is expected that in areas, where there is governmental or non-governmental assistance, farmers are encouraged to use CQPPHMP. As a result, this variable is hypothesized to influence adoption of CQPPHMP positively.

2. Cash shortage during harvest (CSH135): It is expected that those who have better access to credit can adopt improved CQPPHMP because it is expected that credit can solve the financial limitation of farmers. If the farmer gets credit service coded as 0 or otherwise 1 it is hypothesized that credit service is expected to correlate positively with adoption of CQPPHMP.

3. Time constraint during peak harvest (TCPH122): indicates overlap of activities during pick harvest time. It is expected that those farmers who have more time during picking harvest time can adopt improved CQPPHM because it is expected that time limitation can lead to strip harvesting, inappropriate drying and poor storage. If the farmer has no time constraint coded as 0 or otherwise 1. Time constraint during peak harvest is expected to be correlated inversely with quality.

Training access for last year (TALY140): refers to the frequency of DA visits to deliver extension services and training for the farmers and traders to adopt a new technology. This can increase the intensity of adoption. If the farmers and traders get better extension services, they are expected to adopt way of CQPPHM. In this study this variable treated as a dummy variable in that if they get extension service it is coded as 0 or 1 otherwise.

Table 1. Definition of explanatory variables to explain adoption of CQPPHMP by farmers

Variables Code	Definition Category
SHH11	Sex of house hold 1= if male headed house hold or 2= if female headed house hold
HHED14	Educational status of house hold 1= if illiterate or 2 if literate.
AHH12	Age of house hold 1= if >48 or 2= if > 33 or 3 if >18
FS13	Family size 1= if >4 or 2= if <4
D15	District of the study 1= if Gomma or 2= if Manna
ACT16	Ages of coffee tree 1= if<20 or 2. if >20
CTP17	Coffee tree pruning 0= if Yes or 1= if No
TCW19	Types coffee weed 1= if soft weed or 2 = if coach grass or 3= if both
MWC110	Mechanism of weed control 1= if slashing or 2= if hand weeding
CA112	Compost application 1= if Yes or 2= if No
DOCF115	Disease observed in coffee farm 0= if No or 1= if Yes
CMS120	Coffee mixing during selling 0= if No or 1= if Yes
FMSH121	Fruit maturity stage at harvesting 1= if full maturity stage or 2= if green stage or 3 =if immature stage
TCPH122	Time constraint during peak harvest 0= if No or 1= if Yes
WHC127	Who often harvest your coffee 1=if own family or 2= if daily laborer
DMC129	Drying materials used for coffee 1=if on cemented, bricks and mesh wire or 2= if wooden bed and bamboo or 3= if on ground
TCP130	Type of coffee packing materials used 1= if jute bags or 2= if plastic bags or 3= if clay pot
SA131	availability of storage 1= if Yes or 2= if No
TCS134	time of coffee storage 1= if <4 months or 2= if>4 months
CSH135	Cash shortage during harvest 0= if No or 1= if Yes
SCF137	Sell of coffee at flower stage 0= if No or 1= if Yes
SARDO138	Support from ministry of agriculture 1= if Yes or 2. if No
TALY140	Training access for last year 1= if Yes or 2= if No
MCH	Method of coffee harvesting1=selective hand picking 2=strip method 3=from the ground

Table 2. Definition of explanatory variables to explain adoption of CQPPHMP by traders

Variables Code	Definition Category
Sex	Sex of house hold 1= if male headed house hold or 2= if female headed
Age	Age of house hold 1= if >48 or 2= if > 33 or 3 if >18
Family size	Family size 1= if >4 or 2= if <4
Woreda	Woreda of the study 1= if Gomma or 2= if Manna
Type of store floor	1. Concrete 2. Wooden bed 3. Paved ground.
Price decision	1. if based on radio announcement or 2.if own judgment
Availability storage	availability of storage 1= if Yes or 2= if No
Moisture tester	1. If Yes or 2. If No
Checking coffee quality	1. If through observation or 2. If no means of checking
Time of storage	time of coffee storage 1= if <4 months or 2= if>4 months
Extension service	Extension service 1= if service is given yes or 2 = if no service is given
Advisor	Have their own adviser 1= if Yes or 2. If no
Training	Training access for last year 1= if Yes or 2= if No

3.3. Laboratory Analysis

3.3.1. Experimental materials

The experimental materials used for laboratory analysis were coffee samples collected from Gomma and Manna woredas of Jimma zone. A detail of their location is given in Table 3.

3.3.2. Sampling procedures

To investigate and identify coffee quality associated factors in the study areas, a total of 32 coffee bean samples (16 from each woreda from eight PAs) were prepared for organoleptic and bean physical quality characteristics as indicated in Table 3. A sample of 120 kg red cherries were collected from the randomly selected eight PAS (four samples from each study woreda for wet and dry coffee types) and the samples were further divided into two to process using the recommended method (researcher) of dry and wet processing. During harvesting healthy and red-ripe cherries were picked by hand from two woredas and eight PAS. Samples were processed in both recommended wet and dry processing methods.

For comparison, in the vicinity of each selected PAs, 16 green coffee samples, (*i.e.*, eight from dry and another eight from wet processed coffee) were sampled from local traders' stores of both woredas. The samples from local traders' stores were sampled based on the sampling procedures followed by the Coffee Liquoring unit (CLU) (2007) Ethiopia by drawing 3 kg per 10 ton of marketable coffee

Dry processing steps

Drying: For the recommended dry processing method, berries were sun dried on mesh wire for about two to three weeks depending on the unpredictable climate (Appendix I). During drying the moisture content of the bean was measured using Electronic Rapid Moisture Tester (HOH-Express, HE 50 Germany) to know and maintain the moisture level between 10–12% for all samples uniformly (Fig. 1).

Hulling: Fully dried coffee beans were dehulled by pounding with a pestle and mortar. The dried pulp, the parchment skin part of the husk is removed. Mechanically undamaged beans were used both for cup quality and green bean physical characteristics analyses.

Wet processing steps

Pulping: For the recommended wet processing method, red fully ripe cherries were manually picked during the main harvesting season (in November, 2008), separated from foreign materials and unripe green cherries and processed in the wet method, as described by W/Michael (1996). The fresh cherries were pulped using a hand pulper that squeezes the berries between fixed and moving surfaces and well washed by clean water to remove the pulp (Appendix II).

Fermentation: The wet parchment coffees were put in a fermentation tank to undergo fermentation for 40 hours to facilitate decomposition of the mucilage. Under Jimma condition, mucilage normally takes 24 to 40 hours to become completely removed from the bean (Woelore, 1993). Hand fill texture method is employed to check for the removal of mucilage from the pulped coffee.

Washing: After fermentation the beans were washed using three to four changes of clean water to remove all traces and decomposed products of the mucilage. As this stage the coffee is referred as "parchment coffee".

Drying: The wet parchments coffees were placed on mesh wire under sun for drying. Beans with some defects are avoided at this stage. During drying the moisture content of the bean was measured by moisture tester H-E50 to check and maintain the moisture level between 10–12% for all samples uniformly (Fig. 1). The dry parchment coffee was put in sample bags and stored in a well ventilated coffee store at 60% relative humidity and 20^0C temperature till cup testing (Appendix III).

Hulling: Then, it was hulled by hand and polished to remove the parchment and silver skins from the green coffee. Both samples collected from the traders and prepared using the recommended methods of processing were assigned an arbitrary code (an identity letters) in order to secure an unbiased judgment as indicated in Table 3.

Fig. 1. Sample coffee bean moisture testing using digital electronic rapid moisture tester (HOH, Express, HE 50, Germany).

About 300g of green coffee bean sample were prepared for each eight sites for bean physical and organoleptic quality analysis. To obtain uniform bean size for bean physical and organoleptic quality analysis, samples were screened through mesh sieve size.14. Then, samples on screen N0.14 and above screen N0.14, which are defined in the International Organization for Standards (ISO) (1991), were used for analyses as indicated in Fig. 2.

Fig. 2. Samples coffee bean grading using different screen sizes.

Table 3. List of coffee samples studied in the laboratory

SN	Woreda	Sample Code	Altitude	PA	Processing method and preparation type
1	Gomma	Brw1	1800	Bashasha	Recommended Washed
2	Gomma	Chrw2	1650	Chedero	Recommended Washed
3	Gomma	Ogrw3	1850	Omo Gurude	Recommended Washed
4	Gomma	Yrw4	1700	Yachi	Recommended Washed
5	Manna	Drw5	1700	Dowwa	Recommended Washed
6	Manna	Gbrw6	1755	Gudeta Bula	Recommended Washed
7	Manna	Hrw7	1650	Haro	Recommended Washed
8	Manna	Htrw8	1790	Hunda Toli	Recommended Washed
9	Gomma	Bruw9	1800	Bashasha	Recommended Unwashed
10	Gomma	Chruw 10	1650	Chedero	Recommended Unwashed
11	Gomma	Ogruw11	1850	Omo Gurude	Recommended Unwashed
12	Gomma	Yruw12	1700	Yachi	Recommended Unwashed
13	Manna	Druw13	1700	Dowwa	Recommended Unwashed
14	Manna	Gbruw14	1755	Gudeta Bula	Recommended Unwashed
15	Manna	Hruw15	1650	Haro	Recommended Unwashed
16	Manna	Htruw	1790	Hunda Toli	Recommended Unwashed
17	Gomma	Blw17	1800	Bashasha	Local Washed
18	Gomma	Chlw18	1650	Chedero	Local Washed
19	Gomma	Oglw19	1850	Omo Gurude	Local Washed
20	Gomma	Ylw20	1700	Yachi	Local Washed
21	Manna	Dlw21	1700	Dowwa	Local Washed
22	Manna	Gblw22	1755	Gudeta bula	Local Washed
23	Manna	Hlw23	1650	Haro	Local Washed
24	Manna	Htlw24	1790	Hunda Toli	Local Washed
25	Gomma	Bluw25	1800	Bashasha	Local Unwashed
26	Gomma	Chluw26	1650	Chedero	Local Unwashed
27	Gomma	Ogluw27	1850	Omo Gurude	Local Unwashed
28	Gomma	Yluw28	1700	Yachi	Local Unwashed
29	Manna	Dluw29	1700	Dowwa	Local Unwashed
30	Manna	Gbluw30	1650	Gudeta Bula	Local Unwashed
31	Manna	Hluw31	1650	Haro	Local Unwashed
32	Manna	Htluw 32	1790	Hunda Toli	Local Unwashed

3.3.3. Data collection

For laboratory analysis moisture content, defect count, acidity, body, flavor, odor, shape and make and overall quality characters were recorded as quantitative bean quality attributes. The data were recorded as indicated in Table 4, Table 5, Table 6 and Appendix I.

3.3.4. Bean physical and organoleptic quality analysis

By following the procedures of JARC (Jimma Agricultural Research Center) and CLU (Coffee Liquoring Unit of Ethiopia), sensorial quality analyses were carried out at JARC by well trained cup testers.

3.3.4.1. Defect count

A 300g of each coffee sample was taken using digital bean balance as indicated in Fig. 3. The beans were graded by size using standard screens that have different screen size, with round holes as defined in the International Organization for Standards (ISO) (1991). Besides size determination, under graded and broken beans were also separated from each sample during the screening process and defect count was also made for dry processed green coffee beans by internationally fixed standard set as indicated in Appendix I and IX (CLU, 2007). The beans were visually inspected and evaluated for raw quality (accounting for 40% of the total coffee quality) using the parameters shown in Table 4 and Table 6.

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Fig. 3. Sample coffee bean preparation for different laboratory tests, using digital bean balance.

3.3.4.2. Roasting

The roaster machine with six cylinders (Probat BRZ6, welke, Von Gimborn Gmbhan Co. KG) was first heated to about 160^0C-200^0C. About 100 g green coffee beans sample per each site per each replication were put into the roasting cylinder and roasted for an average of seven minutes to medium roast (Fig.4.) The medium roast coffee was tipped out into a cooling tray and allowed to cool down (on an average for four minutes) rapidly by blowing cold air through it. When the roast was cool it was blown to remove the loose silver skins before grinding.

Fig. 4. Sample coffee roasting using six cylinder roasters (PROBAT WELKE, VON GIMBORN GMBHAN CO. KJ. Germany).

3.3.4.3. Grinding

About 12 g medium roasted of each sample was weighed and ground using roasted coffee electrical grinder (MahlKonig, Germany) with middle adjustment (Fig.5). Then 8 g coffee powder was put into a clean standard porcelain cup with 180 ml capacity (Schonwald, Germany).

3.3.4.4. Brewing

Fresh boiled water was poured into the coffee up to about half of the cup. The ground coffee was inspected and nosed for some undesirable smells. Then, the contents of the cup were stirred to ensure a complete infusion of the ground coffee and the cup was filled to full capacity with boiled water. Then, the cup was left for about three minutes, allowing the coffee to brew. The foam was skimmed off with spoon and the cup was left to cool down to a temperature 60^{o}C (drinkable temperature). The brew was made ready for panelists within 8 minutes, for cup test analysis.

3.3.4.5. Cup tasting

Five cups per sample in three replications were prepared for each tasting session (Fig. 6). The samples replicated for each sample were arranged at random. The sensory evaluation of each sample and the cup quality was carried out by a panel of JARC three liquorers. A spoonful of the brew was sucked with air into mouth of a taster and held at the back of the tongue between the tongue and the roof of the mouth where the tasting glands are located. It was held in the mouth and moved around for few (7-10) seconds for sensory evaluation, which involved taste for cleanliness of the cup (defective cups including foul, musty, earthy, chemical, etc.).

Cup quality evaluation consisted of raw (40%) and liquor (60%). Raw value was evaluated as shape & make, color, and odor. Liquor was also evaluated as acidity, body and flavor. Finally mean of each variable by the panel was used for statistical analysis. But, variation among assessors for a given variable was not considered as procedures of Getu (2009). The details of the sensorial evaluation procedure are given in Table 5 and Table 6.

Fig. 5. Sample roasted coffee bean grinding using electrical grinder (MAHLKONIG, Germany).

Fig. 6. Professional coffee tasters of the JARC, cupping for quality evaluation.

3.3.4.6. Grading

Green bean coffee samples evaluation and grading for both raw (40%) and liquor (60%) quality was carried out for 32 samples following the procedures of CLU (Coffee Liquoring Unit) (2007) as indicated in Table 4, Table 5 and Table 6. The overall standard for raw and liquor quality grades of washed coffee range from 1 to 5, where, grade 1 = 81-100%, grade 2 = 61-80%, grade 3 = 41-60%, grade 4 = 21-40% or 1-2 defective cups, grade 5 = 20% or more than 2 defect. On the other hand, the overall standard for raw and liquor quality grades of unwashed coffee range from 1 to 5, where, grade 1 = 81-100%, grade 2 = 63-80%, grade 3 = 50-62%, grade 4 = 31-49% or 2 cups defect, grade 5 = 15-30% or more than 2 cups defect. Besides, a standard check with known quality attributes was also included in the evaluation for the purpose of comparison and judgment.

Table 4. Standard parameters and their respective values used for washed coffee raw quality evaluation (CLU, 2007)

Raw Value (40%)					
Shape & Make	Points	Color	Points	Odor	Points
Very good	15	Bluish	15	Clean	10
Good	12	Grayish	12	Trace	8
Fair/average	8	Greenish	8	Light	5
Mixed	5	Faded	5	Moderate	2
Small	2	Brownish	2	Strong	1

Grade Range: 1 = 81-100, 2 = 61-80, 3 = 41-60, 4 = 21-40 or 1-2 defective cups, 5 = 20 or more than 2 defective cups (defective cups: foul, earthy, and chemical).

Table 5. Standard parameters and their respective values used for washed coffee liquor quality evaluation (CLU, 2007)

Liquor Value (60%)					
Acidity	Points	Body	Points	Flavor	Points
Pointed	20	Full	20	Very good	20
Medium pointed	15	Medium Full	15	Good	15
Medium	10	Medium	10	Average	10
Light	5	Light	5	Fair	7
Lacking	2	Thin	2		

Grade Range: 1 = 81-100, 2 = 61-80, 3 = 41-60, 4 = 21-40 or 1-2 defective cups, 5 = 20 or more than 2 defective cups (defective cups: foul, earthy, and chemical).

Table 6. Standard parameters and their respective values used for unwashed coffee raw & liquor quality evaluation (CLU, 2007)

	Raw Quality (40%)				Cup Quality (60%)					
	Defect point	30%	Odor	Points	Acidity	Points	Body	Points	Flavour	Points
	Range	Value		10%		20%		20%		20%
V.Good	Up To 70	30	Clean	10	Pointed	20	Full	20	Good	20
Good	71-90	25	Trace	8	M/Pointed	15	M/Full	15	F/Good	15
F/Good	91-120	20	Light	6	Medium	10	Medium	10	Average	10
Average	121-140	15	Moderate	4	Light	5	Light	5	Fair	5
Fair	141-160	10	Strong	2						

Grade Range: 1 = 81-100%, grade 2 = 63-80%, grade 3 = 50-62%, grade 4 = 31-49% or 2 cups defect, grade 5 =15-30% or more than 2 cups defect.

3.3.5. Experimental design

The laboratory experiment was arranged in split-plot design in RCBD by considering the processing method as main plot and the preparation type as sub-plot in three replications. For each sample within a replication five cups were prepared for laboratory analysis. Fifteen sample cups were tasted for each of the 32 samples from both preparation and processing methods.

3.4. Statistical Analysis

3.4.1. Analysis of field survey

The data collected from the field through structured questionnaires were analyzed by employing the statistical procedures of SPSS version 14.0 (SPSS, 2006). Using descriptive statistics, the frequency and percentage values of variables were also computed to observe their distribution. Pearson chi-square was also analyzed to study the relationship between the dependent and explanatory variables. The binary logit model was used to analyze factors which affect coffee quality and decision to adopt and practice coffee pre and post harvest management practices (CPPHMP) by farmers.

Binary logistic model

There are many situations in which the response of interest is dichotomous rather than continuous. Examples of variables that assume only two possible values are quality status (the quality is either acceptable or unacceptable). Logistic regression can be binary or multinomial. The binary or Binomial logistic regression is the type of regression which is used when the dependent variable is a dichotomous and the independent variables are of any type while Multinomial logistic regression is used when the dependent variable has more than two categories. When multiple classes of the dependent variable can be ranked, then ordinal logistic regression is preferred to multinomial logistic regression. Continuous variables are not used as dependent variables in logistic regression (Hosmer and Lemshew, 1989).

Logistic regression can be used to predict a dependent variable on the basis of continuous and/or categorical independent variables and to determine the percent of variance in the dependent variable explained by the independent variable to rank the relative importance of independent variables; to assess interaction effects; and to understand the impact of covariate control variable. The logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of dependent variable occurring or not). In this way, logistic regression estimates the probability of a certain event occurring. Note that logistic regression calculates changes in the log odds of the dependent variable, not changes in the dependent variable itself as OLS regression does. Hosmer and Lemshew (1989) pointed out that a logistic regression has got advantage over others in the analysis of dichotomous outcome variables. The logistic regression is also preferred from multiple regressions and discriminate analysis as it results in a biologically meaningful interpretation, it is mathematically flexible and easily used distribution and it requires fewer assumptions (Hosmer and Lemshew, 1989).

To accommodate this final constraint, we fit a model of the form

$$p = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}}$$

Where ***p*** is the probability of "success", ***α*** is the intercept of the line and β is its slope.

The expression on the right, called a logistic function, cannot yield a value that is negative or greater than 1; consequently restricting the estimated value of p to the required range (between 0 and 1).

Thus, modeling the probability p with logistic function is equivalent to fitting a linear regression model in which the continuous response y has been replaced by the logarithm of the odds of success for a dichotomous random variable.

3.4.2. Laboratory analysis

The analysis of variance (ANOVA) for the laboratory analysis was computed by using general linear model (GLM) procedures of SAS version 9.2 (SAS Institute, 2004). Based on the analysis of variance, statistical significance of mean square differences was determined by Least Significance Difference (LSD) tests at 5% and 1% probability level. Means separation using LSD were computed when the whole, subplot and interaction effect found significant. Overall quality grading of the green beans for the processing methods and preparation types were carried out by computing proportion of the green bean physical (40%) and cup quality attributes (60%) evaluation for each sample and woreda.

The experiment was arranged in a Split-plot design by considering the method of coffee processing as main plot and coffee preparation types as sub plots. Analysis of variance was computed to compare the variation between wet and dry processed coffee samples and preparation type by considering the two treatments as factor A and the two coffee preparation type as factor B within each processing method and each treatments applied randomly in each plot and arranged in RCBD in three replications as indicated in Table 7. Therefore, the linear model for the split plots design is:

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \gamma_k + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \varepsilon_{ijk} \quad \begin{cases} i = 1,2,\ldots,r \\ j = 1,2,\ldots,a \\ k = 1,2,\ldots,b \end{cases}$$

Where μ is the parametric mean of the population τ_i, β_j ,and $(\tau\beta)_{ij}$ represent the whole plot and correspond respectively to blocks (or replicates), main treatments (factor A) and whole plot error (replicates (or blocks) XA): γ_k, $(\tau\gamma)_{ik}$, and $(\tau\beta\gamma)_{ijk}$ represent the sub plot and correspond respectively to the sub plot treatment (factor B), the replicates or (blocks)×B and AB interaction, and the sub plot error (blocks×AB)

Table 7. ANOVA for split plot design

Source of variation	Df	SSQ	MS	F
Location	b-1	SSQ_B	$SSQ_{B/(b-1)}$	$MS_{B/}MS_{EM}$
Processing type	t-1	SSQ_{Tr}	$SSQ_{Tr/(t-1)}$	$MS_{TR/}MS_{EM}$
Error main plot (Em)	(t-1)*(b-1)	SSQ_{EM}	SSQ_{EM}((t-1)*(b-1))	
preparation type(S)	s-1	SSQ_s	$SSQ_{B/(s-1)}$	$MS_{s/}MS_{EM}$
Sub plotsXtret(SxT)	(t-1)*(s-1)	SSQ_{SXT}	$SSQ_{SXT/(t-1)*(s-1)}$	$MS_{SXT/}MS_{EM}$
Error sub plot(Es)	t*(b-1)*(s-1)	SSQ_{Es}	$SSQ_{ES/(}$ t*(b-1)*(s-1)	
Total (Tol)	t*b-1*s-1	SSQ_{TOl}		

*where t=number of main treatment; b=number of blocks; s=number of sub plot Df = Degree of freedom; SSQ = Sum of square; MS =Mean square; F = probability value.

4. RESULTS AND DISCUSSION

This study was undertaken both under field and laboratory conditions. The field survey data were collected from respondents using structured questionnaire, while the laboratory analysis was made using samples mentioned in the methodology part (Part 3.3.1.). Hence, the results are separately discussed in two parts: Field survey & laboratory analysis:

4.1. Field Survey

This part is mainly concerned with the description and interpretation of information obtained from farmers and traders.

4.1.1. Response of coffee farmers

4.1.1.1. Analysis through descriptive statistics

I. Demographic factors

In this study, some demographic parameters were collected to know their pattern of distribution in the study areas. As indicated in Table 8, from a total of 164 respondents the majority (96.1%) of household coffee farmers were males, whereas, the remaining were females. Many evidences showed that female households have less access to improved technologies, credit and extension service (Ellis and Mudhara, 1995). According to the findings of Negussie *et al*. (2008), only 26% of the female-headed households had access to improved coffee varieties as compared to 88% for the male-headed and 87% of the male respondents ever used fertilizer as compared to 55% for females in survey made in Gomma woreda. On the other hand, male-headed households have better access for information than female households that helps for adoption of improved agricultural technologies. Therefore, male status of household head is positively correlated with adoption of coffee quality pre and post harvest management practices (CQPPHMP). In terms of family size, the majority of sample farmers (92.6%) had more than four family members, while 7.4% had less than four family members. About 17.8% of the respondents were found in the age category of greater than 18 and less than 33 years, 43% in the age category of greater than 33 and less than 48 years, while the remaining 39.2% were above 48 years of age (Table 8). Most of the farmers (82.2%) were found in the age category between 33 and 48 years. The study of Senkondo *et al.* (2004), in Tanzania revealed that experiences in farming were positive and significant in explaining adoption of RWH technology.

On the other hand, in terms of labor used in coffee harvesting, the result showed that the majority, 59.8% (98) of coffee farmers harvest their coffee by hiring daily laborers while only 40.2% (66) respondent farmers harvested their coffee by themselves. Coffee harvesting by daily laborers may contribute to the deterioration of coffee quality due to careless harvesting of ripe and unripe green berry collectively.

In this analysis attempt was made to observe the association between adoption of pre- and post- harvest coffee quality improving or deteriorating factors with demographic factors such as sex, age, family size, and educational status. Chi-square test was computed and there were no strong association observed between demographic factors and exercising practices of coffee quality improving or deteriorating factors at less than 5% probability level (Table 8). From the survey, it was revealed that the proportion of family headed with male (69%) was higher than family headed with female (33%) in adopting coffee quality improving activities. This result confirmed the prior expectation that male headed households have more access to improved technology, updated information, credit and extension services than female headed household. This result is consistent with other findings. For instance, the findings of Ellis and Mudhara (1995) showed that females have less access to any improved agricultural technologies and extension services, which contribute to lower adoption rates. From the total sampled households, 60% (98) of coffee farmers were literate adopting coffee quality improving factors (Table 8). The finding of several studies (Dasgupta, 1989; Zemedu, 2004) revealed that level of education is strong and significant determinant of farmers' adoption of improved agricultural technologies. Karki *et al.*(2004) undertook a study in a mid-hill district of Nepal to assess the impact of foreign-aided project in technology adoption and food security and to identify factors determining adoption of improved technology in case of small holder peasants. Their result using binomial logit model and qualitative analysis revealed that, coefficient of years of schooling positively influenced farmers' adoption decisions on improved agricultural technologies. Education is very important for the farmers to understand and interpret the information coming from any direction to them. Farmers' education is also pivotal for the effective work of extension personnel, because if the farmer has better education status they can have a capability to understand and interpret easily the information transferred from Development Agent (DA) to them. The finding of Ngigi (2003) in *Kobo,* Ethiopia, also showed positive and significant association between education level of the household and adopting of rain water harvest technology (RWH). Negussie *et al*. (2008) reported that age, gender, family size, extension contact, attendance of training and experience in coffee farming did not significantly influence farmers' perception in survey made in Manna woreda.

Table 8. Frequency, proportion and association (chi-square) of coffee quality with demographic factors among sampled coffee farmers HHs

Independent variables		Frequency	Total	%	coffee quality: Acceptable No̲	Acceptable %	Un acceptable No̲	Un acceptable %	X^2	P-value
Sex	M	297	158	96.1	109	69	49	31	.030	0.86
	F	12	6	3.9	2	33	4	67		
Age	>48	121	64	39.2	46	28	18	11	1.234	0.54
	>33	133	71	43.0	48	29	22	13		
	>18	55	29	17.8	19	12	11	7		
Family size	>4	286	152	92.6	103	63	49	30	2.17	0.14
	<4	23	12	7.4	10	6	2	1		
Educational status	Illiterate	271	144	88	15	9	5	3	0.457	0.50
	Literate	38	20	12	98	60	46	28		
Who often harvest coffee	Daily laborer	185	98	59.8	31	19	67	41	0.044	0.83
	Own family	124	66	40.2	20	12	46	28		

II. Agronomic and physiological factors

As indicated in Table 9, among agronomic and physiological factors affecting coffee yield and quality, age of coffee trees, pruning, weed control, disease prevalence, and application of compost were assessed in this study. Hence, the result of the field survey showed that among 164 coffee farmers interviewed 70.6% (116) owned old coffee trees (>20 years), while 29.4 % (48) of them owned coffee trees less than twenty years old. This result implies that majority of the coffee plantations in the study areas are physiologically declining as their yield and quality might decrease as reported by Clifford (1985). Yigzaw (2005) reported that samples from young trees are likely to be mild and thin, but fine in flavor. Beans from old trees produced strong taste and a harsh characteristic brew. Medium aged trees, 15 to 20 years old, bear beans with good flavor as well as acidity and body Thus, in this study the variable is hypothesized to have inversely related with coffee quality.

Similarly, in this survey it was observed that even though the majority of coffee plantations in the farmers hand were greater than 20 years old, only 27.5% of respondent coffee farmers practiced maintenance pruning. Coffee tree pruning is an extremely important pre harvest activity for reducing incidences of diseases, modifying air movement within the plantation, which in turn reduces leaf drying time. On top of that it was identified that majority of coffee farmers (70.9%) and (71.2%) responded the prevalence of disease and no application of compost in their coffee field, respectively. As the consequence of this the quality and quantity of coffee might have decreased considerably.

On the other hand, chi-square analysis indicated that there were strong association between different agronomic and physiological factors and quality coffee production. Age of coffee tree and disease prevalence were very strongly associated (χ^2 = 50.20, χ^2 = 28.70) with coffee quality at 0.1% probability level, respectively. Similarly, agronomic factors such as coffee pruning and type of weeds prevalent in the field were strongly associated (χ^2 = 10.18, χ^2 = 12.97) with coffee quality at 1% probability level, respectively. This observation was found similar with that of Yigzaw (2005) and Wintgens (2004). Yigzaw (2005) reported that samples from young trees are likely to be mild and thin, but fine in flavor. Beans from old trees produced strong taste and a harsh characteristic brew. Medium aged trees, 15 to 20 years old, beans with good flavor as well as acidity and body (Yigzaw, 2005). On the other hand, (Wintgens, 2004) reported that disease and insect such as leaf miner and mites may also result in lower quality beans. Moreover, compost application was associated (χ^2 = 8.75) with coffee quality at 5% probability level. On the contrary, mechanism of weed control was not associated with quality in this study.

Table 9. Frequency, proportional distribution and association (chi-square) of coffee quality with agronomic and physiological factors among sampled coffee farmers HHs

Independent variables		Frequency	Total	%	coffee quality				X^2	P-value
					Acceptable		Un acceptable			
					No	%	No	%		
Age of the coffee tree	>20	218	116	70.6	66	40	50	30	50.20	0.000
	<20	91	48	29.4	47	29	1	1		
Coffee pruning	yes	85	45	27.5	20	12	25	15	10.18	0.001
	no	224	119	72.5	31	19	88	54		
Weed type	Coach Grass	13	7	4.2	2	1	5	3	12.97	0.002
	Soft weed	226	120	73.1	44	27	76	46		
	Both	70	37	22.7	5	3	32	19		
Weed control mechanism	Slashing	269	143	87.1	46	28	97	59	0.71	0.374
	Hand weeding	40	21	12.9	5	3	16	10		
Compost application	yes	220	117	71.2	31	19	86	52	8.75	0.013
	no	88	47	28.5	20	12	27	17		
Disease observation	yes	219	116	70.9	46	28	70	43	28.70	0.000
	no	90	48	28.5	5	3	43	26		

III. Harvest and post harvest factors

As shown in Table 10, majority of the surveyed farmers were exercising better harvesting and post-harvest management practices in terms of harvesting at full maturity stage (75.4%), selective hand picking (61.8%), drying on wooden and bamboo made raised beds (61.2%), and packing in jute bags (77.0%), which maintain the inherent coffee quality. On the contrary, 51% of the interviewed farmers lacked storage facilities and 55.7% stored their coffee for more than four months, which is considered as coffee quality deteriorating factor. Obiero (1996) reported that storing dried parchment coffee for more than six months resulted in woody flavor, which lowers quality. Wintgens (2004) further indicated that green coffees stored for a longer period described as 'aged' may suffer a loss of their acidity. Length and condition of bean storage also affect cup quality (Yigzaw, 2005). Moreover, long time storage under high relative humidity and warm conditions increase bean moisture content and consequently reduce quality in terms of raw and roasted appearance as well as liquor (Woelore, 1995.)

Chi-square test for harvest and post harvest factors, such as mixing coffee of differently harvested for sell, materials used for drying coffee, types of coffee packing materials used, storage availability, revealed strong association (χ^2 = 41.68, χ^2 = 37.64, χ^2 = 34.39, χ^2 = 85.43) with coffee quality at 0.1% probability level. Similarly, there was association (χ^2 = 4.36) between storage period and coffee quality at 5% probability level. On the other hand, method of coffee harvesting and bean maturity stage at harvest were not associated with coffee quality at 5% probability level in this study. This result could be attributed to the fact that majority of the farmers harvest their coffee at full mature stage by selective hand picking.

Table 10. Frequency, proportional distribution and association (chi-square) of coffee quality with harvest and post harvest factors among sampled coffee farmers HHs

Independent variables		Frequency	Total	%	coffee quality				X^2	P-value
					Acceptable		Un acceptable			
					No	%	No	%		
Mixing coffee for sell	yes	203	108	66	47	28	61	37	41.68	0.000
	no	106	56	34	4	3	52	32		
Bean maturity stage at harvest	Full maturity stage	233	124	75.4	41	26	83	51	6.43	0.093
	Green stage	64	34	20.7	9	6	25	15		
	Immature stage	12	6	3.9	1	0,6	5	3		
Drying materials used	Cemented, bricks and Mesh wire	73	39	23.6	4	2	35	21	37.64	0.000
	On wooden bed and bamboo	189	100	61.2	44	27	56	34		
	On the ground	47	25	15.2	3	2	22	13		
Type of coffee packing materials used	Jute bag	238	126	77.0	50	30	76	47	34.39	0.000
	Plastic bag	48	25	15.5	0	0	25	15		
	Clay pot.	23	13	7.4	1	0.6	12	7		
Storage availability	yes	149	79	48.2	46	28	33	20	95.43	0.000
	no	160	85	51.8	5	3	80	49		
Method of coffee harvesting	Selective picking	191	101	61.8	31	19	70	43	3.08	0.215
	Strip Method	65	34	21.0	8	5	26	16		
	From ground	53	28	17.2	11	7	20	17		
Storage period	<4	137	73	44.3	27	16	46	28	4.36	0.039
	>4	172	91	55.7	24	31	67	41		

IV. Institutional factors

Descriptive statistics of the field survey study result revealed that from a total of 164 coffee farmers interviewed 14.2% (23) of them had no shortage of time, whereas, 85.8 % (141) of them encountered shortage of time during peak coffee harvesting period (Table 11). This implies that majority of farmers are not able to harvest their own coffee on time, probably due to other farm activities/ overlapping of operations. Furthermore, the survey result also indicated that out of the total farmers interviewed, substantial number of farmers (93.2 and 82.2%) were responded the provision of support (such as improved seeds, raised coffee seedlings, etc) and training from the respective ARDO, respectively. On the contrary, the study revealed that 77.3% of the coffee farming family suffered from shortage of money at immature green stage of coffee, particularly, in the late month of August and early September, whereas only 22.7% were responded differently. This might be one of the factors that contribute to the decline in coffee quality due to premature harvesting of coffee to ensure cash sources for their families (Table 10).

This result was in agreement with the findings of Mulugeta (1999), Elias (2005), Admasu (2008) and Alemayehu et al. (2008). Elias (2005) reported that poor quality coffees supplied by farmers are due to poor infrastructure and inadequacy of facilities, lack of institutional credit and coffee production and marketing in the Gomma woreda. According to the author lack of credit service was a problem reported by both the coffee growers (22%) and the coffee traders (21%). Mulugeta (1999) reported that access to credit, farm size, supplementary inputs, technical and institutional support like the extension service determining the adoption of technologies. According to Alemayehu et al. (2008), the small holding coffee farmers in particular could not be able to make use of appropriate inputs and farm tools such as pruning shears, bowsaw and drying materials largely due to unavailability, poor purchasing capacity and absence of appropriate credit systems. The existence of institutions that facilitate extension services are essential for quality coffee production. Admasu (2008) indicated about 85% and 93% of sample farmers in the Gomma woreda respond to have faced cash shortage for the purpose of hiring labor for coffee harvesting and weeding, respectively. Furthermore, the author reported that about 87% of sample farmers in Gomma woreda had shortage of farm tools for the purpose of coffee production.

In this study, time constraint during harvesting and training showed very strong association (χ^2 = 16.85, χ^2 = 23.51) with coffee quality at 0.1% probability level, respectively. Similarly, cash shortage and support from ARDO indicated strong association with quality coffee production at 1% probability level (Table 11).

Table 11. Frequency, proportional distribution and association (chi-square) of coffee quality with institutional factors among sampled coffee farmers HHs

		Total			Coffee quality				x^2	P-value
					Acceptable		Un acceptable			
					No	%	No	%		
Training on the last year	yes	254	135	82.2	50	30	85	52	23.510	0.000
	no	55	29	17.8	1	1	28	17		
Cash shortage	yes	239	127	77.3	46	28	81	50	11.902	0.001
	no	70	37	22.7	5	3	32	19		
Time constraint during harvesting	yes	265	141	14.2	50	30	91	55	16.852	0.000
	no	44	23	85.8	1	1	22	14		
Support from ARDO	Yes	288	153	93.2	50	33	102	62	7.281	0.007
	No	21	11	6.8	0	0	11	6		

(Source: Computed from own survey data, 2009)

4.1.1.2. Binary logit regression model

The logit model was employed in this study to estimate the effects of the hypothesized independent variables on adoption of CQPPHMP. The selection of independent variables was begun with a careful analysis of each variable. Since the Pearson chi-square test is asymptotically equivalent to the likelihood ratio chi-square test, it can also be used to test the significance of univariate relationships. In univariate analysis, using Pearson chi-square test the variables that were found to be significant in the study were ages of coffee tree (ACT16), coffee tree pruning (CTP17), type of coffee weed (TCW19), compost application to coffee (CA112), diseases observation in coffee farm (DOCF115), coffee mixing during selling (CMS120), time constraint during peak harvest (TCPH122), drying materials of coffee (DMC129), type of coffee packing materials used (TCP130), storage availability (SA131), time of coffee storage (TCS134), cash shortage (CSH135), support from ARDO (SARDO138), and training access of last year (TALY140) (Appendix IV). With this regard, Degnet (1999) had summarized different empirical studies on the association between adoption decision and factors, which influence adoption, particularly in less developed countries into personal characteristics (such as age, education, gender, farming experience of the head of the family), farm characteristics (availability of cash) and supply and institutional factors (such as farmers` access to credit, agricultural extension services, market and price of products, and access to availability of inputs).

The variables that were found significant in the chi-square were further used in the analysis of binary Logit regression model. Fourteen independent variables that were included in the model in this study were ages of coffee tree (ACT16), coffee tree pruning (CTP17), type of coffee weed (TCW19), compost application to coffee (CA112), diseases observation in coffee farm (DOCF115), coffee mixing during selling (CMS120), time constraint during peak harvest (TCPH122), drying materials of coffee (DMC129), type of coffee packing materials used (TCP130), storage availability (SA131), time of coffee storage (TCS134), cash shortage during harvest (CSH135), support from ministry of agriculture (SARDO138), and training access of last year (TALY140).

Interpretation of Empirical Results

The results of this study confirmed a priori expectation in that the decision to adopt or not to adopt CQPPHMP technology was influenced by the simultaneous interaction of several demographic, socio-economic, technical and institutional factors. Out of 14 explanatory variables hypothesized to affect coffee quality, six were found to be statistically significant. These factors include compost application, disease prevalence in coffee field, mixing up of differently harvested coffee during selling, types of drying materials used, availability of storage, and time of coffee in storage (Table 12).

Of the six significant variables, four were found to be statistically highly significant at 0.1 % probability level, while two of them were significant at 1 and 5 % probability level, respectively. The result shows that compost application (CA112), disease prevalence in coffee field (DOCF115), mixing up of differently harvested coffee during selling (CMS120), drying coffee on cemented, bricks and mesh wire (DMC129), were positively and significantly related with coffee quality, while drying coffee on ground (DMC129), availability of storage (SA131), and time of coffee in storage were negatively and significantly related with coffee quality.

The value of Pearson Chi-square test shows the overall goodness of fit of the model at less than 1% probability level. Another measure of goodness of fit of the model is based on a scheme that classifies the predicted value of events as one if the estimated probability of an event is equal or greater than 0.5 and 0 otherwise. From all sample farmers, 90.6% were correctly predicted in to either acceptable or unacceptable quality coffee categories by the model.

Table 12. Independent variables in the the maximum likelihood estimates of the binomial logit model

Independent Variables	Estimated Coefficient (B)	Odds ratio (S.E).	Wald Statistics	Df	Sig. Level	Exp(B)
CA112(1)	1.159	0.515	5.058	1	0.025*	3.186
DOCF115(1)	2.780	0.620	20.070	1	0.000***	16.115
CMS120(1)	4.056	0.768	27.892	1	0.000***	57.747
DMC129			32.511	2	0.000***	
DMC129(1)	-0.202	0.783	0.067	1	0.796	0.817
DMC129(2)	-3.388	0.749	20.480	1	0.000***	0.034
SA131(1)	-4.660	0.693	45.195	1	0.000***	0.009
TCS134(1)	-1.812	0.535	11.459	1	0.001**	0.163
CSH135(1)	1.096	0.574	3.649	1	.056	2.993
Constant	4.669	1.045	19.947	1	0.000***	106.584

***, significant at 0.1% probability level **Significant at less than 1% probability level *, Significant at 5% probability level *

Pearson- χ^2 value	238.646***
-2 Log Likelihood	144.293
Correctly Predicted (%)	90.6

The effects of the model estimates were interpreted in relation to the significant explanatory variables in the model as follows:

Compost application (CA112): The variable compost application in the study area related positively and significantly (at less than 5% probability level) with maintaining coffee quality as hypothesized earlier. The odds ratio for this variable indicate that keeping the influences of other factors constant, the practices in favor of maintaining coffee quality increases by a factor of 3.186 as compost application increases. Application of compost improves the activity of micro organisms and improves macro–and micro- nutrient availability. Compost acts as a good soil conditioner and improves the physical, chemical and biological properties of the soil. Good growth conditions usually have a positive effect on bean size and flavor (Wintgens, 2004). Taye (1998) reported the use of decomposed coffee husk at a rate of 10 ton ha^{-1} (4 kg $tree^{-1}$ on dry weight basis) was found to be superior in terms of yield performance of coffee trees. A significant improvement in growth and yield of mature coffees was reported in response to coffee pulp and husk compost application (Chane, 1999). On the contrary, repeated application of elephant grass or livestock manure resulted in an increased percentage of undesirable brown-colored bean and, thus, poor roasting characteristics. This effect was associated with a magnesium deficiency induced by the high potassium content of elephant grass as well as high concentration of potassium and calcium in manure (Wintgens, 2004).

Disease observation in coffee field (DOCF115): The probability of getting farmers that produce poor quality coffee whose coffee farms were infected with disease is 16.115 times greater than those farmers producing acceptable quality coffee (Table 12). The disease occurrence can lead to poor quality coffee that gives off and disagreeable odor Diseases attacks can affect the cherries directly or cause them to deteriorate by debilitating the plants, which will then produce immature or damaged fruits that affect its quality (Wintgens, 2004). For instance, when CBD attacks the fruit in its more advanced stage of growth causes severe damage to the crop and coffee quality (Eshetu and Girma, 2008).

Mixing up of differently harvested coffee during selling (CMS120): The odds ratio 0.768 of producing poor quality coffee indicated that keeping the influences of other factors constant, mixing up of differently harvested coffee during selling is 57.747 times greater than producing quality coffee. Such inferior quality is mainly due to mixing of green, partly ripe, red and black cherries (Wintgens, 2004). Therefore, red ripe cherry should be selectively picked from the tree to maintain the quality of the green beans.

Drying materials used (DMC129(2): The odds ratio 0.749 for this variable indicates that keeping the influences of other factors constant, drying coffee on the ground reduces quality of coffee 0.034 times than drying coffee on wooden and bamboo made bed. On the other hand, the odds ratio for this variable indicates that keeping the influences of other factors constant, drying coffee on the ground reduces quality of coffee 0.817 times than drying coffee on cemented, bricks and mesh (Table 12). OTA (Ochratoxin A) is a form of mycotoxin, produced as a metabolic product of *Aspergillus ochraceus*, *A. carbonarius* and strains of *A. niger* reported to exist on coffee dried on bare ground (Eshetu and Girma, 2008). Therefore, drying coffee on ground can expose the product to such quality deteriorating factor.

Storage availability (SA131): The odds ratio 0.693 for this variable indicates that keeping the influences of other factors constant, farmers who had no access of storage facilities reduces quality of coffee 0.009 times than farmers who had access of storage facilities. Length and condition of bean storage also affect cup quality (Yigzaw, 2005). To maintain coffee quality farmers should store their coffee for short periods of time under cool, dry, well ventilated places protected from direct exposure to the sun and others foreign materials.

Time of coffee in storage (TCS134): The odds ratio for this variable indicates that keeping the influences of other factors constant, storing coffee for more than four months reduces coffee quality 0.163 times than storing coffee for less than four months (Table 12). Obiero (1996) reported that storing dried parchment coffee for more than six months resulted in woody flavor, which lowers quality. Wintgens (2004) further indicated that green coffees stored for a longer period described as 'aged' may suffer a loss of their acidity. Length and condition of bean storage also affect cup quality (Yigzaw, 2005). Long time storage under high relative humidity and warm conditions increase bean moisture content and consequently reduce quality in terms of raw and roasted appearance as well as liquor (Woelore, 1995).

4.1.2. Response of coffee traders

Analysis through descriptive statistics

In the field survey study, similar to study made for farmers assessments were made for coffee traders considering demographic, institutional and technical factors maintaining or deteriorating coffee quality in the study areas.

Demographic factors

In terms of demographic factors out of a total of 30 sampled coffee traders the majority of them (98.3%) (29) were male, while the remaining 1.7 % (1) were female Many evidences showed that female households have less access to improved technologies, credit and extension service (Ellis and Mudhara, 1995). Therefore, male status of household head is positively correlated with adoption of coffee quality post harvest management practices (CQPPHMP). On the other hand, the survey result showed that proportionally 21.4%, 63.2% and 15.4% sampled coffee traders were in the age group of greater than 48, 33, and 18 years old, respectively. Since substantial numbers of traders were in the age groups between 33 and 48 years, this is probably due to their wealth accumulation through long years of trading. Furthermore, the study also indicated that majority of sampled coffee traders had (67.5%) greater than four family members while the rest had (32.5%) less than four (Table 13). All demographic factors surveyed for sampled traders were not significantly associated with the production of quality coffee at 5% probability level.

Table 13. Frequency, proportional distribution and association (chi-square) of coffee quality with demographic factors among sampled traders HHs

Independent variables		Frequency	Total	%	Coffee quality				X^2	P-value
					Acceptable		Unacceptable			
					No	%	No	%		
Sex	F	2	1	1.7	28	93.33	1	3.33	0.072	0.788
	M	115	29	98.3	1	3.33	0	0		
Age	>48	25	6	21.4	6	20	1	3.33	2.341	0.310
	>33	74	19	63.2	18	60	1	3.33		
	>18	18	5	15.4	4	13.33	0	0		
Family size	>4	79	20	67.5	19	63.33	1	3.33	0.580	.446
	<4	38	10	32.5	9	30	1	3.33		

Institutional factors

Institutionally, the majority of sampled coffee traders (73.5% =22) determined coffee price through their own judgment, whereas the remaining (26.5% =8) relay on radio information for price determination in the study areas, respectively. Coffee price own judgment coffee traders is attributed to the production of poor quality coffee by the farmers of the study areas. .On the other hand, substantial number of sampled coffee traders (91.5%=27) check coffee quality for price determination through their own observation, while (8.5% =3) had no mechanism for checking coffee quality for price in the study areas.

Moreover, the survey results indicated that (76.1% =23) of the sampled coffee traders had received extension services to maintain inherent coffee quality, while the remaining (23.9% =7) did not. Mulugeta (1999) reported that access to credit, supplementary inputs, technical and institutional support like the extension service determining the adoption of technologies.

Similarly, there was no strong association between producing quality coffee and decision of prices, and extension services, except checking coffee quality for price (Table 14). This result implies that as opposed to the farmers, coffee traders of the survey areas are more conscious in exercising coffee quality maintaining practices in order to be competent in quality demanding coffee business industry. The chi-square test showed strong association (χ^2= 0.003**) of coffee quality and price of coffee at 1% probability level. This study would helps to influence the farmers to focus on quality of coffee for better price market than bulking coffee harvested at different stage of maturity.

Table 14. Frequency, proportional distribution and association (chi-square) of coffee quality with institutional factors among sampled coffee traders HHs

Independent variables		Frequency	total	%	Coffee quality				X^2	P-value
					Acceptable		Unacceptable			
					No	%	No	%		
Decision of price	radio information	31	8	26.5	7	23	0	0	1.493	0.222
	Own judgment	86	22	73.5	21	70	2	7		
Checking coffee	Through observation	107	27	91.5	26	87	1	3	9.105	0.003**
quality for price	No means of checking	10	3	8.5	2	7	1	3		
Extension service	no	89	23	76.1	21	73	2	3	1.303	0.254
	yes	28	7	23.9	7	24	0	0		

(Source: Computed from own survey data, 2009)

Technical Factors

Similarly, the field survey results indicated that 64.1 % (19) of the sampled coffee traders received training on maintaining inherent coffee quality, while the remaining 35.9 % (11) did not. This may be attributed to the existence of respective ARDO in the study areas, which is responsible for offering training on maintaining inherent coffee quality. In addition to training offered by responsible institutions, the survey results also revealed that 42.7% (13) of coffee traders run their business by hiring business advisors. In coffee trade industry, advisors are also pivotal for the effective work of coffee business, because if the trader has appropriate advisor they can have a capability to understand and interpret easily the information transferred from any source. Furthermore, 28.2 % (8) of coffee traders had moisture tester to test moisture contents of their coffee, as opposed to 71.8% (22) of the remaining. On the other hand, considering availability of storage facilities and type of storage, substantial numbers (82.9%) and (89.7%) of sampled coffee traders had storage and cemented floor type of storage, respectively. The chi-square analysis showed that there were no strong and significant association between producing quality coffee and training, advisors, moisture tester, storage availability and type of storage used (Table 15). This result suggest that the majority of sampled coffee traders have better training, access to storage and concrete type of floor storage facility that maintain the inherent quality of coffee in the study areas.

Table 15. Frequency, proportional distribution and association (chi-square) of coffee quality with technical factors among sampled coffee traders HHs

Independent variables		Frequency	Total	%	Coffee quality				X^2	P-value
					Acceptable		Unacceptable			
					No	%	No	%		
Training	Yes	75	19	64.1	18	60	1	3.33	0.36	0.55
	No	42	11	35.9	10	33.33	1	3.33		
Advisor	Yes	50	13	42.7	12	40	1	3	1.76	0.18
	No	67	17	57.3	17	57	0	0		
Moisture tester	Yes	33	8	28.2	8	27	1	3	0.97	0.32
	No	84	22	71.8	20	67	1	3		
Storage availability	yes	97	25	82.9	24	80	1	3	0.85	0.36
	No	20	5	17.1	5	17	0	0		
Type of store	concrete	105	27	89.7	25	83	2	7	0.47	0.79
	wooden bed	9	2	7.7	2	7	0	0		
	paved ground	3	1	2.6	1	3	0	0		

4.2. Laboratory Analysis

4.2.1. Cup and bean physical quality attributes

Analysis of variance revealed that coffee sampled from different localities varied significantly ($p<0.05$) for moisture content and body and highly significantly varied ($p<0.01$) for shape and make in the methods of processing. This finding was in contrary with the report of Wintgens (2004). Wintgens (2004) indicated that the shape and structure of beans are the result of both genotype and environmental factors. On the other hand, non–significant difference was observed for moisture content, shape and make while variation among the samples was highly significant ($p<0.\ 01$) for body in the preparation type. The interaction between the two processing methods and preparation types revealed non-significant difference for moisture content, shape and make and body and, highly significant ($p<.0.01$) for acidity, odor, flavor and color (Table 16).

Table 16. Mean squares for cup quality and bean physical quality characteristics

SV	DF	MC	SM	OD	CL	AC	BO	FL
L	7	0.14	0.60	0.09	1.32	3.14	3.80	4.92
PM	1	0.35*	990.01**	1.84**	1012.73**	30.07**	19.53*	95.67**
L*PM	7	0.05	0.60	0.07	1.32	1.00	3.17	3.35
PT	1	0.18	1.68	49.20**	2**	50.85**	73.02**	95.67**
PM*PT	1	0.01	1.68	1.26**	2**	35.41**	9.03	60.53**

SV= Sources of Variation; DF=Degree of Freedom; MC = Moisture Contents; SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor; L= Location where coffee sampled; PM=Processing Methods; PT= Preparation Types.
* = significant at P<0.05 and ** = significant at P<0.01.

As indicated in Table 17, the mean separation test revealed that wet processing method resulted in high mean values for good cup quality characters such as acidity, body and flavor and for bean physical quality attributes, like odor, as compared to dry processing method. However, the difference between the two processing methods was non-significant for bean moisture content. From this result it is possible to conclude that wet processing method is the best approach to obtain fine and typical flavor in the cup that interest consumers according to their preference. All available evidences indicate that the liquor characteristics have been predetermined by genetic and environmental factors prior to processing (Brownbridge and Michael, 1971; Getu, 2009). According to Clifford (1985) wet processed arabica is aromatic with fine acidity and some astringency, while dry processed arabica is less aromatic and less acidic but with greater body. This result was in agreement with Obiero (1996); Mburu (1999) and Selmar *et al.* (2001). Selmar *et al.* (2001) reported that sensory evaluation of the roast coffees revealed that the dry and washed coffees could be distinguished with high significance (11 of 11 panel members). According to the authors investigation the differences in quality of differently processed coffees of similar original material is due to the process taking place in the beans during processing. Obiero (1996) reported that the wet method of arabica coffee processing gives better quality coffee as compared to the dry method. This is probably due to ripe red cherries selectively picked and sorted from other immature, diseased, insect damaged and dry berries as well as other foreign materials before wet processing. However, dry processed coffee has generally inferior-brown color, flavor and fragrance (Obiero, 1996).

Table 17. Mean values of processing methods (PM) for cup and bean physical quality characteristics

PM	MC	SM	CL	OD	AC	BO	FL
Wet	9.52a	11.12a	11.25a	9.04a	13.04a	12.73a	12.81a
Dry	9.73a	-	-	7.48b	10.81b	10.92b	9.73b
LSD (5%)	0.24	0.56	0.23	0.44	1.22	1.42	1.57
CV (%)	3.32	13.16	5.47	7.05	13.53	15.80	18.41

Means followed by the same letters within columns are non-significant at 5 % probability level.
PM = processing methods, MC = Moisture Contents; SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor.

Although different coffee research centers recommended appropriate coffee preparation procedures for either wet or dry processing methods with respect to coffee growing ecologies, farmers/traders mostly practice their local preparation way. This study tried to identify the difference between recommended and local coffee preparation approach. Results in Table 18 indicated that, for most of sensorial quality attributes, recommended preparation procedure outsmarts local preparation method. For physical quality attributes, preparation methods were varied only for color and odor. Nonetheless, of the processing methods, in this study, it was observed that, recommended way of preparing coffee promotes the typical quality profile to the final cup quality at the spot of consumer's choice that finally creates interest for the profile in the international coffee market. Therefore, the two study sites represented the ignorance of using recommended coffee processing technology that makes the areas coffee supply to be categorized under lower quality grade. It is also possible to infer that, processing approaches are the gap to provide typical and inherent quality profile of the area.

Table 18. Mean values of preparation type (PT) for cup and bean physical quality characteristics

PT	MC	SM	CL	OD	AC	BO	FL
Recommended	9.70a	5.79a	5.88a	10.04a	13.33a	13.46a	12.81a
local	9.55a	5.33a	5.38b	7.56b	10.81b	10.44b	9.35b
LSD (5%)	0.24	0.56	0.23	0.44	1.22	1.42	1.57
CV	3.32	13.16	5.47	7.05	13.53	15.8	18.41

Means followed by the same letters within a column are non-significant for at 5% probability level.
PT = preparation type; MC = Moisture Contents; SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor.

The interaction between factors considered in this study, showed that the combination of wet processing method with either recommended or local (farmer/trader) way of coffee preparation approach, ranked top for both cup and bean physical quality attributes. Furthermore, the recommended way of dry processing approach was also comparable with the wet processing method for all of coffee quality attributes. However, local way of dry coffee preparation approach was found to be inferior as compared to the rest combinations for most of coffee cup quality attributes. Hence, local dry coffee preparation approach is the main reason for lower grade value of the regions coffee quality profile as indicated in the Table 19. In addition to this color and odor affected by wet local preparation approach. Brownbridge and Michael (1971) have reported that the raw appearance (subsequently the roast) improves in quality as the browning components, which are inherent in the bean, diffuse outwards into the surrounding aqueous mass. This diffusion effect is further facilitated under-water soaking stage following the fermentation stage. According to their report post-fermentation soaking for 24 hours produced better raw and roast appearance of wet processed coffee. On the contrary, Obiero, (1996) indicated that dry processed coffee has generally inferior-brown color, flavor and fragrance. It has long been recognized by the coffee trade that brown-colored ('foxy') raw beans produce inferior liquor, compared to beans free of any such coloration (Brownbridge and Michael, 1971).

Table 19. Mean values of processing method and preparation type for cup and bean physical quality characteristics

PM	PT	MC	SM	CL	OD	AC	BO	FL
Wet	Recommended	9.61a	11.58a	11.75a	10.08a	13.25a	13.71a	13.17a
Wet	Local	9.43a	10.67b	10.75b	8.00b	12.83a	11.75a	12.46a
Dry	Recommended	9.79a	-	-	8.75a	12.79a	13.08a	12.58a
Dry	Local	9.67a	-	-	6.21c	8.83b	8.75b	6.88b

Means followed by the same letter within a column are non-significant at 5 % probability level.
PM = processing methods; PT = preparation type; MC = Moisture Contents; SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor.

In terms of color, it was found that the recommended wet processed coffee is significantly better from local method (Table 19). This is probably due to lack of fermentation followed by soaking under clean water for 24 hours that improves color of wet processed coffee.

Coffee processed in the recommended method showed superior odor than local preparation did. Mean values for odor of both processed in recommended dry or wet way were significantly different from the local preparation type (Table 19 and Fig. 7). But there were no significant variations between coffees processed in the recommended dry or wet way for odor. Brownbridge and Michael (1971) have indicated that high level of coffee skins in fermenting coffee produces inferior raw, roast and liquor qualities compared to skin free controls, with the liquors adversely affected by the development of off-flavors variously described as coarse, bitter, fruity or unclean.

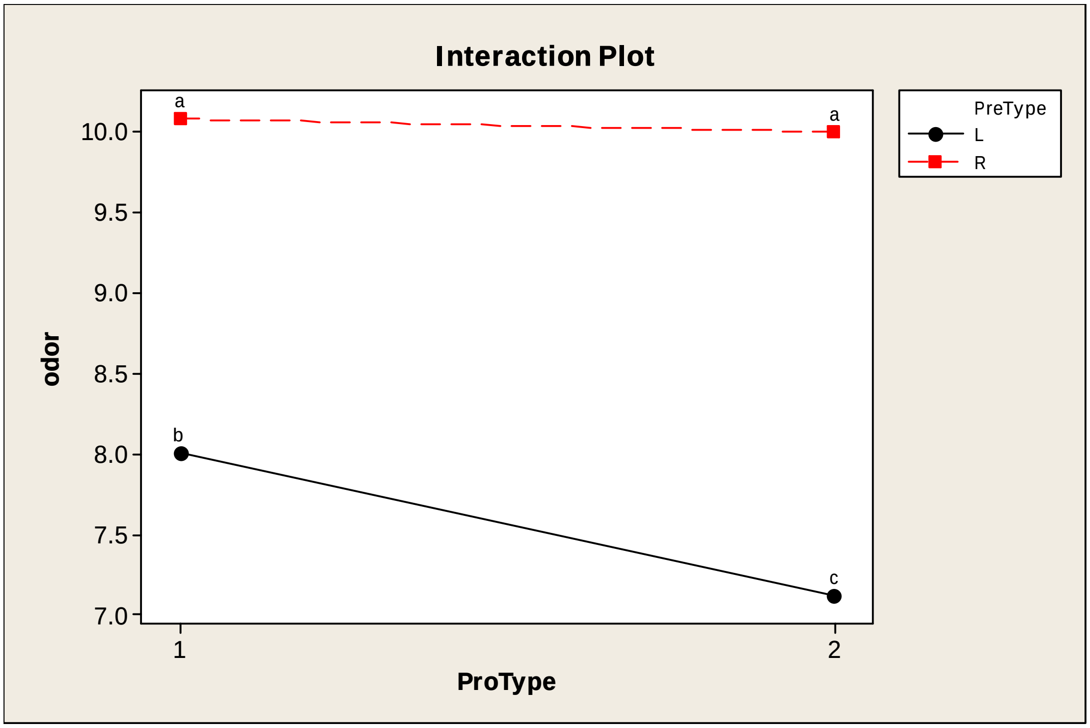

Fig 7. Interaction between processing method and preparation type for odor.

L = Local preparation type; R = Recommended preparation type; 1 = wet processing method = 2= dry processing method.

On the other hand, for both processing method and preparation type no significant mean variations observed for acidity except for dry processed coffee in local way (Table 19 and Fig. 8).

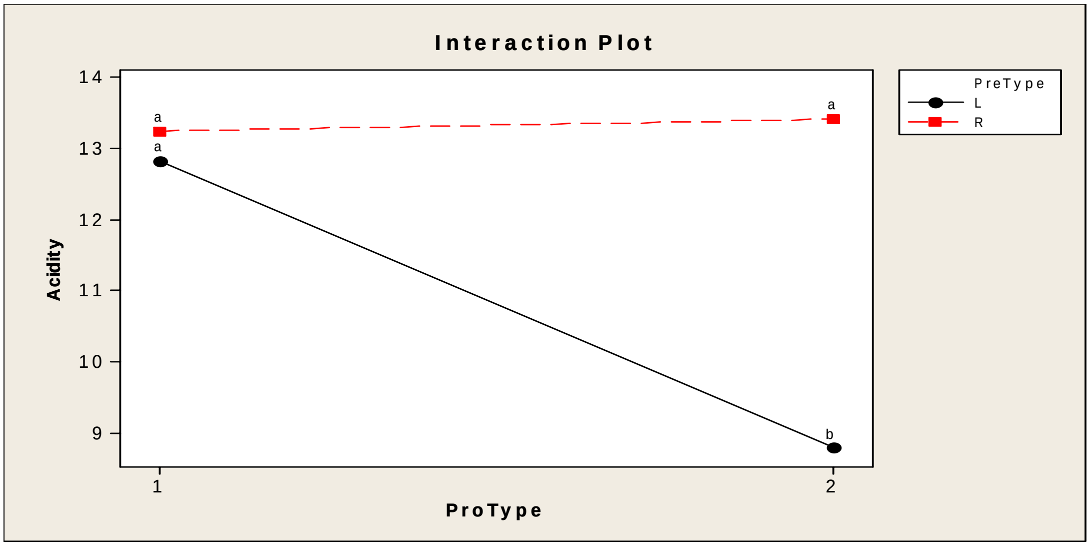

Fig. 8. Interaction between processing method and preparation type for acidity.

L = Local preparation type; R = Recommended preparation type; 1 = wet processing method = 2= dry processing method.

Similarly, for both processing method and preparation type no significant mean variation observed for flavor except for dry processed coffee in local way (Table 19 and Fig 9).

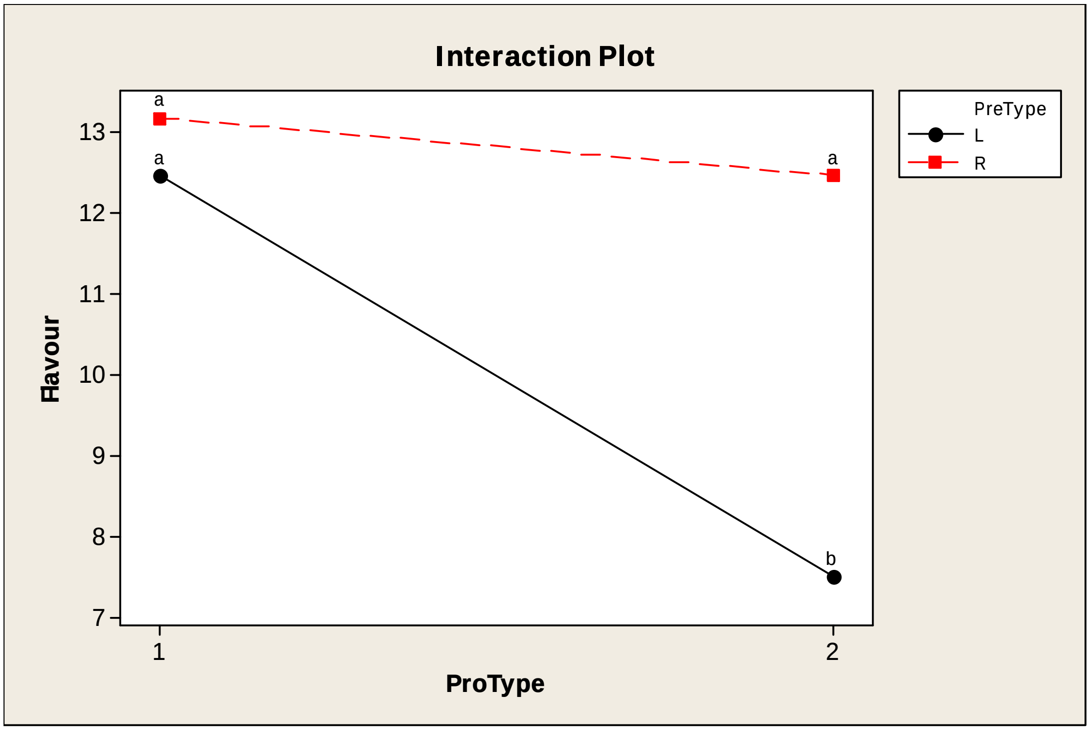

Fig. 9. Interaction between processing method and preparation type for flavor.

L = Local preparation type; R = Recommended preparation type; 1 = wet processing method = 2= dry processing method.

4.2.2. Coffee grades

Results of percentage distribution of woreda grading with respect to processing method and preparation approach indicated that wet processing for the two approaches was profiled under grade 2 for Gomma woreda where as under grade 2 and 3 for Manna woreda (Table 20 and Table 21, respectively). There were differences between localities for quality that might be attributed to poor pre-and post-harvesting management practices as indicated in the survey result. Furthermore, Alemayehu *et al*. (2008), suggested that inadequate systems of harvesting, processing, storage and transportation are responsible for the wide spread failure to maintain the inherent quality of produced coffee in Ethiopia.

Secondly, dry processing method was affected by processing approaches. According to this result, at Gomma woreda, local way of coffee preparation resulted in lower grade (grade 4), which accounted for 75% of sampled materials, while the recommended approach categorized under grade 1 (25%) and grade 2 (75%) (Table 20 and Appendix III). With respect to Manna woreda, relatively good grade was obtained and local way of processing accounted for 25% of grade 2 and 75% of grade 3 (Table 21 and Appendix III). This result was in agreement with the report of Desse (2008). Desse (2008) reported that out of Jimma coffee sent to the coffee quality inspection center laboratory from (2003-2007), more than 60% of dry processed coffee was found to be grade 3 as compared to 80% of wet processed which grouped in to grade 2 and grade 3, this is mainly due to poor processing of sun dried coffee. From this result it is possible to conclude that dry processing is more sensitive to preparation approach. It is also known that high volume of dry coffee is arriving at national auction center from Jimma zone (Desse, 2008). Thus, special attention should be given to dry processing approach through refinement of processing methods and provisions of, extension and training services .Generally, gap on coffee quality management is observed between localities, and different processing methods and approaches. Further research on pre harvest management practices and identification of similar factors in more replicated areas would probably generate a better recommendation.

Samples prepared according to the recommended way in wet preparation method showed good physical and cup quality (2nd grade) for all sample sites, except for Gudata Bula site in Manna woreda (Appendix III). This could be attributed to the use of red-ripe matured cherries for sample preparation, which are selectively picked from the coffee tree, discarding green (immature), over matured and insect damaged cherries (Wrigley, 1988). On the contrary, samples collected from the traders store especially from Manna woreda had inferior quality as compared to samples from Gomma woreda, for both ways of preparation, processed by wet method (Table 20 and Table 21). Specially, locally prepared samples scored inferior grade, which is probably due to mixed maturity and improper fermentation (Wrigley, 1988) as indicated in Appendix III and summarized in Table 20 and Table 21. On the other hand, samples prepared according to the recommended way in dry processing method showed good physical and cup quality for all sites, particularly for Omo Gurede, in Gomma woreda, which scored first grade (Appendix III). The reason for higher qualities of the samples collected from Omo Grude area might be due to its environment, which is high land, while other samples were collected from medium altitude ranges. This was in agreement with the report of Yigzaw (2005), who indicated that, if other factors are kept constant, better quality coffee can be found at higher altitude, while lowland coffees are somewhat bland, with considerable body. Moreover, coffee from high altitude areas is more acidic, with better flavor (Yigzaw, 2005). In addition, it has been found that beans produced at low altitude (hot and humid environment) have a negative effect on the flavor and the structure of the fruits due to accelerated maturation (Wintgens, 2004).

Table 20. Number and percentage of coffee samples classified in different classes of cup quality grades for Gomma woreda

Grades	Wet recommended		Wet Local		Dry recommended		Dry Local	
	No	%	No	%	No	%	No	%
1	-	-	-	-	1	25	-	-
2	4	100	4	100	3	75	-	-
3	-	-	-	-	-	-	1	25
4	-	-	-	-	-	-	3	75

Note: 1. 81-100 grade 1; 2. 61-80 grade 2; 3. 41-60 grade 3; 4. 21-40 grade 4 or 1-2 cup defects; 5. < 20 or more than 2 defective cups for washed coffee, whereas, unwashed coffee grade range: 1 = 81-100%, grade 2 = 63-80%, grade 3 = 50-62%, grade 4 = 31-49% or 2 cups defect, grade 5 =15-30% or more than 2 cups defect.

Table 21. Number and percentage of coffee samples classified in different classes of cup quality grades for Manna woreda

Grades	Wet recommended		Wet local		Dry recommended		Dry local	
	No	%	No	%	No	%	No	%
1	-	-	-	-	-	-	-	-
2	3	75	2	50	4	100	1	25
3	1	25	2	50	-	-	3	75
4	-	-	-	-	-	-	-	-

Note: 1. 81-100 grade 1; 2. 61-80 grade 2; 3. 41-60 grade 3; 4. 21-40 grade 4 or 1-2 cup defects; 5. < 20 or more than 2 defective cups for washed coffee, whereas, unwashed coffee grade range: 1 = 81-100%, grade 2 = 63-80%, grade 3 = 50-62%, grade 4 = 31-49% or 2 cups defect, grade 5 =15-30% or more than 2 cups defect.

In addition to this, samples prepared by the local dry processing method had unacceptable physical character and inferior cup quality. This was attributed to the greater number of average defects observed in the locally prepared coffee samples than those resulted from the recommended approach (Table 22). Out of a 300 g green coffee beans sampled from locally prepared dry method from traders stores in Manna woreda, the average number of defects counted were 9, 8, 8, 8, 4 and 3 for foxy, pest damaged, immature, black, broken beans and stone, respectively, as opposed to, two, each one, and, for, pest damage and broken beans counted in recommended dry processing method (Table 22). Similarly, from 300 g sample coffee collected from local traders' stores in Gomma woreda, the average number of defects counted were 13, 10, 9, 11, 5 and 3, representing foxy, pest damage, immature, black, broken beans, stone, earthy, respectively, compared to 1 broken beans counted for recommended dry processing method (Table 22). This result was in agreement with the report of Desse (2008). He reported that, although the inherent flavor of Jimma coffee is pleasantly winy, some of the common cup defects are earthy, musty with secondary cup defects of taints in the liquor, which are mainly due to post harvest management problems. Among defects observed in this study, the major ones are black, foxy, immature, and pest damaged beans, which have quality deteriorating effects. In most cases black beans are associated with prolonged fermentation of cherries picked from the ground, which then undergo a poor drying process with intermittent periods of wetting (Wrigley, 1988). On the other hand, the foxy beans observed in locally prepared dry coffee was probably due to in appropriate high drying temperature, prolonged drying period extended over a long time and coffee dried on bricks floor (CLU, 2007).

Table 22. Mean values of defects observed in 300 g green beans of dry processed coffee prepared in recommended and local ways in both study areas (Gomma and Manna woredas)

SN	woredas	Average defects in recommended dry Types of defect	No.	Average defects in locally dry Types of defect	No.
1	Manna	Foxy		Foxy	9
		Pest damaged	1	Pest damaged	8
		Immature		Immature	8
		black	-	black	8
		broken	1	broken	4
		Stone	-	Stone	3
		earthy	-	earthy	
2	Gomma	Foxy		Foxy	13
		Pest damaged		Pest damaged	10
		Immature	-	Immature	9
		black		black	11
		broken	1	broken	5
		Stone	-	Stone	5
		earthy	-	earthy	3

Generally, as a result of the above defects the cup test of locally prepared dry processed coffee samples from Bashasha, Chedero and Omo Gurede sample sites were very poor (Appendix III).

5. SUMMARY AND CONCLUSIONS

Arabica coffee (*Coffea arabica* L.) is an economically important crop, which is contributing the highest of all export revenues in Ethiopia. Coffee being the major cash crop of the Jimma Zone, it is produced in eight woredas, namely, Gomma, Manna, Gera, Limmu Kossa, Limmu Seka, Seka Chokorsa, Kersa and Dedo and serves as a major means of income for the livelihood of coffee farming families.

Despite the favorable climatic conditions, variety of local coffee types for quality improvement and long history of coffee production in Jimma Zone, quality of the crop is poor due to traditional and poor pre and post harvest practices, which are still used by majority of the farmers, where the bulk of the production comes from.

Cup quality is a complex characteristic which depends on a series of factors such as species or variety (genetic factors), environmental conditions (ecological factors), agronomic practices (farm management), processing systems (post-harvest factors), storage conditions, preparation of the beverage and taste/preference of the consumer.

This study was, therefore conducted in the year 2008/9 under both laboratory and field conditions in Manna and Gomma woreda of the zone with objectives of assessing the impact of pre-and post-harvest processing practices on the quality of both wet and dry processed coffee, identifying the problems associated with coffee processing practices in the study areas, investigating socio-economic, technical and institutional factors related to coffee quality and drawing recommendations to alleviate the problems of the zone.

In the field survey, a total of 194 respondents (164 household farmers) were randomly selected following sample size determination procedures of probability proportional to size technique. Besides, 30 coffee traders were purposefully selected from the two woredas and interviewed from November to December, 2008 to generate primary data. A binary logit model was employed to determine factors affecting adoption of CQPPHMP practices.

On the other hand, for the laboratory analysis a total of 32 coffee bean samples (16 from each woreda) were prepared for organoleptic and bean physical quality characteristics at Jimma Agricultural Research Center (JARC). The first 16 green coffee samples were collected from the randomly selected eight PAS (8 samples from each study woreda) for recommended wet and dry processing methods. The second 16 green coffee samples were collected for comparison, i.e., eight from dry and another eight from wet processed coffee for laboratory analysis from local traders store from both woredas based on the procedures outlined by the Coffee Quality Liquoring Unit (CLU) by drawing 3 kg per 10 ton proportion. The laboratory experiment was arranged in split plot design considering the processing method as main plot and the preparation type as sub-plot in RCBD with three replications.

A total of 14 explanatory variables were used for the binary logit model out of which six variables were observed to be significant to affect the adoption of CQPPHMP practices by the coffee farmers, whereas none of the explanatory variables were found to be significant in the chi-square analysis, except checking quality for price for traders. In binary logit regression analysis of the field survey data obtained from coffee farmers, those factors that affect coffee quality were found to be disease prevalence in coffee fields, compost application, mixing up of differently harvested coffee during selling, availability of storage, drying materials and time of coffee storage.

The Laboratory analysis revealed that coffee samples from different locality varied significantly ($p<0.05$) for moisture content and body as well as varied highly significantly ($p<0.01$) for shape and make in the methods of processing. On the other hand, non–significant difference was observed for moisture content, shape and make while variation among the samples was highly significant ($p<0. 01$) for body in the preparation type. The interaction between the two processing methods and preparation types revealed non-significant difference for moisture content, shape and make and body and, highly significant ($p<.0.01$) for acidity, odor, flavor and color.

Furthermore, it was revealed that wet processing method resulted in high mean values for good cup quality (attributes like acidity, body and flavor) and bean physical quality (attributes like odor) as compared to the dry processing method. From this result it can be concluded that wet processing method is the best approach to obtain fine and typical quality flavor in the cup that attract consumers according to their preference in the international market.

Moreover, for most of sensorial quality attributes, recommended preparation procedure outsmarted local preparation method. For physical quality attributes, preparation methods were differentiated only by color and odor. Nonetheless, the processing method, in this study indicated that recommended way of preparing coffee promotes the typical quality profile to the final cup quality at the spot of consumers' choice that finally creates interest in the profile in the international coffee market. Therefore, the two study sites represented the ignorance of using recommended coffee processing technology that makes the areas coffee supply to be categorized under lower quality grade. It is also possible to infer that, processing approaches are the gap to provide typical and inherent quality profile of the area.

Of the different interaction levels of the factors considered in this study, the combination of wet processing method with either recommended or local way of coffee preparation approach ranked top for both cup and bean physical quality attributes.

Results of percentage distribution of woreda grading with respect to processing method and preparation approach indicated that wet processing for the two approaches were profiled under grade 2 for Gomma woreda but under grade 2 and 3 for Manna woreda. There were differences between localities for quality that might be attributed to poor pre- and post-harvesting management practices. Secondly, dry processing method was affected by processing approaches. According to this result in Gomma woreda, local way of coffee preparation resulted in lower grade (grade 4), which accounted for 75% of sampled materials while the recommended approach categorized under grade 1 (25%) and grade 2 (75%) in the same woreda. With respect to Manna woreda, relatively good grading was obtained where local way of processing accounted for 25% of grade 2 and 75% of grade 3. From this result it is possible to conclude that dry processing is more sensitive to approach of preparation. Generally, differences in coffee quality management were observed between localities and processing methods and approaches.

According to the finding of this study, the major factors that affect the production of quality coffee in Jimma zone were found to be pre and post harvest management practices. Therefore, based on the major findings of the study, the following recommendations were drawn:

1. Wet processing method should be promoted, in the zone as it exhibited high mean values for good cup quality attributes like acidity, body and flavor and for bean physical quality attributes like odor, as compared to dry processing method. Therefore, wet processing method is the best approach to obtain fine and typical flavor in the cup that attracts consumers according to their preference.

2. Although different coffee research centers recommended appropriate coffee preparation procedures for either wet or dry processing methods with respect to coffee growing ecologies, farmers/traders mostly practice their local preparation way. Therefore, extension intervention could be the best possible approach to enhance awareness among coffee producers to keep typical coffee quality profile of their garden through processing that finally adds value to their crop.

3. The combination of wet processing method with either recommended (researcher) or local (farmers/traders) way of coffee preparation ranked top for both cup and bean physical quality attributes. Furthermore, the recommended way of dry processing approach was also similar with the wet processing approach for most of coffee quality attributes. Therefore, it is advisable to apply these approaches at local level. The importance of extension intervention in the area towards improving the attitude of coffee producing farmers/traders for quality and further refinement of the recommended approach by researchers should also be strengthened.

4. Dry processing method was affected by processing approaches. Thus, special attention should be given to dry processing approach through refinement of the method itself and through extension and training. Furthermore, research on pre-and post-harvest management practices and identification of related factors in more replicated areas would help to come up with more conclusive recommendations.

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7. APPENDICES

7.1. Tables

Appendix I. Dry processed coffee green bean raw evaluation parameters for defect count rating system as the procedures of CLU (2007)

Defect type	Rate	Defect point
1. Immature	5x1	1
2. Pest damaged	5x1	1
3. Foxy	5x1	1
4. Broken	10x1	1
5. Black	1x1	1
6. White	1x1	1
7. Pod	1x1	1
8. Husk	Depends on size	1
9. Stick	Big	10
	Medium	5
	Small	3
10. Stone	Big	10
	Medium	5
	Small	3
11.Wanza	1x10	10
12. Earth (soil)	Big	10
	Medium	5
	Small	3
13.Soil beans	5x1	1

Source : CLU (2007)

Appendix II. ANOVA for cup quality and green bean physical characteristics of 32 *C. arabica* samples

Parameters	SV	Df	SS	MS	F	P-value
MC	Pa	7	1.01	0.14	1.41	0.27
	Protype	1	0.35	0.35*	6.75	0.04
	Pa *protyp	7	0.37	0.05	0.51	0.81
	Pretyp	1	0.18	0.18	1.79	0.23
	Protyp*pretyp	1	0.01	0.01	0.07	0. 80
SS	Pa	7	22.44	3.21	2.18	0.10
	Protype	1	14.65	14.65*	7.35	0.03
	Pa *protyp	7	13.95	1.99	1.35	0.30
	Pretyp	1	1.26	1.26	0.86	0.37
	Protyp*pretyp	1	9.74	9.74*	6.61	0.02
SM	Pa	7	4.21	0.60	1.12	0.40
	Protype	1	990.01	990.01**	1647.56	<.0001
	Pa *protyp	7	4.21	0.60	1,12	0.40
	Pretyp	1	1.68	1.68	3.13	0.10
	Protyp*pretyp	1	1.68	1.68	3,13	0.10
OD	Pa	7	0.61	0.09	1.13	0.40
	Protype	1	1.84	1.84**	27.48	0.001
	Pa *protyp	7	0.47	0.07	0.87	0.55
	Pretyp	1	49.20	49.20**	639.37	<.0001
	Protyp*pretyp	1	1.26	1.26**	16.32	0.001
CL	Pa	7	31.04	4.35	1.87	0.150
	Protype	1	816.69	816.69**	345.06	<.0001
	Pa *protyp	7	37.40	5.34	2.26	0.09
	Pretyp	1	182.12	182.12**	76.95	<.0001
	Protyp*pretyp	1	113.78	113.78**	48.07	<.0001
AC	Pa	7	21.98	3.14	1.05	0.44
	Protype	1	30.07	30.07**	10.04	0.001
	Pa *protyp	7	7.01	1.00	0.33	0.93
BO	Pa	7	26.61	3.80	1.23	0.35
	Protype	1	19.53	19.53*	6.17	0.04
	Pa *protyp	7	22.16	3.17	1.02	0.46
	Pretyp	1	73.02	73.02**	23.63	0.0003
	Protyp*pretyp	1	9.03	9.03	2.92	0.11
FL	Pa	7	34.45	4.92	1.01	0.47
	Protype	1	95.67	95.67**	28.59	0.0001
	Pa *protyp	7	23.42	3.35	0.68	0.68
	Pretyp	1	95.67	95.67**	19.57	0.0006
	Protyp*pretyp	1	60.53	60.53**	12.38	0.0034

*, ** significant at probability level less than 5 and 1%, respectively.

MC = Moisture Contents; SS = Screen Size; SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor; SV=Source of variation; SS=Sum square, MS=mean square.

Appendix III. Cup quality and green bean physical characteristics evaluation of 32 *C. arabica* samples for grading

Location	Sample codes	Raw quality		Cup quality					
		SM(15)	CL (15)	OD(10)	DC(30)	AC(20)	BD(20)	FL(20)	Overall quality
G omma	Brw1	12(15)	12(15)	10(10)		15(20)	15(20)	10^{+}(20)	2nd
G omma	Chrw2	12(15)	12(15)	10(10)		15(20)	15(20)	10^{+}(20)	2nd
G omma	Ogrw3	12(15)	12(15)	10(10)		15(20)	15(20)	15(20)	2nd
G omma	Yrw4	12(15)	12(15)	10(10)		10+(20)	10^{+}(20)	10^{+}(20)	2nd
Manna	Drw5	12(15)	12^{-}(15)	10(10)		15^{-}(20)	10^{+}(20)	10^{+}(20)	2nd
Manna	Gbrw6	8^{+}(15)	12^{-}(15)	10(10)		10+(20)	10^{+}(20)	10^{+}(20)	3rd
Manna	Hrw7	8^{+}(15)	8^{+}(15)	10(10)		10+(20)	15(20)	15(20)	2nd
Manna	Htrw8	12^{+}(15)	12^{+}(15)	10(10)		15(20)	10^{+}(20)	15(20)	2nd
G omma	Bruw9			10(10)	25(30)	10^{+}(20)	15(20)	10^{+}(20)	2nd
G omma	Chruw 10			10(10)	25(30)	10^{+}(20)	10(20)	10^{+}(20)	2nd
G omma	Ogruw11			10(10)	25(30)	15(20)	15(20)	15(20)	1st
G omma	Yruw12			10(10)	25(30)	15^{-}(20)	15^{-}(20)	15^{-}(20)	2nd
Manna	Druw13			10(10)	25(30)	10^{+}(20)	10(20)	10(20)	2nd
Manna	Gbruw14			10(10)	25(30)	10^{+}(20)	10(20)	10(20)	2nd
Manna	Hruw15			10(10)	25(30)	10^{+}(20)	10^{+}(20)	10(20)	2nd
Manna	Htruw 16			10(10)	25(30)	15(20)	15(20)	15(20)	2nd
G omma	Blw17	12(15)	8(15)	8 (10)		10^{+}(20)	10^{+}(20)	10^{+}(20)	2nd
G omma	Chlw18	8^{+}(15)	12(15)	8 (10)		10^{+}(20)	10^{+}(20)	10(20)	2nd
G omma	Oglw19	12^{-} (15)	8^{+}(15)	8(10)		8(10)	10^{+}(20)	15(20)	2nd
Manna	Dlw21	8^{+}(15)	8^{+}(15)	8(10)		8(20)	10(20)	15(20)	3rd
Manna	Gblw22	12^{-} (15)	8^{+}(15)	8(10)		15^{-}(20)	10^{+}(20)	15^{-}(20)	2nd
Manna	Hlw23	8^{+}(15)	8^{+}(15)	8(10)		10(20)	10(20)	10^{-}((20)	3rd
Manna	Htlw24	8^{+}(15)	12(15)	8(10)		8(20)	15(20)	15^{-}(20)	2nd
Gomma	Bluw25			6^{+}(10)	15(30)	10^{-}(20)	10(20)	5(20)	4th
Gomma	Chluw26			8(10)	25(30)	10^{-}(20)	10^{-}((20)	5(20)	4th
Gomma	Ogluw27			6^{+}(10)	15(30)	10^{-}(20)	10(20)	5(20)	4th
Gomma	Yluw28			6^{+}(10)	15^{-}(30)	10^{-}(20)	5 (20)	5(20)	3rd
Manna	Dluw29			10(10)	25^{+}(30)	10^{+}(20)	10^{+}(20)	10^{+}(20)	2nd
Manna	Gbluw30			6^{+}(10)	20^{-}(30)	10(20)	10(20)	5(20)	3rd
Manna	Hluw31			6^{+}(10)	20^{+}(30)	10^{+}(20)	10(20)	10^{-}((20)	3rd
Manna	Htluw32			6^{+}(10)	20^{+}(30)	10(20)	10^{+}(20)	10(20)	3rd

Number in parenthesis indicate weight of total score of sample parameters measured; DC=defect count SM = Shape and Make; OD = Odor; CL = Color; AC = Acidity; BO = Body and FL = Flavor.

Appendix IV. Variables included in multivariate binary logit regression analysis for farmers

Categorical Variables Codlings				
		Frequency	Parameter coding	
			(1)	(2)
Type of coffee bags used	Jute bag	238	1.000	0.000
	Plastic bag	48	0.000	1.000
	clay pot	23	0.000	0.000
Where do you dry your coffee	Cemented, bricks and Mesh wire	73	1.000	0.000
	On wooden bed and bamboo	189	0.000	1.000
	On ground	47	0.000	0.000
Training on the last year	Yes	254	1.000	
	No	55	0.000	
Age of the coffee tree	<20	218	1.000	
	>20	91	0.000	
Coffee tree pruning	Yes	85	1.000	
	No	224	0.000	
Do you apply Compost	yes	220	1.000	
	no	89	0.000	
Do you observe any disease	No	88	1.000	
	Yes	221	0.000	
Do you mix your coffee while selling	No	106	1.000	
	Yes	203	0.000	
Time Constraint during peak coffee harvesting period	No	44	1.000	
	yes	265	0.000	
In the last three years receiving support from ARDO	Yes	288	1.000	
	No	21	0.000	
Cash shortage	No	70	1.000	
	Yes	239	0.000	
Time of coffee in store	<=4	137	1.000	
	>4	172	0.000	
Storage availability	Yes	149	1.000	
	No	160	0.000	
District	Gomma	124	1.000	
	Manna	185	0.000	

Definition of terminology according to (CLU, 2007)

Acidity

This is a desirable characteristic in coffee. It is the sensation of dryness that the coffee produces under the edges of your tongue and on the back of your palate. The role that acidity plays in coffee is not unlike its role as related to the flavor of wine. It provides a sharp, bright, vibrant quality. Without sufficient acidity, the coffee will tend to taste flat. Acidity should not be confused with sour, which is an unpleasant, negative flavor characteristic (CLU, 2007).

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Body

'Body' is the feeling that the coffee has in your mouth. It is the viscosity, heaviness, thickness, or richness that is perceived on the tongue. Typically, Indonesian coffees possess greater body than South and Central American coffees. Coffees with a heavier body will maintain more of their flavor when diluted with milk (CLU, 2007).

Aroma

This is a sensation that is hard to separate from flavor. The aroma contributes to the flavors we discern on our palates. Subtle nuances, such as 'floral' or 'winy' characteristics, are derived from the aroma of brewed coffee (CLU, 2007).

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Flavor is the overall perception of the coffee in your mouth. 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 (CLU, 2007).

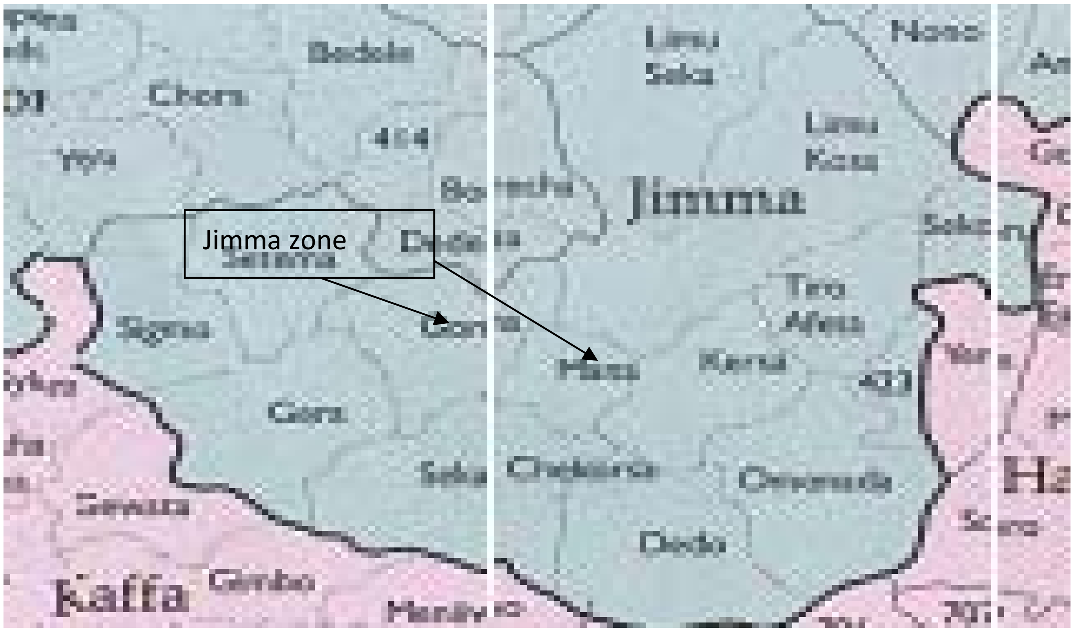
Black beans Color defects such as black beans make the beverage taste bitter, disagreeable, and render it generally undrinkable. The reason for this defect is attributed to prolonged fermentation of cherries picked from the ground, which then undergo a poor drying process with intermittent periods of wetting. The presence of black beans was rare in wet processing, except where the cherry has been harvested from the ground (CLU, 2007).

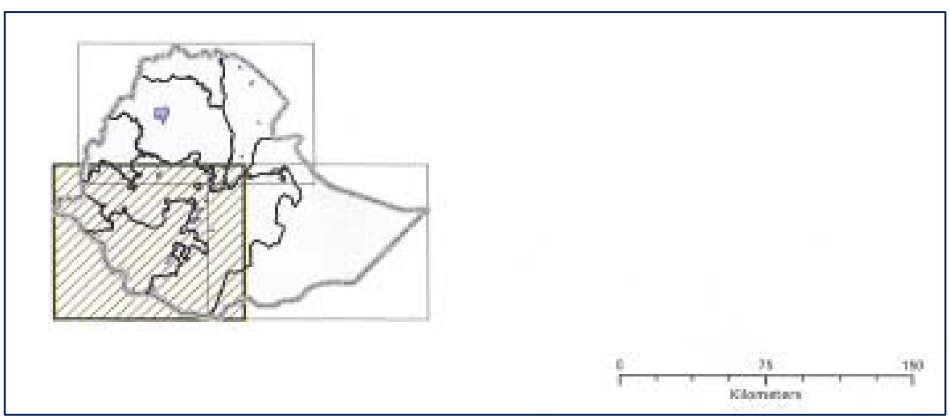
Foxy beans*:* These have red coloring which is essentially due to in appropriate drying which has been overdone. Reasons for this include high drying temperature, drying period extended over a long time, or the beans not having been sufficiently mixed. In some cases it has been attributed to the adherence of a thin film of reddish soil from the drying area during hulling, if the soil has high clay content and coffee dried on bricks floor (CLU, 2007).

Broken beans: These happened due to inadequate adjustment of the hullers, or an excessively rapid rotation of the cylinders during hulling. Breakages most frequently occur during hulling when the coffee is too dry. Broken beans adversely affect the appearance of the batch, but more importantly they roast faster than whole beans, and tend to become charred. Their presence therefore has a negative effect on the quality of the beverage (CLU, 2007).

Pitted beans: The surfaces of beans which have been infested by insects are more or less riddled with small, round holes such as those produced by the berry borer. Cutting them open reveals the pores bored by the insect (CLU, 2007).

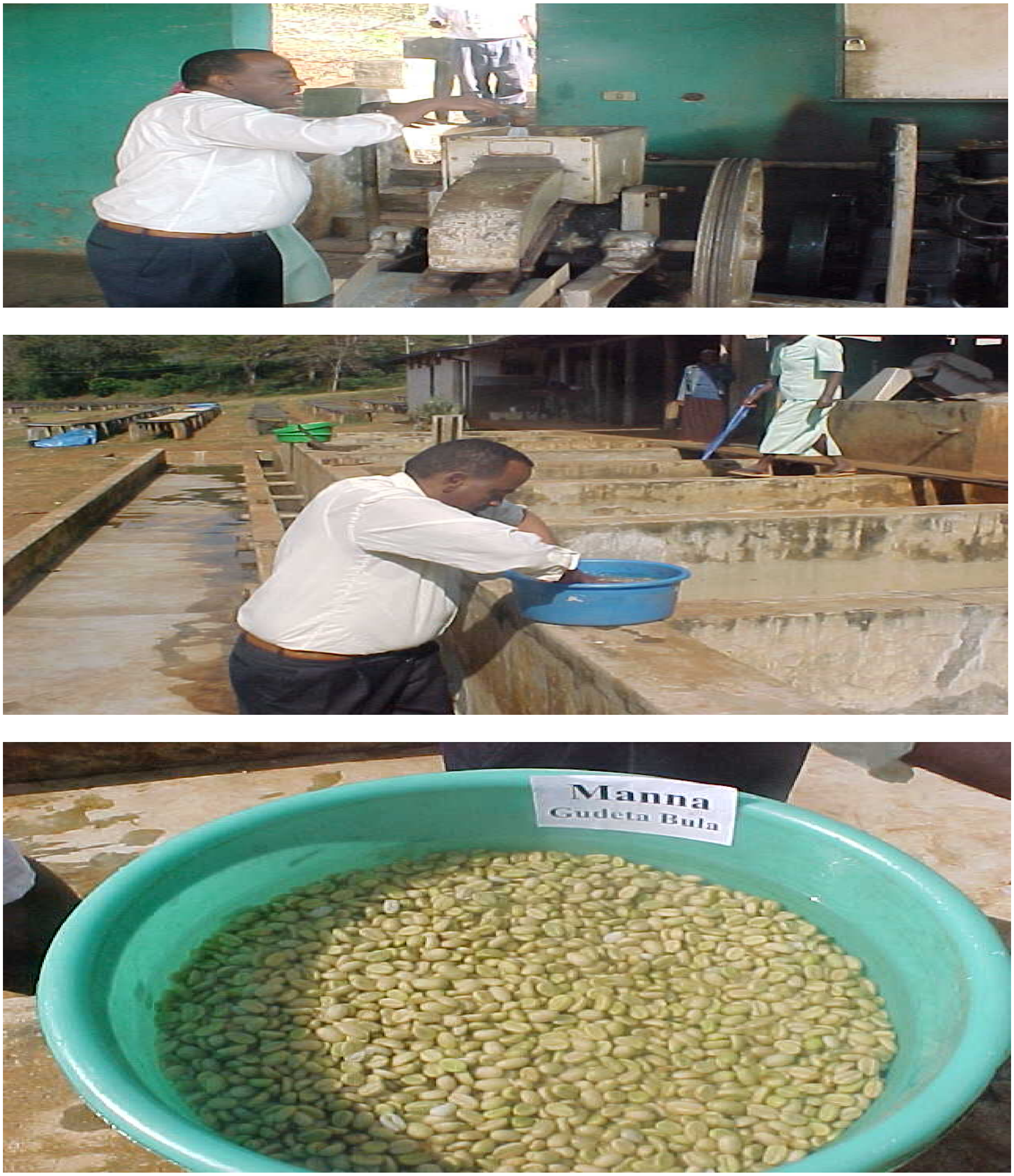
7.2. Figures





Appendix V. Map of survey areas (Gomma & Manna Woredas), Jimma Zone, Ethiopia.

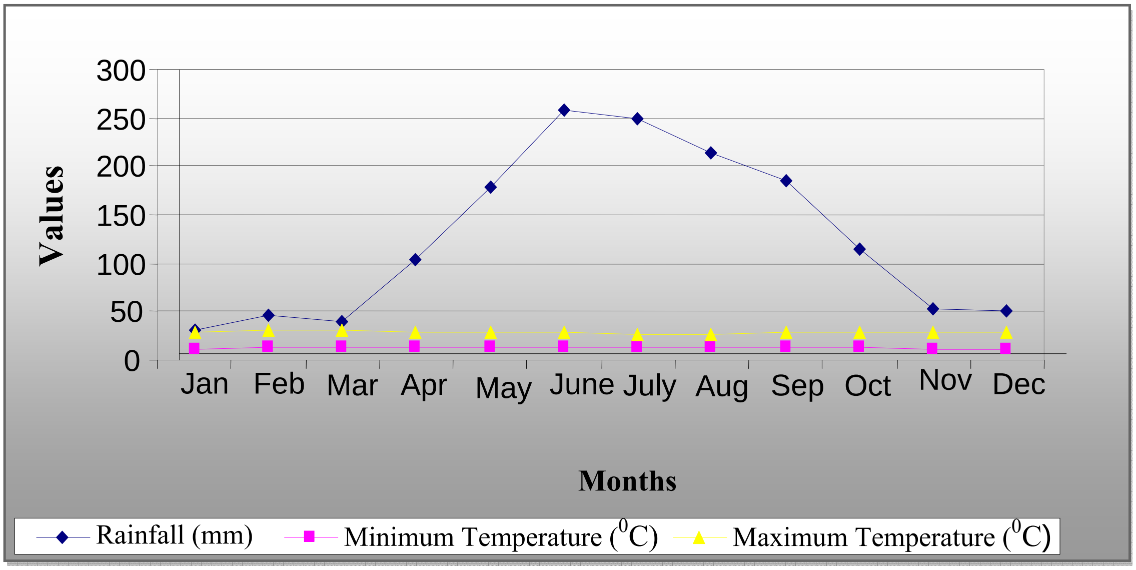
Appendix VI. Partial view of recommended method of dry coffee processing.



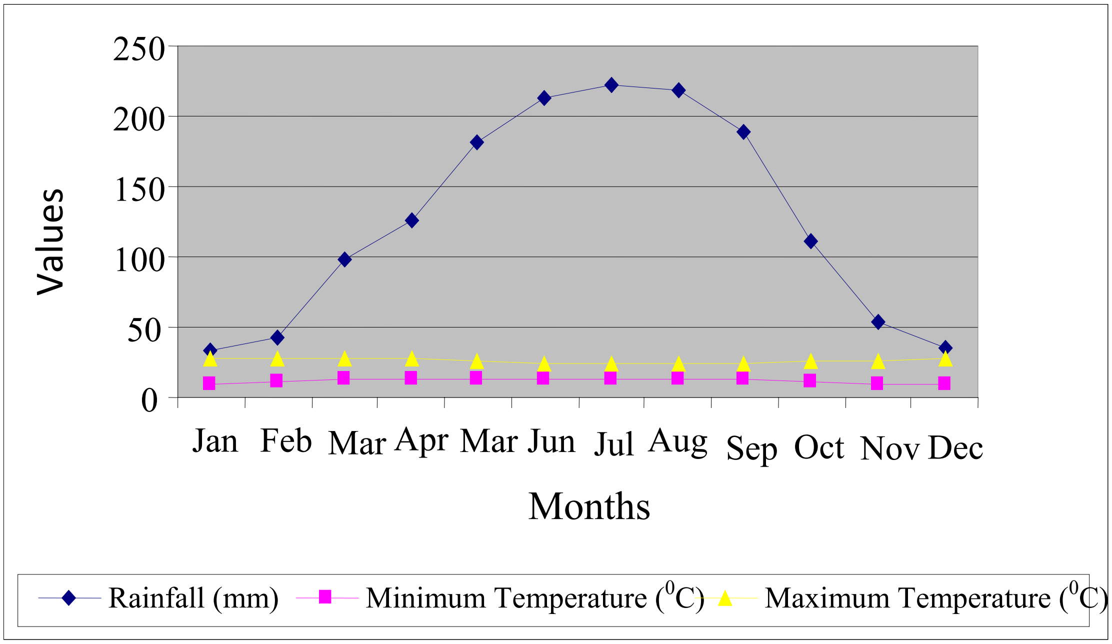
Appendix VII. Partial view of recommended method of wet coffee processing.

Appendix VIII. Dry and wet processed green coffee beans samples.

Appendix IX. Manual counting of coffee defect in the laboratory.



Appendix X. Long-term rainfall and temperature data for Gomma woreda.



Appendix XI. Long-term rainfall and temperature data for Manna woreda.

Appendix XII. Standard parameters and their respective values used for unwashed coffee raw quality evaluation and grading as per ECX (2009)

Raw value (40%)						Cup value (60%)							
Defects (30%)				Odor 10(%)		Cup cleanness (15%)		Acidity (15%)		Body (15%)		Flavour (15%)	
Primary (count) (15%)	Pts	Secondary (wt) (15%)	Pts	Quality	Pts	Quality	Pts	Intensity	Pts	Quality	Pts	Quality	Pts
<5	15	<5%	15	Clean	10	Clean	15	Pointed	15	Full	15	Good	15
6-10	12	<10%	12	F.clean	8	F.clean	12	M.pointed	12	m.full	12	F.good	12
11-15	9	<15%	9	Trace	6	1 CD	9	Medium	9	Medium	9	Average	9
16-20	6	<20%	6	Light	4	2 CD	6	Light	6	Light	6	Fair	6
21-25	3	<25%	3	Moderate	2	3 CD	3	Lacking	3	Thin	3	Commonish	3
>25	1.5	>25%	1.5	strong	0	>3 CD	0	ND	0	ND	0	ND	0

Grade range: grade1=91-100; grade2=81-90; grade3=71-80; grade4=63-70; grade5=58-62; grade6=50-57; grade7=40-49; grade8=31-39; grade9=20-30; under grade=15-19; CD= Cup defect; ND= Not detected

Appendix XIII. Raw defect type & evaluation system of SCAA and Ethiopia unwashed green coffee bean (ECX, 2009)

	Raw defects										
SCAA primary defects		Secondary defects observations									
Type	Bean grade	SCAA	0	1	2	3	Ethiopia	0	1	2	3
Full black		Partial black					Foxy				
Full sour		Partial sour					Under dried				
Fungus		Floater					Over dried				
Foreign matter		Immature					Mixed				
Insect damaged		Withered					Stinkers				
Pod/Husk		Shell					Faded				
		S. insect damaged					Coated				
		Broken					Light				
		Soiled					Starved				
Total (Transfer to grade table)		Total									

Appendix XIV. Standard parameters and their respective values used for washed coffee raw quality evaluation and grading as per ECX (2009)

Raw value (40%)										Cup value (60%)							
Defects (20%)				Shape& make (10%)		Color (5%)		Odor 5(%)		Cup cleanness (15%)		Acidity	(15%)	Body	(15%)	Flavour	(15%)
Primary (count) (10%)	Pts	Secondary (Wt) (10%)	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Intensity	Pts	Quality	Pts	Quality	Pts
0	10	<5%	10	V.good	10	Bluish	5	Clean	5	Clean	15	Pointed	15	Full	15	Good	15
1-4	8	<8%	8	Good	8	Grayish	4	F.clean	4	F.clean	12	M.pointed	12	M.full	12	F.good	12
5-6	6	<10%	6	F.good	6	Greenish	3	Trace	3	1 CD	9	Medium	9	Medium	9	Average	9
7-10	4	<12%	4	Average	4	Coated	2	Light	2	2 CD	6	Light	6	Light	6	Fair	6
11-15	2	<14%	2	Fair	2	Faded	1	Moderate	1	3 CD	3	Lacking	3	Thin	3	Commonish	3
>15	1	>14%	1	Small	1	White	0	Strong	0	>3 CD	0	ND	0	ND	0	ND	0

Grade range: grade1=91-100; grade2=81-90; grade3=71-80; grade4=63-70; grade5=58-62; grade6=50-57; grade7=40-49; grade8=31-39; grade9=20-30; under grade=15-19; CD= Cup defect; ND= Not detected

Appendix XV. Raw defect type & evaluation system of SCAA and Ethiopia washed green coffee bean (ECX, 2009)

Parchment observations										Raw defects											
										SCAA primary defects		Secondary defects observations									
Type	0	1	2	3	Type	0	1	2	3	Type	Bean grade	SCAA	0	1	2	3	Ethiopia	0	1	2	3
Even					Under washed					Full black		Partial					Foxy				
Under grade					Cracked					Full sour		Partial					Under dried				
Improper					Dull					Fungus		Floater					Over dried				
Discolored					Pods					Foreign matter		Immature					Mixed				
Nipped					Mixed fermentation					Insect damaged		Withered					Stinkers				
Fermented					Under fermentation							Shell					Faded				
Loose					Long cont. water							Slightly insect damaged					Coated				
Brownish																	Light Starved				
										total		Total									

7.3. Sample Questionnaires

Part I. Farmers particulars

Demographic information

1.1. Name of farmer __________

1.2. Sex of Household head 1. Female headed household 2. Male headed household

1.3. Age of Household head 1. >48, 2. >33, 3. >18

1.4. Family size 1. >4 family member or 2. <4 family member

1.5. Educational status of Household head 1. literate 2. Illiterate

1.6. Woreda _____________Kebele/PA ____________

Farm practices

1.7. Age of the coffee trees. 1. Less than twenty years 2. Greater than twenty years

1.8. Is there coffee tree pruning? 1. Yes, 2. No

1.9. What type of coffee weeds is prevalent in your coffee field? 1. Soft Weeds 2. Coach Grass 3. Both 4. Others specify

1.10. What kind of mechanism do you use to control weeds? 1. Slashing 2. Hand weeding 3. Chemicals 4. Cover crops 5. IPMS

1.11. Do you apply compost to your coffee farm? 1. Yes 2. No

1.12. Do you observe any disease on your coffee plant? 1. No 2.Yes

1.13. Do you mix differently harvested coffee while selling? 1. No 2.Yes

Post-harvest practice

1.14. At which fruit maturity stage do you harvest your coffee for sale? 1. Full maturity stage 2. Green stage. 3. Immature stage.

1.15. Do you have time constraint during peak coffee harvesting period? 1. No. 2. Yes

1.16. What type of coffee harvesting practices do you use during coffee harvesting? 1. Selective picking 2. Strip method 3. From the ground.4. others______

1.17. Who often harvest your coffee? 1. Own family 2. Daily laborer 3. both

1.18. Where do you dry your coffee? 1. On cemented, bricks and mesh wire 2. On wooden and bamboo made drying bed 3. On ground.

1.19. What type of bag do you use for coffee packaging? 1. Jute bug 2. Plastic bag 3. clay pot.

1.20. Do you have storage house for your coffee to store? 1. Yes 2. No

1.21. How long do you keep your coffee in store before taking to market? 1. < 4 months. 2. > 4 months

1.22. Is there cash shortage until the farmer gets the crop (until coffee get ripen, harvested, and sold to alleviate cash shortage in the household? 1. No 2. Yes

1.23. Do you sell your coffee to others at flower stage? 1. No 2.Yes

1.24. In the last 3 years, did your household receive support from ARDO or an agricultural Extension agent? 1. Yes 2. No.

1.25 Did you get training in the last years? 1. Yes 2. No.

Part II Traders particulars

1. Demographic information

1.1. Sex of Trader 1. Female 2. Male

1.2. Age of Trader: 1. >48, 2.>33, 3. >18

1.3. Family size 1. >4 family member, 2. <4 family member

1.4. Woreda _______________ Town____________ Keble/PA______________

Technical Service

1.5. For the last 12 months, did you take any training about coffee quality? 1. Yes 2. No.

1.6. Do you have market advisor? 1. Yes 2. No

1.7. Do you have moisture tester to estimate the level of dryness (moisture content) before storage? 1. Yes 2. No

Basic market service

1.8. Do you have separate coffee store?1. Yes 2. No

1.9. What type of coffee store floor do you use? 1. Concrete 2. Wooden bed 3. Paved ground.

1.10. How long do you keep your coffee in store before taking to market? 1. < 4 months. 2. > 4 months

1.11. How do you decide coffee price? 1. Based on Radio announcement 2. Own judgment 3. Following leading buyer's Price 4. By discussing with other Akrabi 5. Based on exporters in formation

1.12. While you buy coffee how could you check its quality? 1. through observation and judgment 2. No means of checking 3. Others_______

1.13. Do you get extension service regularly and timely? 1 Yes 2. No