ASSESSMENT OF QUALITY PROFILE AND EFFECT OF DRYING MATERIALS ON ARABICA COFFEE (*Coffea arabica* L.) LANDRACES COLLECTED IN FIVE SELECTED WOREDAS OF NORTHERN ETHIOPIA

M.Sc. Thesis

By

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June, 2013

Jimma, University

Assessment of Quality Profile and Effect of Drying Materials on Arabica Coffee (*Coffea arabica* L.) Landrace Collected in Five Selected Woredas of Northern Ethiopia

M.Sc. Thesis

Submitted to School of Graduate Studies Jimma University College of Agriculture and Veterinary Medicine (JUCAVM)

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Post-Harvest Management (Perishable)

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June, 2013

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DEDICATION

I dedicate this thesis to all my friends, who sacrifices, wishes and praiseworthy to success in all my endeavours

STATEMENT OF AUTHOR

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Place: Jimma, Ethiopia
Date of Submission: ______________

BIOGRAPHICAL SKETCH

The author, Hagos Hadis Asgodom, was born on May 24, 1984 at Mekhoni town Raya-Azebo woreda, Sothern Zone of Tigray State. He attended his education at Degol Elementary School and High schools at Tilahun Yigzaw from 1999-2002 respectively. Following the completion of his High School education, he joined Jimma University in 2002 and graduated with BSc Degree in Horticulture in July, 2006 from Jimma University College of Agriculture and Veterinary Medicine. After graduation, he was employed on November, 2006 by the Bureau of Agriculture and Rural Development in Adwa as expert of Irrigation Agronomy(Fruits and Vegetables). Since May, 2008 he was again transferred to Raya-Azebo woreda as senior expert of irrigation Agronomy, until he joined the graduate studies program of Jimma University College of Agriculture and Veterinary Medicine to pursue a graduate study leading to a Master of Science degree in Post-Harvest Management Specializing in Perishable.

ACKNOWLEDGEMENTS

All praises and thanks are to Almighty GOD, who is the entire source of all knowledge and kinds of wisdom endowed to mankind. Conducting of this thesis research from project proposal, field work, and to the final write up of the thesis could have not been fruitful if it were not for a generous assistance of individuals and institutions. In the first place, I am profoundly indebted to my major advisor Dr. Ali Mohammed and co-adviser Dr. Eyasu Abraha for their encouragement, willingness to supervise my research and their valuable comments from early stage of proposing the research to the final thesis research results write up, which helped me in the completion of the study. So I would like to extend my deepest gratitude to them for their continuous technical support and commitment throughout my research. Without the encouragement, insight and professional expertise of my advisors, the completion of this work would not have been possible.

I would like to thank Jimma University College of Agriculture and Veterinary Medicine for providing me with the fund required for the study. I am grateful to Florensis Ethiopia Commodity Exchange (ECX) for sponsoring me organoleptic analysingof coffee samples with sincere appreciation to Mr.Mekonen, Mr.Mobarek Abaoli and Getnet. In addition, my thanks also go to all staff of the company for providing their unreserved assistance and also the Agriculture and Rural Development of Raya-Azebo, Werababoo, Habru, Kolatemben and Tselemti during my research. I am extremely lucky to have favorites and friends Siba Kiros, Michale Hadera, Mola Haftu, Fiseha Mengesteab, Yirgaiallem Tsehaye, Girma Libelo, Hadis Michalay, Birhanu Kiros, Solomon Baye, Haftu Tsegay and Hadera Hagos who have special my heart place for their dedication in bringing me up and for their strong support throughout my life and my academic career.

Finally, I would like to express my deepest gratefulness for the constant support, for her understanding in the difficult times we had, and graduate to Miheret Ale. This acknowledgement would be incomplete without my brother Tadese Kiros, Semere Kiroos and my wife Atsede Getachew who have been the source of my strength and encouragement.

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
W	Werababoo woreda
H	Habru woreda
R	Raya-Azebo woreda
K	Kolatemben woreda
T	Tselemti woreda
PD	Primary defect
SD	Secondary defect
OD	Odor
TRQ	Total Raw Quality
CC	Cup cleanness
ACD	Acidity
BOD	Body
FLA	Flavor
TCQ	Total Cup Quality
TQ	Total Quality
GR	Grade
FAO	World Food and Agricultural Organization
LSD	Least Significant Difference
M.a.s.l	Meter above sea level
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
OTA	Ochratoxin A
ITC	International Trade Center
IMF	International Monetary Fund

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ABSTRACT

Arabica coffee (Coffea arabica L*.) is an economically important crop, which is contributing the highest of all export revenues in Ethiopia. Despite the favorable climatic conditions, variety of coffee types and long history of its production in Ethiopia, quality of coffee is poor due to lack of adequate information on the effect of pre- and post-harvest practices and handling techniques on coffee quality. Therefore, this study was conducted with the objectives of assessing Quality profile and Effect of drying materials of dry processing of Arabica coffee and to assess the impact of drying materials on the quality of dry processed Arabica coffee and to determine the quality profile of landrace coffee from five selected areas of Northern Ethiopia. For field survey, 300 small-scale farmers were purposefully selected following sample size determination procedures of probability proportional size technique and 50 coffee traders were also purposefully selected from the five selected woredas' and interviewed from November to December 2012. The data collected from the field survey were analyzed by employing the statistical procedures of SPSS version 16.0. On the other hand a total of 75coffee samples(15from five selected coffee growing woredas of werababoo, Habru, Raya-Azebo, Kolatemben and Tselemti in Northern Ethiopia) were prepared for the laboratory analysis (organoleptic and bean physical quality characteristics) at Ethiopia Commodity Exchange(ECX) of Addis Ababa. The laboratory experiment was arranged in factorial combination with five different drying materials (mesh wire, wooden raised bed , bamboo raised bed, cement floor and soil floor) in RCBD design in three replications and organoleptic quality attributes were assessed by trained coffee panels. The laboratory data analysis was computed by using general linear model (GLM) procedures of SAS version 9.2. As a result from the survey analysis, the demographic information in those areas was productive age ranged from 30-50 years old, 70% Male headed and about 62% of the total respondent was illiterate. And about 28.7% had owned a coffee farm less than 0.25ha while 30% and 18.7% had owned a coffee farm of the area between 0.25-0.5 ha. Whereas in Pre-harvest practices 65.3% of the coffee planted was aged without replacing old plant and no use of compost or manure application on the farm, no intercropping, poor harvesting system, poor mechanism of quality coffee identification, no means of moisture content determination and marketing currently replacing by chat, were some of the most problems for the study areas. And the result of the current experiment showed that the raised bed of mesh wire, Bamboo and wood materials were good drying materials for coffee and relatively the maximum grade was recorded grade 2 from Raya-Azebo, Habru and Werababoo woredas' bulked coffee (Landraces) respectively, however the least grade was recorded grade 4. And mesh wirehad got high net income, while Raised bed of Bamboo and Wood with sack mat was medium net income than cement and soil floor. The correlation analysis also indicated that almost all were strong positive correlated and highly significant ($p<0.01$) relationship of the quality attributes, but negative correlated with grade. Therefore Extension intervention could be the best approach to create awareness, Morphological and molecular characterization of the landraces garden coffee growing in those areas is important and an urgent issue, feasibility of semi-washed coffee processing could be tested to further improve the coffee quality and Research geared towards developing or adapting improved coffee varieties from similar agro-ecologies in Ethiopia or other coffee producing countries could be a means to promote better production of coffee in the studied target areas would be make towards maintaining typical coffee quality profile and competence in the international coffee market.*

Key words: - Dry processing, Quality analysis, Cost-benefit analysis

1. INTRODUCTION

Coffee is a global commodity and major foreign earner in many developing countries and it is a non-alcoholic stimulant beverage crop that belongs to the family *Rubiaceae* and genus *Coffea.* Coffee *(Coffea arabica* L.) 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 (Bertrand, 2006). And there are different types of coffee in the world, among different types of coffee; the major economic species are *coffea arabica* L. and *coffea canephora*. Arabica accounts for 80 % of the world coffee trade, and Robusta most of the remaining 20% (Tadesse and Feyera, 2008).Among 100 *Coffea* species in the genus *Coffea*; *C. arabica* is the only species naturally occurring in Ethiopia (Anthony *et al*., 2001; Yigzaw, 2005).And the most important ones are *Coffea arabica* variety typical and *Coffee arabica* variety bourbon (Tadese *et al*., 2008).

Coffee is produced in many places in Ethiopia that ranges in altitude for 550 to 2750 meters above sea level, 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 major *coffea arabica* growing areas are in eastern, southern and wtestern part of Ethiopia, with altitudes ranging from 1300 to 1800 meters above sea level (Akililu and Ludi, 2010). Gale (2009) estimated that from the total Ethiopian coffee production about 10% is obtained from forest coffee systems, 35% from semi-forest coffee systems, 35% from garden coffee systems and 20% from plantations.

The total area covered of coffee is estimated to be around 800,000 hectares, which accounts for 3.14% of the country’s total area under crop cultivation, of which about 95% is cultivated by 1.2 million small scale farmers (MoARD, 2008)., Ethiopia exports 170,000 tons and the domestic consumption is estimated to be about 50% of the total production (Esayas, 2009; Akleilu and Ludi, 2010). The annual coffee production is normally in the range of 300,000-330,000 tones, which is about 600kg/ha. Out of this, 63% is in Oromia, 35.9% in SNNPR and 0.8% in Gambela Smallholder produces are responsible for about 95% of production, while state-owned plantations account for 4.4% and private investor plantations 0.6% while Gojjam, Gonder and Wollo are among the minor coffee growing areas of the country were most of the producer are used only for local consumption (FDRE, 2003). But annual production of Ethiopia increased trend from 3,693,000 bags in 2002 to 5,733,000 bags in 2007 (ICO 2008).

The quality of Ethiopian coffee is determined by two main factors namely geographic origin and the post-harvest processing techniques (Petit, 2007). Methods of coffee processing in Ethiopia are sun-drying of unpulped cherries and wet processing, of which sun drying method is used by farmers. Ethiopia export process about 65-70% natural or sundried coffee and 30-35%wet processed coffee (Russel, 2008; Selamta 2010). Quality is the most important parameter in the world coffee trader. Coffee quality is determined by 40% in the field, 40% at harvest primary processing and 20% at secondary processing and handling including storage. This underscores the importance of primary processing and post-harvest processing in enhancing the quality and value of coffee (Musebe *et al*., 2007).

In Ethiopian coffee production is by small scale farmers, it is difficult to manage quality and significant quality losses occur at various stages. Further quality losses also occur due to poor post-harvest on-farm processing, including poor storage infrastructure and contamination with other products. The bulk of Ethiopian coffee exports are low grade, 3^{rd} or 4^{th} quality grade classification (Dessie, 2008). Anwar (2010) also reported that the pre-harvest and harvest activities of coffee in progress but the post-harvest operation mainly the primary processing activities of natural drying methods are still not practiced in appropriate manner to maintain the intrinsic quality of coffee. Farmers dry their coffee at about 48% of producers spread their coffee on the ground, about 49.5% dry on raised drying beds using either bamboo mats or wire meshes and only 2.5% dry on cemented or bricks floors (Anwar, 2010)

Despite the confirmed information about specific coffee quality problems in Northern Ethiopia there is inadequate information on the effects of post harvest processing and drying.
As coffee is produced in small quantities by many small-scale farmers, it is difficult to manage quality and significant quality losses occur at various stages. Further quality losses also occur due to poor post-harvest on-farm processing, including poor storage infrastructure

and contamination with other products, mixed coffee drying, drying on ground with undesirable layer thickness of coffee upon drying and heaping of coffee before drying favored development of fungus and bacteria low grade coffee improper packing, grading, packing, transporting, are believed to cause quality deterioration in the study areas (Dessie, 2008). This indicates that the produced coffee in the study areas could be less competent in the market because coffee dried on Soil and Cement floor this makes direct contact with foreign matter and was more exposed to re-wetting of cherries, causing quality deterioration of beans. Besides, producers also sale their coffee to local collectors or cooperatives which are not handle the coffee properly and there is no improved technology used all these leads to decrease in quantity and quality, so the major questions the studies were to answering the following questions:

1. In what way do farmers produce, harvest, process, store, prepare and ship their coffee to the market nearby their administrative town?
2. What is the quality of coffee harvested in the study areas?
3. What is the quality profile of coffee from different location in Northern Ethiopia if dried using different structures of drying materials?

Therefore, this study was, designed and conducted with the following objectives:

General objective

- To assess the quality profile and effect of drying materials on dry processing method of Arabica coffee in Northern part of Ethiopia.

Specific objectives

- To assess the impact of drying materials on the quality of dry processed Arabica coffee
- To evaluate the cost benefit analysis of the different drying materials of coffee drying materials
- To determine the quality profile of landrace coffee from selected areas Northern Ethiopia.

2. LITERATURE REVIEW

2.1. Botanical Descriptions

Coffea arabica L. performed over all species because of its superior quality and continued to be the exclusive contributor of all coffee in the world (Yigzaw, 2005) and, it has numerous botanical varieties. Among the many varieties, the most important ones are Coffee Arabica Varity typical and Coffee Arabica variety bourbon (Tadese *et al*., 2008).

Arabica coffee is an evergreen shrub of variable size. The tree grows up to 1.618 m long and 1.0-1.5 cm 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. The coffee plant takes approximately three 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). Its fruit is sub-globular, ovoid, oblong or squat-shaped.

2.2. Economic Importance and Uses of Coffee in Ethiopia

Coffee is the most important crop in the National Economy of Ethiopia and continues to be the leading export commodity. Ethiopia is a well-known not only for being the home of Arabic coffee, but also for its fine quality coffee acclaimed for it is aroma and flavor characteristics. In recent years, different coffee producing countrieshave tremendously expanded their production and export volume (Behailu *et al*., 2008).

Coffee has only one value to give the consumer pleasure and satisfaction through flavor, aroma and desirable physiological effects (Yigzaw, 2005). Therefore coffee quality especially liquor or cup quality, determine 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 act as

Yardstick for price determination (Agwanda *et al .,* 2003).The most suitable of exportable coffee producing regions are Kaffa, Illubabor, Wellega, Sidamo, and Hararghe. The total production in Ethiopia is estimated to about 170,000 tones. However, more than 50% of this consumed locally. As a result Ethiopia is the first (largest) consumer of coffee in Africa and the 4th in the world (Esayas, 2009; Akleilu and Ludi, 2010).

Table 1: Ethiopian Coffee Production, Consumption and Export 2005/06 to 2011/12

Coffee Season	2005/06	2006/7	2007/08	2008/09	2009/10	2010/11	2011/12
Washed coffee	59,655	70,712	61,469	45,948	66,259	71,207	234,600
Natural sun dried	143,002	166,000	168,779	98,240	142,574	144,573	156,400
Total Exports	202,657	168,779	230,248	144,188	208,833	215,780	391,000
Consumption	105,906	73,433	125,331	138,812	280,733	233,403	17,765
Total Production	308,563	310,145	355,579	283,000	489,632	440,183	408,765

Source: ICO (2012)

2.3. Coffee Quality

Quality as it is defined by ISO (2000) and Dessie *et al.*, (2008), in its more practical definition, can be the ability of a product to satisfy consumer's expectation and quality is the most important parameter in the world coffee trade. The quality of coffee can be predetermined by the genotype, the climatic conditions and the soil characteristics of the area in which it is grown. In principle, there is no inherently bad coffee by nature.

If a coffee presents poor quality, the cause usually is traced to 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 (Dessie, 2008).

There are different views of expressing quality. ITC (2002) defines that the quality of a parcel of coffee comes from combination of the botanical variety, topographical conditions, weather conditions, and the care taken during growing, harvesting, storage, export preparation and transport. According to the current context of over production and low price of the coffee market, improvement and valorization of coffee quality could provide the coffee chain with a new impetus (Leroy *et al.,* 2006).

Coffee without physical and sensorial defects and with a good physical appearance is normally required (Solomon and Behailu, 2006). Coffee quality is affected by many factors. The most important factors that dectate coffee quality are harvest and post-harvest handling, environmental and genotype. These major factors control coffee quality together. It is estimated that the quality of coffee is determined by the conditions (40%) in the field, (40%) post-harvest primary processing, and (20%) secondary/ export processing in enhancing the quality and value of coffee (Musebe *et al*., 2007).

At the farmer level, coffee quality is a combination production level, price and easiness of culture at the exporter or importer level, coffee quality is liked to been size, lack of defects and regularity of provision, tonnage available, physical characteristics and price; at the roaster level, coffee quality depends on moisture contents, 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, standard 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).

2.3.1. Environmental and Genetic factors Affecting Coffee Quality

Factors affecting quality are edapho-climatic conditions, coffee berry at harvest bean processing genetic properties (Harding *et al*., 1987). Elevation is very important factor to produce high quality coffee (FAO, 2010). Yigzaw (2005) stated that provided other factors are kept constant, better quality coffee can be produced at higher altitudes, while low land coffees are somewhat bland, with considerable body. Beverage quality is therefore partly determined by environmental factors (Avelino *et al*., 2005).

The ultimate size of coffee bean is determined by the amount of rainfall during the rapid expansion period (Tesfaye *et al*., 2008). Although partly genetic, the size can be modified by ecological conditions and crop husbandry. Ecological conditions considerably affect the growth of coffee tree. The production of good quality coffee beans in specific areas characterized by their climatic conditions clearly shows that climate is an important factor in determined the quality of the coffee beverage (Emerson *et al*., 2005).

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). 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).

Climate, altitude, and shade play an important role through temperature, availability of light and water during the ripening period (Carr, 2001; Decazy *et al*., 2003). Rainfall and sunshine distributions have a strong influence on flowering, bean expansion, and ripening. The role of soil types has been well studied. It is generally admitted that the most acidic coffees are grown on rich volcanic soils (Harding *et al*., 1987). Shade decreases coffee tree productivity by about 20%, but reduces the alternate bearing pattern (Avelino *et al*., 2007). Shade positively affects bean size and composition as well as beverage quality by delaying berry flesh ripening by up to one month. Higher sucrose, chlorogenic acid and trigonelline concentrations in sun-grown beans than in shade-grow beans suggest incomplete bean maturation and account for increased bitterness and astringency of the coffee beverage (Muschler, 2001 and Vaast *et al*., 2006) reported the effects of elevation on cup quality. The production system is one of the factors that govern the shape and make quality of the beans (rounded, oval, elongated, bourbon, flat, etc) (Endale, 2008).

Literature show that volcanic soils often produce a potent acidity and a good body, and such soils can lead to a more balanced cup (Bertrand *et al*., 2006; Decazy *et al*., 2003). In the natural habitat of coffee, soils are acidic to slightly acidic with limited phosphorus availability (Feyera, 2006). Coffee grown with heavy application of nitrogen fertilizer had poorer, lighter and thinner quality than that from unfertilized fields.

2.3.1.1. Agronomic Practices

The application of elephant grass or livestock manure resulted in an increased percentage of undesirable brown-colored bean and, thus, poor roasting characteristics 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. 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 suboptimal (low altitude) coffee production zones, by promoting slower and balanced filling and uniform ripening of berries. Furthermore, Yemaneberhan (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.

2.3.1.2. Effects of tree physiology on quality

Coffee 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 with in tree and fruit to leaf lattice and a strong influence on the chemical content of green bean (Vast *et al*., 2006). Maturation also has a strong influence on coffee quality (Leory *et al*., 2006).

According to subedi (2010), bean size plays an important role for roasting whole coffee beans because many consumers associate bean size with quality, however, large bean do not necessary mean better than smaller one. The size and shape of the beans differ depending up on the variety, environmental conditions and managemental practices. On average, beans are 10mm long, 6-7mm wide, 3-4mm thick on weigh between 0.15 and 0.20g. Furthermore, Arabica varieties were diverse in respect of average hundred bean weight with values ranging between 18.2g and 9.2g (Wintegens, 2004), but Agwanda *et al*.(2003) reported that unlike the popular belief, bean size was not a good indicator of crop quality.

2.3.1.3. Genetic Variation for quality

The genus *coffea* includes more than 100 hundred species among which a large variation in terms of chemical compositions observed. Coffee produced from *coffea Arabica* L. is known to have a good quality and the presence of large inherent difference among genotypes for bean and cup quality attributes (Walyaro, 1983). Yigzaw (2005) reported that inherent variability that exists in the representative varieties, suggests suitability of acidity and body as there was a reported variation in the body among genotypes of genetic variability among Ethiopia coffee selection for green bean physical characterstics, cup quality, green bean caffeine, chlorogenic acids, and sucrose and trigonelline. Similarly, Van der vossen (1985) observed significant differences among different Arabica coffee cultivars for quality attributes.

Flavor is the coffee's principal character, the mid-range notes, in between the first impression given by the coffee's first aroma and acidity to its final after taste (Agwanda, 1999). It can be indicated by inhaling the vapor arising from the cup or nasal perception of the volatile substances evolving in the mouth (Petracco, 2000). In this regard, Agwanda (1999) compared four traits (acidity, body, flavour and overall standard) for their suitability as selection criteria for the genetic improvement of overall liquor quality. Based on correlation, repeatability and sensitivity analysis, flavour 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 (Agwanda, 1999). On the other hand, Walyaro (1983) and Van der Vossen (1985) observed fairly high heritability for the overall standard of cup quality and indicated the possibility of good selection progress. Carvalho (1988) reported the dominant nature of good cup quality in Arabica coffee. These are the most important criterion of evaluation of green coffee, as their presences alter the final cup quality by generating off flavor.

Generally, both physical and organoleptic attributes are an important attribute of coffee and used for quality evaluation (Kathurima *et al*., 2009). However, Agwanda *et al.* (2003) and Roche (1995) stated that bean physical quality traits were not useful for enhancement of genetic gains on cup quality and vice-versa.

2.3.2. Effects of Harvesting and Post-harvest Operation on Coffee Quality

Harvesting is one of the important stages that have considerable impact on quality cherries of good quality can produce good cup quality provided ripe fruits are harvested properly processed and dried. 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 *Coffea arabica* in Costa Rica, early picking of red cherries gives the best coffee (Bertrand *et al.,* 2006). For instance, if coffee is harvested at immature stage, the end product will show the test of coffee classified as undesirable (Anwar, 2010). In addition, if coffee is harvested after the cherries are over ripe, the bean becomes foxy and the end product will affect the cup cleanness (Bhailu *et al*., 2008). The type of odor at a given sample processed depends on the way coffee is harvested (Endale, 2008).

Sun drying can be an economical and effective method, producing high quality coffee under good ambient conditions (ICO, 2010). In this process, the product is spread on surfaces such as cement or brick terraces, bamboo and sisal mats, raised tables covered with wire mesh**.** The structure and location of these facilities has a great influence on their performance, when drying coffee on surfaces given the potential problems associated with drying and its negative image (FAO, 2010).While drying on bricks floor in contact with soil becomes dirty and blotchy resulting into dull aroma and earthy flavour in coffee beverage (Subedi, 2010). Similarly, drying coffee on terraces, the development of micro organisms on the surface of cherries and increase in respiration rate and temperature are factors that accelerate the fermentation process to facilitate deterioration (Silvano, 2004). Drying tables covered with mesh or mats are used where frequent showers can be expected during the harvesting period because tables present two surfaces for moisture loss. The open lower surface prevents condensation and allows drying to continue slowly (FAO, 2010).

The drying operation is the most important stage of the process, since it affects the final quality of the green coffee (Hicks, 2002). The dryness of coffee is important not only to prevent fungal growth, but also to maximize value, since green coffee is sold on a weight basis (Selmar *et al*., 2006). Degree of dryness is tested with two methods: dental and digital. The digital method relied on a digital grain moisture meter. This meter has a range of 10 to 24% moisture content, reads to 0.1% moisture, with an accuracy of +/- 1% (Reh *et al*., 2006).

In Ethiopia, farmers dry their coffee using different approaches. About 48% spread their coffee on the ground, 49.5% dry on raised drying beds and 2.5% dry on cemented /bricks floors (Musebe *et al*., 2007). The use of drying beds, as opposed to traditional ground drying, allows air to circulate around the beans for even drying and a richer, more flavorful product (Selmar *et al.,* 2006). In processing sun-dried coffee; the cherry is dried from a moisture content of about 65% to 12%. The cherries are dried on beds constructed from chicken wire and fixed on wooden frames raised about 80 cm above the ground. A metal mesh base allowed airflow to help speed the drying process. The result is cleaner cupping specialty naturals with beans that have a more consistent appearance. In the cup, natural coffees exhibit heavier body and flavor profiles; it was possible to enter into the specialty market (News Release, 2008**).**

Drying tables covered in mesh or mat is used where frequent showers can be expected during the harvesting period because this system simplifies protection of the crop from re-wetting (ICO, 2010). Lower *et al.* (2007) also reported that coffee beans may require more days to dry depending on the methods of drying and the density at which the beans are dried. According to Anwar (2010) dry processing method is affected by processing approaches. Coffee drying on raised beds covered with mesh wire and bamboo mats has better quality. Dry processed coffee on mesh wire took much longer time and coffee drying on bamboo and cement floor dried earlier (Beza, 2011). The sun dried coffee variety dried on raised beds with mesh wire following appropriate management had a good physical and over all cup quality with a value of 84.25 points, as far as their total physical and cup quality are concerned (Mekonnen, 2009).

2.4. Coffee Quality Characteristics

Quality coffee means better market access which in turn implies competitive prices and better income (EAFCA, 2008). Leory *et al*. (2006) mentioned the important quality characteristics in order to the problems and constraints one faces to improve coffee quality three of them, i.e. Moisture content, physical and organeloptic quality are used all along the production chain.

2.4.1. Physical and Organoleptic Quality

The quality of coffee drink is directly related to various physical and chemical constituents that are responsible for the appearance of roasted bean and characteristics taste and aroma of the drink (Ross and Nogueira, 2001). In general dry processed coffee produced a beverage with a strong aroma, moderate acidity, strong body and natural wetness (Prodollient, 2004). Grade systems in coffee reveal a high diversity of classification system is applied and the use of the ‘’ export cuppers’’ is the norm. There is no a unique and universal system system is applied world-wide for the quality control of green coffee. Producers are mostly geared to facilitate the trading of the commodity and sensory quality and in most cases described by ’’cuppers’’ or ‘’Liquorers’’ using professional opinion and tasting experience accumulated over the years (Alejandro, 2002).

2.4.1.1. Moisture content

Beginning at the time of harvest, moisture is a key determinant of the maturity of the berry for harvest. This maturity has a continuing influence on the quality of the coffee at each of the next step. According to GTZ (2002), during drying cherries, the moisture trapped inside the bean slowly migrates to the outside and is absorbed by the warm air. Thus, moisture evaporates from the inside of the bean to travel to the surface. It is a principal economic factor due to weight loss of the green bean during storage and roasting. Which brings the moisture of the beans from above 50% drown to 10-12% for well dried beans. This is the most often accomplished with solar energy (Selmar *et al*., 2008).

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 due to fading or tainting, or the introduction of unpleasant flavours, by infestation of storage insects or by infection with molds or bacteria (Behailus *et al*., 2008). Green coffee behaves very differently at high or low moisture content although, there is no exact standard defining the ideal moisture content, it is generally recognized that it should range between 8.0-12.5% (Prodollit *et al.* 2004). According to Leory *et al*., (2006) moisture is an important attribute and indicator of quality. The moisture content influences the way coffee roasts and the loss of weight during roasting.

2.4.1.2. Bean physical quality

The physical properties of coffee like shape, size, color, uniformity or irregularity and defect count, size is analysis based on human sense of sight (eye) and with the help of other techniques to identify and classify coffee. In addition, this size and shape difference of coffee beans were influenced by botanical variety and environmental growth circumstances (EAFCA, 2008). The internationally acceptable screen unit is 1/64 of an inch. For example, beans of screen size 18 refer to those that retained by a sieve with aperture (holes) of diameter 18/64 of an inch (ISO, 2000; EAFCA, 2008).

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 and the ICO (2002) Coffee Organization 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).

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).

2.4.1.3. Organoleptic Quality Attributes

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 of a given liquor quality is an important attribute of coffee and acts as yardstick for price determination (Agwanda *et al*., 2003). When assessing organoleptic quality, one has to take into account that consumers have a specific taste according to their nationality, which leads to an unreliable definition of organoleptic quality (Wintgens, 2004; Leroy *et al*., 2006).

The smell of the ground-roasted coffee before water added sometimes called fragrance. Then, one can smell the aroma, evaluate the body and perceive taste and flavors. Organoleptic quality measurement relies on overall or sensory evaluation (Leroy *et al.,* 2006). 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). Thus, coffee cupping is a technique used by cuppers to evaluate the flavor profile of a coffee, to understand minor differences between growing regions, to evaluate coffee for consistence and defects to subsequently make buying decision and to crate coffee blend (EAFCA, 2008).

Acidity is a primary coffee taste sensation created as the acids in the coffee combines with the sugar to increase the overall sweetness of the coffee (EAFCA, 2008). 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 will be more acidic, with better aroma and flavor. This is a characteristic of high grown coffees such as Ethiopian Yirgachafe, Sidamo, and Limu as well as coffees from Guatemala, Costa Rica, and Kenya (EAFCA, 2008).

Body is synonymous with mouth feel and viscosity and/or linked with density viscosity of the brew (Petit, 2007). However, there is no simple relationship between beverage viscosity measured instrumentally and body judged subjectively and flavor is the coffee's principal character, the mid-range notes, in between the first impression given by the coffee's first aroma and acidity to its final after taste. It can be indicated by inhaling the vapor arising from the cup or nasal perception of the volatile substances evolving in the mouth (Petit, 2007).

2.4.1.4. Diseases and Insect pests

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).

2.5. Coffee Grading

The market at arrival quality grading system provides standards to compare tin the premium in the domestic market (ECX, 2009). Commercially, grade indicators are used to classify coffees where bean size, number of defects, altitude of growing etc. are taken to account, depending on the producing country. In this sense, most producing countries have their-own classification and grade charts (News Release, 2008). In Ethiopia, coffee grading is conducted through a combination of two methods. They are green coffee (Raw been) analysis and Cup tastes (Liquring or organoleptic analysis).

Green coffee analysis involves visually inspection of physical characteristics of coffee bean. This includes screen analysis, which makes size assessment, defect count and appearances or color and odor. Cup test is based on analysis (chemical process) by which aroma; acidity; body and flavor components are tested (Endale, 2007). Accordingly to Ethiopia commodity Exchange (ECX) grading system currently applied in the country since 2009. The ECX contracts of grading factors of unwashed coffee are characterized in two categories: The raw value and cup value. The raw value scores 40% (defects =30%, odor=10%) and cup value scores 60% (cup cleanness=15%, acidity=15%, body=15% and flavors=15%) (ECX, 2009).

Grading is the process of categorizing coffee beans on the basis of various criteria such as size of the bean, where and at what altitude it was grown, how it was prepared and picked, and how good it tastes, or its cup quality. Coffees also may be graded by the number of imperfections (defective and broken beans, pebbles, sticks, etc.) per sample. The primary issues of coffee grading are country (region) of origin, physical characteristics and sensory standards (taste). There is no universal coffee grading system except the recommended standards (ITC, 2002).

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). On the other hand, recently ECX (2010) established a new grading system of the overall standard for raw and liquor quality grades for unwashed coffee. The grades range from one to nine respectively (Appendix Table 7).

2.6 Costs-benefit Analysis

Costs-benefit analysis is a simple but effective technique for assessing the profitability of new technology for drying materials. New technology can be evaluated in terms of its impact on the productivity, profitability, acceptability and sustainability of farming systems (Harrington,

L. 1982). Clearly, these criteria are interdependent and all have biological, economic and social dimensions, although the attention devoted to each criterion has differed both among disciplines and over time. Net benefit is the difference between the value of the additional output and/or resources saved and the value (opportunity cost) of additional resources used when a particular technology is adopted for drying of coffee (Harrington, L. 1982).

2.7. Socio-economic Characteristics

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'. According to their report adoption of improved varieties, literacy, visit and proximity to research center positively influenced farmers' perception.

2.8. Coffee Market Constraints

There are several constraints in many coffee growing areas which inhibit the development of alternative, including agro ecological constraints, limited access to markets for other commodities, the perennial nature of coffee plants, and strong cultural attachment to coffee (Ponte, 2005).The commodity problem of declining terms of trade and increased price volatility, combined with shifts in the structure of world markets and 'governance' of the global commodity chain, in the past 20 years mean that many farmers and governments receive poorer returns from coffee exports. A greater proportion of value added coffee is captured outside the producing countries: technical changes mean that farmers and some producing countries are no longer competitive: and long term prospects on the world coffee market is poor. Ethiopia is no exception, despite some immediate gains in supply response and associated export performance (NRI, 2006).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Werababoo and Habru Woredas in Northern Wollo zone of Amhara region and Raya-Azebo, Kolatemben and Tselemti of Tigray Region on the minor coffee garden production areas in Northern part of Ethiopia. They were conducive and suitable for coffee production areas like the other parts of Ethiopia; however the rain fall distribution in Northern part of Ethiopia was the bottle-neck for coffee production. As a result irrigation was used for coffee production. And they divided in to two agro-ecological conditions: Werababoo, Habru and Raya-Azebo are woredas that are found in North-East of Ethiopia at a geographical location of $11^0$34’’N-$12^0$39’’570’N to $39^0$37’’E-$39^0$35’’357’E, and having mean range of temperature, rainfall and altitudeof 20-25^0c, 700-800mm and 1700-1850 m.a.s.l, respectively. The dominanttype of soil is sandy clay loam. And Kolatemben and Tselemti are also found in Northern part of Ethiopia with geographical location of $13^0$21’’N-$13^0$16’’N and $38^0$36’’-38037’’E. These woredas have altitude of 1400-1700masl, temperature that lies between 25 and 35^0c and rainfall ranging from 400 to 600mm (Table 2).

Table 2: Description of Werababoo, Habru, Raya-Azebo, Kolatemben and Tselemti Woreda

	Woredas				
Description	Werababoo	Habru	Raya-Azebo	Kolatemben	Tselemti
Geographical location	$11^0$34’N	$11^0$35’N	$12^0$39’570’’N	$13^0$21’N	$13^0$16’N
	$39^0$37’E	$39^0$36’E	$39^0$35’357’’E	$38^0$36’E	$38^0$13’E
Distance from Addis(Km)	418	480	650	878	1003
Altitude range(m.a.s.l)	470-2610	1430-2750	1400-1850	1413-2600	1300-1700
Temperature (^oC)	15-30	20-27	25-32	25-34	27-38
Rainfall (mm)	1000-1300	700-1000	400-600	450-550	500-750
Soil type	clay loam	vertisoil	sandy clay loam	silty loam	Clay loam
Total area coverage(ha)	450	295	400	35	75
Administrative center	Werababoo	Merssa	Mekhoni	Abiadi	Maytsebri

Source: BoARD (2012)

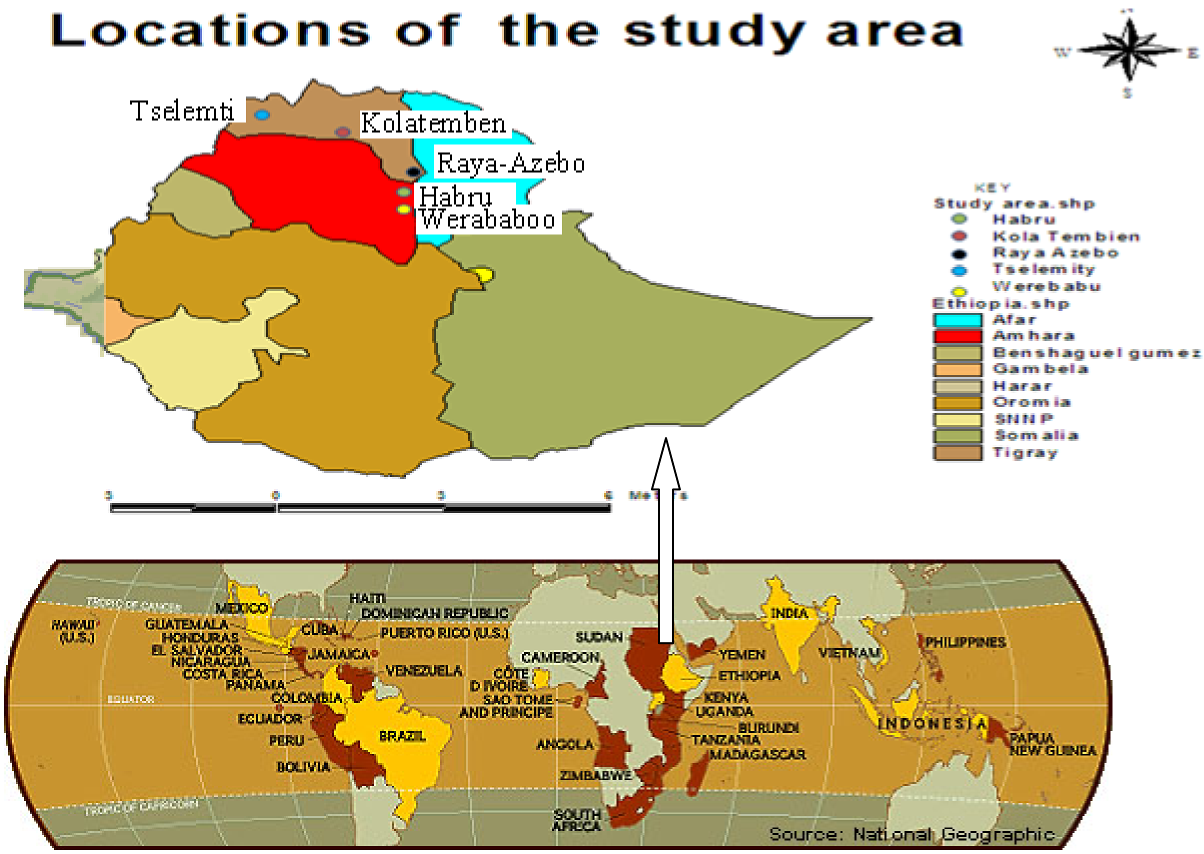

Figure: 1. Geographical Map of the five selected woredas' of the minor coffee production in Northern Ethiopia

3.2. Field Survey

Sampling Techniques: First five woredas were selected using purposive sampling technique based on coffee production potentials (personal experience), representation of Amhara and Tigray national region (BoARD, 2010) as well as previous information in the other districts. Werababbo and Habru from Amhara region,and Raya Azebo, Kola-Temben and Tselmti woredas were from Tigray region., Three representative kebeles were also selected from each district using purposive sampling techniques based on agro ecological zones with respect to coffee production potential in which highland (>2300m), midi-land (1500-2300m) and lowland (<1500m). Before the selection of sample households in each selected farmers sample size were established. This would be done primarily by recording total household in respective household farmers. After gotten the total number of household in each kebeles the next level would be determine total sample size of the survey. Total number of sample size of the survey would be determined using probability proportional to sample size-sampling technique using the formula developed by (Cochran, 1977). As a result a total 300 and 50 (60 farmers + 10 traders) small-scale and traders were purposefully selected for formal interview.

3.3. Experimental Design and Treatments

The experiment was laid out in a 5x5 factorial experiment in a Randomized Complete Block Design (RCBD), replicated three times. The treatments consisted of five Woreda bulked Coffee and five different structural drying materials (Soil floor, cement floor, Bamboo raised bed, Wooden raised bed and Mesh wire) which were combined and randomly assigned to the experimental plots of each block. The experiment was conducted at Raya-Azebo woreda station. A total of 25 treatment combinations were used in this experiment (Table 3).

Table 3: Details of Treatment Combinations of the study area in Northern Ethiopia

Treatment	Woreda bulked coffee (Land races)	Drying materials	Treatment combinations
1	Werababoo	Soil floor	Werababoo X Soil floor (WS)
2	Werababoo	Cement floor	Werababoo X Cement floor (WC)
3	Werababoo	Bamboo raised bed	Werababoo X Bamboo raised bed (WB)
4	Werababoo	Wood raised bed	Werababoo X Wood raised bed (WW)
5	Werababoo	Mesh wire Raised	Werababoo X Mesh wire Raised (WM)
6	Habru	Soil floor	Habru X Soil floor (HS)
7	Habru	Cement floor	Habru X Cement floor (HC)
8	Habru	Bamboo raised bed	Habru X Bamboo raised bed (HB)
9	Habru	Wood raised bed	Habru X Wood raised bed (HW)
10	Habru	Mesh wire Raised	Habru X Mesh wire Raised (HM)
11	Raya-Azebo	Soil floor	Raya-Azebo X Soil floor (RS)
12	Raya-Azebo	Cement floor	Raya-Azebo X Cement floor (RC)
13	Raya-Azebo	Bamboo raised bed	Raya-Azebo X Bamboo raised bed (RB)
14	Raya-Azebo	Wood raised bed	Raya-Azebo X Wood raised bed (RW)
15	Raya-Azebo	Mesh wire Raised	Raya-Azebo X Mesh wire Raised (RM)
16	Kolatemben	Soil floor	Kolatemben X Soil floor (KS)
17	Kolatemben	Cement floor	Kolatemben X Cement floor (KC)
18	Kolatemben	Bamboo raised bed	Kolatemben X Bamboo raised bed (KB)
19	Kolatemben	Wood raised bed	Kolatemben X Wood raised bed (KW)
20	Kolatemben	Mesh wire Raised	Kolatemben X Mesh wire Raised (KM)
21	Tselemti	Soil floor	Tselemti X Soil floor (TS)
22	Tselemti	Cement floor	Tselemti X Cement floor (TC)
23	Tselemti	Bamboo raised bed	Tselemti X Bamboo raised bed (TB)
24	Tselemti	Wood raised bed	Tselemti X Wood raised bed (TW)
25	Tselemti	Mesh wire Raised	Tselemti X Mesh wire Raised (TM)

3.3.1. Experimental Materials: The experimental materials used for laboratory analysis were coffee samples collected from five woredas bulked coffee; Werababbo, Habru, Raya Azebo, Kola-Temben and Tselemti of Northeast and North part of Ethiopia respectively and five structural drying materials namely Soil floor, cement floor, bamboo raised, wooden raised bed and Raised mesh wire. For uniform drying bed size (1m x 0.6 m) was constructed at a height of one meter above the ground. Similarly, equal bed sizes were also included on the ground using cemented floor and bare soil surface. The coffee samples of each treatment were divided into equal halves, prepared and dried on each drying bed.

3.3.2. Experimental procedure:

3.3.2.1. Harvesting: A three (3 kg) fresh cherries was harvesting manually picked, according to Bertrand *et al*., (2006), 3kg of cherries for dry method to get approximately 0.6 kg of green coffee beans. A total of 75 samples were prepared for dry processed method based on the treatment combination that means 225kg fresh red cherry samples (45kg of fresh red cherry collected from each woreda). And the red Cherries harvested were sorted by removing of unripe, over ripe, dry, diseased and insect damaged cherries from the sound and red ripe ones

3.3.2.2. On- farm processing: Primary processing was done immediately after harvesting for about three to four weeks depending on the climate and drying materials; since the quality of the bean begins to be affected within hours after picking. The red cherries were labeled and properly spread on Soil floor and Cement floor raised drying tables made up of bamboo mats, Wooden and mesh wire. The red ripe cherries were carefully partitioned into levels of cherry drying layer thicknesses and laid on their plots at random according to the treatment allocations. The cherries were covered during the hottest part of the day and at night to avoid over drying and re-wetting, respectively and the samples were labeled and properly dried and regularly turned to maintain uniform drying. In all treatments coffee was spread at 5 cm drying depth and also the moisture content of the bean was measured using Electronic Rapid moisture Tester (HOH-Express, HE 50 Germany),when the samples uniformly attained moisture on average of 11%.

3.3.2.3. Hulling and packing*:* then coffee was de-hulled to produce clean coffee beans and each coffee sample from each treatment in the woreda was separately labeled (Having the name of woreda bulked coffee or landraces and drying materials). Finally the samples were packed and brought to Addis Ababa coffee quality inspection and grading center for quality analysis.

3.3.3. Quality Analysis

For further quality evaluation; clean coffee bean sample of 500 g was taken from each treatment combination based on sampling procedure set by Ethiopian standard (ESBN 8.001) and (MoA), which is on the basis of drawing 3 kg per 10 tons. Representative samples were drawn and laboratory size samples were prepared from bulk samples. For further physical and organoleptic analysis maximum of 350 g green coffee sample with optimum moisture content (11.5%) was prepared following the procedure described by ECX (2009).The quality analysis, which was carried out from March 11 to April 18, 2011.Green bean physical and cup quality characteristics were evaluated by three Q certified professional coffee tasters. Each sample was coded according to the standard procedure used for unwashed coffee raw and cup quality evaluation. The raw quality constitutes 40% (Defect=30% (primary defects=15% and secondary defects=15%) and Odor=10%).The cup quality value scores 60 % (Cup Cleanness =15%, Acidity =15%. Body=15% and Flavour = 15 %) of the overall coffee quality. The comparative sensorial tests describe a grading scale from 1 to 9 where 9 corresponded to the worst cup and 1to the best cup as per ECX procedure (ECX, 2009) as indicated in Table 3.

3.3.3.1. Raw coffee quality evaluation

As a general requirement for commencement of quality analysis, about 350 g of green coffee bean sample was prepared from each sample as per the procedure described by Specialty Coffee Association of America (SCAA, 2009) set as the standard conditions for the analysis of green coffee and organoleptic quality characteristic.

Coding: The samples collected from each treatment were assigned to arbitrary codes in order to secure unbiased judgments.

Moisture testing: The moisture content of each sample bean was measured with a standard moisture tester certified in 2011 by Quality and Standard Authority of Ethiopia to maintain it within a permissible range (9-11.5%).

Screen analysis: Bean size distribution was evaluated by means of rounded perforated plate called screen. The size of the screen holes was specified in 1/64 inch. Since market acceptable bean size is above screen number 14, to obtain homogenous and healthy beans, samples were screened through a mesh sieve size on screen 14 and those retained above were used for analysis (ECX, 2009). From each treatment a 350 g beans were passed through a series of sieves with round perforations of 14, 15, 16, 17, 18 and 19 and weighed to determine the percentage out of the total sample as the procedure set by (ISO, 2004; EAFCA, 2008).

Defects count: black beans, fungus damaged, sever insect damaged, foreign matter out of bean origin and foreign matter out of coffee origin were counted and scored out of 30% as the procedure set by ECX (2009). Out of a 350 g green coffee beans sampled from each treatment combinations; the number of defected beans with unacceptable physical character for full black, full sour, insect damaged, husk and foreign matter were recorded accordingly. The primary defects (count) scored (15%) and the secondary defect (by weight) counts scored (15%) respectively.

Roasting

A six cylinder-batch roaster (Probat BRZ6, Welke, Von Gimborn Gmbhan Co. KG) equipped with a cooling system in which air was forced through a perforated plate and capable of roasting up to 500g of green coffee bean was used for roasting with roasting temperature 170-200^{o}C for an average of seven minutes to achieve medium roast.

Figure 2: Roasting mechanism of coffee sample at ECX collected from Northern Ethiopia

Grinding

About 12 g medium roasted samples were weighed and ground using roasted coffee electrical grinder (MahlKonig, Germany) with middle adjustment. Then eight gram coffee powder was put into a clean standard porcelain cup with 180 ml capacity (Schonwald, Germany).

Brewing

Fresh boiled water was poured into the coffee up to about half of the cup. The ground coffee was inspected and sniffed 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 of 60^{o}C (drinkable temperature). The brew was made ready for panelists within eight (8) minutes for cup test analysis.

Figure 3: Cupping of the sample coffee for quality evaluation of landraces done by professional coffee tasters at ECX.

Cup tasting

Five cups per sample in three replications were prepared for each tasting session (Fig 4). 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 ECX three liquors'. 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.).

Figure 4: Cup tasting done by trained panels at ECX of the Sampled Landraces Coffee collected from Northern Ethiopia

Cup quality evaluation consisted of raw (40%) and liquor (60%) attributes. Raw value was evaluated as primary defect, secondary defect, and odor. Liquor was also evaluated as cup cleanness, acidity, body and flavor. Finally mean of each variable by the panel group was used for statistical analysis. But, variation among assessors for a given variable was not considered as procedures of Getu (2009).

Grading

Evaluation and grading coffee samples for both raw (40%) and liquor (60%) quality was carried out following the procedures of Coffee Liquoring Unit (ECX, 2010)

Table 4: Standard parameters and their respective values used for unwashed coffee raw quality evaluation (ECX, 2010)

Grade	Total Value (Raw Value + Cup Quality Value)
Grade 1	91-100
Grade 2	81-90
Grade 3	71-80
Grade 4	63-70
Grade 5	58-62
Grade 6	50-57
Grade 7	40-49
Grade 8	31-39
Grade 9	20-30
	Under grade coffee
Grade UG	15-19(Total Value)
Sound Beans % by weight	<50
Flavours	Fair

3.4. Data Collected

Prior to the actual survey of the structured questionnaire, information obtained from secondary data, formal and informal survey for the demographic, pre-harvest, harvest and post-harvest and trader information, were developed and pre-tested for its consistency and applicability to the objectives of the study. And the data for experiment of physical quality attributes of green bean (primary defect, secondary defect and odor) and Cup quality attributes (cup cleanness, body, acidity and flavor) were collected by combining the different coffee cupping techniques followed at Addis Ababa, Ethiopia Commodity Exchanges (ECX, 2010)

3.4.1. Physical Quality Attributes

3.4.1.1. Primary Defect: A 300g of each clean coffee sample was taken using digital bean balance. Internationally a stand is fixed for those green defects (over ripe, foxy, under ripe, immature, blacks, whites, stones, soils, earthy, broken, etc.,) (Endale, 2008). For defects <5=15, <10=12, <15=9, <20=6, <25=3, and >25=1.5 and the result was recorded accordingly (ECX, 2010).

3.4.1.2. Secondary Defect: These defects are measured by weight and expressed in percent as indicated in the following formula.

$$\mathbf{SD} = \frac{\text{total defect weight}}{350\text{g}} \times 100$$

Where, <5%=15, 6-10%=12, 11-15%=9, 16-20%=6, 21-25%=3, and >25 %defects recorded as=1.5 and the result recorded accordingly (ECX, 2010).

3.4.1.3. Odor: Olfaction evaluated as 10=clean, 8=F. clean, 6=Traces, 4=Light, 2=Moderate and 0=Strong (ECX, 2010), the result is recorded accordingly.

3.4.1.4. Total Raw Quality: It is the summation of Primary defect, Secondary defect and Odor and it express the physical bean quality of the coffee (ECX, 2010).

3.4.2. Organeloptic Quality Attributes:

3.4.2.1. Cup cleanness: It indicates freeness of the coffee from defects, if there is problem during roasting and its ranged from 0-15 where, 0=>3 cup defect, 3=3 cup defect, 6=2 cup defects, 9=1cup defect, 12=fair clean and 15=clean (ECX, 2010), the result is recorded accordingly.

3.4.2.2. Acidity: It is the sensation of dryness that the coffee produces under the edges of the tongue and on the back of the plate. Acidity should not be confused with sour. Cup acidity was evaluated as 0=Not detect, 3=Lacking, 6=Light, 9=Medium, 12=M.pointed and 15=Pointed (ECX, 2010), the result is recorded accordingly.

3.4.2.3. Body: Body is the feeling that the coffee has in the mouth. It is the viscosity, heaviness, thickness, or richness that is perceived on the tongue. Cup body was evaluated using as, 0= Not defect, 3=Thin, 6=Light, 9=Medium, 12=Medium full and 12=Full (ECX, 2010), the result is recorded accordingly.

3.4.2.4. Flavor: Flavor is the overall perception of the coffee in the mouth. Acidity, aroma and body are all components of flavor and measured as 0=Not defect, 3=Commonish, 6=Fair, 9=Average, 12=F.good and 15=Good (ECX, 2010), the result is recorded accordingly.

3.4.2.5. Total Cup Quality: It is the summation of Cup cleanness, Acidity, Body and Flavor.

3.5. Total Quality: It is the summation of Raw Quality from 40% and the Cup Quality from 60% was carried out for 75 samples (ECX, 2010).

3.6. Grade: Evaluation and grading of coffee samples for both raw (40%) and liquor (60%) quality were carried out following the procedures of Coffee Liquoring Unit (ECX, 2010). The overall standard for raw and liquor quality grades of unwashed coffee range from 1 to 9, where, grade 1 = 91-100%, grade 2 = 81-90%, grade 3 = 71-80%, grade 4 = 63-70%, grade 5= 58-62, grade 6=50-57, grade 7=40-49, grade 8=31-39 and grade 9=20-30.

3.7. Method of Data Analysis

Farmers and Traders from each woreda were interviewed on the coffee production system of the area. The data collected from the field through structured questionnaires were analyzed by employing the statistical procedures of SPSS version 16.0 (SPSS, 2007). Using descriptive statistics, the frequency and percentage values of variables are also computed to observe their distribution, whereas the laboratory analysis of variance (ANOVA) for the laboratory analysis was computing by using general linear model (GLM) procedures of SAS version 9.2 (SAS Institute, 2008). And square root transformation was done for primary defect, secondary defect, cup cleanness, acidity, body, flavor and and total cup value of the laboratory data in order to fulfill the assumption before ANOVA analysis and the means were back transformation to original. Means separation using LSD at 5% probability level were computed when the treatment combinations found significant.

Overall quality grading of the green beans for the processing methods was carrying out by computing proportion of the raw physical (40%) and cup quality attributes (60%) evaluation for each sample of Woreda. Therefore, a total of 75 coffee samples were prepared for both processing methods at Addis Ababa Ethiopia Commodity Exchanges (ECX). Therefore, the following model for factorial RCBD was used.

$$y_{ijk} = \mu+\alpha_i+\beta_j+ (\alpha\beta)_{ij}+ \epsilon_{ijk} \quad \begin{cases} i =1, 2\ldots \text{ Woredas' bulked coffee(Landraces)} \\ j =1, 2\ldots \text{ Different drying Materials} \\ k=1, 2\ldots \text{ Number of replication} \end{cases}$$

Where, μ = the overall mean effects

αi = the effects of i^{th} Woredas' bulked coffee, i = 1-5

βj = the effects of the j^{th} Different drying Materials, j = 1-5

(αβ) ij = the interaction effects between Woredas' bulked coffee(Landraces) and Drying Materials

€ijk = the random error compared for the whole factor

k = number of replication

3.8. Cost-benefit Analysis

It is used for assessing the profitability of new technology like different structural materials for an existing enterprise. It also provides the foundation for comparing the relative profitability of alternative treatments, evaluating their riskiness, and testing how robust profits are in the event of changing product or input prices (Herdt, 1987). First, it is assumed that farmers have conducted practices in order to identify the major constraints on farm productivity and understand their agronomic and socio-economic conditions. It is used to test the solutions that are potentially feasible for farmers to adopt. Second, the procedures assume that the level of net benefit is an important criterion for farmers when they evaluate alternative technologies coffee for drying. Net benefit is the difference between the value of the additional output and/or resources saved and the value (opportunity cost) of additional resources used when a particular technology is adopted (Harrington, L. 1982). Preparation of a partial budget in order to estimate the net benefitsthe following values must be calculated on a per quintal basis:

a. value of all inputs which differ in kind or amount used across treatments (called total costs that vary TC=TFC+TVC)
b. Net Benefit = Gross Benefit-TC and the gross benefit was taken as equivalent of the price obtained from ECX (2012) according to the current price per kg of coffee for the specific grade.

4. RESULTS AND DISCUSSION

4.1. Field Survey

4.1.1. Demographic factors

Werababoo, Habru and Raya-Azebo woredas were categorized in the same agro-ecological zone and the coffee tree planted in those areas'. Mostly coffee growers small-scale farmers were more than 75% Muslim and the coffee currently under production in Worababoo, Habru and Raya-Azebo woredas' they are said to be the coffee plant introduced from Argoba and Harare by Muslim students who went, therefore religious study based on the interviewing. While, Kolatemben and Tselmti woreda in North Ethiopia and they said to be it was introduced from Gojam by the Christianity religious followers (monks). Coffee production in those areas was not much care and olive tree was also dominantly grown in those areas as a result this was one of the problem for quality coffee production.

Among the demographic information significant variation ($p<0.05$) was observed in marital status and education level of the total respondent of the five selected woredas in Northern Ethiopia, but not significant variation in the meditative variable of age and sex of the respondent (Appendix Table 1). From the survey, 70.3% of household coffee farmers were male headed and the remaining 29.7% were female headed. Many evidences shows that female households have less access to improved technologies, credit and extension service. On the other hand, male-headed households have better access for information than female households that helps for adoption of improved agricultural technologies

And the majority of the small scale farmers interviewed had three and more than four family members at about 33%, while 24.5% and 10% were one family member interims of family size respectively (Appendix Table 1). The survey results also indicated that about 27.7% of the respondents were found in the age category of ≥50 years, 44.3% in the age category between 30 and 50 years, respectively this assures that since the members were young, they could easily accept the coffee farm practice better than elders, while the remaining 28% were less than 30 years of age. But in terms of educational status of the total 300 respondents were also 38% recorded literate and 62% illiterate because education takes as one of the main component for good coffee production. The age of the total respondents were in productive level, but the educational level of each woredas was 66.67%, 63.33%, 55%, 63.33% and 61.67% in Raya-Azebo, Werababoo, Habru, Tselemti and Kolatemben respectively (Appendix Table 1 and Fig 5).

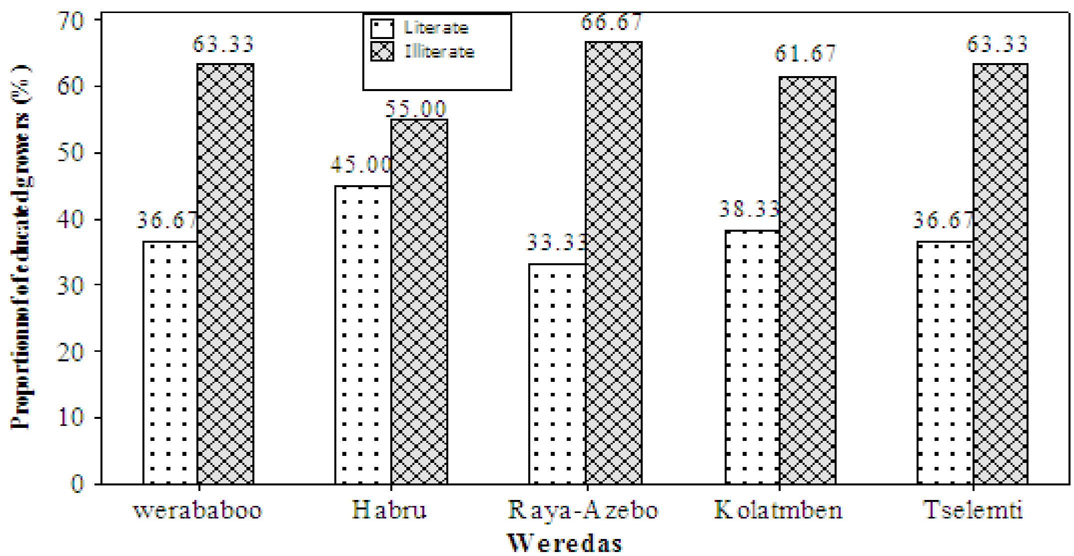

Fig 5: Education level of coffee growers in selected woredas in North Ethiopia

On the other hand, from the total respondents (28.7%) had owned a coffee farm less than 0.25ha while 30% and 18.7% had a coffee farm size ranging between 0.25-0.5ha and 0.5-1ha,respectively (Appendix Table 1 and Fig 6).

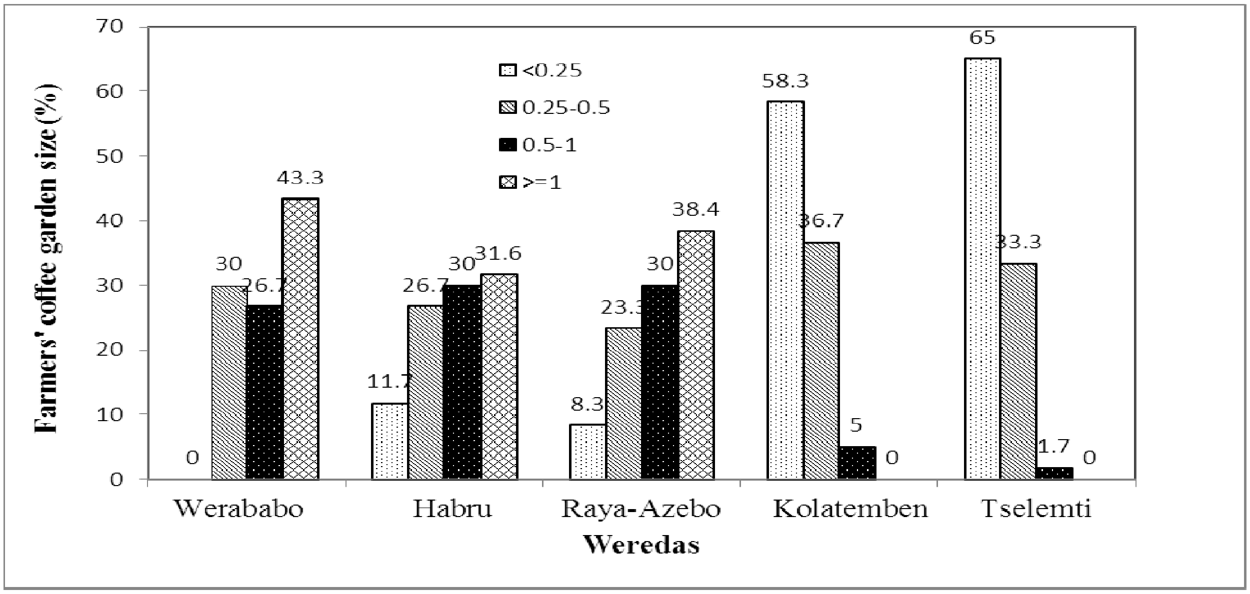

Fig 6: Area covered with coffee in the five selected woredas in Northern Ethiopia

From the Figure 6, we observed that there were 43.33%, 31% and 38.4% of the respondents were owned the farm greater than one hectare in Werababoo, Habru and Raya-Azebo, while the low farm land (58.3% and 36.7%), which owned by Kolatemben and Tselemti woreda.

This result was agreement with that of 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'. According to their report adoption of improved varieties, literacy, visit and proximity to research center positively influenced farmers' perception. But, according to Zemedu, (2004) revealed that level of education is strong and significant determinant of farmers' adoption of improved agricultural technologies for coffee production.

4.1.2. Pre-harvest practices

Among agronomic and physiological factors affecting coffee yield and quality, age of coffee trees, pruning, irrigation, interval of irrigation, weed control, disease prevalence, and application of compost were assessed in this study. As a result there was highly significant variation ($p<0.01$) observed for those age of coffee, coffee pruning, space, irrigation, interval of irrigation ,major problems and controlling mechanism of disease and pests on the coffee farms (Appendix Table 2).

From the field survey showed that among 300 respondents of small-scale farmers interviewed, 65.3%% owned aged coffee trees (>20 years old), while 34.7 % of them owned coffee trees less than 20 years old in general, but 100% in Kolatemben and 53% in Tselemti were aged coffee plants, while the other woredas namely Werababoo, Habru and Raya-Azebo planted coffee almost equalized by replacing the old coffee planted. The common spacing between plants in the farms of the study areas was 3m in about 77.3% of the cases, whereas 20.3% below 3m and 2.4% above 3m, respectively. In most coffee growing areas of Ethiopia, pruning is not a common field practice. The scenario was same in the study area as there is nearly no pruning practice (93.7%) except for few farmers (6.3%) in the woredas of Werababoo and Raya-Azebo woredas which simply practiced removal of diseased branches when the farmers perceive the branches not productive (Appendix Table 2).

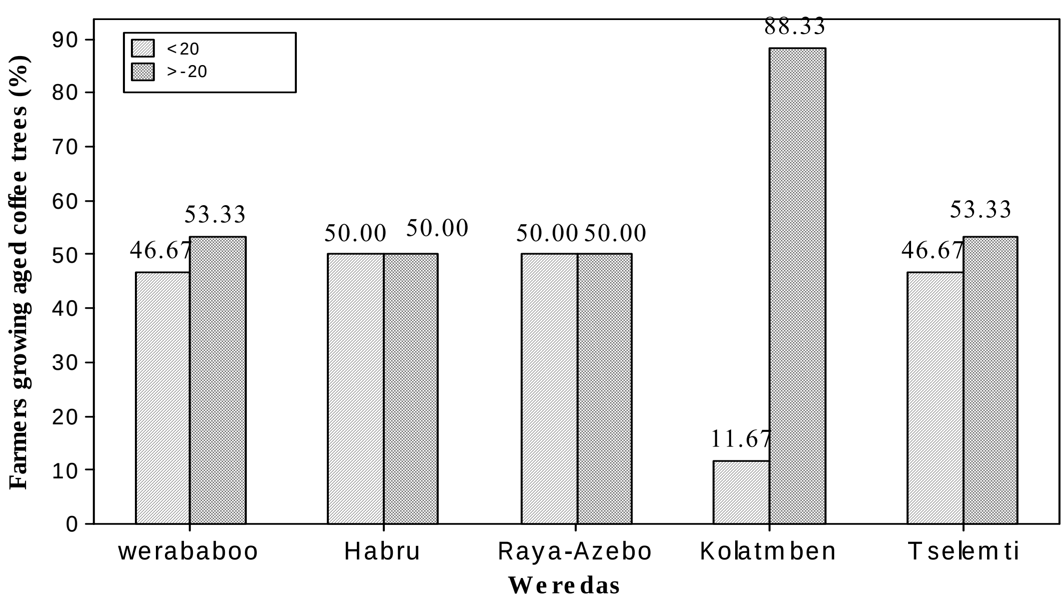

Fig 7: Farmers growing aged coffee trees in selected woredas of North Ethiopia

But as we observed from the Figure 7, the aged coffee replaced and planted new coffee tree in the woredas' of Weababoo, Habru and Raya-Azebo,bu almost none (88.33) for the woreda of Kolatemben.

Regarding the use of shade trees, about 80.3% of the total respondents were no shading therefore their coffee, which indicates that coffee is growing in an open area but shade is reported to reduce light intensity and day time temperature in hot areas. Shades also reduces the over-time bearing dieback, increases coffee quality by providing a cooler microclimate to coffee plants and thereby lengthen the maturity period which in turn permits the formation of good bean size, bean biochemical composition and ultimately crop quality. Intercropping of coffee with chat (*Chat edulis*) being practiced especially for the areas of Werababoo, Habru and Raya-Azebo woredas. And from the interviewing, in Werababoo and Raya-Azebo woreda, farmers have negative perception to apply farmyard manure or fertilizer to the coffee field, and also they think farmyard manure have worm and may damage the coffee trees in the selected woredas'of Northern Ethiopia.

The annual rainfall and distribution in the study of areas of Northern Ethiopia was found to be generally very low and it is Mono modal type of rain distribution, but for the woredas' of Werababoo, Habru and Raya-Azebo Bio modal type of rain fall, even in those woredas erratic type of distribution. This is insufficient for coffee production as a result which coffee production in those areas was found to be mainly used by irrigation system.

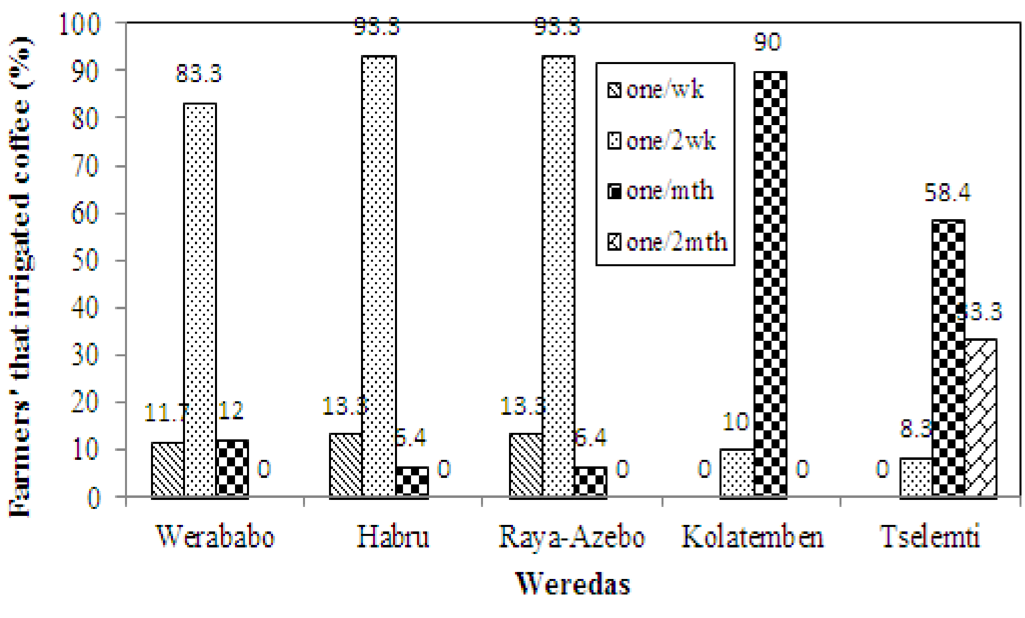

Fig 8: Frequency of Irrigation for coffee in selected woreads of North Ethiopia

From the survey result the irrigation frequency in the study areas was mostly (79.7%) once/2week up to monthly interval and the remaining 9.7% once/wk, 6.67% once/month and

6.4% once/2mth supplementary irrigation was appliedas whole (Appendix Table 2), but 83.3%, 93.3% and 93% of the respondent of Werababoo, Habru and Raya-Azeboworedaswere coffee irrigated one per two week, whereas Kolatemben and Tselemti coffee tree irrigated 90% and 58.4% per month respectively. The farmers complain that the leaf and fruit drying and death totally if irrigation applied in November and December. And some farmers in these areas not used they only expected from rainfall as a result very small amount with poor quality of coffee harvested (Fig 8).

The rural extension service is an average of major shifts in extension service delivery through the farmer training center system. But in the survey result of the study areas, the advisory service was given by the governmental workers mostly at seedling /planted stage (81%) of the total respondent.

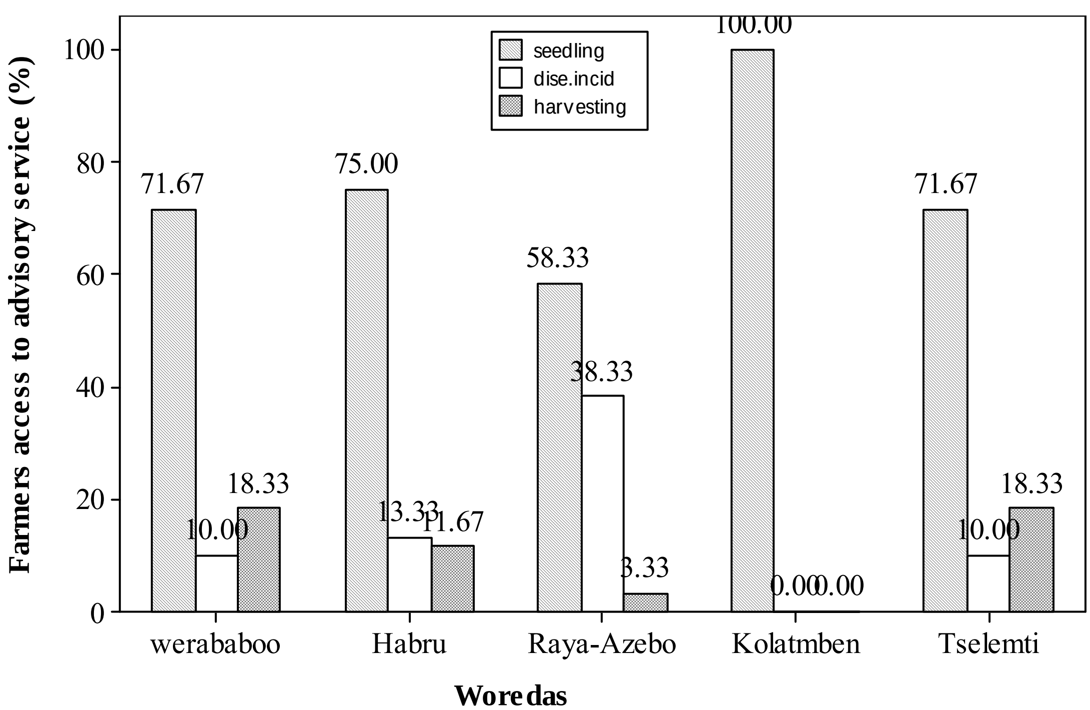

Fig 9: Farmers acess to advisory service in selected woredas in North Ethiopia

But, there were 38.3% at disease incidence was observed at Raya-Azebo woreda, 11.43% at Habru woreda because of some advisory service given to the coffee growers' coffee directly or indirectly by government or visitors.

Generally there was no land preparation activity taken at the field before transplanted time. As a result, in werababoo, Habru and Raya-Azebo woreda coffee farms, weed controlling by digging done at April first stage and September second stage and they believe that digging at April gives tree strength; while in September gives better shape and make the coffee seed bearing based on the interviewed respondent. And in the study areas broad leaves and grassy weeds dominantly grown in the area. As you know coffee tree is highly susceptible to weed by competition of moisture and nutrients as a result wild grasses infest on the coffee farms. Of those areas the protection method was by hand slashing and digging mechanism and this is the same with all country farmers' practices. As a result there was good quality for those woredas of Werababoo, Habru and Raya-Azebo when compared to those Kolatemben and Tselemti woredas.

This result was agreed with Decazy *et al*., (2003). And they reported that the environmental has also a strong influenced on coffee quality such as altitude, daily temperature fluctuations, amount and distribution of rainfall, physical and chemical characteristics of soil. Furthermore, Yemanebirhane (1998) observed that shade increased sugar concentration, which is an important factor for creating the aroma coffee.

And the result was contrary to Wintgens (2004), 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. Taye (1998) also reported the use of decomposed coffee husk at a rate of 10 ton/ ha (4 kg tree/ha on dry weight basis) was found to be superior in terms of yield performance of coffee trees.

4.1.3. Harvest and post-harvest factors

The existing condition of harvesting in the study areas is mostly by mixed type and harvesting and post-harvest factors are the most important for coffee production to get better coffee quality. However, as shown in Table 8, coffee harvesting, harvesting quintal per hectare , drying mechanism, storage duration, transport system and market information were highly significant ($p<0.01$) relationship among them and positively influenced in harvesting and post harvest management of the coffee, but not significant ($p>0.05$) for packaging materials and coffee storage in the study areas of Northern Ethiopia.

Based on the interviewing, the coffee flowering in woredas' of werababoo, Habru and Raya-Azebo are two times per year, the first in April-May and the second major one is in July-August. Following the flowering pattern the main harvest is November-December and February-March for the first and second respectively. And for the Northern part of Ethiopia, Kolatemben and Tselemti woredas were mostly they harvested in the first round (November-December), but can possible produce in the second round harvested it , irrigated and managed properly.

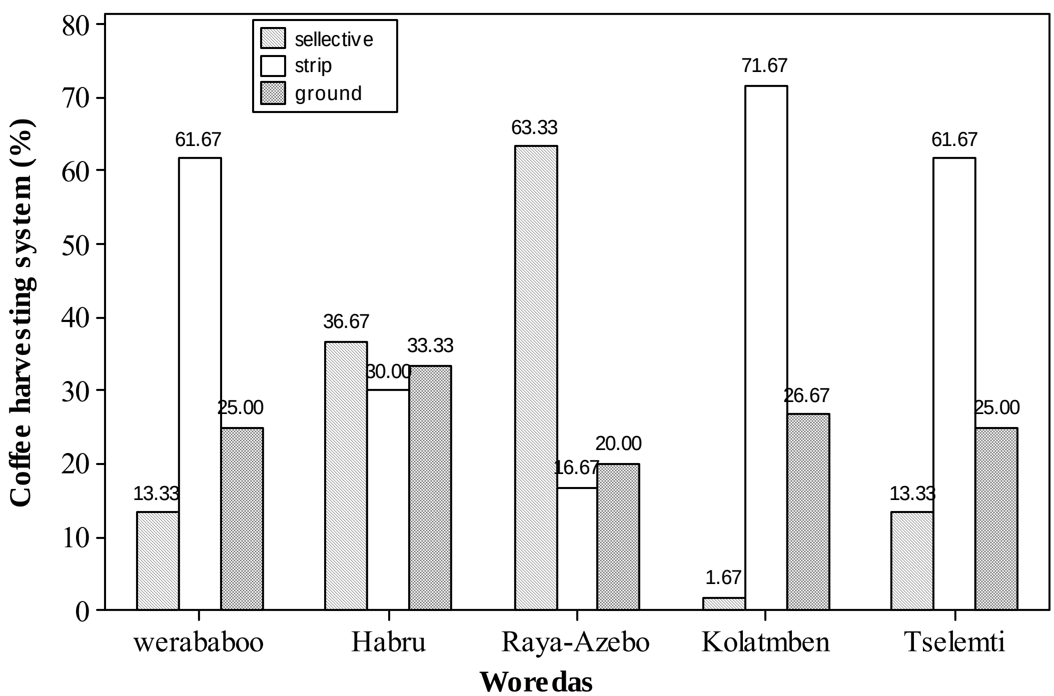

Fig 10: Method of coffee harvesting in selected woredas in North Ethiopia

From the survey result, farmers were mostly exercising at selectively hand picking of red ripe cherries (25%), strip (46.7%) and from ground were 30.3%, but the percentile of coffee harvested for each woredas: Werababoo (13.3% selective, 61.7% strip and 15%from ground), Habru (13.3% Selective, 33.3% Strip and 30% from ground), and for Raya-Azebo (36.7% Selective 16.7% Strip and 26.4% was from ground. The difference in the same agro ecology in North-East part of Ethiopia, areas was due to some private traders and Nongovernmental workers given some training and awareness how to coffee produces, while in woredas of Kolatemben and Tselemti was low know how in coffee production and very small coffee coverage. In those areas above 70% of coffee harvested by strip and old coffee tree dominantly this is a poor management system (Appendix Table 3 and Fig 10).

On the other hand the harvested coffee was dried by almost all farmers on the soil floor (81 %), whereas 4% on cement 5% on bamboo and 10% on wood generally in the study areas. Furthermore, coffee stored mixed at about 87% from the total respondent of small-scale farmers and they stored in their house which are not separately and the way of shipments to the market by putting into container of jute (78%) and plastic by 22% (Appendix Table 3).

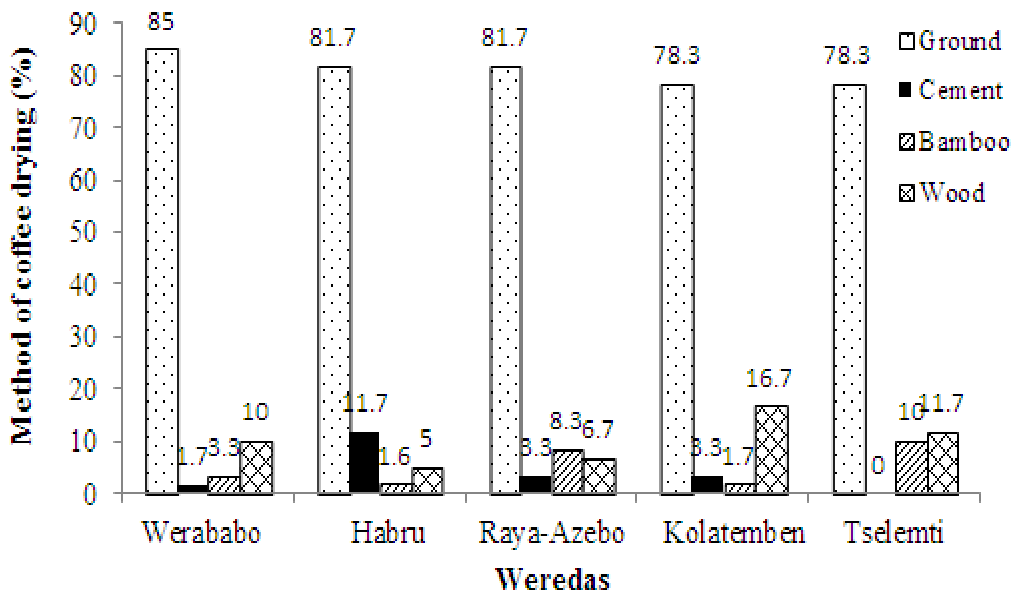

Fig 11: Method of coffee drying in selected woredas in North Ethiopia

Therefore the stored coffee becomes moldy or musty floors and the type of storage especially the jute one is very suitable for being contaminated by nearly chemicals or fuels. And the jute might have been made on machinery lubricated with petroleum oils and the produced coffee and exposing to whatever elements surrounded thereby because jute bags have extremely porous, finally can lead to the harvested coffee become a baggy or oily taste.

And mostly the farmers' coffee growers in the study area were stored less than four months (88%) of the total respondent before shipment to the market. The small-scale farmers coffee producers were selling 7.3% Red ripe, 7.4% Green and 85.3% Mixing type of coffee and also 82.3% of the produced coffee farmers transported by Animals the remaining one was by Human transporting system. Quality of the harvested coffee which is sold as well as market information in those areas was very poor. From the survey result about 74% market information done by their-own judgment and the price of produced coffee in the study area was fair (69.8%) when compared to National market in general (Appendix Table 3).

But the bean size of coffee from the study areas were small and starved beans due to deficiency of nutrients and the watering problems though relatively good coffee harvested in the woredas of Werababoo, Habru and Raya-Azebo. Based on the study areas, the quality assessment of the coffee was fetch premium price in international market. Had it not beans for the starved been the current quality evaluation grade would have been better than it is by now. But, most in time in the study areas poor pre and post-harvest practices, such as coffee harvested at immature stage, ripe and dried cherries together and mixed with dropped coffee bean in the ground with ripen harvested coffee cherries. In some case, some small-scale farmers practiced the immature green bean roasted at traditional stove,which was called ''achelalia'', this practice was done mostly when at ceremony or strangers comes for their house used for inviting purpose.

This result agreed with Endale (2008) and he reported that coffee with a better attention or management turn out to have a better odor and given the potential problems associated with drying on soil surface and its negative image, the practice of direct drying of coffee soil is strongly discouraged coffee with a better attention or management turn out to have a better odor. Similarly, (Eshetu and Girma, 2008) they reported that more tradition way of drying coffee on the grounds obviously produces bad and unwanted odours; this could be due to contamination with dirty which not only produce earthy odour but also bring about a large microbial load including, in many cases OTA producers and also Demanu (2008) reported that coffee quality as a combination of botanical varieties, topographical condition, climactic condition and the care taken during growing harvesting, storage export preparation and transporting systems.

4.1.4. Traders Information

In Ethiopia, more than 50% coffee is consumed locally. As a result Ethiopia is the first (largest) consumer of coffee in Africa and the 5th in the world. According the survey result out of the 50 traders, Trade experience, Moisture content checking, duration of coffee storage and general problem of the trader information were highly significant ($p<0.01$) variation relationship and positive influence on coffee quality, but mechanism of identifying and type of buying were not significant ($p>0.05$) variation relationship and response for quality generally of the five selected woreda in Northern part of Ethiopia (Appendix Table 4)

The trade experience of Northern Ethiopia, mostly (66%) had greater than four years and 34% were less than four years trade experienced and the type of coffee bought from the producers (small-scale) were dry cherry at about 94% (Appendix Table 4).

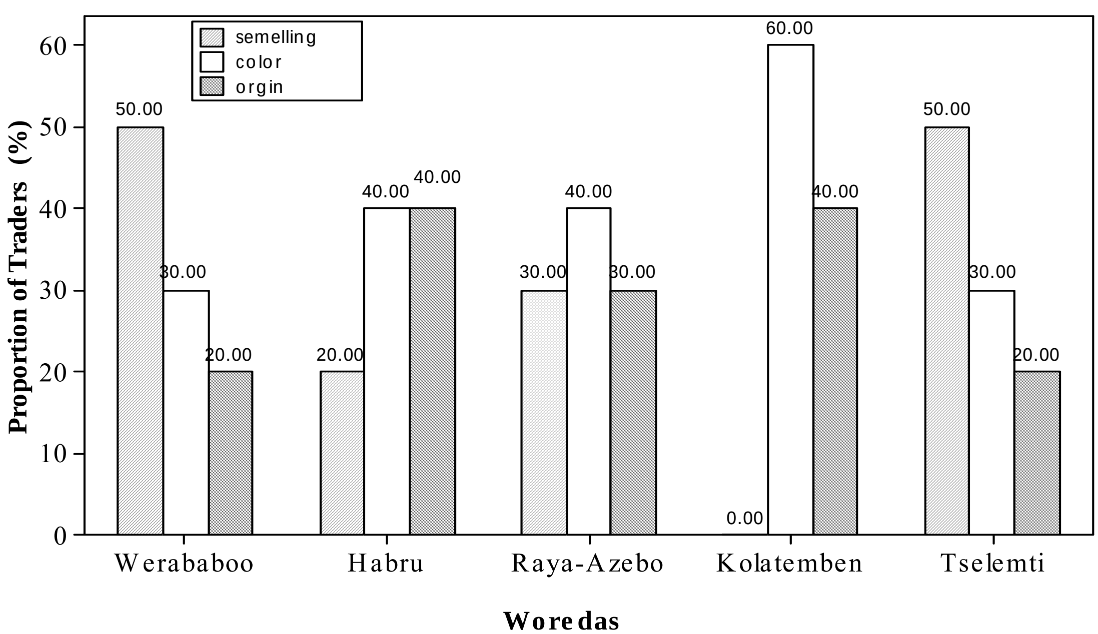

Fig 12 : Mechanisms of Traders to identify quality coffee in selected woredas in North Ethiopia

The mechanism of identifying coffee was also 20% by smelling, 50%by color and 30% by the origin of the coffee where they come from in general, but from place to place mechanism of identifying of coffee were different in each districts namely: Werababo (50%, 30% and 20%) mechanism of coffee identifying by smelling, color and origin respectively, Habru (20%, 40% and 40%) mechanism of coffee identifying by smelling, color and origin respectively and Raya-Azeboworedas also (30%, 40% and 30%) mechanism of coffee identifying by smelling, color and origin respectively, but for Kolatemben 60% by color and 50% by smelling in Tselemti woredas' (Figure 12).

On the other hand, the moisture content of buying coffee from the producer as well as from marketing was determine by sound 34%, by cutting 8% and 56% of the total respondent by no means of checking the moisture content, and this indicates checking by try and error finally there is high loss of the coffee quality as well as quantity lost during storing (Figure 13).

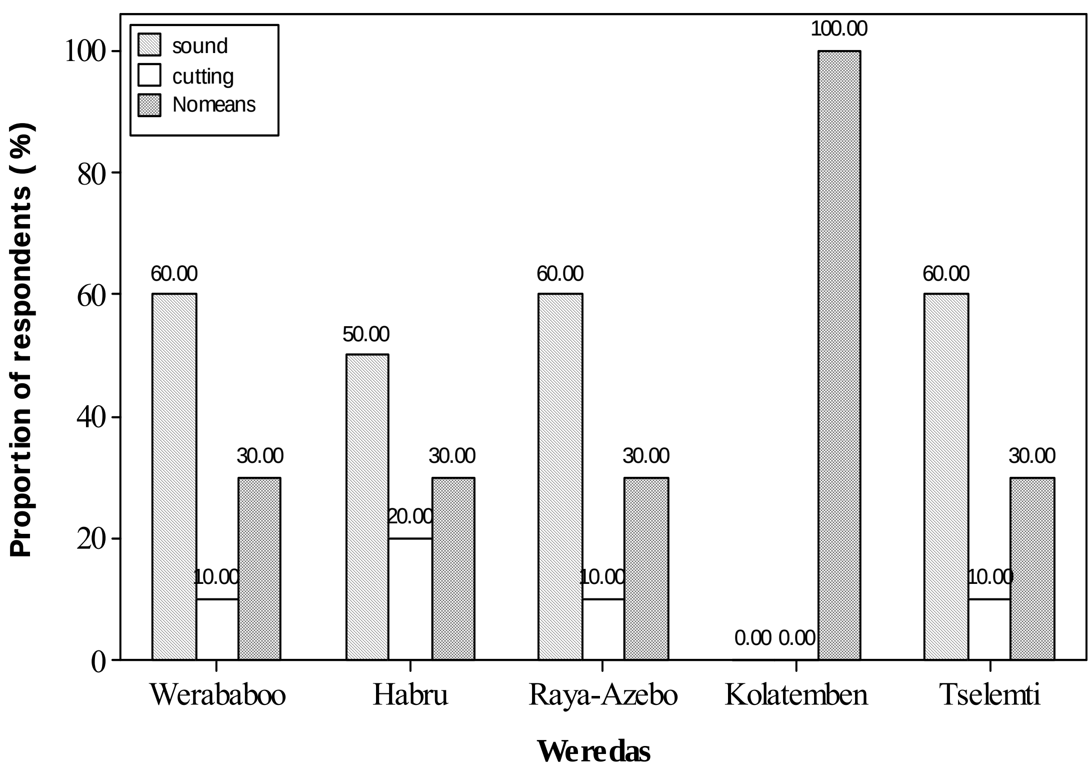

Fig 13 Method of dry coffee moisture determination in selected woredas in North Ethiopia

Detailed s understanding of the structured working of the world coffee market is essential to identify constraints and opportunities (what the market wants, rather than what Ethiopia producers wants to sell or traders to buy), even farmers are not homogenous, differentiated by farm size, sources of income and different response to hazard. This result is related to NRI, (2006) and he reported that long term prospects on the world coffee market is poor. Ethiopia is no exception, despite some immediate gains in supply response and associated export performance and Yigzaw (2005) reported that Length and condition of bean storage also affect cup quality 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.

4.2. Laboratory Analysis

4.2.1. Physical Coffee quality attributes

4.2.1.1. Primary defect

The analysis of variance indicated that there was highly significant interaction effect ($p<0.01$) between woreda bulked coffee (Landraces) and Different drying materials (Appendix Table 5). The result showed that Habru bulked coffee (Landraces) gave the highest mean value (14.00, 14.00 and 15.00) of primary defect with the combination of dried on the raised bed of bamboo, wooden raised bed and mesh wire respectively and also Raya-Azebo bulked coffee (Landraces) with combination of dried on mesh wire was recorded high mean value (14.00) and Raya-Azebo bulked coffee (Landraces) dried on soil floor, cement floor, raised wood mat and bamboo were also recorded medium mean value(13.00, 13.00, 12.00 and13.00) respectively (Table 5).

Whereas Kolatemben and Tselemti bulked coffee (Landraces) showed relatively small mean primary defect value (4.00 and 5.00) this was mainly due to pre and post-harvest practices; such as the aged coffee cannot be replaced, coffee planted without shade, almost no compost or manure used and with poor advisory services: Improper post-harvest practices, like harvesting the coffee by strip or collecting fruits from the ground are the main problem in the study area, and also this could be due to the structural differences on the drying materials. When coffee is placed on raised beds, took longer time to dry due to the sagging nature of mesh tables. While; when coffee is dried on Soil and Cement floors, took shortest drying period as compared to raised beds covered with bamboo, woodden mats and mesh wire. This is also because of Soil and Cement floors have characteristics of high absorption of heat during the day time.

The above result supports the findings of Lower *et al.* (2007) who reported that coffee beans may require more days to dry depending on the methods of drying and the density at which the beans are dried. The result also agrees with the reports of ICO (2010), indicating that as good drying conditions, terraces perform better than tables because of higher temperature effect. Similarly, the result of the present study was also in agreement with the findings of Beza (2011) and Birhanu, (2012), who reported that dry processed coffee on mesh wire took much longer time and coffee drying on bamboo mats and cement floor dried earlier. On the other hand, bricks floor resulted in shorter period (10 days) than did other drying materials across locations.

Table 5: The interaction effect between woredas bulked coffee (Land races) with drying materials on Raw value of coffee from the five selected woredas

Treatments		Responses Variables			
Woreda B. C.	Drying Mtls	Primary defect	Secondary defect	Odor	Total Raw quality
WBC	D1	5(2.35)^{fg}	7(2.65)^{bcde}	8.00^{d}	20.00^{efg}
WBC	D2	8.3(2.88)^{def}	10(3.16)^{abc}	9.70^{b}	27.67^{cd}
WBC	D3	12(3.46)^{abc}	10(3.16)^{abc}	10.00^{a}	32.00^{abc}
WBC	D4	7(2.65)^{fe}	10(3.16)^{ab}	10.00^{a}	27.67^{cd}
WBC	D5	11(3.31)^{abc}	11(3.32)^{ab}	10.00^{a}	32.00^{abc}
HBC	D1	7(2.65)^{fe}	6.5(2.55)^{defg}	8.00^{d}	21.50^{efg}
HBC	D2	11(3.32)^{abc}	9(3.00)^{abcd}	9.30^{b}	30.00^{bc}
HBC	D3	14(3.74)^{a}	9(3.00)^{abcd}	10.00^{a}	33.00^{ab}
HBC	D4	14(3.74)^{a}	9(3.00)^{abcd}	10.00^{a}	33.00^{ab}
HBC	D5	15(3.87)^{a}	12(3.46)^{a}	10.00^{a}	37.**00**^{a}
RBC	D1	13(3.61)^{ab}	9(2.97)^{abcd}	8.00^{d}	30.00^{bc}
RBC	D2	13(3.61)^{ab}	6(2.45)^{defg}	10.00^{a}	29.00^{bc}
RBC	D3	12(3.46)^{ab}	9(3.00)^{abcd}	10.00^{a}	31.00^{abc}
RBC	D4	13(3.60)^{ab}	8(2.82)^{abcd}	10.00	31.00^{abc}
RBC	D5	14(3.74)^{a}	11(3.32)^{ab}	10.00^{a}	35.00^{a}
KBC	D1	4(2.00)^{g}	5.5(2.23)^{defg}	8.00^{d}	17.5**0**^{g}
KBC	D2	6(2.45)^{ef}	3(1.73)^{g}	10.00^{a}	19.00^{fg}
KBC	D3	8(2.83)^{def}	5(2.35)^{defg}	8.00^{d}	21.00^{def}
KBC	D4	6(2.45)^{efg}	3(1.73)^{g}	10.00^{a}	19.00^{efg}
KBC	D5	8(2.83)^{edf}	6(2.45)^{defg}	10.00^{a}	23.67^{de}
TBC	D1	7(2.65)^{fe}	4.5(2.12)^{efg}	8.00^{d}	19.50^{efg}
TBC	D2	8(2.83)^{def}	3.5(1.87)^{fg}	8.70^{c}	20.83^{efg}
TBC	D3	6(2.45)^{efg}	3(1.73)^{g}	10.00^{a}	19.00^{fg}
TBC	D4	6(2.45)^{efg}	5.5(2.35)^{defg}	10.00^{a}	21.50^{efg}
TBC	D5	5(2.35)^{fg}	5(2.23)^{defg}	10.00^{a}	20.00^{efg}
$LSD_{(5\%)}$		1.44	1.57	0.29	1.93
$CV_{(\%)}$		20.75	29.55	4.2	10.01

Means of the same main effect within a column followed by the same letter are not significantly different at $p < 0.05$, WBC=werababoo bulked coffee, HBC=Habru bulked coffee, RBC=Raya-Azebo bulked coffee, KBC=kolatemben bulked coffee, TBC=Tselemti bulked coffee, D1=Soil floor, D2=Cement floor, D3=Raised bamboo bed, D4=Raised wood with mat and D5=Raised mesh wire

4.2.1.2. Secondary defect

With regard to secondary defect, there was significant variations ($p<0.05$) interaction effect was observed between woreda bulked coffee (Landraces) and different drying materials (Appendex Table 5). From the laboratory analysis relatively high mean value (12.00) was obtained from Habru bulked coffee (Landraces) with the combination of dried on mesh wire and also medium mean value (11.00 and 10.00) was recorded in Werababoo woreda bulked coffee with the combination of dried on mesh wire and wood with sack mat and Raya-Azebo woreda bulked coffee with the combination of dried on mesh wire. However relatively the lowest mean value (3.00, 3.00) was recorded for the Kolatemben woreda bulked coffee dried with cement floor and wood with sack mat and in Tselemti woreda bulked coffee on cement floor (Table 5). Because coffee hygroscopic by nature and coffee dried on the raised bed save from external materials, whereas coffee dried on cement floor and soil floor contaminated by different materials.

This result was in agreement with the finding of Dessie (2008) who reported that, although the inherent flavour, 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. Similarly, the result was in line with the report of CLU (2007) indicating that foxy beans commonly observed in locally prepared dry coffee and coffee dried on bricks floor. And according to Wrigley (1988) reported that, coffee quality depends on genetic factors, environmental conditions, agronomical practices, processing systems and storage conditions.

4.2.1.3. Odor

There was significant variation ($p<0.05$) results were obtained for the interaction effects between bulked coffee and drying materials (Appendix Table 5). The woredas' bulked coffee (Werababoo, Habru, Raya-Azebo, Kolatemben and Tselemti) with dried on raised bed of bamboo, wood with sack mat and mesh wire were recorded relatively high mean value (10.00), whereas coffee dried on soil floor were obtained the lowest mean value (8.00).

The possible reasons for this could be the combined effect of processing methods, varietal characteristics which could have determined green coffee bean odor. As a result, Soil and

Cement floor having in contact with undesirable elements and incidence of re-wetting of cherries by rain and dews might have favoured mould development and facilitated deterioration by inducing off-flavours. Whereas, drying tables performed better because of ample air movement and limited condensation and, thus, maintaining the natural odor of coffee bean. The finding of the present work supports the reports of ICO (2010) and Subedi (2010), indicating that coffee dried on bricks floor in contact with soil becomes dirty and blotchy, resulting dull aroma and earthy flavour in the beverage. Drying tables covered with wire mesh or mats would protect the crop from re-wetting, since tables provide two surfaces for moisture loss. Similar results have been reported by Silvano (2004) and FAO (2010) for Arabica coffee processing on drying tables covered with mesh wire or mats, favouring in protection of the dried coffee from re-wetting.

4.2.1.4. Total Raw quality

Total Raw quality is the physical characteristics of the harvested coffee and the sum of the Primary defects, Secondary defects and Odors. Based on this study, there was highly significant variation ($p<0.01$) interaction effect between bulked coffee and drying materials (Appendix Table 5).

From the laboratory analysis relatively the high mean value (37.00 and 35.00) was recorded in Habru and Raya-Azebo woreda bulked coffee (Landraces) dried on mesh wire, while the the lowest mean value (17.50 and 19.00) was obtained in Kolatemben woreda bulked coffee dried on soil and cement floor respectively (Table 5).

This could be attributed to the combined effect of environmental factors and pre-and post-harvest management practices. As a result; coffee dried on Soil and Cement floor in particular had direct contact with foreign matter and was more exposed to re-wetting of cherries, causing quality deterioration of beans. While, raised beds with thick layers favoured mould development and induced blotchy and foxy nature of beans. In general, inappropriate post harvest management practices increased the reddish black (foxy) bean formation, maximized the amount of defects and deteriorated the odor and colour of coffee and finally affected the overall raw quality of green beans. It also revealed that at raised beds using bamboo, wooden and mesh wire may be advantageous for better raw coffee quality characteristics. These findings are quit in agreement with the reports of Musebe *et al.* (2007) and ICO (2010), indicating that sun-drying of coffee on raised beds under good ambient conditions is an effective method for producing improved high quality coffee .The results of the present study also support the findings of Hicks (2002) who reported that mixing different types of coffee or different days of harvest greatly affects the final quality of the green bean.

4.2.2. Organoleptic Quality Attributes

Cup quality assessment is done by panels of experienced coffee tasters and determined on the bases of the level of acidity, cup cleanness, body and flavors of the brew sampled coffee and the mean square of Quality attributes is summarized as in Table follows;

4.2.2.1. Cup cleanness

Cup cleanness is one of among the cup quality attributes and the analysis of variance indicated that there was highly significant ($p<0.01$) variation in cup cleanness at the main factor drying materials only (Appendix Table 6). The result showed that Coffee dried on raised mesh wire have recorded high cup cleanness mean value (15.00) and medium mean value (14.80) was recorded in cup cleanness of coffee dried on raised bed of bamboo and wood with sack mat, however the lowest value was recorded coffee dried on cement floor and soil floor (14.20 and 12.80) respectively (Table 6).

Table 6: Effect of drying materials on Cup cleanness and Acidity of five selected woredas

Drying Materials	Cup cleanness	Acidity
SF	12.80D	10.40D
CF	14.20C	11.80C
BRB	14.80B	13.00A
WRB	14.80B	12.20B
MW	15.00A	13.00A
LCD $_{(5\%)}$	0.20	0.27
CV $_{(\%)}$	3.49	4.84

Means of the same main effect within a column followed by the same letter are not significantly different at p < 0.05, SF= Soil Floor, CF=Cement Floor, BRB=Bamboo Raised Bed, WRB=Wooden Raised Bed, MW=Mesh Wire

The possible reason for this could be differences among the combination effect of genetic, environmental and pre- and post harvest practices of the areas due to the fact that cement and soil floor is direct contact with foreign mater and exposing to rewetting of cherries with rain or dews including off-flavours. The finding of present was supported by Subedi (2010) who confirmed that coffee dried on bricks floor in contact with soil becomes dirty and blotchy, resulting in dull aroma and earthy flavour of the beverage. Similar results have been reported by Selmar *et al*., (2006) and ICO (2010), indicating that Arabica coffee drying tables covered with mesh or mats are used to minimize re-wetting, since tables have two surface for moisture loss or air movement and may result in better quality.Anwar, (2010) Beza, (2011) and Birhanu, (2012) also they reported that Coffee drying on cemented floor, bricks floor and raised bed of mesh wire, bamboo and wood materials has better quality than coffee drying on the ground.

4.2.2.2. Acidity

Acidity is the primary coffee test sensation, and high acid coffee has a pointed sharp pleasing flavour more over when the sugar concentration increase, the overall sweetness of the coffee also increase. From the laboratory analysis, the main factor of Drying materials was statistically highly significant (p<0.01) variations (Appendix Table 6).

From the laboratory analysis we observed that, drying materials of mesh wire and bamboo raised bed (13.00) the same with other findings high value was recorded in terms of Acid and coffee dried on wooden with sack bed also was obtained moderately mean value acid (12.00), whereas cemented floor and soil floor dried bulked coffee (11.80 and 10.40) had the lowest mean value of acid (Table 6). This difference is based on the drying materials, environmental condition: Altitude, daily temperature fluctuation, amount and distribution of rainfall, physical and chemical characteristics of soil, pre and post-harvest practices.

The findings are quite in agreement with the reports of Musabe *et al*.(2007) and ICO (2010), indicating that the sun drying of coffee on raised beds under good ambient conditions is an effective method for produced improved high quality coffee. And 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. And also agreed with the findings of Anwar (2010) and Beza (2011) and they reported that Coffee drying on cemented floor, bricks floor and raised bed of mesh wire, bamboo and wood materials has better quality than coffee drying on the ground.

4.2.2.3. Body

There was marginal significant variation ($p<0.0597$) results were obtained for the interaction effects between bulked coffee and drying materials (Appendix Table 6). The woredas' bulked coffee Raya-Azebo dried on raised bed of mesh wire were recorded statistically high mean value was recorded (15.00), whereas Tselemti woreda bulked coffee dried on cement floor and soil floor were obtained the lowest mean value (9.00) (Table 9). The observed result could be due to the combined effect of the genetic variation, environmental condition: Altitude, daily temperature fluctuation, amount and distribution of rainfall, physical and chemical characteristics of soil, pre and post-harvest practices. This finding is in line with that of Yigzaw (2005) and Avelino et al. (2005), indicating that provided other factors are kept constant, better quality coffee can be produced at higher altitudes, while lowland coffees are somewhat bland, with considerable body. Beverage quality is, therefore, partly determined by environmental factors. and also agreed with the findings of Anwar (2010) and Beza (2011) and they reported that Coffee drying on cemented floor, bricks floor and raised bed of mesh wire, bamboo and wood materials has better quality than coffee drying on the ground.

4.2.2.4. Flavour

Flavour indicates that fragrance of the liquor either by direct inhaling of the vapours rising from the cup or nasal perception of the volatile substances evolving in the mouth. As a result from the laboratory analysis, both the main factors of woredas' bulked coffee and drying materials are statistically high significant ($p<0.01$) variation (Appendix Table 6).

Table 7: Effect of woredas bulked coffee (Land races) and drying materials on the Flavor of coffee collected from the five woredas

Parameter	Soil floor	Cement floor	Bamboo rased bed	Wood raisedbed	Mesh wire	Mean
WBC	12(3.46)	12(3.46)	13(3.60)	12(3.46)	15(3.87)	12.80B
HBC	12(3.46)	12(3.46)	13(3.60)	13(3.60)	11(3.31)	12.20C
RBC	12(3.74)	15(3.46)	14(3.87)	15(3.74)	15(3.87)	14.20**A**
KBC	11(3.31)	11(3.31)	12(3.46)	12(3.46)	13(3.60)	11.80D
TBC	12(3.45)	10(3.15)	13(3.6)	12(3.46)	12(3.46)	11.80D
Mean	11.80CD	12.00C	13.00AB	12.80BC	13.20**A**	
LCD $_{(5\%)}$	0.31					
CV $_{(\%)}$	5.02					

Means of the same main effect within a column followed by the same letter are not significantly different at $p < 0.05$, WBC=werababoo bulked coffee, HBC=Habru bulked coffee, RBC=Raya-Azebo bulked coffee, KBC=kolatemben bulked coffee, TBC=Tselemti bulked coffee

As a result from the laboratory analysis, Raya-Azebo woreda bulked coffee (Landraces) statistically high mean value (14.20) recorded. However, the lowest mean value (11.80 and 11.80) was obtained in Tselemti and Kolatemben woredas' bulked coffee. Furthermore, the drying materials of bamboo raised bed and mesh wire high mean value (13.00 and 13.20) in terms of flavour respectively. In addition, coffee dried on wooden with sack mat was recorded moderately mean value acid (12.80), whereas coffee dried on cemented floor and soil floor (12.00 and 11.80) had the lowest mean value in acid respectively (Table 7). The difference is based on the combined effect of the genetic variation, environmental condition: Altitude, daily temperature fluctuation, amount and distribution of rainfall, physical and chemical characteristics of soil, pre and post-harvest practices. The present finding agrees with the report of Endale (2008) who reported that coffee with a better attention and continuous stirring resulted in a better flavour. Prodolliet **(**2004) and FAO (2010) also reported that natural coffees present strong body and aroma, mildly acidity and sweet flavour. Coffee beans grown at medium to higher elevations tend to be denser, larger, and have better flavour.

Negussie *et al.,* (2009) also reported that properly processed coffee is free of off-flavour and has balanced and good acidity, body and flavour. In addition, Wintgens (2004) indicated that beans produced at low altitude have a negative effect on the flavour and the structure of the fruits due to accelerated maturation. In general, provided that other factors are kept constant, dry processing using raised beds covered with bamboo, Wooden mats and mesh wires improved cup quality characteristics.

On the contrary, Soil and Cement floors exposed to undesirable elements favoured further fermentation which in turn deteriorated the cup quality attributes. The present study agrees with the findings of ICO (2010) and Musebe et al. (2007) who confirmed that improved sun-drying using raised beds is advantageous for improved quality. Anwar (2010) also reported that coffee drying by using raised bed with mesh wire and bamboo mats have resulted in better quality. Furthermore, Behailu (2008) also reported that higher heaps may result in admixture of under and over dried beans and unevenly heaped coffee yields inferior cup quality.

4.2.2.5. Total cup quality

From the laboratory analysis, both the main factors of woredas' bulked coffee and drying materials are statistically high significant ($p<0.01$) variation (Appendix Table 6). As shown in the laboratory analysis, Raya-Azebo woreda bulked coffees (Landraces) statistically high mean value recorded (52.20). However, the lowest mean value (48.20 and 48.20) was obtained in Tselemti and Kolatemben woredas' bulked coffee. Furthermore, the drying materials of bamboo raised bed, wood with sack mat and mesh wire the same with other findings high mean value were recorded (52.20, 52.20 and 52.20) in terms of total cup quality respectively. Whereas cemented floor and soil floor dried bulked coffee (47.60 and 46.80) had relatively the lowest mean value of acid respectively (Table 8).

Table 8: Effect of woredas bulked coffee (Land races) and drying materials on Total Cup quality of the five selected woredas

Parameter	Soil floor	Cement floor	Bamboo raisedbed	Wood raisedbed	Mesh wire	Mean
WBC	48(6.93)	48(6.95	54(7.35)	54(7.35)	55(7.41)	51.80B
HBC	48(6.93)	50(7.07)	52(7.21)	53(7.28)	46(7.43)	49.80C
RBC	47(6.85)	50(7.07)	54(7.35)	53(7.28)	**57(7.55)**	**52.20A**
KBC	47(6.71)	45(6.71)	49(7.00)	50(7.07)	52(7.21)	48.60D
TBC	**44(6.63)**	45(6.71)	52(7.21)	51(7.14)	51(7.14)	48.60D
Mean	46.80BC	47.60B	**52.20A**	**52.20A**	**52.20A**	
LCD $_{(5\%)}$	0.29					
CV $_{(\%)}$	2.52					

Means of the same main effect within a column followed by the same letter are not significantly different at p < 0.05, WBC=werababoo bulked coffee, HBC=Habru bulked coffee, RBC=Raya-Azebo bulked coffee, KBC=kolatemben bulked coffee, TBC=Tselemti bulked coffee

The difference was based on the combined effect of the genetic variation, environmental condition: Altitude, daily temperature fluctuation, amount and distribution of rainfall, physical and chemical characteristics of soil, pre and post-harvest practices. This is related with finding of (Petraco, 2000; EAFCA, 2008) and they reported that High acid coffees have a sharp, pleasing snappy flavor, not biting gives better quality and more intense aroma to the beverage. And according to Behailu et al., (2008) said that Quality of coffee is a product of the desirable characteristics such as clean raw attractive aroma and good Cup taste.

4.3. Total Quality

The Total quality of coffee is the overall quality of the coffee based on that result it is used to determine and evaluate the quality potential of the coffee variety. Among the different woredas bulked coffee (Landraces) evaluated for their total quality, there were highly significant variations ($p<0.01$) interaction effect was observed between woreda bulked coffee and Drying materials (Appendix Table 6).

The maximum total quality mean value (93.00 and 91.00) was recorded from the woredas' bulked coffee (Landraces) of Habru and Raya-Azebo respectively with the coffee dried on raised bed mesh wire respectively, while the least mean value was recorded (63.47) from the woredas' bulked coffee (Landraces) of Kolatemben dried on cement floor (Table 9).

Table 9: Interaction effect of woredas bulked coffee (Land races) withDrying materials of Body, Total quality and Grade in Northern Ethiopia

Treatments			Responses Variables	
Woreda B. C.	Drying Materls	Body	Total Quality	Grade
WBC	D1	12(3.46)^{bcd}	68.17^{ghij}	3.67^{bcd}
WBC	D2	11(3.32)^{cde}	74.00^{fg}	3.33^{cde}
WBC	D3	12(3.46)^{bcd}	86.00^{bcd}	1.67^{ij}
WBC	D4	13(3.61)^{abc}	83.00^{bcde}	2.00^{hi}
WBC	D5	13(3.60)^{abc}	88.00^{abc}	1.33^{ij}
HBC	D1	11(3.32)^{cde}	66.33^{hig}	4.00^{abc}
HBC	D2	11(3.32)^{cde}	79.67^{def}	2.33^{fg}
HBC	D3	13(3.61)^{abc}	85.00^{bcde}	2.00^{hi}
HBC	D4	12(3.46)^{bcd}	87.33^{abcd}	2.00^{hi}
HBC	D5	14(3.74)^{ab}	93.00^{a}	1.00^{j}
RBC	D1	11(3.32)^{cde}	78.33^{ef}	2.67^{efg}
RBC	D2	11(3.32)^{cde}	79.00^{def}	2.67^{efg}
RBC	D3	14(3.74)^{ab}	83.00^{bcde}	2.00^{gh}
RBC	D4	14(3.74)^{ab}	84.00^{bcde}	2.00^{gh}
RBC	D5	15(3.87)^{a}	91.00^{ab}	1.00^{j}
KBC	D1	10(3.15)^{ed}	63.47^{j}	4.00^{abc}
KBC	D2	12(3.46)^{bcd}	65.67^{ij}	4.67^{a}
KBC	D3	11(3.32)^{cde}	68.00^{ghij}	4.00^{abc}
KBC	D4	12(3.46)^{bcd}	69.00^{ghij}	3.67^{bcd}
KBC	D5	14(3.74)^{ab}	74.33^{fg}	3.00^{def}
TBC	D1	9(3.00)^{e}	63.83^{ij}	4.33^{ab}
TBC	D2	9(3.000)^{e}	65.17^{hij}	4.00^{abc}
TBC	D3	14(3.74)^{ab}	71.00^{gh}	3.33^{cde}
TBC	D4	12(3.46)^{bcd}	70.00^{ghi}	3.67^{bcd}
TBC	D5	13(3.61)^{abc}	71.00^{gh}	3.33^{cde}
LSD $_{(5\%)}$		0.3	2.63	0.33
CV $_{(\%)}$		5.41	4.7	15.76

Means of the same main effect within a column followed by the same letter are not significantly different at p < 0.05, WBC=werababoo bulked coffee, HBC=Habru bulked coffee, RBC=Raya-Azebo bulked coffee, KBC=kolatemben bulked coffee, TBC=Tselemti bulked coffee, D1=Soil floor, D2=Cement floor, D3=Raised bamboo bed, D4=Raised wood with mat and D5=Raised mesh wire

This could be due to the drying period is very long when coffee is dried on cement therefore when the time drying take too much time with high moisture content it is hard to determines and also based on the environmental condition: Altitude, daily temperature fluctuation, amount and distribution of rainfall, physical and chemical characteristics of soil, pre and post-harvest practices. These results are in agreement with the findings of Avelino et al. (2005) and Yigzaw (2005) reported that, beverage quality is partly determined by environmental factors. Similarly, this result also agrees with the findings of Mekonnen (2009) the sun dried coffee on raised beds with mesh wire following appropriate management had a good physical and over all cup quality.

Furthermore, Negussie et al. (2009) have indicated that sun dried coffee on raised beds following appropriate management had a good physical and over all cup quality. Silvano (2004) also reported that drying coffee on bricks terraces, favours the development of micro organisms on the surface of cherries increases respiration rate, accelerates the fermentation process and facilitates deterioration. Van der Vossen (1985) has also reported that there exist significant differences among Arabica coffee cultivars for cup quality attributes.

4.4. Grading

Grading is the process of categorizing coffee beans on the basis of various criteria; size of the bean, where and at what altitude it was grown, how it was prepared and picked, how good it tasted or its cup quality. Coffee also graded by the number of imperfections (defective and broken beans, pebbles, sticks, etc.) per sample. Based on the laboratory result, there was highly significant ($p<0.01$) variation interaction effect between the woredas' bulked coffee and drying materials (Appendix Table 6). The maximum grade (1.00) was recorded from the combination of Habru and Raya-Azeboworeda bulked coffee (Landraces) dried with raised mesh wire, while the least grade was recorded (4.67) from the combination of woredas' bulked coffee (Landraces) of Kolatemben dried with cement floor (Table 9).

These observations could be associated with the nature of drying materials, as drying tables covered with bamboo, woodden mats and mesh wire provide protection of the crop from re-wetting because the open lower surface prevents condensation resulting in better quality grades. However, the farmers' conventional systems induce intermixing and re-wetting of cherries and, thus quality deterioration. This result is in line with Yigzaw (2005) who has reported that better quality coffee can be obtained from high altitudes. Anwar (2010) has also indicated that dry processing coffee by using raised bed with mesh wire and bamboo mats produced better quality. Coffee produced in the woredas' of Werababoo, Habru and Raya-Azebo woredas are graded under grade 2, which is relatively best quality even in the country. However, Coffee collected from Kolatemben and Tselemti was grouped as grade 4, which was the lowest grade from the sampled coffee.

Furthermore, the result of this study was in agreement with the finding of Mekonnen (2009) and Beza (2010) who have reported that coffee varieties dried on raised beds following appropriate management had a good physical and over all cup quality. Subedi (2010) has also reported that drying coffee on bricks floor in contact with soil has a great influence on its aroma and flavour. Negussie et al. (2009) have confirmed that properly processed coffee having balanced and good acidity, body and flavour can attain higher grades. The result of the present study is also in line with findings of Yigzawu (2005), indicating the presence of genetic variability among Ethiopian coffee selections for green bean physical characteristics and cup quality attributes. Since the comparative sensorial test as described test as described by ECX (2010) are evaluated based on 1 to 9 scales, where 9 corresponded to the worst cup and 1 to the best cup.

4.5. Correlation Studies

The relationship between green bean physical and cup quality characteristics was assessed and presented in Table 10. The simple correlation analysis showed that Primary defect was highly significant ($p<0.01$) and positively correlated with secondary defect ($r=0.56$), odour ($r=0.34$), cup cleanness ($r=0.26$), body ($r=0.27$), flavour ($r=0.36$) and total cup quality. It is strongly correlated with total Raw quality ($r=0.90$) and Total quality (0.80) and highly significant ($r=0.76$) and negatively correlation with grade (Table 10).

Secondary defect was highly significant ($p<0.01$) and positively correlated with acid ($r=0.31$), flavour ($r=0.36$) and Total cup quality (0.51). It is also significantly ($p<0.05$)and positive correlated with odour ($r=0.23$), cup cleanness ($r=0.15$) and body ($r=0.28$). And highly significant ($p<0.01$) and positive correlated with Total raw quality ($r=0.85$), Total quality ($r=0.78$) and strong negative correlated with grade ($r=0.75$) (Table 10).

Odour was significant ($p<0.5$) and positive correlation with Total raw quality ($r=0.35$), cup cleanes ($r=0.63$), acid ($r=0.54$), body ($r=0.50$), flavour ($r=0.31$), Total cup quality (0.67) and Total quality ($r=0.56$) and negative correlated with grade ($r=0.55$).

Total raw quality was significant ($p<0.05$) and positive correlation with cup cleanness ($r=0.26$), acid ($r=0.40$), body ($r=0.30$), flavour ($r=0.38$) and Total cup quality ($r=54$). It is highly significant ($p<0.01$) and strong positive correlation with Total quality ($r=91$) and strong negative correlation with Grade ($r=0.87$).

Cup cleanness was highly significant ($p<0.01$) and positive correlation with acidity ($r=0.40$), body ($r=0.43$), Total cup quality ($r=0.54$) and Total quality ($r=0.42$) and negative correlated with grade ($r=0.41$). It is significant ($p<0.05$) and positive correlation with flavour ($r=0.23$). Acidity was also highly significant ($p<0.01$) and positive correlation with body ($r=0.32$), Total cup quality ($r=0.54$) and Total quality ($r=0.52$) and significant ($p<0.05$) and positive correlation with flavour ($r=0.17$). It was also highly significant ($p<0.01$) and positively correlated with Grade ($r=0.54$) (Table 10).

Body was highly significant ($p<0.01$) and positively correlated with Total cup quality ($r=0.54$) It was also significant ($p<0.05$) and positive correlated with flavour ($r=0.28$) and significant ($p<0.05$) and negative correlation with Grade ($r=0.48$). Flavour was also highly significant ($p<0.01$) and positive correlated with Total cup quality ($r=0.44$) and Total quality ($r=0.43$) and negative correlated with Grade ($r=0.43$). Total cup quality was highly significant ($p<0.01$) and strong positively correlated with Total quality ($r=0.79$) and strong negative correlation with Grade ($r=0.80$). Furthermore, Total quality had highly significant ($p<0.01$) and strong negative correlated with Grade ($r=-0.97$).

Table 10: Pearson correlation coefficients between the physical and cup quality parameter of Coffee

	PD	SD	OD	TRQ	CC	ACD	BOD	FLA	TCQ	TQ	GR
PD	1	0.56**	0.34**	0.90**	0.26*	0.33**	0.27*	0.36**	0.41**	0.80**	-0.76**
SD		1	0.23*	0.85**	0.15*	0.31**	0.28*	0.36**	0.51**	0.78**	-0.75**
OD			1	0.35**	0.63**	0.54**	0.50**	0.31**	0.67**	0.56**	-0.55**
TRQ				1	0.26*	0.40**	0.30**	0.38**	0.54**	0.91**	-0.87**
CC					1	0.40**	0.43**	0.23*	0.54**	0.42**	-0.41**
ACD						1	0.32**	0.17*	0.54**	0.52**	-0.54**
BOD							1	0.28*	0.54**	0.48**	-0.48**
FLA								1	0.44**	0.43**	-0.45**
TCQ									1	0.79**	-0.80**
TQ										1	-0.97**
GR											1

**, ** indicate significant at 5% and 1% probability level respectively*
PE= Primary defect, SD=Secondary defect, OD=Odour, TRQ=Total Raw Quality, CC= Cup cleanness ACD = Acidity, BOD =Body, FLA= Flavor, TCQ=Total Cup quality, TQ=Total Quality and GR=Grade

4.6. Cost-benefit Analysis

It is used for assessing the foundation for comparing the relative profitability of the drying materials. The cost of coffee processing using different drying material was shown as (Appendix Table 10). The main costs involved in coffee dry processing were the installation cost of the material and the labour cost. Some of the materials used are durable and can be used for at least five years consequently, while most of the materials are used for one-Two year. In addition to that the materials have almost the same costs of coffee cherry for their harvested. However the time taken for coffee cherry drying on these drying of materials in open sun drying was less time observed in Cement floor, Soil floor and Wood with sack mat at the range of 16-17 days, while coffee cherry dried on raised bamboo and mesh wire was taken relatively much time 19-21 days respectively.

Table 11: partial budget analysis of different materials for the five selected woredas

Location	Materials	Total Cost	Revenue	Net benefit
Werababoo	Mesh wire	40	50.75	10.75
	Woodwith sack	42.25	49	7.75
	Bamboo	42.5	49	7.5
	Cement floor	39	45.50	6.5
	Soil floor	36.5	36.75	0.25
Habru	Mesh wire	40	50.75	10.75
	Woodwith sack	42.25	49	7.75
	Bamboo	42.5	49	7.5
	Cement floor	39	45.50	6.5
	Soil floor	36.5	36.75	0.25
Raya-Azebo	Mesh wire	40	50.75	10.75
	Woodwith sack	42.25	49	7.75
	Bamboo	42.5	49	7.5
	Cement floor	39	45.50	6.5
	Soil floor	36.5	36.75	0.25
Kolatemben	Mesh wire	40	50.75	10.75
	Woodwith sack	42.25	49	7.75
	Bamboo	42.5	49	7.5
	Cement floor	39	45.50	6.5
	Soil floor	36.5	36.75	0.25
Tselemti	Mesh wire	40	50.75	10.75
	Woodwith sack	42.25	49	7.75
	Bamboo	42.5	49	7.5
	Cement floor	39	45.50	6.5
	Soil floor	36.5	36.75	0.25

The revenue from coffee processing greatly depends on the quality of the drying material used. However, based on this study the revenue was found to be the highest value (50.75) birr in mesh wire, while 49 birr for both wood and bamboo materials. But the lowest value 45.50 and 36.75 birr for coffee drying on cement and soil floor this is because of the low quality of coffee obtained from dry processing done on bare ground and cement floor.As a result, coffee by nature hygroscopic in nature and, like temperature fluctuation, Relative humidityand atmospheric condition, unexpected rainfall and expose to so many external materials on the place of the coffee cherry drying. So, the coffee processing methods dried on mesh wire resulted high Net benefit (10.75) birr, while on wood with sack mate, bamboo and cement drying materials had got (7.75, 7.5 and 6.5) birr respectively on the other hand coffee dried on soil floor was the lowest almost negative (0.25) birr Net income (Table11).

5. SUMMARY AND CONCLUSION

The relationship between Ethiopians and coffee is deep rooted with Ethiopian history, culture and economy as a result coffee has been cultivated, traded and consumed over centuries and still plays a significant role in the daily life of most Ethiopians. Though coffee is not a major cash crop in the selected study areas, however, it still is very important especially for the werababoo, Habru and Raya-Azebo woreda as compared to those Kolatemben and Tselemti woredas. This study was, therefore conducted in the year 2012/13 under both field and experiment conditions with objectives of assessing quality profile and effect of drying material on the dry processing method of coffee and to assess the impact of drying materials on the quality of dry processed Arabica coffee and to determine the quality profile of landrace coffee from Selected areas Northern Ethiopia.

From the survey results the agronomic practices; pre-harvest and post-harvest practices were not far from the other coffee production areas in Ethiopia. The demographic information for those areas was, 70% Male headed and the remaining 30% female headed, whereas about 62% of the total respondent was illiterate and 44.3% were productive age ranged from 30-50 years old. On the other hand, about 28.7% had owned a coffee farm less than 0.25ha while 30% and 18.7% had owned a coffee farm of the area between 0.25-0.5 ha and 0.5-1 ha. In Pre-harvest practices, 65.3% of the coffee planted in those areas was aged without replacing old plant and no use of compost or manure application on the farm, no intercropping, poor harvesting system, poor mechanism of quality coffee identification, no means of moisture content determination and marketing currently replacing by chat, were some of the most problems for the study areas. Therefore, combination of these may result in complex problem affecting the tree morphology and physiology and finally produce poor quality and low yield of coffee. However spacing between coffee plants (77.3%) and irrigated to the coffee farm (85.7%) during the shortage of rainfall as well as in main rainy seasons could be taken as a good practices for these areas.

And the result of the current experiment showed that the combination effect of raised bed of mesh wire, Bamboo and wooden materials with the woredas bulked coffee or Landraces of

Raya-Azebo Habru and Werababoo was maximum grade recorded grade 2. However the least grade was recorded for the Kolatemben and Tselemti woredas, which was under grade 4. From the economic point of view: Coffee dried on mesh wire had better income (10.75 birr), while bamboo and wood with sack materials (7.5 and 7.75 birr) were next to mesh wire. But coffee dried on cement and soil floor resulted in low income (6.5 and 0.25 birr) due to the poor quality of the coffee. Association among quality attributes (primary defects, Secondary defects Odour, total Raw Quality, acidity, body flavour, Total Cup Quality and Total Quality) were positive correlated and statistically highly significant ($p<0.01$), but negative correlation with grade i.e. less grade score means best quality

6. RECOMMENDATION

In order to be competent in the global market, the country should produce high quality coffees, which can fetch premium prices for the benefit of the growers. On the basis of its affordability appropriate dry processing with sun-drying methods uses fewer infrastructures to produce high quality coffee. Pre-and post-harvest management are needed to improve the quality of dry processed Arabica coffee. With this research out puts, the following recommendation were drawn

- Farmers in Northern part of Ethiopia have limited access to extension service, and coffee grows without shade under excessive light with no replacing of the old age coffee, almost no use of compost or manure application on the farm, no intercropping, poor harvesting system, poor mechanism of quality coffee identification and no means of moisture content determination. Therefore, combination of these may result in complex problem affecting the tree morphology and physiology and finally produce poor quality and low yield of coffee produced.
- Coffee dried on Soil and Cement floor in particular had direct contact with foreign matter and was more exposed to re-wetting of cherries, causing quality deterioration of beans. While, raised beds of mesh wires, bamboo and wooden materials were advantageous for better raw coffee quality and cup quality characteristics.
- Coffee dried on mesh wire had better income, while bamboo and woodden materials were next to mesh wire. But coffee dried on cement and soil floor resulted in low income due to the poor quality of the coffee processed.

7. Future Line of Work

Coffee quality can be best improved through application of appropriate dry processing practices. Hence, from the present findings, gaps have been identified for future research consideration:

- Research geared towards developing or adapting improved coffee varieties from similar agro-ecologies in Ethiopia or other coffee producing countries could be a means to promote better production of coffee in the studied target areas.
- morphological and molecular characterization of the landraces garden coffee growing in those areas is important and an urgent issue
- As wet coffee processing could be challenging in the target woredas, feasibility of semi-washed coffee processing could be tested to further improve the coffee quality.

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8. APPENDICES

Appendix Table 1: Demographic Information Obtained from the Five Selected Woredas' in Northern Ethiopia

Variable	Categor	Woredas																								P Value
		Werababoo (n=60)				**Habru (n=60)**				**Raya Azebo (n=60)**				**KolTemben (n=60)**				**Tselemtie (n=60)**				**Total (n=300)**				
		Fr	%	Mn	SD	Fr	%	Mn	SD	Fr	%	Mn	SD	Fr	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	
Age of respondent	<30	22	36.7			19	31.7			20	33.3			13	21.7			10	16.7			84	28			
	30-50	20	33.3			23	38.3			23	38.3			32	53.3			35	58.3			133	44.3			
	>=50	18	30			18	30			17	28.3			15	25.0			15	25.0			83	27.7			
	Total	60	100	1.93	0.82	60	100	1.98	0.79	60	100	1.95	0.79	60	100	2.03	0.69	60	100	2.08	0.65	300	100	2.00	0.75	0.81
Sex of respondent	M	45	75			37	61.7			37	61.7			48	80			44	73.3			211	70.3			
	F	15	25			23	38.3			23	38.3			12	20			16	26.7			89	29.7			
	Total	60	100	1.25	0.44	60	100	1.38	0.49	60	100	1.38	0.49	60	100	1.20	0.40	60	100	1.27	0.45	300	100	1.30	0.46	0.81
Education level	L*	22	36.7			27	45			20	33.3			23	38.3			22	36.7			114	38			
	IL*	38	63.3			33	55			40	66.7			37	61.7			38	63.3			186	62			
	Total	60	100	1.63	0.47	60	100	1.55	0.50	60	100	1.67	0.48	60	100	1.62	0.49	60	100	1.63	0.47	300	100	1.62	0.49	0.04*
Marital status	Mrrd	45	75			31	51.7			41	68.3			30	50			34	56.7			181	60.3			
	Sigl	10	16.7			15	25			17	28.3			25	41.7			20	33.3			87	29			
	Divo	3	5			12	20			1	1.7			3	5			4	6.7			23	7.7			
	Wdw	2	3.3			2	3.3			1	1.7			2	3.3			2	3.3			9	3			
	Total	60	100	1.37	0.74	60	100	1.75	0.90	60	100	1.37	0.61	60	100	1.62	0.74	60	100	1.57	0.77	300	100	1.53	0.76	0.02*
Family size	1	11	18.3			19	31.7			18	30			14	23.3			11	18.3			73	24.3			
	2	5	8.3			2	3.3			1	1.7			10	16.7			13	21.7			31	10.3			
	3	20	33.3			20	33.3			19	31.7			20	33.3			20	33.3			99	33			
	>=4	24	40.1			19	31.7			22	36.6			16	26.7			16	26.7			97	32.4			
	Total	60	100	2.95	1.11	60	100	2.65	1.23	60	100	2.75	1.24	60	100	2.63	1.12	60	100	2.68	1.07	300	100	2.73	1.16	0.76
Area coverage	<0.25	0	0			7	11.7			5	8.3			35	58.3			39	65			86	28.7			
	.25-.5	18	30			16	26.7			14	23.3			22	36.7			20	33.3			90	30			
	.5-1	16	26.7			18	30			18	30			3	5			1	1.7			56	18.7			
	>=1	26	43.3			19	31.6			23	38.4			0	0			0	0			68	22.6			
	Total	60	100	3.13	0.86	60	100	2.82	1.02	60	100	2.98	0.98	60	100	1.47	0.60	60	100	1.37	0.52	300	100	2.35	1.12	0.05*

Appendix Table 2: Some pre-harvest practices of the selected minor coffee producing woredas in Northern Ethiopia

Variable	Catego	Woredas																								P Val.
		Werababoo (n=60)				Habru (n=60)				Raya Azebo (n=60)				KolaTemben (n=60)				Tselemtie (n=60)				Total (n=300)				
		Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	
Age of tree	<20	28	46.7			30	50			30	50			7	11.			9	15			104	34.7			
	>=20	32	53.3			30	50			30	50			53	88.3			51	85			196	65.3			
	Total	60	100	1.53	0.50	60	100	1.50	0.50	60	100	1.50	0.50	60	100	1.86	0.32	60	100	1.85	0.36	300	100	1.65	0.48	0.00**
Coffee pruning	Yes	5	8.3			0	0			9	15			4	6.7			1	1.7			19	6.3			
	No	55	91.7			60	100			51	85			56	93.3			59	98.3			281	93.7			
	Total	60	100	1.92	0.28	60	100	2.00	000	60	100	1.85	0.36	60	100	1.93	0.25	60	100	1.98	0.13	300	100	1.94	0.24	0.00**
Compost/Fertilizer Application	Yes	5	8.3			5	8.3			4	6.7			2	3.3			1	1.7			17	5.7			
	NO	55	91.7			55	91.7			56	93.3			58	96.7			59	98.3			283	94.3			
	Total	60	100	1.92	0.28	60	100	1.92	0.28	60	100	1.93	0.25	60	100	1.97	0.18	60	100	1.98	0.13	300	100	1.94	0.23	0.39
Space between plants	<3m	3	5			1	1.7			0	0			29	48.3			28	46.7			91	20.3			
	3m	52	86.7			57	95.3			60	100			31	51.7			32	53.3			232	77.3			
	>3m	5	8.3			2	3.3			0	0			0	0			0	0			7	2.4			
	Total	60	100	2.03	0.37	60	100	2.02	0.23	60	100	2.00	000	60	100	1.52	0.50	60	100	1.53	0.50	300	100	1.82	0.44	0.00**
Shade practice	Yes	16	26.7			14	23.3			15	25			0	0			14	23.3			59	19.7			
	No	44	73.3			46	76.7			45	75			60	100			46	76.7			241	80.3			
	Total	60	100	1.73	0.44	60	100	1.83	0.38	60	100	1.78	0.42	60	100	1.90	0.30	60	100	1.73	0.45	300	100	1.80	0.40	0.14
Irrigation used	Yes	52	86.7			52	86.7			54	90			58	86.7			41	68.3			257	85.7			
	NO	8	13.3			8	13.3			6	10			2	13.3			19	31.7			43	14.3			
	Total	60	100	1.13	0.34	60	100	1.13	0.34	60	100	1.10	0.30	60	100	1.03	0.18	60	100	1.32	0.47	300	100	1.14	0.35	0.00**
Interval of irrigation	1/wk	7	11.7			8	13.3			8	13.3			0	0			0	0			23	7.7			
	1/2w	46	83.3			48	93.3			48	93.3			6	10			5	8.3			153	51			
	1/mth	7	12			4	6.4			4	6.4			54	90			35	58.4			104	31.7			
	1/2m	0	0			0	0			0	0			0	0			20	33.3			20	6.4			
	Total	60	100	2.00	0.49	60	100	1.93	0.45	60	100	1.93	0.45	60	100	2.90	0.30	60	100	3.25	0.60	300	100	2.40	0.73	0.00**
Inter cropping	Yes	15	25			10	16.7			13	21.7			6	10			16	26.7			60	20			
	No	45	75			50	83.3			47	78.3			54	90			44	73.3			240	80			
	Total	60	100	1.75	0.44	60	100	1.83	0.38	60	100	1.78	0.42	60	100	1.90	0.30	60	100	1.73	0.45	300	100	1.80	0.40	0.14
Major problems	Weed	37	61.7			42	70			41	68.3			19	31.7			35	58.3			174	58			
	Disea	14	23.3			10	16.7			10	16.7			24	40			16	26.7			74	24.7			
	Pest	9	15			8	13.3			9	15			17	28.3			9	15			52	17.3			
	Total	60	100	1.53	0.75	60	100	1.43	0.72	60	100	1.47	0.75	60	100	1.97	0.78	60	100	1.57	0.75	300	100	1.59	0.77	0.01**
Mechanical control	Trad	47	78.3			46	76.7			55	91.7			60	100			60	100			268	89.3			
	Che	13	21.7			14	23.3			5	8.3			0	0			0	0			32	10.7			
	Total	60	100	1.22	0.42	60	100	1.23	0.43	60	100	1.08	0.28	60	100	1.00	000	60	100	1.00	000	300	100	1.11	0.31	0.00**

Appendix Table 3: Some harvest and post-harvest practices of the five selected minor coffee production woredas in Northern Ethiopia

Variable	Category	Woredas																								P Val.
		Werababoo (n=60)				Habru (n=60)				Raya Azebo (n=60)				KolaTembien (n=60)				Tselemtie (n=60)				Total (n=300)				
		Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	
Coffee harvesting	Selcv	8	13.3			22	13.3			38	36.7			1	1.7			0	0			69	23			
	Strip	37	61.7			18	30			10	16.7			43	71.7			32	53.3			140	46.7			
	Grond	15	25			20	33.3			12	20			16	26.6			28	46.7			91	30.3			
	Total	60	100	2.12	0.61	60	100	1.97	0.84	60	100	1.57	0.81	60	100	2.25	0.47	60	100	2.47	0.50	300	100	2.07	0.73	0.00**
Quintal per harvest	<3Q	5	8.3			9	15			3	5			42	70			60	100			119	39.7			
	3-4Q	18	30			8	13.3			11	18.3			17	28.3			0	0			54	18			
	>=4Q	37	61.7			43	71.7			46	76.7			1	1.7			0	0			127	42.3			
	Total	60	100	2.53	0.65	60	100	2.57	0.75	60	100	2.72	0.56	60	100	1.32	0.50	60	100	1.00	000	300	100	2.03	0.91	0.00**
Who harvest coffee	Famly	47	78.3			53	88.3			46	76.7			60	100			60	100			266	88.7			
	Labor	13	21.7			7	11.7			14	23.3			0	0			0	0			34	11.3			
	Total	60	100	1.22	0.42	60	100	1.12	0.32	60	100	1.23	0.43	60	100	1.00	000	60	100	1.00	000	300	100	1.11	0.32	0.00**
Dried the harvested coffee	Groud	51	85			49	81.7			49	81.7			47	78.3			47	78.3			243	81			
	Cemt	1	1.7			7	11.7			2	3.3			2	3.3			0	0			12	4			
	Bamb	2	3.3			1	1.6			5	8.3			1	1.7			6	10			15	5			
	Wood	6	10			3	5			4	6.7			10	16.7			7	11.7			30	10			
	Total	60	100	1.38	0.96	60	100	1.30	0.74	60	100	1.40	0.91	60	100	1.57	1.14	60	100	1.55	1.10	300	100	1.44	0.97	0.51
Packaging material	Juite	44	90			41	68.3			48	80			47	78.3			56	83.3			236	78.7			
	Plstic	16	10			19	31.7			12	20			13	21.7			4	6.7			64	21.3			
	Total	60	100	1.27	0.45	60	100	1.32	0.47	60	100	1.20	0.40	60	100	1.22	0.42	60	100	1.07	0.25	300	100	1.21	0.41	0.13
Coffee storage	Selctv	7	11.7			8	13			24	40			0	0			0	0			89	13			
	Mix	53	88.3			52	86.7			36	60			60	100			60	100			261	87			
	Total	60	100	1.88	0.32	60	100	1.87	0.34	60	100	1.00	000	60	100	1.00	000	60	100	1.00	000	300	100	1.87	0.34	0.00**
Storage duration	<=4m	32	53.3			52	86.7			60	100			60	100			60	100			264	88			
	>4m	28	46.7			8	13.3			0	0			0	0			0	0			36	12			
	Total	60	100	1.47	0.50	60	100	1.13	0.34	60	100	1.00	000	60	100	1.00	000	60	100	1.00	000	300	100	1.12	0.33	0.00**
Consumers	Pr.Tr	58	96.7			60	100			49	81.7			60	100			60	100			287	95.7			
	Far.C	2	3.3			0	0			11	18.3			0	0			0	0			13	4.3			
	Total	60	100	1.03	0.18	60	100	1.00	000	60	100	1.18	0.39	60	100	1.00	000	60	100	1.00	000	300	100	1.04	0.20	0.00**
Transport system	Anim	44	90			43	71.7			40	66.7			60	100			60	100			247	82.3			
	Huma	16	10			17	28.3			20	33.3			0	0			0	0			53	17.7			
	Total	60	100	1.27	0.45	60	100	1.28	0.45	60	100	1.33	0.48	60	100	1.00	000	60	100	1.00	000	300	100	1.18	0.38	0.00**
Type of selling	Green	9	15			10	16.7			3	5			0	0			0	0			22	7.3			
	Mix.	37	61.7			48	96.7			51	85			60	100			60	100			256	85.3			
	Redrp	14	23.3			2	3.4			6	10			0	0			0	0			22	7.4			
	Total	60	100	2.08	0.62	60	100	1.87	0.43	60	100	2.05	0.39	60	100	2.00	000	60	100	2.00	000	300	100	2.00	0.38	0.02*
Selling price versus national market	Over	28	46.7			21	35			27	45			0	0			0	0			76	25.3			
	Fair	32	53.3			39	65			33	55			55	91.7			50	83.3			209	69.7			
	Under	0	0			0	0			0	0			5	8.3			10	16.7			15	5			
	Total	60	100	1.53	0.50	60	100	1.65	0.48	60	100	1.55	0.50	60	100	2.08	0.28	60	100	2.17	0.38	300	100	1.80	0.51	0.00**
Market information	Own	41	68.3			36	60			25	41.7			60	100			60	100			222	74			
	Radio	7	11.7			4	6.7			9	15			0	0			0	0			20	6.7			
	Buyer	12	20			20	33.3			26	43.3			0	0			0	0			58	19.3			
	Total	60	100	1.52	0.81	60	100	1.73	0.94	60	100	2.02	0.93	60	100	1.00	000	60	100	1.00	000	300	100	1.45	0.80	0.00**

Appendix Table 4: Some information pertaining to coffee traders in five selected woredas of Northern Ethiopia

Variable	Category	Woredas																								P Value
		Werababoo (n=10)				Habru (n=10)				Raya Azebo (n=10)				Kola Tembien (n=10)				Tselemtie (n=10)				Total (n=50)				
		Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	Fr.	%	Mn	SD	
Trade experience	<4yr	3	30			0	0			6	60			8	80			0	0			17	34			
	≥4yr	7	70			10	100			4	40			2	20			10	100			33	66			
	Total	10	100	1.70	0.48	10	100	2.00	000	10	100	1.40	0.52	10	100	1.20	0.42	10	100	2.00	000	50	100	1.66	0.48	0.00*
Types coff of buying	D.chr	10	100			9	90			8	80			10	100			10	100			47	94			
	R.ch	0	0			1	10			2	20			0	0			0	0			3	6			
	Total	10	100	1.00	000	10	100	1.10	0.32	10	100	1.20	0.42	10	100	1.00	000	10	100	1.00	000	50	100	1.06	0.24	0.23
Duration of coffee storage	≤4m	6	60			8	80			10	100			10	100			10	100			44	88			
	>4m	4	40			2	20			0	0			0	0			0	0			6	12			
	Total	10	100	1.40	0.52	10	100	1.20	0.42	10	100	1.00	000	10	100	1.00	000	10	100	1.00	000	50	50	1.12	0.33	0.01*
Market Place	Local	7	70			8	80			6	60			10	100			10	100			41	82			
	AA	3	30			2	20			4	40			0	0			0	0			9	18			
	Total	10	100	1.30	0.48	10	100	1.20	0.42	10	100	1.40	0.52	10	100	1.00	000	10	100	1.00	000	50	100	1.18	0.39	0.00*
General problem	Trsprt	2	20			3	30			1	10			9	90			5	50			20	40			
	Markt	8	80			7	70			9	90			1	10			5	50			30	60			0.0*1
	Total	10	100	2.80	0.42	10	100	2.70	0.48	10	100	2.90	0.32	10	100	2.10	0.32	10	100	2.50	0.53	50	100	2.60	0.50	

Appendix Table 5: Mean square of Physical bean Quality of Landraces coffee collected from Northern Ethiopia

Mean squares					
Source of Variation	Df	Primary defect	Secondary defect	Odour	Total Raw Value
Block	2	0.62	0.91	0.01	0.62
WBC	4	4.01**	4.94**	0.01ns	4.5**
DM	4	0.51**	0.77**	0.33**	0.70**
WBC * DM	16	0.45**	0.26*	0.01*	0.32**
Error	48	0.14	0.22	0.01	0.08
SE(±)		0.37	0.47	0.07	0.28
CV (%)		12.24	18.12	4.2	10.01

**= significant, **= highly significant, ns= non-significant, Df =degree of freedom, WBC=woreda bulked coffee DM= Drying materials*

Appendix Table 6: Mean square of Cup value of the selected woredas' bulked coffee (Landraces) in Northern Ethiopia

Mean squares								
Source of Variation	Df	Cup Cleanness	Acidity	Body	Flavour	Total Cup Quality	Total quality	Grade
Block	2	0.03	0.02	0.16	0.11	0.01	0.40	0.07
WBC	4	0.04ns	0.05ns	0.11*	0.25**	0.29**	2.82**	1.08**
DM	4	0.23**	0.38**	0.60**	0.17**	0.84**	1.72**	0.79**
WBC* DM	16	0.01ns	0.04ns	0.06*	0.04ns	0.02ns	0.13**	0.07**
Error	48	0.02	0.03	0.04	0.03	0.03	0.04	0.02
SE(±)		0.13	0.17	0.19	0.18	0.18	0.21	0.13
CV(%)		3.49	4.84	5.41	5.02	2.52	2.42	8.13

**= significant, **= highly significant, ns= non-significant, Df =degree of freedom, WBC=woreda bulked coffee DM= Drying materials*

Appendix Table 7: Standard parameters and their respective values used for unwashed coffee raw quality evaluation and grading as per ECX (2010)

Raw Value (40%)				Cup Value (60%)									
Defects(30%)				odor (10%)		Cup clean (15%)		Acidity (15%)		Body (15%)		Flavor (15%)	
Primary (count)	Pts (15%	Secondary (count)	Pts (15%	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.clen	12	MPointed	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	2CD	6	Light	6	Light	6	Fair	6
21-25	3	<25%	3	Moderate	2	3CD	3	Lacking	3	Thin	3	Commonish	3
>25	1.5	>25%	1.5	Strong	0	>3CD	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 Defect

Appendix Table 8: Dry Processed coffee bean raw evaluation parameters for defect count rating system.

Defect type	Rate	Defect point
Immature	5x1	1
Pest damage	5x1	1
Foxy	5x1	1
Broken	10x1	1
Black	1x1	1
White	1x1	1
Pod	1x1	1
Husk	Depend on size	1
Stick	Big	10
	Medium	5
	Small	3
Stone	Big	10
	Medium	5
	Small	3
Wanza	1x10	10
Earth (soil)	Big	10
	Medium	5
	Small	3
Soil beans	5x1	1

Source: ECX (2010)

Appendix Table 9: Raw defect type&evaluation system of SCAA and Ethiopia unwashed green coffee bean (ECX,2009)

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

Source: ECX (2010)

Appendix Table 10: Partial Budget analysis of the selected woreda minor coffee production in Northern Ethiopia

Location	Materials	Installation Cost 1	Materials Lifetime 2	Installation Cost for the first yr 3	Days to Drying 4	Labor price/dy /5kg cherry 5	Cost of coffee Cherry(5kg) 6	Total Cost (3+5+6) 7	Revenue	Net benefit
Werababoo	Mesh wire	25	5	5	20.5	5	30	40	50.75	10.75
	Woodwit sack	14.5	2	7.25	17	5	30	42.25	49	7.75
	Bamboo	15	2	7.5	19	5	30	42.5	49	7.5
	Cement floor	20	5	4	17	5	30	39	45.50	6.5
	Soil floor	1.25	1	1.25	16	5	30	36.5	36.75	0.25
Habru	Mesh wire	25	5	5	20.5	5	30	40	50.75	10.75
	Woodwit sack	14.5	2	7.25	17	5	30	42.25	49	7.75
	Bamboo	15	2	7.5	19	5	30	42.5	49	7.5
	Cement floor	20	5	4	17	5	30	39	45.50	6.5
	Soil floor	1.25	1	1.25	16	5	30	36.5	36.75	0.25
Raya-Azebo	Mesh wire	25	5	5	20.5	5	30	40	50.75	10.75
	Woodwit sack	14.5	2	7.25	17	5	30	42.25	49	7.75
	Bamboo	15	2	7.5	19	5	30	42.5	49	7.5
	Cement floor	20	5	4	17	5	30	39	45.50	6.5
	Soil floor	1.25	1	1.25	16	5	30	36.5	36.75	0.25
Kola-Temben	Mesh wire	25	5	5	20.5	5	30	40	50.75	10.75
	Woodwit sack	14.5	2	7.25	17	5	30	42.25	49	7.75
	Bamboo	15	2	7.5	19	5	30	42.5	49	7.5
	Cement floor	20	5	4	17	5	30	39	45.50	6.5
	Soil floor	1.25	1	1.25	16	5	30	36.5	36.75	0.25
Tselemti	Mesh wire	25	5	5	20.5	5	30	40	50.75	10.75
	Woodwit sack	14.5	2	7.25	17	5	30	42.25	49	7.75
	Bamboo	15	2	7.5	19	5	30	42.5	49	7.5
	Cement floor	20	5	4	17	5	30	39	45.50	6.5
	Soil floor	1.25	1	1.25	16	5	30	36.5	36.75	0.25

Jimma University

College Of Agriculture and Veterinary Medicine

Department Of Post-Harvest Management

Questionnaires

Dear respondents, I am conducting a research on the Assessment Coffee Quality Profile on Dry Processed of Northern Ethiopia. So, Woreda-----------------------in -------------------Keble Administration. This questionnaire is designed to collect reliable and relevant information from you on the issue under study. Hence, you are kindly requested to complete (fill) this questionnaire sincerely and honestly. Please, make ‘circle on the numbered.

Region-----------------------Zone-------------------Woreda-----------------Kebelles--------------

Name of Interviewer---

I. Demographic Information

1. Age of respondent 1. <30 2. 30-50 3. >=50
2. Sex of respondent 1 male Headed 2 .female headed
3. Marital status; 1. Married 2. Single 3. Divorced 4. Widowed
4. Family size; 1. One 2. Two 3. Three 4. . >=4
5. Educational level; 1. Illiterate. 2. Literate 3 others
6. Area under coffee; 1. <0.25ha 2. 0.25- 0.5 ha 3. 0.5-1 ha 4. >1ha

II. Pre-Harvest Factors

1. Age of the coffee trees. 1. < 20 years 2.> 20 years

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

3. Do you practice compost/fertilizer application? 1. Yes 2. No

4. What is the space b/n the plant?1. <3M 2.3M 3.>3M

5. Could you use Irrigation beside of Rainfall? 1. Yes 2. No

6. If yes how many times/interval 1. One/week 2.Two/week 3.One /month 4. Two/month

7. Do have shade practice on your farm? 1. Yes 2. No

8. Do you use intercropping on coffee farm with other crops? 1. Yes 2. No

9. What is the major problem in your coffee s farm? 1. Disease 2. Pest 3. Weed 4. Other

10. By what mechanism do you control? 1. Traditionally 2. Chemically

11. Do you get advisory service from extension agents on coffee growing?

1. During seedling planting 3. During harvesting

2. during incidence of disease 4. Any time where technically problem

III. Post-harvest practice

1. What type of coffee harvesting practices do you use during coffee harvesting? 1. Selective picking 2. Strip method 3. From the ground.4. others
2. How many quintal you harvest in your farm 1. <4Qt 2 .4Qt 3. >4Qt
3. By whom do you harvest your coffee? 1On family 2. Daily labor 3. Both
4. Where you dried the harvested coffee 1. On ground 2. On cement 3. On meshwire 4. On wood/bamboo like
5. What type of packaging material use either for transporting or storing? 1. jute bag 2. Plastic material 3. Clay pot 4. Others
6. In what condition can you store the coffee?1. In separate room 2. Mix with other crop 3.Other
7. How long do you store? 1. <4 month 2. >4 month
8. Where did you sell your products? 1. To farmer cooperative 2. To private traders 3.Governmental organization 4. Local market
9. What kind of transport system used? 1. Animal back 2. Truck 3. Human kind
10. What kind/ type of coffee you selling 1. Green coffee 2. Mixed 3. Red-ripe coffee
11. How is the sale price as compare to national market? 1. Fair 2. Under 3. Over
12. From where you get market Information 1. From Radio 2. From own judgment 3. From buyers information

IV. Questionnaires' for Traders

Region-----------------------Zone---------------Woreda----------------Kebeles-----------

Name--

1. Age 1. <35 years 2. >-35 years
2. Level of education 1. Illiterate 2.Literate 3. Others
3. Trade Experience 1. <4years 2. >4years
4. By what mechanisms you to identify the quality of the coffee while buying?
    1. Smelling 2. Color 3. By its locally origin
5. Which type of coffee does you buying?
    1. Dry cherries 2. Parchments 3. Red cherries
6. Method of checking the coffee moisture during buying or before storage?
    1. Cutting the bean 2. Hearing of the sound 3. No means of checking
7. Do you have storage for coffee only? 1. Yes 2. No
8. How long do you keep your coffee in store before taking to market? 1. <4month 2. >4month
9. What is your marketing place? 1. Locally towns 2. Addis Ababa
10. What are the general problems of marketing? 1. Storage 2. Transport 3. PHL 4. Marketing place