Evaluation of harvesting and postharvest processing method on raw quality attributes of green Arabica Coffee beans produced in Hararghe, eastern Ethiopia

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The study was conducted to evaluate different harvesting and postharvest handling methods on the inherent raw quality characteristics of Hararghe coffee. The experiment was designed as a factorial combination of two harvesting (selective and strip harvesting) and six postharvest processing (dry processed dried on bare, cemented and plastic sheet ground, and dry, wet and semi-washed processed dried on mesh wire) methods in a Completely Randomized Design with three replications. The samples were prepared from a Hararghe coffee genotype at Mechara. Samples were evaluated for their raw quality attributes. The results indicated that the main effect of harvesting method was highly significantly influenced all raw quality attributes whereas the effect of postharvest processing methods was highly significantly influenced all raw quality parameters, except odor of unwashed and all raw quality parameters of washed coffee. However, the two interaction effect showed significance variation in bean size. The selective harvesting was better in producing superior quality beans in all parameters. Dry processed method coupled with drying coffee on mesh wire was best in producing coffee beans with high raw quality. In contrast, dry processing using bare ground produced inferior coffee for all raw quality attributes. Wet processing showed superiority over semi-washed processing method.

Key words: Hararghe coffee, harvesting and postharvest practices, green coffee bean, raw quality attributes

INTRODUCTION

Coffee is the world’s most valuable and second most traded agricultural commodity after oil in international trade (ICO, 2007; Alemseged and Yeabsira, 2014). Today, coffee is one of the most important non-alcoholic beverage crops grown in over 80 countries and exported in different forms to more than 165 nations of the world (Dessalegn et al., 2008). It is used as a source of income to several developing countries in Africa, Asia and Latin America (Alemseged and Yeabsira, 2014). Among the 103 diverse species of genus Coffea (Davis et al., 2006), only two species namely Arabica (Coffea arabica L.) and robusta (Coffea canephora Pierre) are under commercial cultivation (Anthony et al., 2002; Pearl et al., 2004). The center of origin of the genus Coffea is geographically isolated from the center of origin of Arabica coffee which is believed to the plateau of southwestern Ethiopia (Anthony et al., 2002; Steiger et al., 2002), the former Limmu province of Jimma, Limmu Kossa district, chorra village.

As the origin of all origins, Ethiopia has another unique feature for the hundreds of heirloom varietals. In many cases, farmers grow their own unique heirloom varietals, the majority of which grow else in the world (Boot, 2011). For example, among the several renowned types of coffee known with very fine quality coffee in Ethiopia Hararghe (former Harar), Sidama and Yirgachefe coffees are well known in contributing their own special quality coffee.
acclaimed for its aroma and flavor characteristics to the world (Boot, 2011; Emebet et al., 2013). Currently these coffee types are registered for trademark in 27 European countries, USA, India, Japan, Canada, Saudi Arabia, China and South Africa (Emebet et al., 2013). Thus, they are sold at a premium price both at domestic and international coffee markets (ITC, 2002).

The region known as Hararghe comprises the eastern most of the coffee growing regions of Ethiopia. It is subdivided into east and west Hararghe zone (Boot, 2011). Coffee produced in this region is a Coffea arabica species growing in the highland and midland areas of the zones and well recognized specialty and exemplified category coffee which is grown mostly without shade (Desse, 2008). It is characterized by medium sized beans with greenish yellow color, medium acidity and full body and a distinctive mocha flavor. Quality of Hararghe coffees are notable for a fruity characteristic and have a distinct note of blueberry, though many other fruity and fruit-like aromatic flavors can occur. Furthermore, it can be differentiated by its amber or golden bean coffee (Boot, 2011). Internationally it is known and recognized as Harar trade brand name and highest premium coffee in the world (EMT, 2012). Therefore, this distinctive fine quality coffee type of this region is currently known by the name of specialty coffee in international market. Among the Hararghe (Harar) coffee, east Hararghe coffees tend to have the most distinct blueberry flavors as the result of a certain varietal growing in a certain soil type in East Hararghe. This is “naturally occurring” amber bean coffee, and often has an excellent, vibrant and rich blueberry flavor. However, often west Hararghe coffees have a thicker, smoother body, and a milder fruit flavor (Boot, 2011). Interns of production quantity west Hararghe zone is contributing about 65% of Hararghe coffees.

As a foreign exchange earner Hararghe coffee is exported to all over the world, but there is a particular demand for it in Saudi Arabia. This constant demand and its premium quality tend to keep the price for commercial grade Hararghe coffee slightly higher than most other Ethiopian coffee regions (Boot, 2011). However, merely having such potential will not bring significant contribution to country’s income unless and otherwise the products meet the demand of customers in terms quality. This mainly requires the improvement of agronomic practices such as harvesting, processing and handling practices. Most farmers in the area harvest coffee by allowing more cherries to mature, immature, some to dry, some to fallen on the ground and some cherries are unripe on the mother tree. They do not practice the recommended selective picking. The main reason discourages farmers not to harvest and process their coffee with great care is absence of premium price for good quality harvest and drying coffees at primarily transaction center (Mohammedsani, 2014). Additionally, in Hararghe only natural sundried method has been used in which coffee cherries are harvested once from the tree and dried on plastic sheet or bare ground (Boot, 2011; Mohammedsani, 2014). These indicate that, the deterioration of physical bean quality of Hararghe coffee. Related to this Desse (2008) reported that, poor harvesting practices such as stripping and collecting dropped fruits from the ground and improper postharvest handling practices such as bad processing and drying on bare ground have contributed a significant share for the production of low quality of green coffee bean. Particularly, in Hararghe coffee raw bean quality is declining from time to time due to poor harvesting and postharvest processing practices (Mohammedsani, 2014).

This adverse situation has been largely attributed to the unsatisfactory quality of the coffee beans rising from poor harvesting and processing methods (Mutua, 2000) attempted to gain some insight into the resolution of the problem. Thus, there is a strong interest for this region of coffee in producing and marketing coffee of higher quality to alleviate financial difficulties encountered by coffee farmers (Behailu et al., 2008). With these reasons, the first priority in research is on coffee quality, paying much attention to quality improvement and maintenance in the coffee growing regions. Hence, in order to produce and supply Hararghe coffee bean with its inherent quality characteristics, it is necessary to conduct research on this first research priority topic that have never been studied in the areas. Therefore, this study was initiated with the specific objective to evaluate the effects of harvesting and postharvest processing methods on raw quality attributes of a Hararghe coffee genotype.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Mechara Agricultural Research Center (MCARC) in 2013 cropping season on young established Hararghe coffee genotype. The center is located near Mechara town in Darolabu district of West Hararge Zone, eastern Ethiopia. It is 434 km east of Addis Ababa, the capital city and 115 km southeast of Chiro town, the zonal capital. Geographically, it is located between latitude of 40°19’29” North and longitude of 8°36’38” East at an altitude of 1760 m.a.s.l. The soil of the center is sandy clay loam that is suitable for Arabic coffee production (MCARC, 2015). The area receives an average annual rainfall of 1100 mm with high variability in the onset and cessation of the main rainfall season. Its annual mean minimum and maximum air temperatures are 14°C and 26°C, respectively.

Experimental material

One promising Hararghe coffee selection namely H-622/98 was used from coffee variety verification research trial started in 2005. The selected genotype was previously collected from Gemmechis district (Chirkane
site) of west Hararghe zone in 1998 and planted at Mechara on station in July 2005. It is among the top yielding genotype from the 14 promising Hararghe coffee selections under evaluation. Regarding its bean quality characteristics, good flavor note is scored for this genotype which shows the typical quality profile of Hararghe coffee (Abdi et al., 2011).

Experimental design

The treatments were arranged using factorial arrangement in a completely randomized design with three replications. Accordingly, the treatments consists of two types of coffee harvesting methods viz.; strip harvesting and selective picking were combined with six types of postharvest processing methods viz.; dry processing drying on bare ground, dry processing drying on cemented ground, dry processing drying on plastic sheet ground, dry processing drying on mesh wire, semi-washed processing and wet processing drying on mesh wire.

Experimental procedures

Coffee harvesting

Coffee cherries were harvested following both harvesting methods (strip harvesting and selective picking). In these methods, cherries were harvested at different times. This is because under strip harvesting, cherries were harvested once at a time when ripe red, turned red, immature green and turned dried cherries (when 75% of the cherries were reached at full ripe) whereas selective picking required more than one harvesting since only red ripe cherries were harvested as they attained this stage. For this, fruit bearing coffee trees were assigned for the two harvesting treatments in such a way that the odd and even number coffee trees were used for strip and selective harvesting methods, respectively. Consequently, harvesting of the coffee cherries was done from October to December 2013. Finally, all cherries harvested by each harvesting method was passed to different postharvest processing methods.

Dry processing

All cherries harvested using both harvesting methods were immediately spread out to dry in the sun using four drying methods (bare, cemented and plastic sheet ground and raised mesh wire table). They were stirred regularly to promote even drying, prevent fermentation and the development of mold in each treatment. All sample cherries were dried up to when their outer shell skin became dark brown and brittle (Clark, 1985; Boot, 2011) or when their approximate moisture content attained 11.5%. Finally dried coffee cherries were collected and hulled with mortar as farmers are practicing carefully and cleaned (ISO, 2004).

Wet processing

Under this processing method the cherries were pulped using single disc hand pulper separately as per the harvesting method. The pulped cherries were collected inside the large size plastic buckets where pulps and floater parchments bean were removed. Subsequently, the wet parchment beans were transferred into other bucket and fresh water was added on it until parchment beans were totally submerged inside the water for fermentation. They were fermented for 40 hours (Woelore, 1993) during which the water was changed three times. When the mucilage was totally degraded, parchment coffee beans were washed intensively for the total removal of mucilage (Boot, 2011). The resulting green parchment beans were prepared and allowed to dry under full sun condition on 80cm above ground raised mesh wire table (Behailu et al., 2008) until approximately their moisture content attained 11.5%. Finally, the samples were slowly hulled and hand polished to remove the parchment and silver skins from green coffee beans (ISO, 2004).

Semi-washed processing

Similar to wet processing method, the harvested cherries were pulped with single disc hand pulper and collected in large size plastic buckets. However, as opposed to it, parchment beans were immediately washed manually and rubbed with canvass cloth by hand until the mucilage was clearly removed from the parchment beans then after the parchment beans were transferred to above ground mesh wire drying table under full sun conditions (ES, 2001). Finally, similar to wet processing method the parchment beans were prepared for raw quality evaluation.

Laboratory analysis

All samples prepared by using the above harvesting and processing methods were assigned an arbitrary code (an identity letter and number) and brought to coffee quality laboratory of Jimma Agricultural Research Center where the green coffee beans were evaluated for different raw quality attributes. The moisture content of the sample was checked using Electronic Rapid Moisture Tester (HE 50, Germany) to make the uniform required moisture level of all samples.

Bean defect collection

Currently, Ethiopian Commodity Exchange (ECX) evaluated raw coffee bean quality with bean defect (primary and secondary defect), odor, color, shape and make as raw quality attributes of green bean in Ethiopia (ECX, 2010). Accordingly, 350 g of green coffee bean sample from each treatment combination was used for defect green bean quality evaluation. Thus, as per ECX (2010) evaluation standard, green coffee beans were evaluated for bean defect by counting primary defect and weighting secondary defects. Defects like full black, full sour, fungus attacked, foreign matter and insect damaged beans were considered as primary defects whereas partial black, partial sour, floater, immature, withered, shell, slightly insect damaged, foxy, under dried, over dried,
mixed dried, stinkers, faded, coated, light and starved beans were identified as type of secondary defects.

**Data collection**

**Bean size:** it is the size of coffee beans which was determined by the conventional screen analysis in which the weight fractions retained on sieve of screen 14 with respective hole diameter of 5.55 mm were recorded and percentage was calculated and used for data analysis.

**Bean weight:** hundred (100) beans were randomly counted from each 350 g sample and their weight was measured in gram using a two digit sensitive balance.

**Primary defect (counted):** different types of coffee bean defects recognized as full black, full sour, fungus attacked, foreign matter and insect damaged were counted from 350 g of green beans sample and the percentage of total defect number was calculated and scored out of 15% for unwashed and 10% for washed coffee bean

**Secondary defect (weighted):** other bean defect type including partial black, partial sour, floater, immature, withered, shell, slightly insect damaged, foxy, under dried, over dried, mixed dried, stinkers, faded, coated, light and starved were collected together from 350 g of green beans and weighed by using a sensitive balance. The percentage of total defect weight was calculated and scored out of 15% for unwashed and 10% for washed coffee bean

**Shape and make:** it is the structural make up of different kinds of beans. It was evaluated out of score 10% only for washed coffee as very good, good, fairly good, average, fair and small and weighed accordingly (ECX, 2010).

**Color:** it is the overall physical appearance of coffee beans that was evaluated out of score 5% only for washed coffee as bluish, grayish, greenish, coated, faded and white (ECX, 2010) and weighed accordingly.

**Odor:** it is the olfaction of coffee beans which was evaluated out of score 10% for unwashed and 5% for washed coffee as clean, fairly clean, trace, light, moderate and strong (ECX, 2010).

**Data analysis**

Data were subjected to analysis of variance (two way ANOVA) using general linear model (GLM) procedure of Statistical Software Program (SAS 9.2). Whenever ANOVA showed significant variation, LSD at 5% probability level was used for treatment mean separation.

**RESULTS AND DISCUSSION**

**Bean size**

Coffee harvesting methods resulted significant (P≤0.01) variation on bean size, while the effect of postharvest processing methods had no significant effect on bean size. This shows processing did not change the size of the bean since it processes bean as it is. However, the interaction effect of harvesting methods by postharvest processing methods showed significant (P≤0.05) variation on bean size. The interaction effect of coffee harvesting and postharvest processing methods on total percentage of bean size retained above screen size 14 ranged from 84% to 93% for selective harvesting and the dry processed dried on cemented ground and semi-washed processed dried on mesh wire, respectively (Table 1). This depicted that coffee beans harvested by selective picking and treated with different postharvest processing methods can meet export standards. In line with this the finding by Mekonen (2009) indicated that, selective harvested coffee of different varieties showed significant variation in bean size by recording highest percentage of beans retained above screen.

However, postharvest processing methods combined with strip harvesting ranged from 69 to 76% for washed and unwashed coffee dried on mesh wire and bare ground, respectively. These can fall under category of rejected commercial coffee according to ECX (2010) standard, in which any Ethiopian export coffee shall have the minimum 85% of bean weight remaining on top of screen 14. This could be due to the effect of collecting different type of fruits viz; immature, mature, red, dried, small, and big size beans. These all together might produce the size of the bean with less uniformity and low percentage of beans below the required screen size. Similarly, Anteneh (2011) reported that, poor harvesting practices, such as stripping different type of fruits together, reduces quality and increases losses by promoting uneven distribution of bean size. In contrast, selective harvesting of red fruits produced uniform bean size that is above the minimum required bean screen size. This in agreement with the finding of Bertrand et al. (2006), who suggested that for C. arabica, picking of red cherries at appropriate maturity stage, gives the best coffee bean size. Similarly, ITC (2002) reported that the quality of a bean size comes from care taken during harvesting.

In general, the percentage of green bean size decreased from selective harvesting (93%) to strip harvesting (69%) combined with semi-washed processing and drying on raised mesh wire table, respectively (Table 1). This is because in contrast to selective harvesting, for strip harvesting there was no any sorting practice rather the beans were directly taken to processing that could increase the number of under sized bean coming from striping of immature and defective cherries. Hence, sorting under size beans can increase percentage of beans retained above screen size 14, though it incurs additional costs. Currently, coffee traders often practice this before transporting it to central market for quality assurance and grading in order to improve quality of coffee and economic return from export market. This support with result of Anteneh (2011) who reported that in order to improve
quality of Hararghe coffee, traders practice some value adding activities like removing defective and under sized beans through sorting and cleaning.

From the present finding, the uniform, bold and heavy coffee beans were obtained from selective harvesting coffee treated under different postharvest processing methods. Besides, this result perhaps attributable due to the genetic characteristics of Hararghe coffee that known by medium bean size that have acceptability in history of Ethiopian coffee market and also good growth habit of this genotype may contribute to the present finding in production of medium to large bean size. This would improve final raw and cup quality of the beans and mostly preferred by roasters to pay premium price. According to Agwanda et al. (2003), bean physical characteristics such as bean size are unified criteria for conducting coffee business within the international market. Similarly, bold and medium bean size has a particular importance to roasters, as uniform bean size would produce uniform roast (Yigzaw, 2005; EAFCA, 2008). Additionally, Barel and Jacquet (1994) supported that, roasting uneven sized beans the smallest tend to burn and the largest tend to be under-roasted, this tend to reduce final quality of the brew.

**Bean weight**

The results indicated highly significant variation in 100 bean weight due to the main effect of harvesting and postharvest processing methods. But the interactions did not significantly affect 100-bean weight. As a result, higher value was recorded from selective harvesting method compared to strip harvesting (Table 2). This might be due to collection of different stage and sized fruits together at once during harvesting which not only affect coffee bean size but also bean weight of the coffee. ITC (2011) also reported that, picking of immature cherry with mature cherries could cause the reduction of weight of the beans. In conformity with this Boot (2006) reported that under almost all conditions, the specific weight of a ripe cherry is greater than that of an immature cherry, it is heavier, weighing up to 20% more.

Similarly, processing methods highly differed and produced an average of 100-bean weight ranging from 12.43 g to 14.97 g. Dry processed and dried on different methods showed light to medium beans and wet processed had medium to heavy beans with mean value of 14.97 g per 100-beans (Table 2). This result generally revealed that dry processed coffee produced bean weight lighter than that of wet processed coffee. This is because under dry processed coffee all harvested cherries (mature and immature) were directly spread to full sun without sorting and clearing as opposed to washed processed in which sorting of abnormal, immature and floaters were performed. In agreement with this, Mekonen (2009) found out that significant difference in bean weight due to effect of processing methods in which dry processed coffee had lower weight than wet processed because of the removal of immature and immersed fruits in washed processing.

**Primary defect**

The effect of harvesting and postharvest processing methods was highly significant variation on primary defect in unwashed or dry processed coffee. Likewise, harvesting methods significantly (P≤0.01) influenced the primary
defect, but postharvest processing methods did not influence in washed coffee processing. Similarly, the combined effect of harvesting and processing methods did not significantly influence primary defect in both washed and unwashed coffee.

The lowest average numbers of primary defects were counted with mean value of 14% out of 15% in unwashed coffee (Table 3) and 9.67% out of 10% in washed coffee (Table 4) for selective harvesting. In contrast, beans from strip-harvested coffee recorded the highest number of primary defect with mean value of 3.25% in unwashed coffee (Table 3) and 6.67% in washed coffee (Table 4). From each treatment, only few numbers of defects like full black, fungus attacked and insect damage were recorded as primary defects in selective harvesting, indicating reduced problems of coffee harvested with selective red ripe cherries gave beans free from primary defect in both processing methods. Similarly, Elsa et al. (2015) found that the probability of coffee varieties free from any primary defect with mean value of 15% was due to proper harvesting of red ripe cherries followed by proper postharvest handling. Moreover, the result revealed that strip harvesting produced coffee beans with high number

<table>
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<tr>
<th>Table 2. Main effect of coffee harvesting and postharvest processing methods on 100-bean weight of promising Hararghe coffee genotype at Mechara</th>
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<tr>
<td><strong>Treatments</strong></td>
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<tr>
<td><strong>Harvesting Methods</strong></td>
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<tr>
<td>Strip harvesting</td>
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<tr>
<td>Selective harvesting</td>
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<tr>
<td>LSD (5%)</td>
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<tr>
<td><strong>Postharvest Processing Methods</strong></td>
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<tr>
<td>Dry processed dried on bare ground</td>
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<tr>
<td>Dry processed dried on cemented ground</td>
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<tr>
<td>Dry processed dried on plastic sheet ground</td>
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<tr>
<td>Dry processed dried on mesh wire</td>
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<tr>
<td>Semi-washed processed dried on mesh wire</td>
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<tr>
<td>Wet processed dried on mesh wire</td>
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<tr>
<td>LSD (5%)</td>
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<tr>
<td>C.V (%)</td>
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<tr>
<td>Mean</td>
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Mean values followed by the same letter(s) within a column are not significantly different at P≤0.05 level of significance.

<table>
<thead>
<tr>
<th>Table 3. Raw quality attributes of natural sun-dried coffee as affected by main effect of harvesting and dry processing methods</th>
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<tbody>
<tr>
<td><strong>Treatments</strong></td>
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<tr>
<td><strong>Raw quality parameter</strong></td>
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<tr>
<td>PD (%)</td>
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<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Harvesting methods</strong></td>
</tr>
<tr>
<td>Strip harvesting</td>
</tr>
<tr>
<td>Selective harvesting</td>
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<tr>
<td>LSD (5%)</td>
</tr>
<tr>
<td><strong>Postharvest processing methods</strong></td>
</tr>
<tr>
<td>Dry processed dried on bare ground</td>
</tr>
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<td>Dry processed dried on cemented ground</td>
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<tr>
<td>Dry processed dried on plastic sheet ground</td>
</tr>
<tr>
<td>Dry processed dried on mesh wire</td>
</tr>
<tr>
<td>LSD (5%)</td>
</tr>
<tr>
<td>CV (%)</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

Mean values followed by the same letter within columns are not significantly different at P≤0.05 level of significance; PD=Primary defect; SD=Secondary defect; NS=Non-significant.
of defects which may be due to harvesting of insect and fungus damaged fruits. This was in agreement with the finding of Barel and Jacquet (1994), who reported traditional selective hand pricking as opposed to strip harvest, produced the best quality green coffee by decreasing the percentage of defects in coffee batches.

With regard to effect of dry processing on primary defect, the highest (11.25%) and the lowest (6.25%) mean values were produced for cherries dried on mesh wire and bare ground, respectively. However, coffee cherries dried on plastic sheet and cemented ground had the same value of 6.50% (Table 3). This might be due to the fact that, fruits dried on bare, plastic sheet and cemented floor had contact with foreign matter, exposed to re-wetting of cherries and less air movement during drying than the raised mesh wire. This could favor development of mold as well as black bean formation. This in turn might have increased the number of primary defect counts that can affect final physical appearance of the beans. The results support Enyan et al. (2013) who pointed out that the drying of coffee beans on the concrete floor and black polythene sheet on concrete floor resulted in a higher percentage of defective beans than on the raised raffia plastic sheet. The authors additionally reported that insect damage and black beans constituted more than 70% of the defective beans, related to the processing methods used.

This is in line with Berhanu et al. (2014) who reported that, inappropriate postharvest management practices increase the foxy bean formation that maximizes the degree of defect counts and affects the odor and color of the coffee that finally affects the raw quality of green beans. Similarly, the present study showed that the presence of defects in coffee was indicative of its reduced quality that translated into price and acceptability of the coffee on the commodity market. Negussie et al. (2009) also pointed out that properly processed coffee is free of off-flavor with few defective beans.

Secondary defect

The result from analysis of variance showed that, there was a highly significant variation in secondary defects due to main effect of harvesting and postharvest processing methods for unwashed coffee. Similarly, the effect of harvesting methods was significant (P≤0.01) but not for postharvest processing methods that showed non-significant variation in washed coffee. However, the interaction effect of harvesting and postharvest processing methods did not significantly affect secondary defect in both dry and washed coffees.

Selective harvesting had high mean value of 12.75% indicating relatively pure coffee bean. However, the lower mean value (3.23%) was recorded from strip harvesting, which indicates high number of secondary defect in poorly harvested and unwashed coffee (Table 3). Similarly, in washed coffee, the highest mean value (9.33%) of secondary defect was recorded for selective harvesting and the lowest (3.33%) for strip harvesting (Table 4). These showed that selective harvesting produced coffee beans free from secondary defects as compared to strip harvesting in dry and wet processed coffee. This is because selective harvesting involves only picking of the red, fully ripe and normal cherries carefully from tree, while in strip harvesting collecting of entire crop (immature, mature, ripe, over mature, dried, insect damaged) just by one pass through cropping season. This result is in line with Hicks (2002) who described that although selective picking is more expensive, but it can produce the best results of coffee by reducing number of defects thereby increase overall quality of coffee that are competent in the world market.

Moreover, coffee processed and dried with different methods showed significant variation on secondary defects. Hence, the highest mean value (12%) was recorded for dry processed coffee and dried on mesh wire, while the lowest value (6.75%) of secondary defect was

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**Table 4. Raw coffee quality attributes of washed coffee as affected by main effect of coffee harvesting and postharvest processing methods**

<table>
<thead>
<tr>
<th>Harvesting Methods</th>
<th>Raw quality attributes</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>PD (%)</td>
</tr>
<tr>
<td>Strip harvesting</td>
<td>6.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Selective harvesting</td>
<td>9.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>1.72</td>
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<table>
<thead>
<tr>
<th>Postharvest processing methods</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Semi-washed processed dried on mesh wire</td>
<td>8.33</td>
<td>6.00</td>
<td>4.56</td>
<td>7.16</td>
</tr>
<tr>
<td>Wet processed dried on mesh wire</td>
<td>8.00</td>
<td>7.00</td>
<td>4.61</td>
<td>7.03</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>C.V (%)</td>
<td>15.80</td>
<td>17.80</td>
<td>4.20</td>
<td>4.50</td>
</tr>
<tr>
<td>Mean</td>
<td>8.17</td>
<td>6.5</td>
<td>3.67</td>
<td>7.10</td>
</tr>
</tbody>
</table>

Mean values followed by the same letter within columns are not significantly different at P≤0.05 level of significance; NS=Non-significant; PD=Primary defect; SD=Secondary defect; SM=Shape and make
recorded in dry processed and dried on bare ground followed by dried on cemented and plastic sheet ground (Table 3). The present finding agrees with Olamcam (2008) result where coffee that is well harvested and properly processed has no or very few broken beans and free of foreign matter (stick, stones, and leaves). Hicks (2002) identified that coffee that has been inappropriately dried would become brittle and produce too many broken beans that considered as secondary defect during hulling. Among the secondary defect observed in this study, the major ones are partial black, foxy, immature, and slightly insect damaged beans, coated, broken, shell and faded beans that have quality deteriorating effects.

Odor

The analysis of variance for unwashed coffee revealed significant variation (P≤0.05) on odor due to the main effect of coffee harvesting and did not affected by postharvest processing methods. In washed coffee, this was highly significant for harvesting methods, but did not differ due to postharvest processing methods. However, in both unwashed and washed coffee, the interaction effect showed non-significant variations on odor.

In both harvesting methods, comparable higher mean values of odor (>8%) were recorded. However, for selective harvesting the mean values of odor was higher than strip harvesting in unwashed coffee (Table 3). All beans had odor point ranging from 8 to 9% which can be categorized as fair clean to clean (ECX, 2010). These showed that green coffee smell was affected due to improper harvesting method. This is in line with the finding of Olamcam (2008) who explained that, properly harvested and processed beans are free of unpleasant (bad) smells. In accordance with this result, Endale (2008) reported that, coffee with better management in each stage starting from harvesting until cupping turn out to have better odor.

On the other hand, in washed coffee higher mean value above four of odor was recorded for selective harvesting method, which can be categorized under clean odor (Table 4). In general, unwashed coffee had fair clean odor and washed coffee had clean odor. Likewise, Anwar (2010) reported that, coffee with better management in each stage starting from harvesting until cupping turn out to have better odor.

Shape and make

Coffee beans significantly (P≤0.01) varied for shape and make due to main effect of harvesting methods, but not significantly affected by postharvest processing methods and the interaction. The highest average value of 8.14% was recorded for selective harvested coffees which possessed a very good shape and make with more uniform appearance (Table 4). Correspondingly, Mekonen (2009) reported the selectively picked red fruits of different coffee accessions have very good shape and make under both wet and dry processing. In contrast, the lower shape and make (6.04%) was recorded from strip-harvested coffees indicating fairly good shape and make with small bean size (Table 4). This perhaps is due to the mixing of mature, immature, under sized and over fermented (on mother tree dried) cherries during strip harvesting that could produce poor appearance beans thereby reduce the flavor and acidity of coffee. In connection with this Anteneh (2011) reported that, either mixing defective beans during harvesting by producers was the main reasons for deteriorating coffee physical appearance. However, Wintgens (2004) indicated that the shape and structure of beans are the result of both genotype and environmental factors.

Color

Green coffee bean color was significantly (P≤0.01) influenced by harvesting methods, however, both postharvest processing and interaction effects of harvesting and postharvest processing did not influence bean color of washed and semi-washed coffee. The result was as opposed to the result of Mekonen (2009) who reported high significant variations among coffees processed in different processing methods. This may be due to the unique genetic characteristics of a Hararghe coffee genotype that can maintain its bean color in any processing method.

Thus, higher mean value (4.10%) was recorded for selective harvested coffees as compared to striped coffee beans (Table 4). This might be due to the mixture of harvesting of different fruits together at once. This agreed with the report of ITC (2002) in that uneven color of the beans revealed from mixing of immature, overripe and ripe coffee cherries during harvesting. Anwar (2010) also found that if coffee is harvested before the beans are ripe or at immature stage, the end product will show color defect. Similarly, Olamcam (2008) reported that, well harvested and processed coffee had clean and uniform color. Furthermore, uneven bean color can be from poor processing, incorrect moisture content during the fermentation, premature aging of the coffee, poor drying techniques, harvesting of overripe cherries, keeping cherries a long time before pulping and/or insufficient washing after natural fermentation (ITC, 2002).

CONCLUSION

Improper harvesting and postharvest processing are adversely affecting quality of the coffee produced in Hararghe region. Taking these problems into account, this study was conducted to evaluate the effect of harvesting and postharvest processing methods on raw quality of a Hararghe coffee genotype. For the study, the coffee cherry samples were prepared from one young established Hararghe coffee selection planted at the Mechara. The evaluation for raw appearance of green bean was conducted in the coffee quality laboratory. Hence, the finding indicated that, bean size was...
significantly affected by harvesting and the interaction of harvesting and postharvest processing methods while, bean weight was affected highly by both harvesting and postharvest processing methods. Coffee beans harvested by selective harvesting and treated under different postharvest processing methods had 85% and above the minimum required bean size for export coffee as compared to strip harvested beans in which all beans are recorded under rejected coffee due to a number of small beans (<76%). Similarly, weight of 100-beans was higher for coffee samples harvested by selective harvesting as compared to strip harvesting. Primary and secondary defects and odor of both unwashed and washed coffee as well as color, shape and make of washed coffees were highly significantly influenced by harvesting methods. Selective harvesting produced beans with high raw quality of all attributes in both washed and unwashed coffee. Postharvest processing treatment highly significantly influenced all raw quality attributes except odor of unwashed coffee but these were not significantly affected in washed coffees. Natural sundried coffee on raised mesh wire was better in producing high raw bean quality with the lowest primary and secondary defects followed by coffee dried on plastic sheet ground floor. In general, the overall findings of the present study indicated that strip harvesting as practiced by many Hararghe coffee producers has a determinant effect on raw and physical appearance of coffee quality in the Hararghe areas. This showed that if producers avoid stripping cherries and practiced selective picking of red cherries only, the quality of coffee could be improved. Moreover, drying coffee on bare ground highly reduced raw, abnormal color and unpleasant odor. Therefore, proper harvesting and drying practices were found to be crucial in maintaining the typical inherent quality characteristics of Hararghe coffee beans.

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