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Research Article

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Impact of Sun Drying Methods and Layer Thickness on the Quality of Highland Arabica Coffee Varieties at Limmu, Southwestern Ethiopia

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Abstract

Coffee is the most important crop in the national economy of Ethiopia and continues to be still the leading export commodity. Despite the economic importance, productivity and quality of the crop is very low. Improper post-harvest processing techniques largely contribute to the decline in coffee quality. However, lack of information on the effects of post-harvest processing and drying on quality necessitates a comprehensive study. Therefore, this experiment was carried out to determine the effects of sun drying methods, variety and cherry drying layer thickness on quality of coffee at highland areas of Limmu, Jimma zone. Accordingly, on-farm processing experiments were conducted at state owned coffee farms under Limmu Coffee Plantation Development Enterprise (LCPDE) from September up to December, 2010. The experiment was laid out in 3 × 3 × 4 Split-Split-plot design arranged in CRD with three replications. The three factors comprise three drying materials: bricks floor, raised beds with bamboo mats and mesh wires assigned to the main-plots. Three coffee varieties: 744, 74110 and 744+74110 assigned to sub-plots and four levels of cherry layer thicknesses: 20; 30; 40 kg/m^2 (uniformly spread) and the farmers' conventional practices (40 kg/m^2) as sub-sub plot treatments. The data were computed by using list significant differences (LSD) procedures of SAS version 9.2. As a result, the interaction effects were highly significant ($P \leq 0.01$) for total coffee quality and significant variations were observed ($P \leq 0.05$) for drying period, total raw quality, total cup quality and coffee grades. The finding revealed that; processing coffee on raised beds using appropriate layer thickness loads of 20 to 40 kg/m^2 at high altitudes produce quality coffee identified as total quality scores ranging 80-89.99 points and can attain "Specialty Grade 1 and 2" classification profiled under grade 2. While, the conventional systems produce low quality coffee identified as commercial grade classifications profiled under grade 3 to 4. Hence, using appropriate dry processing approaches, it is possible to produce specialty coffee.

Keywords: Sun-drying; Layer thickness; Total quality; Specialty coffee

Introduction

Ethiopia is the original home of *Coffea arabica* L, and thus, possesses the largest diversity in coffee genetic resources [1,2]. The total area coverage of coffee in Ethiopia is estimated to be around 800,000 ha of which about 95% is produced by 1.2 million small scale farmers. Currently, Ethiopia exports 170,000 tons and has a domestic consumption is estimated to be about 50% of the total production [3,4]. Coffee processing in Ethiopia is executed by both dry and wet processing methods, of which sun drying is widely practices by farmers and hence it accounts for 71% of the total while washed coffee preparation accounts 29% [5].

Jimma zone is one of the major coffee producing areas with about 105,140 ha of land covered with coffee and it contributes 27% of the country's export coffee and 43% export share of Oromia region [6]. However, Jimma area coffee is the least priced coffee as compared to the other origins it's mainly because of inappropriate processing methods. About 48% of producers spread their coffee on the ground while 49.5% of them dry the crop on raised drying beds using either bamboo mats or wire meshes and only 2.5% dry on cemented/bricks floors [5].

Regardless of the importance of the crop, poor post-harvest processing techniques largely contribute to the decline in coffee quality [7,8]. In general, the traditional processing practices employed by producers have imparted a negative impact on Ethiopian coffee quality [8,9].

Accordingly, few research attempts have been made to optimize with regard to fermentation, drying depth and time of storage for wet processing of coffee [8]. However, post-harvest processing of unwashed coffee at field level has received only a limited attention of researchers. This calls for a concerted effort to identify post-harvest practices for sun drying of coffee to come up with technical recommendations to ensure premium coffee quality. Therefore, this experiment was carried out to determine the effects of sun drying methods, variety and cherry drying layer thickness on quality of Arabica coffee at the highland areas of Jimma. Zone at Limmu Kossa Worda.

Materials and Methods

Description of the study areas

Field processing experiment was carried out at state owned Limmu Coffee Plantation Enterprise (LCPE) in Jimma zone at Kossa coffee

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farm. It is representing the highland coffee growing region with geographical location of 70501N & 360531E. The farm suited at altitude 1850 m.a.s.l. and average maximum and minimum temperature of 25°C and 12°C, respectively with an annual average rain-fall 1680 mm.

Experimental design and treatments

The experiment consisted of three factors, namely, drying method (bricks floor, raised bed with bamboo mats and raised bed with mesh wire), three coffee variety (744, 74110 and their mixture 744+74110 to simulate actual farmers practice) and four cherry layer thickness (with the cherry weight of 20, 30 and 40 kg/m^2 uniformly treated and the farmers conventional practices of mixed drying of different days' harvest (40 kg/m^2) arranged in 3 × 3 × 4 Split-Split-plot design in CRD arrangement with three replications [10]. Drying materials were assigned as main plots, coffee varieties as sub plots and cherry layer thicknesses as sub-sub plot treatments

Data collection and quality analysis

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. The quality analysis 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. Data for the physical and organoleptic analysis were taken from 350 g green coffee sample with optimum moisture content (11.5%). These include: days to drying(days), total raw quality (Primary defect (count) (15%), Secondary defect (weight) (15%) and Odor (10%)), total cup quality (Cup cleanness (15%), Acidity (15%), Body (15%), and flavor (15%)), total quality (Sum total of both physical and organoleptic quality: 90-100=Outstanding specialties, 85-89.99= Excellent Specialties, 80-84.99=Very Good specialties and <80.0= Below Specialty coffee quality (Not Specialty) and grading (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=15-19) [11]. Finally, quality analysis was conducted at Oromia Coffee Farmers Cooperative Union (OCFCU) coffee cupping laboratory in Addis Ababa.

Statistical analysis

The data were checked for normality and subjected to Analysis of Variance (ANOVA) using SAS statistical software (version 9.2). Based on results of the homogeneity test, combined analysis was applied over locations as described by Roger [12]. When ANOVA showed significant differences, mean separation was carried out using Least Significant difference (LSD) test at 5 % and 1% level of significance [13].

Results and Discussion

Drying period

The influence of cherry layer thickness on drying period shows highly significant ($P \leq 0.01$) differences among the density levels of cherries at Kossa (Table 1). When coffee dried on bricks floor with the density levels of 20 kg/m^2 took the shortest time (16 days) to dry cherries. Whereas, when coffee dried on raised beds covered with mesh wire using the layer thicknesses loads of 40 kg/m^2 treated as conventional practices recorded the longest time of drying (24 days). This could be possibly occurred due to the combined effect of the drying methods and the density levels of cherries per unit area together with the location effect have a great influence on rate of dehydration and the performance of the drying period. Coffee dried with thick density levels require longer time to dry when drying on mesh wire due to the sagging nature of mesh tables induced slow dehydration. Lower et al. [14] Reported coffee beans may require more days to dry depending on the methods of drying and the density at which the beans are dried. ICO [15] also confirmed that mesh tables characteristically wilt with the result that layer thickness, and consequently drying rates, are not uniform. For a given thickness layer, the length of the drying process depends mainly on weather conditions and degree of moisture content and size of the cherries [16].

	Drying Material	Levels of Layer Thickness (kg/m^2)			
		20	30	40	40 (conv.)
	Bricks	16.56 h	18.78 f	19.44 e	19.78^e
	Bamboo mats	17.68 g	19.67 e	21.56 c	21.56^c
	Mesh wire	20.68 d	22.44 b	24.56 a	24.56^a
LSD (1%)	0.425				
CV (1%)	2.19				

Table 1: Interaction effects between drying materials and layer thickness on days to drying.

Similarly, the analysis of variance on primary processing activities held at Kossa presented in Figure 1 shows highly significant ($P \leq 0.01$) variations among coffee varieties with respect to days to drying.

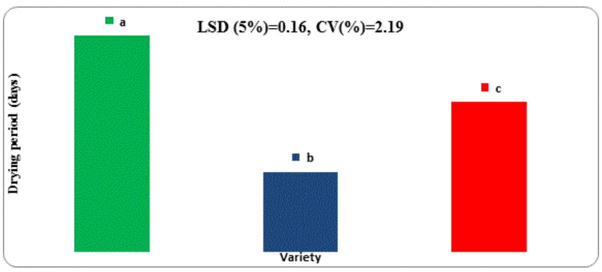

Figure 1: Effects of variety on days to drying of cherries at Kossa.

Coffee variety 744 took the longest time of drying (21 days). On the other hand, the variety 74110 recorded the shortest drying period (20 days). This could be possibly due to the fact that the varietals characteristics and the size of the cherries (beans) have an influence on the drying periods. Coffee variety 744 is identified by its big size beans and luxurious mucilage and requires more time to dry. The result agrees with the findings reported by Gomez et al. [16] the coffee cherry

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dried with its intact outer pulp and large beans may require longer time to dry. Similar results were reported by Solomon et al. [17] who stated that in Arabica coffee for a given thickness layer, the length of the drying process depends mainly on weather conditions and degree of moisture content and size of the berries.

Total raw quality

The analysis of variance in the three way interaction effects showed in Table 2 among drying materials, coffee varieties and cherry layer thicknesses levels showed the presence of significant ($P \leq 0.05$) variability on the total raw quality of coffee at Kossa. Coffee variety 74110 dried on bamboo mats with density level of 20 kg/m^2 scored the highest mean total raw quality value (37.00) points. On the other hand, coffee variety 744, 74110 and (744+74110) dried on bricks floor using the density levels of 40 kg/m^2 and the conventional system recorded the lowest mean total raw quality value (24.50) points respectively. These could be due to the combined effects of the structure of the drying methods, the varietals characters and the density levels of cherries. In the three way interactions, bricks in particular with the thick cherry layers favored for mould development and further fermentation during processing. Hence, inappropriate processing increases the degree of defect counts and affects both color and odor of the beans. The above finding also supports with the findings given by Subedi [18] who confirmed that coffee dried on bricks floor in contact with soil becomes dirty and blotchy resulting into dull aroma and earthy flavor in coffee beverage. Similar results were reported by ICO and Selmar et al. [15,19] processing Arabica coffee on drying tables covered in mesh or mats are used and simplify protection of the crop from re-wetting. Furthermore, the finding of the present work supported by Negussie et al. [20] who pointed out that properly processed coffee is free off- flavor and very few defective beans.

Drying material	Variety	Layer Thickness (kg/m^2)	Total raw quality
Bricks	744	20	26.50^{ijkl}
Bricks	744	30	25.83^{jkl}
Bricks	744	40	24.50l
Bricks	744	40(conv.)	24,50^{l}
Bricks	74110	20	28.00^{fghijk}
Bricks	74110	30	26.50^{ijkl}
Bricks	74110	40	25.17^{kl}
Bricks	74110	40(conv.)	26.50^{ijkl}
Bricks	744+74110	20	26.50^{ijkl}
Bricks	744+74110	30	25.17^{kl}
Bricks	744+74110	40	25.17^{kl}
Bricks	744+74110	40(conv.)	24.50^{l}
Bamboo mats	744	20	30.50^{defg}
Bamboo mats	744	30	35.00^{ab}
Bamboo mats	744	40	29.50^{efghi}
Bamboo mats	744	40(conv.)	27.00^{hijkl}
Bamboo mats	74110	20	37.00^{a}
Bamboo mats	74110	30	35.00^{ab}
Bamboo mats	74110	40	34.00^{abc}
Bamboo mats	74110	40(conv.)	33.00^{bcd}
Bamboo mats	744+74110	20	34.00^{abc}
Bamboo mats	744+74110	30	34.00^{abc}
Bamboo mats	744+74110	40	35.00^{ab}
Bamboo mats	744+74110	40(conv.)	26.50^{ijkl}
Mesh wire	744	20	31.00^{cdef}
Mesh wire	744	30	28.00^{fghijk}
Mesh wire	744	40	29.00^{efghij}
Mesh wire	744	40(conv.)	27.00^{hl}
Mesh wire	74110	20	34.00^{abc}
Mesh wire	74110	30	35.00^{ab}
Mesh wire	74110	40	33.00^{bcd}
Mesh wire	74110	40(conv.)	31.00^{cdef}
Mesh wire	744+74110	20	33.00^{bcd}
Mesh wire	744+74110	30	32.00^{bcde}
Mesh wire	744+74110	40	27.50^{ghijkl}
Mesh wire	744+74110	40(conv.)	30.00^{defgh}
LSD (5%)			3.393
CV (%)			6.97

Table 2: Interaction effects among drying materials, variety and layer thicknesses on total raw quality of unwashed Arabica coffee at Kossa.

Total cup quality

The sensory evaluation revealed significant ($P \leq 0.05$) variations among the coffee varieties on total cup quality characteristics. The highest overall total cup quality mean value (46.50) points were noticed from the variety 74110. Whereas, the varieties 744 scored the least total cup quality mean value (44.83) points (Figure 2). This result possibly found due to the inherent variability that exists in the respective varieties. The variety 74110 is identified by JARC [21] with its small sized beans and commercially accepted quality, while the variety 744 is revealed by its large sized beans and commercially accepted quality. The present finding disagrees with the findings of Van et al. [22] who reported that coffee variety SL28 has big sized beans (46% AA grade size) and excellent cup quality, while Caturra and Rumen Sudan are characterized by small sized beans and lower cup quality. Yigzaw Dessalegn [23] Reported that the presence of genetic variability among Ethiopian coffee selections for green bean physical characteristics and cup quality attributes. This statement also supports the findings of Subedi [18] pertaining to bean size play an important role in roasting processes because many consumers associate bean size with quality. However, large beans do not necessarily taste better than smaller one. Similarly, Agwanda et al. [24]

reported that unlike the popular belief, bean size is not a good indicator of cup quality.

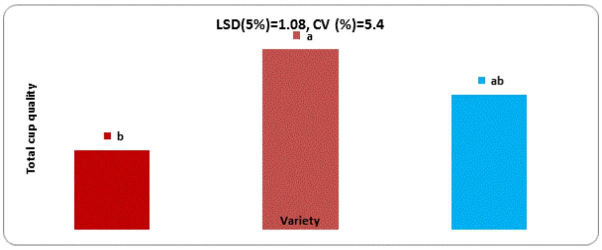

Figure 2: The effects of variety on total cup quality of natural coffee at Kossa.

Similarly, on the basis of the sensory evaluation presented in Table 3 for total cup quality significant ($P \leq 0.05$) variation revealed between the interactions effects of drying materials and levels of cherry layer thicknesses at Kossa. Coffee dried on raised beds covered with bamboo mats with average density levels of 30 kg/m^2 recorded the highest total cup quality mean value (49.33) points. On the other hand, coffee dried on bricks with the coffee loads of 40 kg/m^2 treated as the conventional practices scored the lowest total cup quality mean value (41.33) points. This result possibly found due to the combined effect of the drying methods and the density levels used in coffee processing. The raised beds covered by bamboo mats having flat surfaces with ample air movement using thin layer thicknesses spread uniformly on the drying surfaces prevent uneven drying and maintained the inherent quality attributes of coffee quality. On the contrary, bricks exposed to undesirable elements favored for mould development due to slow dehydration and further fermentation during drying could affect the cup quality attributes. The present finding agrees with the findings of ICO, Musebe et al. [15,25] who confirmed that improved sun-drying wherein coffee is dried on raised drying beds is advocated for improved quality. Furthermore, this result is in line with Aklilu et al. [4] reported that coffee drying by using raised bed with mesh wire, wooden and bamboo mats have better quality. The finding of the present work supported by Subedi [18] who confirmed that coffee dried on bricks floor in contact with soil becomes dirty and blotchy resulting into dull aroma and earthy flavor in coffee beverage. Furthermore, Solomon et al. [17] also reported that higher heaps result a mixture of under dried and over dried beans. Consequently, the coffee is heaped unevenly yielding inferior cup taste or quality. The finding of the present work supported by Antonym et al. [26] the natural coffee processing can produce high quality coffee and creates a highly preferred coffee compared to full wash and wet- hulled indicating that processing does have an identifiable influence on cup taste.

Drying Materials	Layer Thickness (kg/m^2)	Total cup quality
Bricks	20	46.33^{bcd}
Bricks	30	47.00^{abc}
Bricks	40	43.00^{ef}
Bricks	40(conv.)	41.33^{f}
Bamboo mats	20	48.00^{ab}
Bamboo mats	30	49.33^{a}
Bamboo mats	40	46.66^{bc}
Bamboo mats	40(conv.)	45.33^{cde}
Mesh wire	20	46.66^{bcd}
Mesh wire	30	44.33^{de}
Mesh wire	40	45.67^{cd}
Mesh wire	40(conv.)	44.67^{cde}
LSD (5%)		2.336
CV(%)		5.40

Table 3: Interaction effects of drying materials and Layer thicknesses on total cup quality coffee at Kossa.

Total coffee quality

The total coffee quality involves the evaluation of both the physical and sensory analysis used to determine the quality potential of coffee. With regards to the total coffee quality at Kossa, the three way interaction effects among sun drying methods, varieties and cherries layer thicknesses revealed significant ($P \leq 0.05$) variations of Arabica coffee (Table 4). The variety 74110 and 744 dried on raised beds covered with bamboo mats using the density levels of 20 and 30 kg/m^2 recorded statistically similar and the highest mean total quality points (86.00) respectively and detected to excellent specialty taste received a "Specialty Grade 1" classification. Furthermore, the variety 744 using the density levels of 20 kg/m^2; the variety 74110 using the layer thickness loads of 30 and 40 kg/m^2 and the combination of the two varieties (744+74110) dried on raised beds covered with bamboo mats with the density levels of 20; 30 and 40 kg/m^2 recorded the mean total coffee quality values (83.00; 84.00; 82.00; 82.00 84.00; and 82.00) points respectively. Similarly, the variety 74110 dried on mesh wire using the density levels of 20 and 30 kg/m^2 scored the mean total quality point (81.00 and 80.00) respectively detected to very good specialty taste received a "Specialty Grade 2" classification. Whereas, coffee variety 744 dried on bricks using thick layer thickness loads of 40 kg/m^2 and similar loads treated as the conventional practices recorded statistically similar and the lowest mean total quality points (64.50 and 63.50) respectively. The rest of the three ways interaction effects of the treatment combinations were identified as commercial grade classifications with specified range (71-80 and 63-70) total quality points profiled under grade 3 and 4 respectively. These results possibly found to be due to the combined effects of all the three factors: sun-drying methods, the inherent variability in the respective varieties and the influence of cherry density levels per unit area. Hence, properly processed coffee drying on raised beds covered with bamboo mats and mesh wire using thin layer thicknesses loads of 20 to 30 kg/m^2 can attains high total coffee quality points and detected to very good specialty taste received a "Specialty Grade 2" classification.The result agrees with the findings of Appropedia [27] who pointed out that a good quality finished dry processed product can only be obtained through the application of appropriate and scientifically tested practices and proper management. Similarly, this result is in line with Anwar and Mekonen Hailemichael, et al. [28,29] who reported that coffee drying by using raised bed with mesh wire and bamboo mats following appropriate management have better quality as far as their total physical and cup quality are concerned. The present finding also

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supports the findings of Antonym et al. [26] who confirmed that if consistent quality control is applied to dry processing the resulting coffee is highly preferred by the specialty coffee industry.

Drying material	Variety	Layer Thickness (kg/m^2)	Total coffee quality
Bricks	744	20	73.50^{ghij}
Bricks	744	30	68.50^{kl}
Bricks	744	40	64.50^{m}
Bricks	744	40(conv.)	63.50^{m}
Bricks	74110	20	77.00^{efg}
Bricks	74110	30	75.50^{fg}
Bricks	74110	40	69.17^{kl}
Bricks	74110	40(conv.)	68.83^{kl}
Bricks	744+74110	20	73.83^{ghi}
Bricks	744+74110	30	71.17^{ijk}
Bricks	744+74110	40	65.50^{lm}
Bricks	744+74110	40(conv.)	64.50^{m}
Bamboo mats	744	20	83.00^{abc}
Bamboo mats	744	30	86.00^{a}
Bamboo mats	744	40	74.50^{fghi}
Bamboo mats	744	40(conv.)	75.00^{fgh}
Bamboo mats	74110	20	86.00^{a}
Bamboo mats	74110	30	84.00^{ab}
Bamboo mats	74110	40	82.00^{bc}
Bamboo mats	74110	40(conv.)	78.00^{def}
Bamboo mats	744+74110	20	82.00^{bc}
Bamboo mats	744+74110	30	82.00^{bc}
Bamboo mats	744+74110	40	82.00^{bc}
Bamboo mats	744+74110	40(conv.)	71.50^{hijk}
Mesh wire	744	20	75.00^{fgh}
Mesh wire	744	30	74.00^{ghi}
Mesh wire	744	40	74.00^{ghi}
Mesh wire	744	40(conv.)	70.00^{jk}
Mesh wire	74110	20	81.00^{bcd}
Mesh wire	74110	30	80.00^{cde}
Mesh wire	74110	40	78.00^{def}
Mesh wire	74110	40(conv.)	78.00^{def}
Mesh wire	744+74110	20	78.00^{def}
Mesh wire	744+74110	30	77.00^{efg}
Mesh wire	744+74110	40	73.00^{ghij}
Mesh wire	744+74110	40(conv.)	76.00^{fg}
LSD (5%)			3.720
CV (%)			3.01

Table 4: Interaction effects of drying materials, variety and layer thicknesses on total quality of unwashed Arabica coffee at Kossa.

Coffee grading

The effects of coffee variety presented in Figure 3 shows highly significant differences at ($P \leq 0.01$) on grades of unwashed Arabica coffee at Kossa. The variety 74110 recorded the highest coffee grading score (2.81) points. While; the variety 744 and the combination of the two varieties (744+74110) scored the lowest and statistically similar coffee grading (3.14 and 3.03) points respectively. The probable reason could be due to the fact that the variability between the inherent quality characteristics of coffee varieties. JARC [21] Identified that coffee variety 74110 is highly suitable in highland areas and induces its intrinsic quality and attained its maximum and commercially acceptable quality grades. This result is in line with Yigzaw Dessalegn [23] who confirmed that the presence of genetic variability among Ethiopian coffee selections for green bean physical characteristics and cup quality attributes. The present finding support Agwanda et al. [24] who reported that unlike the popular belief, bean size was not a good indicator of cup quality. Anwar, et al. and Beza Teklu [28,30] confirmed that dry processed variety 74110 dried on mesh wire, and bamboo mats was profiled under Grade 2. While, the conventional way of coffee preparation samples took lower grade 4 and 3 respectively.

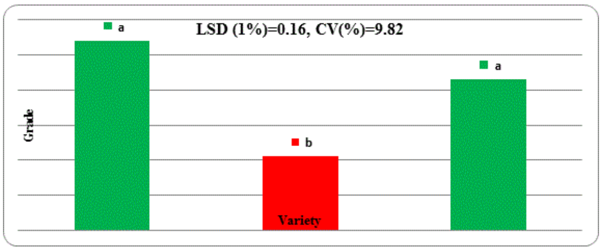

Figure 3: The effects of variety on grades of green bean of natural coffee at Kossa.

Similarly, the two way interaction effects between sun drying methods, and cherry layer thicknesses has significant differences at ($P \leq 0.05$) on grades of unwashed Arabica Coffee Kossa (Table 5). The statistically similar scores of the highest coffee grade (2.00) points respectively were recorded from the coffee dried on bamboo mats using cherries density levels of 20 and 30 kg/m^2. Whereas, the lowest coffee grade score (4.00) was recorded from the coffee dried on bricks with loads of 40 kg/m^2 treated as the conventional practices (mixed drying). The probable reason for coffee grade variations could be due to the fact that the combined effect of the processing technologies and the levels of cherry layer thicknesses during processing determine the coffee quality grades. The farmers' conventional system induced intermixing and re-wetting of cherries to be favored for mould development and quality deterioration. On the other hand, drying tables covered with bamboo mats prevent have flat surfaces and ambient air movements in two sides to facilitate drying and scored the specialty coffee grades. ICO [15] indicated that the thinner the layer the earlier to drying and producing high quality coffee, for coffee drying under good ambient conditions. Moreover, the structure of drying facilities has also a great influence on their performance of produce quality. This result is in line with Anwar, et al. [28] who reported that dry processing method was affected by processing approaches. The finding is also supported by Negussie Efa, et al. [20] who confirmed that properly processed coffee having balanced and good acidity, body and flavor can attain higher grades.

Drying Materials	Layer Thickness (kg/m^2)	Coffee grades
Bricks	20	3.11^{bcd}
Bricks	30	3.56^{abc}
Bricks	40	3.89^{ab}
Bricks	40(conv.)	4.00^{a}
Bamboo mats	20	2.00^{e}
Bamboo mats	30	2.00^{e}
Bamboo mats	40	2.56^{df}
Bamboo mats	40(conv.)	3.00^{cd}
Mesh wire	20	2.78^{cde}
Mesh wire	30	2.89^{cd}
Mesh wire	40	2.89^{cd}
Mesh wire	40(conv.)	3.22^{abcd}
LSD ($P \leq 0.05$)		0.878
CV(%)		9.82

Table 5: Interaction effects of drying materials and Layer thicknesses on grades of dry processed Arabica coffee at Kossa.

Conclusions

Even though Ethiopia is known to be the leading coffee producer and exporter in Africa and fifth major supplier of the global market, its share accounts for only 3% of the global coffee trade. This calls for transition to more dynamic and innovative quality approaches. At Kossa, the finding revealed that coffee drying period is determined by varietals characters and density levels of cherries. Hence, small sized beans (74110) dried earlier while; big sized beans (744) took longer drying period. On the other hand, coffee dried on bricks with layer thickness levels of 20 kg/m^2 dried earlier while, coffee dried on mesh wire with the layer thickness levels of 40 kg/m^2 took much longer time of drying.

Hence, drying coffee on raised beds covered with bamboo mats and mesh wire with thin layer thicknesses loads of 20 to 30 kg/m^2 earned better raw quality attributes. On the contrary, coffee dried on bricks with thick layer thickness (40 kg/m^2) earned the lowest raw quality score.

Variety 74110 scored the highest cup quality points while; variety 744 recorded the lower quality points. Hence, the small sized beans scored the highest cup quality value at Kossa (highland areas).With regards to the two way interactions, coffee dried on bamboo mats with density levels of 20 to 30 kg/m^2 produce better total cup quality attributes. On the other hand, coffee dried on bricks with thick layer thickness loads of 40 kg/m^2 produce poor cup quality characteristics.

Coffee variety 744 and 74110 dried on bamboo mats with layer thickness levels of 30 and 20 kg/m^2 respectively scored statistically similar and the highest total quality points (86.00) and detected to excellent specialty taste received a “Specialty Grade 1” classification. Furthermore, variety 744 dried on raised beds covered with bamboo mats and variety 74110 dried on mesh wire with the density levels of 20 and 30 kg/m^2 recorded the total quality value (>80.00) points detected to very good specialty taste received a “Specialty Grade 2” classification. Similarly, variety 74110 and the combination of the two varieties (744+74110) dried on bricks with the density levels of 20; 30 and 40 kg/m^2 noticed the total quality value (>80.00) points detected to very good specialty taste received a “Specialty Grade 2” classification. Hence, processing coffee with sun drying methods using raised beds covered with bamboo mats and mesh wire using appropriate density levels was noticed to produce a “Specialty Grade” classification.

Variety 744 recorded the lowest grade points whereas, the variety 74110 scored the highest grade points and received a “Commercial Grade” classification profiled under grade 3 and 2 respectively under Kossa condition (highland area) .Similarly, coffee dried on bricks with layer thickness load of 20, 30 and 40 kg/m^2 and the conventional system received “Commercial Grade” classification profiled under grade 3 and 4 commercial grades not specialty standards.

Generally, appropriate dry processing of coffees on raised beds covered with bamboo mats with the density levels of 20 to 4 kg/m^2 and mesh wire using the density levels of 20 to 30 kg/m^2 produce high quality specialty coffee. On the contrary, quality deterioration associated with dry processing in conventional system lowers the quality standards of coffee and is strongly discouraged under smallholders’ farmers’ condition. Hence, special attention should be given to dry processing approaches through refinement of sun drying methods and provisions of extension and training services on post-harvest processing practices for quality improvement of dry processed Arabica coffee. Consequently, based on the interest of consumers and specialty market, producing high quality coffee earns more income for coffee farmers in particular and the coffee industry as a whole.

References

1. Mayne R, Tola A, Kebede G (2002) Crisis in the birth place of coffee: the coffee crisis in the Kaffa province of Ethiopia. Oxfam International Research Papers.
2. Girma Mammo (2003) Agrometriology Geographic Information System to Enhance Coffee V., 2002. Impact of Specialty Coffee Increased Quality & Profits for small holders. California, Colombia.
3. Esayas Kebede (2009) Scaling up Higher Quality Coffee in East Africa-Experience from Ethiopia Internet document.
4. Aklilu A, Ludi E (2010) The Effect of Global Coffee Price Changes on Rural Livelihoods and Natural Resource Management in Ethiopia. A Case Study from Jimma Area. NCCR North-South Dialogue, no. 26. Swisspeace Bern, Switzerland
5. Subedi RN (2010) Comparative Analysis of Dry and wet processing of coffee with respect to Quality in Kavre District, Nepal.An M.Sc. Thesis submitted to Wagengen University. The Netherlands 43-51.

6. Dessie Nure (2008) Physical Quality Standards and Grading System of Ethiopian Coffee in Demand Supply Chain:In Coffee Diversity and Knowledge. EIAR. AddisAbaba, Ethiopia 307-317.
7. Bayetta B, Bahailu A, Gibramu T (1998) Description and Production Recommendations for New Cultivar of Arabica coffee. EARO Research Report No. 34, Addis Ababa, Ethiopia 1-13.
8. Behailu WS, Abrar S, Nigusie M, Solomon E (2008) A Review of coffee Processing and Quality Research in Ethiopia. In: Girma A., Bayeta B, Tesfaye S.(eds). Coffee Diversity and Knowledge. Ethiopian. Institute of Agricultural Research 307-316.
9. Lower ST, Amoah FM, Opaku-Amoyowo K (2007) Drying Process and Ghanian Green Coffee quality Crude Protein, Caffain levels. Cacoa Research Institute of Ghana, Ghana 698-699.
10. Poduska J (2008) Building Split-Split-Plot Designs in Statistical Software. Internet document
11. ECX (2009) ECX Coffee Contracts. Volume 2. Adddis Ababa, Ethiopia
12. Roger GP (1994) Agricultural Field Experiments. Design and Analysis. Marcel Dekker, Inc. New York.
13. Gomez K, Gomez Artrol A (1984) Statistical Procedure for Agricultural Research. (2ndedn). John Wiley and Sons ,Inc.Canada 138-170.
14. Lower ST, Amoah FM, Opaku-Amoyowo K (2007) Drying Process and Ghanian Green Coffee quality Crude Protein, Caffain levels. Cacoa Research Institute of Ghana, Ghana 698-699.
15. ICO (2010) International Coffee Organization, 2010.V (3): 10. http://tw.myblog.yahoo.com/jw!gGk._TCGBxzkQso4M2w-/article?mid=393. pp.1-20
16. Gomez K, Gomez Artrol A (1984) Statistical Procedure for Agricultural Research. (2ndedn.) John Wiley and Sons ,Inc. Canada, 138-170.
17. Solomon E, Behailu WS (2006) The Quality of Wet Processed Arabica Coffee as Influenced by Depth of Parching and Covering Period during Drying. EIAR, Jimma Center 544-548.
18. Subedi RN (2010) Comparative Analysis of Dry and Wet processing of coffee with respect to Quality in Kaure District, Nepal. An M.Sc. Thesis submitted to Wagengen University. The Netherlands 43-51.
19. Selmar D, Bytof G, Knopp SE, Breitenstein B (2006) Plant Biol (Stuttg) 8: 260-264.
20. Negussie Efa, Mitiku Mekonnen, Agwada C (2009) Does Acquisition of Information and Knowledge Suffice? Lesson in Improving Coffee Quality through an innovative and integrated approach in Ethiopia. CABI Africa, Addis Ababa 1237-1241.
21. JARC (1996) Recommended Production Technologies for Coffee and Associated Crops. Jimma Research Center; Jimma, Ethiopia.
22. Van Der Vossen, HAM (1985) Coffee Selection and Breeding. In: Coffee Botany, Biochemistry and Production of Beans and Beverages .ds MN Clifford and KC Wilson Croom Helm, London. New York, sidny 40-96.
23. Yigzaw Dessalegn (2005) Assessment of cup quality, morphological, biochemical and molecular diversity of Coffea arabica L. genotypes of Ethiopia. A PhD Dissertation Presented to University of Free State, South Africa.
24. Agwanda CO, Baradat P, Eskes AB, Cilas C, Charrier C (2003) Selection forbean and liquor qualities within related hybrids of Arabica coffee in multi-local field trials. Euphytica. 131: 1-14.
25. Musebe R, Agwenanda C, Mekon M (2007) Primary Coffee Processing in Ethiopia: In Africa Crop Science Society. Africa Crop Science Conference Proceedings 1417-1421.
26. Antonym M, Surip M (2010) The influence of Primary Processing Methods on Cup Taste of Arabica Coffee from the Indonesian Island of Flores. Indonesian Coffee and Cocoa Research Institute, Indonesia. 1-6.
27. Appropedia K (2010) Code of Practice for Prevention and Reduction of Ochratoxin A contamination in Coffee's-BY-SA Privacy.CAC/RCP 69-2009. 1-10.
28. Anwar, Abasambi (2010) Assessment of Coffee Quality and its Related Problems in Jimma Zone of Oromia Regional State. An M.Sc.Thesis, presented to the school of Graduate studies of JUCAVM, Ethiopia. 91-110.
29. Mekonen Hailemichael (2009) Influence of Genotype, Location and processing methods on the quality of coffee (Coffee Arabica L.). An M.Sc. Dissertation, presented to the schoolof Graduate studies of Hawasa University, Hawasa, Ethiopia. 42-71.
30. Beza Teklu (2011) Effect Of Processing Methods And Drying Materials On The Physical And Sensorial Quality Attributes Of Coffee (Coffea arabica L.) Varieties at Gera and Jimma. An M.Sc. Thesis, presented to the school of Graduate studies of JUCAVM, Ethiopia.