Physical Quality Performance of Some Early Released Coffee Varieties at three Locations in South-west Ethiopia

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Abstract
Ethiopia is the of origin for Coffea Arabica L, which favor researchers, to select 37 CBD resistance varieties for different agro-ecologies/regions. However, the bean qualities of these varieties are not well studied across locations. Therefore, the specific objectives of this research were, to assess the physical quality performance of seven early released coffee varieties at Jimma, Gera and Metu under wet and dry processing methods. A factorial experiment in CRD with three replications was used. The error variances were comparable for the quality attributes considered and the results of combined analysis showed that variety for primary defect, odor & grade, and interaction effect of Loc*PM, Loc*Var, PM*Var for primary defect, secondary defect, total raw & grade whereas interaction effect of Loc*Var*PM for bean size were significant. The highest average bean size was recorded for744 x dry x Gera. The highest total raw quality result was measured for washed and compact coffee varieties at Gera and Jimma where almost all the coffee varieties had more than 37% total raw quality. In contrast, the lowest total raw quality was from variety 744 from Metu. Secondary defects of both wet and dry coffees, maximum values obtained from all coffee varieties under Gera and Jimma as opposed to those under Metu. Coffee odor showed variations among varieties and the lowest result was recorded for variety 744. Total raw was significantly and positively correlated with secondary defect. In general, it can be concluded that the superior coffee quality performance was determined under Gera, Jimma and Metu conditions in that order. The study demonstrated that the compact coffee varieties were superior over the open cultivars, indicating the influence of increased elevation in favoring adaptation and inherent quality traits and detecting suitable processing techniques. The present findings add evidence to coffee genetic diversity and environmental factors and the need to consider more suitable coffee cultivars and processing technique for ensuring sustainable production and supply of the finest quality coffees consistently and improving the livelihoods of the people, particularly the small-scale key actors.
Keywords: Variety, location, processing method, quality

1.Introduction

Coffee belongs to the family *Rubiaceae* and genus *Coffea L.* comprised 104 species native to forests and scrublands of tropical Africa, Madagascar, and the Mascarene Islands in the Indian Ocean (Davis *et al*., 2006, 2010) based on a pre-phylogenetic circumscription. As a result of evolutionary studies, Davis *et al*. (2011) recently subsumed psilanthus Hook. f. into *Coffea* which increases the number of *Coffea* species to 124, with the geographic distribution considerably extended to tropical Asia and Australasia.

Physically, most of the coffee species are originated from tropical African countries. Ethiopia is believed to be the origin and primary center of diversity for the tetraploid *Coffea arabica*, and Central and West African countries are for other coffee species (Berthaud and Charrier, 1988). According to ICO (2012), Ethiopia is the first in Africa and fifth worldwide largest coffee producer next to Brazil, Vietnam, Indonesia and Colombia with a production of 6,500 thousand bags during the crop year 2011/12.

In the past four decades, the Jimma Agricultural Research Center (JARC) has been showing a concentrated effort to develop, release and distribute improved coffee varieties that are high yielding, disease resistance and adaptable to different agro-ecological zones. However, due to the urgency of arresting the progress of coffee berry diseases (CBD) in early 1970s as a serious disease outbreak in the country, and lack of trained personal and detail physical quality evaluation criteria, the early released CBD resistant varieties lack recent physical quality standards. The limited information attached to these coffee varieties was their general physical quality and commercial acceptance as shown in Table 2. In line with the increasing focus to quality-oriented production and trading systems, it is an agenda of top priority to assess and update the physical quality standard of all the released cultivars and promising under different locations using ideal processing methods. This study was initiated to;

- Evaluate physical quality performance of some early released coffee varieties under Jimma, Metu and Gera conditions.
- Evaluate the effect of processing methods on physical quality attributes of these coffee varieties under Jimma, Metu and Gera conditions.

2 . Materials and Methods

2.1. Experimental Varieties

Table 1. Characteristics of the early released and studied coffee varieties

Variety	Yield (q/ha)		Canopy nature	Raw quality	Commercial acceptance	Disease resistance	Released year
	Research	Farmer					
744	16.6	8.9	Open	Average/Good	Acceptable	Resistance	1979/80
74110	19.1	9-10	Compact	Average/Good	Acceptable	Resistance	1978/79
74112	18.1	9-10	Compact	Good	Good and Acceptable	Resistance	1978/79
74140	19.7	9-10	Compact	Average	Hardly Acceptable	Resistance	1978/79
74158	19.1	9-10	Compact	Good	Acceptable	Resistance	1978/79
74165	17.3	8-9	Compact	Good	Acceptable	Resistance	1878/79
75227	17.8	8-9	Open	FAQ	Acceptable	Resistance	1980/81

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

2.2. Experimental Procedures

The data was collected independently for each locality to see the variability that exists among the three locations on coffee physical quality attributes of dry and wet Arabica coffee varieties. Red fully ripe cherry coffees were collected carefully selected from the already established coffee seed orchards having age of ten years. Harvesting was undertaken during the peak season of first round between September and December in 2012. Ripe cherry were simply random harvested from the coffee plant and continue according to the procedure described by ECX for wet and dry processing method. Then, each variety was sub divided in to two processing methods (dry and wet) as follows.

Dry processing: After foreign materials and unripe green berries removed by sorting, samples (three kg per sample) were sun dried on raised compartmented mesh wire drying table (about 0.8m above the ground) and regularly turned to maintain uniform drying to moisture level of 11.5%. During drying the moisture content of the bean was measured using Electronic Rapid Moisture Tester (HE 50, Germany) to know the moisture level of all samples at similar level. Finally dried coffee cherries were collected and hulled using manual/hand hulling machine.

Wet processing: Fresh cherries were pulped using single disc motorized pulper which squeezes the cherries between fixed and moving surface. Subsequently wet parchment coffees were put in fermentation tank according to the agro-ecology to facilitate breakdown of mucilage. After complete fermentation the parchment coffee was properly washed and under gone further fermentation time of soaking (Woe lore, 1993), followed by washing, using clean water to remove all traces and decomposed products of mucilage. Then, wet parchment coffee was sun dried on mesh wire raised bed. Continuous follow up took place till the needed moisture content was achieved. The moisture content of the beans was uniformly maintained at 11.5% for all samples. Finally, the samples were hulled and hand polished to remove the parchment and silver skins from green coffee beans.

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

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% (sundried) and 20% (washed) as the procedure set by (ECX, 2011). 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 counted and secondary defect weighted.

2.3. Data Collection

Screen analysis: is important to identify the different coffee bean size distribution by means of rounded perforated plate called screen. The size of the screen holes was specified in 1/64 inch. The data measured based on coffee bean retained by screen above 14.Three samples are taken in random representing each treatment combinations.

Physical Defect: Defects were manually separated and counted according to their type;
Primary defect (counted): Full Black, Full Sour, Fungus Attacked, Foreign Matter and Insect Damaged
Secondary defect (weighted): Partial Black, Partial Sour, Floater, Immature, Withered, Shell, Slightly Insect Damaged, Foxy, Under Dried, Over Dried, Mixed Dried, Stinkers.

Oder: Whether the coffee was contaminated with bad odor of foreign material or not.
Shape and make: The structural makeup of the different kinds of beans. Shape uniformity and size of the beans i.e., if there was Oval, round, elongated, bourbon, flat, etc was evaluated.
Appearance/Color: The overall appearance (bluish, grayish, greenish, faded, brownish etc.) was analyzed in comparisons to the standard.
Total raw value: The summation of physical quality attributes according to the types of processed coffee in the treatment; accounting 40% of the total coffee quality.

3. Results And Discussion

3.1. Analysis of Variance

Analysis of variance results for raw/physical qualities obtained from the two processing methods of seven varieties grown in three locations. The result revealed non-significant differences among varieties for shape and make, odor and color in all factors. Bean size was significantly influenced by all factors except location and processing methods. The three way interaction (Loc x PM x Var), (PM x Var) and Variety exhibited highly significantly ($P<0.01$) influenced bean size while the two way interactions; Loc x PM and Loc x Var significantly affected bean sizes of varieties. Total raw bean quality of varieties was significantly influenced by all factors (variety, location, processing method and all possible interactions) except the three way interactions. The analysis of grade indicated highly significance ($P<0.01$) for location, processing method, variety and Loc x PM and no significance variation for the others.

The result of primary, secondary and odor of wet and dry processing method were analyzed separately because the value measured for each parameter was different according to the standard of ECX, 2010. The combined analysis of variance depicted that primary and secondary defects were significantly ($P<0.01$) affected by location, variety and their interactions in natural sundried coffees. In here, coffee varieties also significantly differ in odor ($P<0.05$). While, location and Loc x Var indicated no significant differentiation of odor. Likewise, secondary defects of washed processed coffee were highly significant due to the main treatment (location and varieties), and interaction (Loc x Var). Except the significant variation in primary defects of washed coffee among coffee varieties ($P<0.05$) but no significance variation from location and Loc x Var.

3.2. Physical Quality

3.2.1. Bean size

The three way interaction of location, variety, and processing methods was highly significant for bean size. Out of all treatment combinations Gera x 744 x sundried gave the highest (98.53) percentage of bean size. However, other treatments combinations, namely Gera x (74112, 74140, 74158 and 74165) x sundried, Jimma x (744, 74112, and 74158) x sundried, Metu x (744 and 74165) x sundried, Gera x (744, 74110, 74140 and 75227) x washed, Jimma x (74112, 74140 and 75227) x washed, Metu x (744, 74110, 74112 and 74158) x washed, were statistically identical with respect to producing high bean size. On the other hand, percentage of bean size also decreased to 92.13 due to treatment combination of Gera x 74110 x sundried, which was statistically similar with values recorded from the treatment combination of Jimma x (74140 and 75227) x sundried, Metu x (74110 and 74158) x sundried, and Jimma x 74158 x washed. In general, all varieties showed more than 92% of beans were retained above 14 screen size, depicting that all varieties had uniformity in bean size and good market acceptable (Table 2). This result was perhaps attributable due to the limited genetic variation among varieties and open canopy varieties were large bean size. As per results of Yigzaw (2005) and Tesfaye (2006) coffee genotypes collected from northwestern Ethiopia were characterized by bold and medium size beans and bean size is determined by botanical variety and processing method that has a particular importance to roasters since uniform bean size would produce uniform roast.

Table 2. Interaction effect of variety, location and processing methods on bean size of seven coffee varieties

Treatment	Processing method	Location		
Variety		Gera	Jimma	Metu
744	Dry process	98.53[a]	97.50[a-e]	97.96[a-d]
	Wet process	96.50[a-i]	94.40[i-l]	97.96[a-d]
74110	Dry process	92.13[m]	95.90[d-k]	94.03[k-m]
	Wet process	96.50[a-i]	96.26[b-k]	96.86[a-h]
74112	Dry process	98.20[abc]	98.43[ab]	95.06[h-l]
	Wet process	95.63[e-k]	96.56[a-i]	96.36[a-j]
74140	Dry process	97.76[a-e]	93.06[lm]	95.73[d-k]
	Wet process	96.30[a-j]	97.36[a-g]	95.80[d-k]
74158	Dry process	97.50[a-e]	97.36[a-g]	93.26[lm]
	Wet process	94.96[h-l]	94.20[j-m]	96.83[a-h]
74165	Dry process	97.43[a-f]	95.53[e-k]	97.60[a-e]
	Wet process	95.16[g-l]	95.93[d-k]	96.16[c-j]
75227	Dry process	95.23[f-l]	93.20[lm]	94.50[i-l]
	Wet process	96.60[a-i]	96.63[a-i]	95.53[e-k]
LSD (5%)		2.26		
CV (%)		1.45		
Mean		96.06		

Means followed by same letter(s) with in a column are not significantly different at P<0.05

3.2.2. Total raw quality

Among coffee quality parameters evaluated, total raw was highly significantly affected by the interaction effect of location and variety (P<0.01). The treatment combinations of Gera x 744, Gera x 74110, Gera x 74140, Gera x 74158, Gera x 74165 and Gera x 75227 registered the highest total raw values which were statistically similar with treatment combinations of Gera x 74112, Jimma x744, Jimma x74110, Jimma x74112, Jimma x74140, Jimma x74158, Jimma x74165, Jimma x75227 and Metu x 74165. However, the least total raw value was recorded from treatment combination of Metu x 744 (27.50) and that was in turn statistically similar with Metu x 74158 (29.83) and Metu x 75227 (30.16) respectively (Table 3). This may be due to slowed-down ripening process of coffee berries at lower air temperatures and long drying period increase quality. The result is in accordance with (Yigzaw, 2005), if other factors are kept constant, better quality coffee can be produced at higher altitudes, while lowland coffees are somewhat bland.

Table 3. Mean value of total raw (%) quality as influenced by location x variety and processing method x variety

Parameter	Total raw				
Interaction effect	Location x Variety			Variety x Process method	
Variety	Gera	Jimma	Metu	Dry process	Wet process
744	38.83[a]	37.00[abc]	27.50[f]	32.33[b]	36.55[ab]
74110	39.00[a]	38.58[ab]	32.83[de]	35.77[ab]	37.83[a]
74112	38.50[ab]	38.66[ab]	34.83[bcd]	36.22[ab]	38.44[a]
74140	39.00[a]	37.00[abc]	33.25[cde]	35.16[ab]	37.66[a]
74158	39.00[a]	38.25[ab]	29.83[ef]	35.50[ab]	35.88[ab]
74165	39.00[a]	38.41[ab]	37.16[ab]	38.44[a]	37.94[a]
75227	38.66[a]	38.33[ab]	30.16[ef]	34.83[ab]	36.61[ab]
LSD (5%)	3.85			4.31	
CV (%)	4.52			4.52	
Mean	36.37			36.37	

Means followed by same letter(s) with in a column are not significantly different at P<0.05

The combination effect of variety and processing method of total raw showed a significant variation (P<0.01). The highest total raw value was recorded from treatment combinations of Wet x 74110, Wet x 74112, Wet x 74140 and Wet x 74165 and Dry x 74165, which were statistically similar Wet x 744, Wet x 74158, Wet x 75227, Dry x 74110, Dry x 74112, Dry x 74140, Dry x 74158 and Dry x 75227 but treatment combination of 744 x Dry (32.33) that had the minimum mean value (Table 3). This may be due to the effect of processing methods, during post harvest processing unwanted materials was removed, fast to dry and minimize accumulation of moisture. This result agreed with the other quality report (ECQIAC, 2007), the coffee produced by wet processing method is usually of better quality but commands higher prices.

The interaction effect between location and processing method revealed a highly significant difference (P<0.01) on total raw of coffee. The highest total raw holds the treatment combinations of Gera x dry and Jimma x dry with mean value of 39.61 and 38.85 respectively this is statistically significance with treatment combination of Gera x wet (38.09). On the other hand, the minimum total raw value was registered from treatment combination of Metu x dry (Table 4). This may be due to better management of coffee obtained during processing, post harvest and properly prepared sundried coffee was better quality.

Table 4. Mean value of total raw grade of coffee quality as influenced by location and processing method

Parameter	Total Raw		Grade	
Location	Dry Process	Wet Process	Dry Process	Wet Process
Gera	39.61[a]	38.09[ab]	1.90[c]	2.14[c]
Jimma	38.85[a]	37.21[bc]	2.00[c]	2.52[b]
Metu	27.92[d]	36.52[c]	3.33[a]	2.66[b]
LSD (5%)	1.53		0.29	
CV (%)	4.52		17.1	
Mean	36.37		2.42	

Means followed by same letter(s) with in a column are not significantly different at P<0.05

3.2.3. Primary defect

Similarly; primary defect of dry processing methods showed significant variations (P< 0.01) between location and variety. All treatment combinations for Gera, Jimma and Metu registered the highest value of primary defects with mean of 15.00 varieties 744 and 74110 which gave the lowest mean value of 8.00 and 12.00, respectively (Table 5). Primary defect plays a great role in total raw as well as total quality of coffee. This result agreed with the work done by Tesfaye (2006) and Negussie et al. (2009) that pointed out that properly processed coffee is free from off- flavor and very few defective beans.

Table 5. Effect of location and variety on primary defect (%) of sundried coffee quality

Variety	Gera	Jimma	Metu
744	15.0[a]	15.0[a]	8.0[c]
74110	15.0[a]	15.0[a]	12.0[b]
74112	15.0[a]	15.0[a]	15.0[a]
74140	15.0[a]	15.0[a]	15.0[a]
74158	15.0[a]	15.0[a]	15.0[a]
74165	15.0[a]	15.0[a]	15.0[a]
75227	15.0[a]	15.0[a]	15.0[a]
LSD (5%)	1.61		
CV (%)	6.73		
Mean	14.52		

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

The effect of variety on primary defect of washed coffee was also significantly (P<0.05). Varieties 74112, 74158, 74165 and 75227 contained best quality freeness of any defect and statistically similar with variety 74110 and 74140 but variety 744 was obtained the highest primary defect (Figure 1). This is probability due to proper harvesting of ripe cherries, well caring during washing and drying time. The present result in line with (Clifford and Wilson, 1985), washed coffee carefully prepared and handled, is clean in flavor and free from undesirable element.

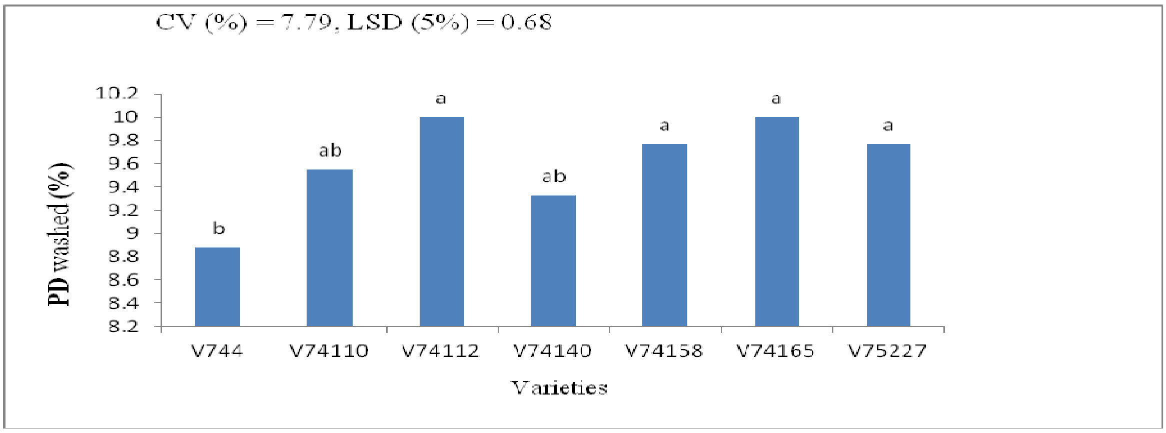

Figure 1. Effect of variety on primary defect of washed Arabica coffee

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

3.2.4. Secondary defect

Secondary defect was other parameters of raw coffee that affects total quality. The analysis of variance showed significant variations (P<0.01) between the interaction of location and variety on secondary defect of dry processing methods. The treatment combinations of Gera x (744, 74110, 74112, 74140, 74158, 74165, and 75227), Jimma x (74110, 74140, 74158, 74165 and 75227) were recorded highest mean value of 15.00 that indicates purity of coffee. On the other hand, the lowest mean value records from Metu x (744, 74110, 74112, 74140 and 74165) especial Metu x (74158 and 75227) with mean value of 1.50 and statistically similar with treatment combination of Metu x 744 (Table 6). This probably due to pre-harvest (during ripening) conditions of low land was susceptible to bean borer disease where as in the highland and midland reverse is true. This was in line with (Wintgens, 2004) disease and insect attack (such as leaf miner and mites) may also result in lower quality beans. For instance, the coffee berry borer *Hypothenemus hampii* feeds and reproduces inside the coffee beans and causes their quality to deteriorate.

The two way interaction effect between variety and location on secondary defect of wet coffee showed significant variation (P<0.01). Treatment combinations of Gera x (744, 74110, 74112, 74140, 74158, 74165 and 75227), Jimma x (744, 74110, 74112, 74140, 74158, 74165 and 75227) and Metu x (74110, 74112, 74140 and 74165) were recorded best quality with average value of 10 which showed clarity of the coffee, except treatment combination of Metu x (744, 74158 and 75227) which gave the least mean value of 7.33, 5.33 and 6.0 respectively (Table 6). This result was similar with Behailu *et al*. (2008) who indicated that quality coffee is a product that has desirable characteristics such as clean raw and roasted appearance, attractive aroma and good cup taste. Yonas (2005) identified the strong genetic x environment interaction effect on coffee bean physical quality attributes.

Table 6. Effect of location and variety on secondary defect (%) on dry and wet processed coffee

	Dry process			Wet process		
Variety	Gera	Jimma	Metu	Gera	Jimma	Metu
744	15.0^{a}	12.0^{bc}	4.0^{de}	10^{a}	10^{a}	7.3^{b}
74110	15.0^{a}	15.0^{a}	6.0^{d}	10^{a}	10^{a}	10^{a}
74112	15.0^{a}	14.0^{ab}	6.0^{d}	10^{a}	10^{a}	10^{a}
74140	15.0^{a}	15.0^{a}	4.5^{d}	10^{a}	10^{a}	10^{a}
74158	15.0^{a}	15.0^{a}	1.5^{e}	10^{a}	10^{a}	5.3^{c}
74165	15.0^{a}	15.0^{a}	11.0^{c}	10^{a}	10^{a}	10^{a}
75227	15.0^{a}	15.0^{a}	1.5^{e}	10^{a}	10^{a}	6.0^{c}
LSD (5%)	2.62			1.19		
CV (%)	13.90			7.62		
Mean	11.45			9.46		

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

3.2.5. Odor

There was significant variation among coffee varieties in terms of odor. Varieties 74110, 74112, 74158, 74165 and 75227 except variety 74140, all tested varieties showed higher odor without significant difference among themselves (Figure 2). This result may be a subjective evaluation of the panelists of the quality this is naturally (genetically) different odor as compare to the others varieties. This result was in line with (Endale, 2008) coffees with a better management in each stage of coffee starting from harvesting till cupping turn out to have a better odor.

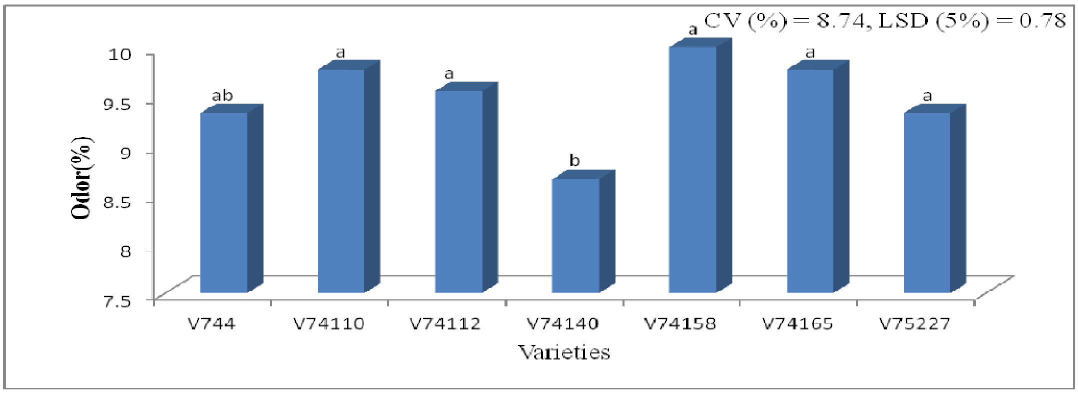

Figure 2. Effect of variety on odor of sundried coffee

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

3.3. Correlation studies

Secondary defect showed non-significant and positive association with primary defect (r = 0.28). Odor was weakly and positively associated with primary defect(r = 0.22) and secondary defect (r = 0.08). Total raw indicated not significant and positively correlated with primary defect (r = 0.68) and odor (r = 0.28) but significant and positively correlated with secondary defect (r = 0.88).

Grade showed non- significant and negative correlation with primary defect(r = -0.52), secondary defect(r = -0.60), odor (r = -0.23), total raw (r = -0.69), flavor (r = -0.65). But significantly and negatively associated with acidity (r = -0.80), cup quality value(r = -079) and overall quality(r = -0.93). This shows the attributes for which one has to focus to avoid defects and improve cup quality attributes for high coffee quality grades. Bean size showed non- significant and negative association (Table 7) with primary defect (r = -0.43), odor (r = -0.16), total raw (r = -0.11), acidity (r = -0.29), flavor (r = -0.36), cup quality value (r = -0.35), overall quality (r = -0.28) but positive association with secondary defect (r = 0.10) and grade (r = 0.14). This suggests the direct and indirect contribution of bean nature on coffee quality for future breeding program as elaborated by other authors (Mekonen, 2009; Beza, 2011).

Table 7. Correlation values(r) of coffee quality attributes under different processing methods

	Primary Defect	Secondary Defect	Oder	Total Raw	Grade	Bean Size
Primary Defect	1					
Secondary Defect	0.28^{ns}	1				
Oder	0.22^{ns}	0.08^{ns}	1			
Total Raw	0.68^{ns}	0.88^{*}	0.28^{ns}	1		
Grade	-0.52^{ns}	-0.60^{ns}	-0.23^{ns}	-0.69^{ns}	1	
Bean Size	-0.43^{ns}	0.10^{ns}	-0.16^{ns}	-0.11^{ns}	0.14^{ns}	1

Where *, ** = *statistically significant difference at 5% and 1% probability level respectively; ns= non-significant difference*

4. Summary and Conclusions

The combined analysis of variance showed significant difference for most quality attributes such as odor, primary and secondary defects, total raw and grades. The result indicated that bean size was influenced by the three way interaction (variety x processing method x locations). The highest bean size was obtained for variety 744 x Gera x dry processing (98.53) as opposed to the lowest values for 74110 x Gera x dry processing (92.13). Total raw quality was significantly affected by the interaction effect of location with variety and processing method. It was also influenced due to the combined effect of processing method and coffee variety. The maximum values for total raw were obtained from wet and compact coffees (74110, 74112, 74140 and 74165) at Gera and sundried coffee at Jimma while the least was recorded for sundried 744 (27.50) variety at Metu. But, primary defect of sundried coffee varieties at all locations were high except for varieties 744(8.00) and 74110 (12.00) at Metu, which indicates purity of the coffee.

Moreover, varieties 74112, 74158, 74165 and 75227 processed using wet methods had the highest values but the least was for variety 744. The results also depicted high values of secondary defect of sundried coffee varieties grown at Gera and Jimma as compared to the minimum defects for sundried processed coffee varieties under Metu condition that indicates lack of purity. By contrast, coffee varieties collected from all the study locations revealed high values as compared to varieties 74158 and 75227 at Metu Research Center.

In general, coffee varieties harvested from higher altitude (Gera areas) had the highest values for freeness of primary and secondary defect. And coffee varieties 74110, 74112 and 74158 had the highest values for physical quality attributes. The present findings were quite in consistent with the earlier quality performances for the studied coffee varieties, demonstrating the long-year stability of quality traits for future quality evaluation. The interaction between genetic, environment and processing methods was also evident for increasing production and trading of traceable quality standards. As a whole, the results revealed superior coffee quality performance under Gera, Jimma and Metu conditions in that descending altitude order.

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