

## Research Article

# Organoleptic Quality Attributes and Their Association with Morphological Traits in Arabica Coffee (*Coffea arabica* L.) Genotypes

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Arabica coffee is an essential crop in the national economy of Ethiopia. There is little information available about the cup quality profile of Teppi coffee, despite several sites across the country having conducted research on the organoleptic properties of various coffee types. Therefore, an experiment was conducted to determine the quality attributes of the genotypes and correlate their inherited quality with morphological traits. The experiment was superimposed on five-year-old plants of 17 coffee genotypes during the 2018 cropping season at Teppi and Gemadro sites. Using the wet processing method, six kilograms of red coffee cherries were carefully harvested, processed, and sun dried to a moisture content of 10.5% to 11.0%. To obtain the necessary number of replications, each sample was divided into three, and three cups for each sample were prepared for the tasting sessions. Organoleptic quality attributes were scored using the standard established. The analysis of variance for aromatic quality, acidity, flavor, and overall cup quality showed a highly significant difference ( $P=0.01$ ) among the tested coffee genotypes. All of the organoleptic quality attributes evaluated showed a no significant correlation with morphological traits like body ( $r=-0.11$ ) and hundred-bean weight and, flavor ( $r=-0.1$ ) and bean thickness. However, there was a strong correlation between organoleptic quality attributes like flavor ( $r=0.95^{**}$ ) and acidity ( $r=0.94^{**}$ ), demonstrating that any organoleptic characteristic is an important element in beverage quality. It is challenging to simultaneously choose for cup quality and bean physical features because there were no significant correlations between organoleptic quality and these traits. In this study, genotype 3/8 showed outstanding performance across locations for all organoleptic quality attributes, which can be used in the Arabica coffee-breeding program.

## 1. Introduction

The coffee plant (*Coffea arabica* L.) is a member of the Rubiaceae family and is a nonalcoholic stimulant beverage crop. *Coffea* is a genus with about 130 species. [1]. It grows mainly in tropical and subtropical regions [2]. As a result, originating in Ethiopia, there is significant genetic diversity in southwestern parts of the country [3, 4].

Arabica coffee is an important crop for the national economy of Ethiopia. Coffee provides a living for over 15 million people [5]. It is the most significant export

commodity for Ethiopia, making up roughly 29% of all exports in 2018–19 [6].

Ethiopia has suitable agroecology for coffee production and can produce large amounts of differentiated high-quality green coffee beans, which are liked for their unique flavor and taste [7]. However, environmental elements can have an influence, while climate and soil are the main limiting factors for coffee quality [8, 9]. The Institute of Trade Center [10] defines the quality of the coffee as combining the botanical variety, topographical conditions, weather, and the care taken during cultivation, harvest,

storage, export preparation, and transit to determine the quality of a coffee parcel. According to Bekele [11], coffee quality is greatly influenced by its genetic origin. The genetic background of the variety and the environmental conditions in which it grows affects chemical substances that serve as fragrance precursors expressed during coffee roasting [12]. As coffee beans are an economical part of the plant, information that correlates the composition of green beans with the quality of roasted coffee brews and identification of its possible quality markers is essential to producers and consumers. The caffeine content of coffee was found to have a significant negative correlation with organoleptic quality attributes but no association with bean physical characteristics in the literature [13].

Quality coffee is a product with desirable trait that looks clean, raw, and roasted, has an alluring aroma, and tastes delicious [14]. Coffee quality includes the fragrance, aroma, flavor, sweetness, acidity, and overall taste that the customer experiences after a cup [15]. Consumers have different tastes depending on their nationality; thus, while evaluating organoleptic quality, one must consider this. That resulted in the changeable definition of organoleptic quality [16]. The genetic origin of the plant critically influences its quality [11].

Therefore, organoleptic quality is the main worry of producers, consumers, traders, and others involved in the coffee sector. Multilocation trials for organoleptic quality attributes evaluation determine the procedure and design of breeding strategies that could be followed during variety development [17]. The present study used coffee genotypes which was collected from different districts of Southwestern Ethiopia and (CIFC) Oeiras, Portugal. The agro-morphological and sensory quality of different Arabica coffee varieties were tested at different locations. As coffee is one of the most important cash crops in Ethiopia, understanding the relationship between quality attributes and morphological traits is quite important to design breeding programs that help to improve yield and quality of coffee. Therefore, this research was done to profile coffee quality attributes in these genotypes and correlate their inherent quality with morphological traits that would serve as baseline information to be translated into other set of genotype.

## 2. Materials and Methods

**2.1. The Study Area.** The experiment was conducted at two locations in Southwestern Ethiopia, namely Teppi, Yeki district, and Gemadro, Anderacha, detailed description of the study area is presented in Table 1. Figure 1 shows the map of the study districts. Source: Ethiopia shape file-dataset.

**2.2. Genetic Materials.** Seventeen coffee genotypes among which fourteen advanced genotypes and three commercially grown released varieties were used for this study (Table 2).

**2.3. Experimental Design and Treatment.** The experiment was carried out by superimposing second-bearing stage coffee trees that were previously arranged in randomized

complete block design (RCBD). The experiment was grown under shade trees of *Sesbania sesban* at a spacing of 4 m × 4 m as temporary shade and *Albizia schimperiana* at a spacing of 18 m × 18 m as permanent shade simultaneously, as recommended by Endale et al. [17]. The plot consisted of two rows, each having ten trees. To minimize border effects, each plot has a single row of boundary trees planted. Rows and plants were spaced 2 m × 2 m apart, and blocks were kept 4 m apart. According to the recommendations of Endale et al. [17], all relevant agronomic activities were carried out.

### 2.4. Experimental Procedure

**2.4.1. Data Collected Morphological Traits.** Agro-morphological characters were measured based on the coffee descriptors developed by the International Plant Genetic Resource Institute (IPGRI) [18].

Plant height (cm): measured in centimeters from the ground level to the tip of the apical shoot using meter tape from five plants per plot, and the average was used for the data analysis.

Number of nodes per branch: primary branches without secondary or tertiary were selected for five sample trees per plot. The number of nodes per primary branch was counted on two branches.

Number of fruit per branch: primary fruiting branches without secondary or tertiary were selected for five sample trees per plot. Fruits per branch were counted on two branches.

Number of fruits per node: primary fruiting branches without secondary or tertiary were selected from five sample trees. Fruits per fruiting node were counted on two branches, and the average was used for data analysis.

Fruit length (mm): the length of 25 normal fruits harvested from five plants per plot (5 fruits from each tree) was measured at the longest part using caliper, and the mean values was computed and used for analysis.

Fruit width (mm): the width of 25 normal fruits harvested from five plants per plot (5 fruits from each tree) was measured at the widest part using caliper, and the mean values was computed and used for analysis.

Fruit thickness (mm): the thickness of 25 normal fruits harvested from five plants per plot (5 fruits from each tree) was measured at the thickest part using caliper, and the mean values was computed and used for analysis.

Bean width (mm): the widths of 25 normal beans harvested from five plants per plot (5 beans from each tree) was measured at the widest part using caliper, and the mean value was computed and used for analysis.

Bean length (mm): the length of 25 normal beans harvested from five plants per plot (5 beans from each tree) was measured at the longest part using caliper, and the mean value was computed and used for analysis.

TABLE 1: Description of the study area.

Location	Altitude (m.a.s.l)	Rainfall (mm)	Latitude	Longitude	Temperature		Soil information			
					Max (°C)	Min (°C)	N (%)	P (ppm)	OC (%)	OM (%)
Gemadro	1200	2243.3	7°28'	35°24'	28	14	3.77	0.53	3.27	5.62
Teppi	1200	1678	7° 3'	35° 18'	30	16	0.706	11.96	5.06	8.70

Source: author's elaboration based on the study by Endale et al. [17].

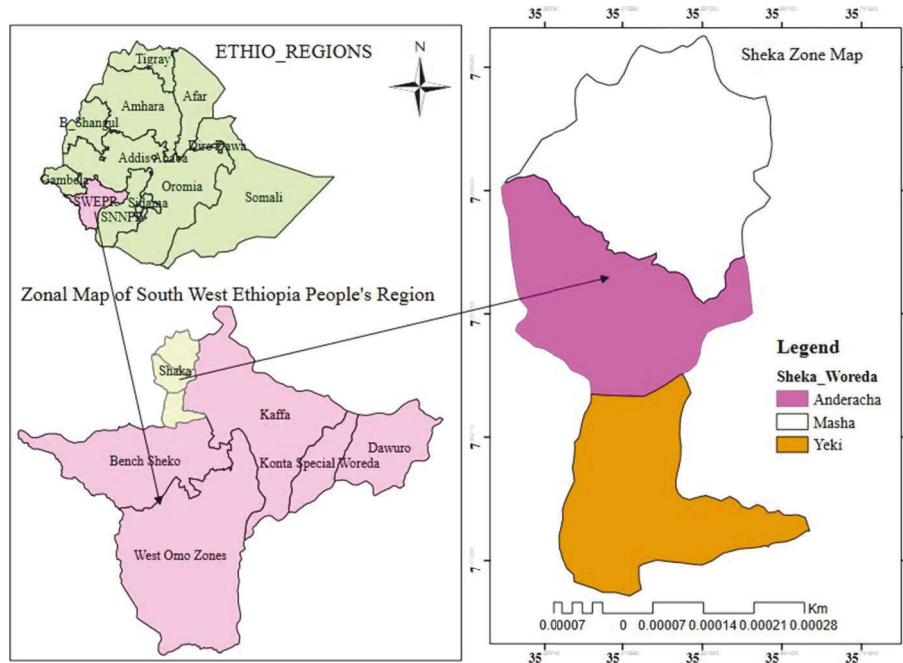


FIGURE 1: Map of the study districts. Source: Ethiopia shape file-dataset.

TABLE 2: Description of genotypes used in the study.

No	Genotype name	Genotype status	Place of collection
1	Accession3/82	Advance	Southwestern Ethiopia
2	Accession28/82	Advanced	Southwestern Ethiopia
3	Accession29/82	Advanced	Southwestern Ethiopia
4	Accession32/82	Advanced	Southwestern Ethiopia
5	Accession37/82	Advanced	Southwestern Ethiopia
6	Accession39/82	Advanced	Southwestern Ethiopia
7	Accession42/82	Advanced	Southwestern Ethiopia
8	Accession44/82	Advanced	Southwestern Ethiopia
9	Accession45/82	Advanced	Southwestern Ethiopia
10	Accession48/82	Advanced	Southwestern Ethiopia
11	Accession235/A	Advanced	Southwestern Ethiopia
12	Accession 17/79	Advanced	Oeiras, Portugal
13	Accession 20/79	Advanced	Oeiras, Portugal
14	Accession 22/79	Advanced	Oeiras, Portugal
15	Catimor J-19	Released	Released varieties
16	Catimor J-21	Released	Released varieties
17	Geisha	Released	Released varieties

Source: Jimma Agricultural Research Center database.

**Bean thickness (mm):** the thickness of 25 normal beans harvested from five plants per plot (5 beans from each tree) was measured at the thickest part using caliper, and the mean value was computed and used for analysis.

**100-coffee bean weight (gm):** using the formula (“Bean weight at 0% moisture content” × 100)/ (“Bean number” × 0.89) [18], calculated at a moisture content of 11%. The beans were dried in an oven to remove all moisture, and a delicate balance was used to weigh them.

**2.5. Harvesting of Coffee Cherries.** About six kilograms of red-ripe coffee cherries from each coffee genotype were hand-picked during the 2018 cropping season. To keep the red-ripe cherries healthy, mature, green cherries were separated from foreign material before pulping. .

**2.6. Sample Preparation.** The red cherries were carefully pulped, fermented, and washed using the wet processing method. After fermentation of mucilage, washing by clean water took place, and the parchment coffee was dried to a standard moisture content of 10.5 to 11.5%. To obtain the requisite number of replications, each sample was divided into three. About 300 gm of green coffee bean samples were prepared separately for each genotype to evaluate cup quality characteristics [19].

**2.7. Roasting and Grinding.** Roasting and grinding of the sample take place at Jimma Agricultural Research Center's laboratory of liquoring coffee, roasting, and grinding. 100g

of green coffee beans' each sample was placed into the roasting cylinder after the roaster machine has been heated to 180–200°C. Above the screen, size 14 (which means 14/64 of an inch diameter of rounded perforated plate called screen) sieved samples were used for roasting. A medium roasting color is used [19]. The gas source for the heater was adjusted throughout roasting to maintain the roaster temperature at 200°C under tight supervision. The roasted coffee samples were ground to medium size using an electrical grinder. Half of the roasted coffee in each sample was used for grinding. The grounded sample was then kept in a plastic bag. After grinding each sample, the grinder was thoroughly cleaned to avoid cross-contamination.

**2.8. Preparing Brew.** With a 180 ml capacity, eight grams of coffee powder were used in each cup (3 cups per sample unit). In order to make sure the mixture is homogeneous, freshly boiled water is added to the grounded coffee until it fills about half of the cup. Before filling the cup to full size, the volatile aromatic quality and intensity parameters were evaluated by sniffing. Then, cups were filled to the full size (180 ml) and left to settle. Allow the grinds to steep without being disturbed or steered. After three minutes, the floater was removed, and the panelists could start tasting the brew in cups. Because coffee bean defects are kept at zero or free for research data, our cupping practice differs significantly from the commercial approach. Three cups are sufficient for every sample since our sample preparation is efficient and error-free.

**2.9. An Evaluation Procedure for Cup Quality Parameters.** Three cups of coffee liquor per sample were brewed for the tasting sessions. Cup quality analysis was carried out once the beverage cooled to a drinkable temperature (60°C) [19] by three cuppers for three sessions of certified quality grader professional panelists from Jimma Agricultural Research Center.

**2.10. Evaluation of Cup Quality Parameters.** Based on the standard description (Table 3), cuppers evaluated cup quality parameters, including aromatic quality, aromatic intensity, body, flavor, bitterness, astringency, acidity, and overall cup quality.

**Aromatic intensity:** the magnitude of aroma, which is evaluated based on a scale of 0 to 5.

**Aromatic quality:** this is measured using a cupper's sense on a scale of 0 to 5.

**Acidity:** the coffee brew produces a sense of dryness under the tongue's margins and behind the palate. It is evaluated using points ranging from 0 to 10.

**Astringency:** this describes the complicated sensation produced by the tannins' shrinking, drawing, or puckering of the mouth's mucosal surface. An assessment scale from 0 to 5 is used to grade it.

**Body:** weight of the coffee on the tongue. The tongue senses the viscosity, heaviness, thickness, or richness. It was rated between 0 and 10 on a scale.

**Bitterness:** the perception of the panelists towards the coffee brew on their tongues during cup tasting. It is the opposite of sweetness, which was evaluated using a scale ranging from 0 to 5.

**Flavor:** this refers to the overall perception of the panelists towards the acidity, aroma, and body of the brew.

The balance of this quality attribute was scaled from 0 to 10.

**Overall cup quality standard:** a scale from 0 to 10 was used to grade the average outcomes of each panelist [19]. For each sample unit of treatment, each panelist gave his or her independent assessment, and the average results of all panelists were used for data analysis.

## 2.11. Statistical Analysis

**2.11.1. Analysis of Variance (ANOVA).** Prior to doing a combined study of the locations, Bartlett's test was used to determine whether the error variances among environments (locations) were homogeneous. In SAS [20] version 9.3 software, the PROC GLM method was used to evaluate the combined variance over locations, while the PROC CORR program carried out the Pearson correlation between attributes. Using the least significant difference (LSD) at a 5% probability level, the mean separation was performed.

## 3. Results and Discussion

**3.1. Analysis of Variance for Morphological Traits.** Analysis of variance revealed significant differences ( $P=0.01$ ) among genotypes, location, and genotype-by location interaction for plant height, fruit length, and 100-bean weight, and the analysis of genotypes showed significant ( $P=0.05$ ) differences for all traits evaluated except bean thickness (Table 4). This indicated that yield and yield-related traits of coffee genotypes were highly influenced by environmental factors and the presence of genetic inconsistency among the tested genotypes for the significant traits. Significant genotype by location for most yield-related traits showed that the genotype performs differently in different locations. Different authors [21–23] reported related results about the presence of genotype by location interaction for yield-related traits in Arabica coffee. However, most yield-related traits showed no significant genotype by location interaction, except plant height, fruit length, fruit width, and hundred-bean weight. This result was similar to the findings of Walyaro [24], who reported nonsignificant genotype by environment interaction effects on bean quality characters.

**3.2. Analysis of Variance for Organoleptic Quality Traits.** The analysis of variance for organoleptic quality traits indicated that the presence of significant variation among the genotypes for aromatic quality ( $P=0.006$ ), acidity ( $P=0.001$ ), flavor ( $P=0.001$ ), overall standard characters ( $P=0.0014$ ), and aromatic intensity ( $P=0.01$ ) (Table 5). Such a significant difference among the genotypes indicates the presence of fundamental genetic differences. Similar to this finding, Yilma [16] reported highly significant variations

TABLE 3: Cup quality parameters and their descriptive values [19].

Aromatic quality		Aromatic intensity		Acidity		Astringency		Bitterness		Body		Flavor		Overall cup quality standard	
Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts	Quality	Pts
Excellent	5	V. strong	5	Pointed	10	Nil	5	Nil	5	Full	10	V. good	10	Excellent	10
Very good	4	Strong	4	M. point	8	V. light	4	V. light	4	M. full	8	Good	8	V. good	8
Good	3	Medium	3	Medium	6	Light	3	Light	3	Medium	6	Average	6	Good	6
Regular	2	Light	2	Light	4	Medium	2	Medium	2	Light	4	Fair	4	Regular	4
Bad	1	V. light	1	Lacking	2	Strong	1	Strong	1	V. light	2	Bad	2	Bad	2
Nil	0	Nil	0	Nil	0	V. strong	0	V. strong	0	Nil	0	Nil	0	Unacceptable	0

M. full = medium full, V. light = very light, V. strong = very strong, M. pointed = medium pointed. Source: author's elaboration based on research data.

TABLE 4: Mean square of analysis of variance for morphological traits of tested coffee genotypes.

	Sources of variation						Mean	CV (%)
	Location	Rep (loc)	Genotype	GEI	Error			
DF	1	3	16	32	48			
PH	11727.1**	4252.5*	4437.8**	2398.9**	637.7	275.70	9.2	
NNPB	17.7**	28.6**	10.83**	5.02 <sup>ns</sup>	2.93	21.6	7.92	
NFPB	25805.8**	429.06 <sup>ns</sup>	2468.4**	312.8 <sup>ns</sup>	242.2	67.3	23.1	
NFPN	183.2**	2.5 <sup>ns</sup>	17.6**	0.75 <sup>ns</sup>	2.2	7.5	19.8	
FL	75.7**	1.10 <sup>ns</sup>	4.6**	1.6**	0.63	16.02	5.0	
FW	34.6**	5.7**	0.69**	0.41*	0.21	13.23	3.5	
FTH	37.90**	4.2*	0.904*	0.44 <sup>ns</sup>	0.48	11.37	6.1	
BL	1.72**	0.2 <sup>ns</sup>	1.14**	0.3 <sup>ns</sup>	0.19	9.41	4.6	
BW	0.14 <sup>ns</sup>	0.012 <sup>ns</sup>	0.25**	0.73 <sup>ns</sup>	0.07	6.5	4.1	
BTH	1.28**	0.0004 <sup>ns</sup>	0.022 <sup>ns</sup>	0.04 <sup>ns</sup>	0.02	3.78	4.0	
HBW	49.6**	0.022 <sup>ns</sup>	2.4**	1.0**	0.2	15.90	2.8	

PH = plant height, NNPB = number of nodes per branch, NFPB = number of fruit per branch, NFPN = number of fruit per node, FW = fruit width, FL = fruit length, FT = fruit thickness, BW = bean width, BL = bean length, BTH = bean thickness, and HBW = hundred-bean weight.

TABLE 5: Mean square of analysis of variance for organoleptic quality of tested coffee genotypes.

S.V	DF	AI	AQ	AC	AS	BI	BO	FL	OVS
Genotype	16	0.19*	0.25**	0.49**	0.13 <sup>ns</sup>	0.192 <sup>ns</sup>	0.31 <sup>ns</sup>	0.43**	0.41**
Location	1	0.003 <sup>ns</sup>	0.20 <sup>ns</sup>	1.41**	0.35 <sup>ns</sup>	0.25 <sup>ns</sup>	4.12**	1.92**	3.18**
Rep(loc)	4	0.25*	0.43**	0.26 <sup>ns</sup>	1.71**	1.72**	0.29 <sup>ns</sup>	1.44**	0.37*
Gen x loc	16	0.09 <sup>ns</sup>	0.11 <sup>ns</sup>	0.31*	0.55 <sup>ns</sup>	0.15 <sup>ns</sup>	0.29 <sup>ns</sup>	0.34**	0.30*
Error	64	0.09	0.10	0.17	0.13	0.13	0.18	0.16	0.18
Total	101								
Mean		3.73	3.63	7.01	3.65	3.53	7.0	6.8	6.95
CV(%)		7.75	8.73	5.29	9.70	9.89	5.93	5.06	5.45

\*\* and \* = significant difference at  $P < 0.01$  and  $P < 0.05$ , respectively, AI = aromatic intensity, AQ = aromatic quality, AC = acidity, AS = astringency, BI = bitterness, BO = body, CV = coefficient of variation, DF = degrees of freedom, FL = flavor, and OVS = overall cup quality standard.

among the genotypes tested for aromatic quality, flavor, and overall cup quality standard. In this study, a significant difference in location was revealed for acidity ( $P = 0.0021$ ), body ( $P = 0.0001$ ), flavor ( $P = 0.0002$ ), and overall cup quality standard ( $P = 0.0001$ ) (Table 5). On the other hand, there was no significant difference for most of the organoleptic quality traits for genotype by location interaction, except for flavor ( $P = 0.0013$ ), acidity ( $P = 0.012$ ), and overall cup quality standard ( $P = 0.019$ ). Similar to this finding, Gimase et al. [25] reported lower genotype effects on organoleptic quality characters by location interaction. Van der Vossen [26] also reported insignificant effects of genotype by environment interaction on cup and bean quality characteristics of coffee.

**3.3. Mean Performance of Organoleptic Quality Traits across Locations Acidity.** The genotypes showed significant variations in acidity. The highest value of acidity (7.92) was recorded for genotype 3/8, while the lowest acidity value (6.67) was recorded for genotype 45/82 (Table 6).

**3.4. Flavor.** For the flavor quality trait, genotype 3/82 fell under a reasonable scale (7.58), and it was superior to the other genotypes, while genotype 17/79, Catmor J-19, and Catmor J-21 scored average flavor (6.58) (Table 6). In this study, genotype 3/82 showed superior performance over the rest of the genotypes. Generally, for all quality attributes, genotype 3/82 exhibited better organoleptic quality. The

TABLE 6: Mean performance of coffee genotypes for acidity, flavor, and overall cup quality standards.

Genotypes	Traits		
	AC	FL	OVS
3/82	7.92 <sup>a</sup>	7.58 <sup>a</sup>	7.75 <sup>a</sup>
28/82	7.17 <sup>bc</sup>	7.0 <sup>bc</sup>	7.17 <sup>b</sup>
29/82	6.83 <sup>cd</sup>	6.75 <sup>bc</sup>	6.92 <sup>bcc</sup>
32/82	6.83 <sup>cd</sup>	6.75 <sup>bc</sup>	7.0 <sup>bc</sup>
37/82	6.92 <sup>bcd</sup>	6.67 <sup>bc</sup>	6.75 <sup>bc</sup>
39/82	7.33 <sup>b</sup>	7.1 <sup>b</sup>	7.1b <sup>c</sup>
42/82	7.1 <sup>bcd</sup>	7.0 <sup>bc</sup>	7.17 <sup>b</sup>
44/82	6.92 <sup>bcd</sup>	6.67 <sup>bc</sup>	6.75 <sup>bc</sup>
45/82	6.67 <sup>d</sup>	6.58 <sup>c</sup>	6.67 <sup>c</sup>
48/82	7.1 <sup>bcd</sup>	7.0 <sup>bc</sup>	7.0 <sup>bc</sup>
235/71A	7.0 <sup>bcd</sup>	6.92 <sup>bc</sup>	7.0 <sup>bc</sup>
17/79	7.0 <sup>bcd</sup>	6.58 <sup>c</sup>	6.75 <sup>bc</sup>
20/79	6.92 <sup>bcd</sup>	6.67 <sup>bc</sup>	6.75 <sup>bc</sup>
22/79	6.92 <sup>bcd</sup>	6.58 <sup>c</sup>	6.92 <sup>bc</sup>
Cat J-19	7.0 <sup>bcd</sup>	6.67 <sup>bc</sup>	7.0b <sup>c</sup>
CatJ-21	6.92 <sup>bcd</sup>	6.58 <sup>c</sup>	6.83 <sup>bc</sup>
Geisha	6.67 <sup>d</sup>	6.58 <sup>c</sup>	6.67 <sup>c</sup>
Mean	7.01	6.8	6.95
CV(%)	5.85	5.89	6.1
LSD(5%)	0.47	0.40	0.44

AC = acidity, FL = flavor, and OVS = overall cup quality standard.

flavor is an essential quality attribute since it has a significant positive correlation with all cup quality traits. Gimase et al. [25] also reported that flavor was identified as the ideal selection criterion for improving the hereditary cup quality of the Arabica coffee variety. Overall cup quality standard evaluated based on all the characteristics of liquor quality (intensity, aromatic quality, acidity, astringency, body, bitterness, and flavor).

Genotype 3/82 scored the very good organoleptic quality scale for the overall standard quality character, which shows significant differences from the other genotypes. However, all genotypes fell under the good to very good scale range (6.67–7.75) (Table 6).

**3.5. Aroma/Aromatic Intensity and Aromatic Quality.** The highest mean value of aromatic intensity was 4.1 for 3/82, 3.92 for genotypes 28/82, 29/82, 39/82, 44/82, and (3.75) for 32/82 and 48/82 and Catmor J-19 and (7.83) for 45/82 while the lowest aromatic intensity (3.5) was recorded in three genotypes, namely 17/79, 22/79, and Geisha (Table 7). High aromatic quality among evaluated genotypes was recorded from the following genotypes: genotype 3/82 (4.00), genotype 29/82 (3.92), genotype 28/82 (3.83), genotype 44/82 (3.83), genotype 39/80 (3.75), genotype 39/82 (3.75), genotype 48/82 (3.75), genotype 32/82 (3.67), genotype 42/82 (3.67), and genotype 45/82 (3.67). The lower aromatic quality (3.25) was recorded from genotype 17/79 (Table 7). When we consider the aromatic quality and intensity of coffee genotypes of different origins, their quality attributes are differentiated depending on their source. Most of the genotypes of Ethiopian origin scored the highest aromatic quality and intensity, while genotypes introduced from Portugal showed lower mean performance for aromatic quality and intensity.

TABLE 7: Combined mean performance of genotypes for organoleptic quality traits at Teppi and Gemadro district, Southwest Ethiopia.

Genotypes	AI	Trait AQ	AS	BI	BO
3/82	4.1 <sup>a</sup>	4.0 <sup>a</sup>	3.92	4.0	7.42
28/82	3.92 <sup>ab</sup>	3.83 <sup>abc</sup>	3.83	3.58	7.33
29/82	3.92 <sup>ab</sup>	3.92 <sup>ab</sup>	3.67	3.5	7.17
37/82	3.58 <sup>bc</sup>	3.42 <sup>de</sup>	3.42	3.5	7.0
39/82	3.92 <sup>ab</sup>	3.75 <sup>abcd</sup>	3.75	3.67	7.25
42/82	3.67 <sup>bc</sup>	3.67 <sup>abcd</sup>	3.75	3.58	7.17
44/82	3.92 <sup>ab</sup>	3.83 <sup>abc</sup>	3.58	3.42	6.83
45/82	3.83 <sup>abc</sup>	3.67 <sup>abcd</sup>	3.5	3.42	6.58
48/82	3.75 <sup>abc</sup>	3.75 <sup>abcd</sup>	3.5	3.58	6.83
235/71A	3.58 <sup>bc</sup>	3.58 <sup>bcd</sup>	3.83	3.67	3.67
17/79	3.5 <sup>c</sup>	3.25 <sup>e</sup>	3.58	3.33	6.67
20/79	3.67 <sup>bc</sup>	3.42 <sup>de</sup>	3.42	3.17	6.83
22/79	3.5 <sup>c</sup>	3.58 <sup>bcd</sup>	3.67	3.42	7.1
Cat J-19	3.75 <sup>abc</sup>	3.5cd <sup>e</sup>	3.75	3.67	6.92
CatJ-21	3.58 <sup>bc</sup>	3.5cd <sup>e</sup>	3.5	3.5	6.83
Geisha	3.5 <sup>c</sup>	3.42d <sup>e</sup>	3.67	3.58	7.0
Mean	3.73	3.63	3.65	3.53	7.0
CV (%)	7.83	8.85	9.92	10.36	6.13
LSD (5%)	0.334	0.37	NS	NS	NS

AI = aromatic intensity, AQ = aromatic quality, AS = astringency, BI = bitterness, BO = body, CV = coefficient of variation, and LSD = least significant difference.

**3.6. Astringency.** The results of the analysis of variance showed that the genotype had no effect on the astringency, location, and interaction. The astringency of genotypes grown across locations ranged from 3.5 to 3.92, with no significant difference (Table 7). While the cup quality character of astringency is a complex feeling accompanied by a drawing inward of the skin or mucosa in the mouth. .

**3.7. Bitterness.** Bitterness, like astringency, was not significantly influenced by genotype, location, and their interaction (Table 7). Bitterness is not considered to be a desirable quality [27]. Similar to these findings, Sualeh et al. [27] reported moderately light coffee bitterness on a sample collected from a district in the Teppi area. Melese [28] reported that the astringency of coffee varieties grown across locations was not affected by location.

**3.8. Body.** The variance analysis revealed that the body of coffee beans' genotype and genotype by location interaction were not statistically significant. The average value of body quality of coffee genotypes ranged from 6.58 to 7.42 (Table 7), which failed between average to good flavor quality without statistical difference. Similar to these findings, Wase [28] reported related results in different coffee varieties grown in the northern high lands of Ethiopia.

**3.9. Association between Organoleptic Quality and Morphological Traits.** The correlation coefficients between the organoleptic quality attributes and morphological traits were analyzed. As a result, there was a significant positive correlation between mean fruit length ( $r = 0.85^{**}$ ) and hundred-

TABLE 8: Correlation coefficients between organoleptic quality and agro-morphological traits.

VRB	PH	NNPB	NFPB	NFPN	FrL	FW	FTh	BL	BW	BTH	HSW	AI	AQ	AC	As	BI	BO	FL	OQ
PH	1.00																		
NNPB	-0.66**	1.00																	
NFPB	-0.65**	0.68**	1.00																
NFPN	-0.62	0.58*	0.97	1.00															
FrL	0.24	-0.23	-0.05	0.07	1.00														
FW	0.11	-0.01	0.16	0.10	0.30	1.00													
FTh	-0.46	0.39	0.67**	0.63*	-0.24	0.74**	1.00												
BL	-0.62**	-0.65**	-0.83**	-0.84**	0.85**	-0.06	-0.57*	1.00											
BW	-0.54*	0.37	0.72**	0.71**	-0.46	0.36	0.84**	-0.66	1.00										
BTH	0.30	-0.55*	-0.09	-0.05	0.01	0.09	0.05	0.07	0.04	1.00									
HSW	0.32	-0.63	-0.42	-0.41	0.70**	0.18	-0.04	0.58*	0.03	0.17	1.00								
AI	0.25	-0.06	0.00	0.05	-0.32	-0.25	-0.18	-0.12	-0.07	-0.13	-0.28	1.00							
AQ	0.26	-0.09	-0.16	-0.12	-0.28	-0.34	-0.40	0.00	-0.32	-0.11	-0.37	0.86**	1.00						
AC	0.16	-0.19	-0.03	0.06	-0.29	-0.41	-0.31	-0.09	-0.11	-0.15	-0.19	0.73**	0.66**	1.00					
AS	0.18	0.22	0.12	0.16	-0.24	-0.18	-0.29	-0.13	-0.23	-0.51	-0.46	0.60*	0.67**	0.63**	1.00				
BI	0.25	-0.03	0.03	0.13	-0.22	-0.19	-0.25	-0.13	-0.28	-0.17	-0.43	0.67**	0.75**	0.77**	0.81**	1.00			
BO	0.16	-0.02	-0.10	-0.06	-0.17	-0.28	-0.32	0.04	-0.18	-0.40	-0.11	0.61*	0.62**	0.79**	0.74**	0.72**	1.00		
FL	0.24	-0.23	-0.05	0.07	-0.26	-0.36	-0.34	-0.04	-0.15	-0.10	-0.22	0.76**	0.74**	0.94**	0.72**	0.84**	0.78**	1.00	
OQ	0.32	-0.21	-0.08	0.02	-0.13	-0.27	-0.33	0.02	-0.23	-0.21	-0.23	0.73*	0.67**	0.94**	0.77**	0.86**	0.77**	0.95**	1.00

PH = plant height, NNPB = number of nodes per branch, NFPB = number of first primary branches, FW = fruit width, FrL = fruit length, FT = fruit thickness, BW = bean width, BL = bean length, BTH = bean thickness, HBW = 100 bean weight, AI = aromatic intensity, AQ = aromatic quality, AC = acidity, AS = astringency, BI = bitterness, BO = body, FL = flavor, and OVS = overall cup quality standard.

bean weight ( $r=0.70^{**}$ ). Significant and negative correlation of bean length with the number of fruits per node and fruits per branch showed that as fruit per node increases, it is clear that the number of fruits per branch increased and the reverse is true for bean length on that particular coffee tree. All quality attributes evaluated in this study showed no significant correlation with plant height, number of nodes per branch, number of fruits per branch, number of fruits per node, and fruit and bean traits. On the other hand, there was a strong correlation among organoleptic qualities. Similar to our findings, Gimase et al. [25] reported a strong correlation between organoleptic quality attributes in coffee. Aromatic intensity significantly correlated with aromatic quality, acidity, bitterness, and flavor overall cup quality standard, and a moderate relationship with astringency ( $r=6.0^*$ ) and body ( $r=0.61^*$ ). This indicated that those cup quality attributes contribute more to coffee cup quality. Aromatic quality was exhibited strongly with all organoleptic attributes, and it showed no significant correlation with morphological traits. Bitterness ( $r=0.77^{**}$ ), body ( $r=0.79^{**}$ ), flavor ( $r=0.94^{**}$ ), and overall cup quality standard ( $r=0.94^{**}$ ) all had a strong positive correlation with acidity, as did astringency ( $r=0.63$ ). Astringency also showed a strong positive correlation with all tested organoleptic quality attributes. The bitterness quality test showed a strong correlation with astringency, acidity, aromatic intensity, and aromatic quality, and a weak correlation with all morphological traits. The body exhibited a strong correlation with acidity, astringency, and bitterness, and it showed a moderate correlation with aromatic intensity and aromatic quality. In contrast, it exhibited no significant correlation with most morphological traits and bean length and plant height. Flavor showed a highly significant correlation with all organoleptic quality attributes and a nonsignificant correlation with all tested morphological traits. Aromatic intensity ( $r=0.73^{**}$ ), aromatic quality ( $r=0.67^{**}$ ), acidity ( $r=0.94^{**}$ ), astringency ( $r=0.77^{**}$ ), bitterness ( $r=0.89^{**}$ ), body ( $r=0.77^{**}$ ), and flavor ( $r=0.95^{**}$ ) were all strongly related to overall cup quality. Bitterness was significantly and positively correlated with overall cup quality standard of coffee that indicates bitterness is always not bud quality attribute, it is a complimentary to other cup quality characters. Similar to this finding, Abdulmajid [29] reported that all organoleptic quality characters evaluated were significantly correlated (Table 8).

All organoleptic quality traits showed a nonsignificant correlation with all evaluated morphological traits in this study. Similar to this finding, Malau [30] reported that most organoleptic quality attributes showed no significant correlation with hundred-bean weight.

Abdulmajid [29] concluded that there were no significant correlations between organoleptic and physical bean characteristics. Kumar et al. [31] also observed that coffee bean size was not an indicator of good organoleptic quality and found no strong correlation between bean size and cup quality. Contrary to this research, Wahyudi and Pujiyanto [32] discovered a strong relationship between green bean weight and flavor, while Abdulmajid [29] revealed a significant correlation between green bean weight and body.

There were strong relationships between various sensory attributes, indicating that any organoleptic feature is important to the quality of beverages. However, flavor ( $r=0.95^{**}$ ) and acidity ( $r=0.94^{**}$ ) showed the highest correlation with overall cup quality standards. Similar to these findings, Kathurima et al. [33] reported a high correlation between flavor and preference and recommended flavor as the best selection criterion for improving cup quality in Arabica coffee. There were no significant correlations between organoleptic quality and bean physical characteristics, despite the fact that beans with a low hundred-bean weight had superior organoleptic quality than heavier beans. Therefore, it is challenging to select beans for organoleptic quality and physical characteristics at the same time. These outcome disagree with those of Dessalegn et al. [34], who found the probability of simultaneous selection for organoleptic quality and coffee bean physical characteristics.

#### 4. Conclusion

The highly significant variation among genotypes over location for aromatic quality, acidity, flavor, and overall cup quality traits indicated fundamental genetic differences for sensory quality among the evaluated Arabica coffee genotypes across locations. Most organoleptic quality attributes like aromatic intensity, aromatic quality, acidity, astringency, bitterness, body, flavor, and overall cup quality show a nonsignificant correlation with agro-morphological traits. However, there is a significant correlation between agro-morphological traits and organoleptic properties, and a highly significant correlation among them. The existence of positive correlations among many organoleptic properties suggests that any organoleptic property is an important determinant of beverage quality. Although coffee genotypes with large beans are preferred and considered to have better organoleptic quality than small beans, there were no significant correlations between organoleptic quality and bean physical characteristics. Therefore, simultaneous selection for sensory quality and bean physical character is challenging. This study identifies a genotype, 3/82, which showed superior performance for all organoleptic quality attributes across the test locations. Therefore, the genotype that exhibits desired cup quality traits should be given priority. Generally, this study showed no considerable relationship among organoleptic quality and morphological traits. However, superior genotypes for organoleptic quality traits were found. Further study needs to be conducted to evaluate the superior genotypes in different coffee-growing regions to measure the extent of the correlation between organoleptic quality and morphological traits.

#### Data Availability

All the data that support the findings of this study are included in the manuscript.

#### Conflicts of Interest

The authors declare that they have no conflicts of interest.



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