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Bean quality and taste of robusta coffee (*Coffea canephora* Pierre ex A. Froehner) from Bale village on Halmahera Island, Indonesia

B. Bahtiar ^{1,*}, M. Nasir Tamalene ¹, S. Suparman ¹, Yusmar Yusuf ¹ and Slamet Haryadi ²

¹ Biology Education, Faculty of Teacher Training and Education, Universitas Khairun, Indonesia.

² Biology Education, Faculty of Teacher Training and Education, Universitas Jember, Indonesia.

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Abstract

North Maluku is one of the provinces producing Robusta coffee (*Coffea canephora* Pierre ex A. Froehner) in Indonesia. Although coffee production is smaller than in other provinces, coffee can be found in many locations in the provinces, namely Halmahera Island, Bacan, Obi, Tidore, and Ternate. Bale Village, located on Halmahera Island, is one of the villages in the Oba sub-district, Tidore Island. The village is known on Halmahera Island, Ternate Island, and the surrounding areas as a producer of coffee beans and coffee powder. Some of the people in the village live as farmers and home coffee entrepreneurs using traditional processing methods. The quality and taste of the coffee beans from smallholder coffee plantations from Halmahera Island, especially Bale Village, need to be studied to set the status of bean quality and taste of local coffee in Indonesia. This study is an effort to gain an initial illustration that will become a foundation for a comprehensive local coffee development in North Maluku. It will encourage resorts to generate local coffee with a unique taste that is widely known, favored by many people, and has the potential to be a Geographical Indicator (IG) of Halmahera coffee. The research result indicates that Robusta coffee beans from Bale Village Halmahera Island are free from live insects, not rotten or moldy, and do not contain foreign matters with moisture content meets the general requirement of SNI 01-2907-2008. The result of quality testing of Robusta coffee beans from Bale village is within the criteria of quality 4b in the SNI 01-2907-2008. The attributes of coffee taste consisting of fragrance/aroma, flavour, bitter/sweet, and mouthfeel/body are in an excellent category, whereas clean cup and uniformity are in an outstanding category. The final score and cup testing is 84.62, which is in the specialty coffee category.

Keywords: Quality beans; taste; Robusta coffee; Bale Village; Halmahera Island

1. Introduction

Robusta coffee (*Coffea canephora* Pierre ex A. Froehner) grows in tropical countries including Indonesia, Vietnam, Columbia, and Brazil [1]. The plant is more resistant to disease attack compared to Arabica coffee and it tastes more bitter, more sour, and contains higher caffeine levels [2][3]. It is the most cultivated type of coffee in Indonesia and one of the superior commodities in the agriculture and plantation sectors [4].

A common issue in robusta coffee commodity is the low physical quality of coffee beans due to improper cultivation techniques and plant maintenance, traditional post-harvest coffee bean processing, and inappropriate selection of coffee seedlings. The genetic traits of coffee beans and the growing environment determine the bean classes and sensory attributes (taste) of coffee [5]. The physical quality of coffee beans produced is varied and inconsistent and some of them do not meet the SNI 01-2907-2008 [6]. Lots of coffee beans produced have no comprehensive advantages and are unable to compete in the global market. Defects are often found in coffee beans consisting of broken beans, brown beans, black beans, or hollow beans [7][8]. Indonesia cannot compete with Brazil, Vietnam, and Colombia in the global market [9][10][11] despite its high geographical variation of coffee producer areas that have the potential to be developed to increase Indonesia's coffee competitiveness in the global market [6].

* Corresponding author: Bahtiar

Halmahera Island is the largest island in Maluku Islands, Indonesia. The island is part of the Maluku Province. It has an area of 17.780 km² or 6.865 square miles [12]. Its main plantation products are coconut, nutmeg, and clove. North Maluku is one of the largest Robusta coffee producers in Indonesia. Although the production is relatively smaller than in other provinces, coffee plants and products can be found in many locations on the Halmahera Island, Bacan, Obi, Tidore, and Ternate [13][14]. The mapping of community needs and assets indicates that the characteristics of the area, land, and climate of North Maluku, including Halmahera Island, support the plantation of coffee, especially Robusta coffee.

Bale Village is located on Halmahera Island. It is one of the villages in the Oba Sub-district that is included in the administrative area of Tidore Kepulauan City. The village is known as a coffee beans and coffee powder producer marketed on Halmahera Island, Ternate Island, Tidore Island, Bacan Island, and other small islands in its surrounding. Some of the people in the village live as coffee farmers and home coffee entrepreneurs using traditional processing systems.

Coffee bean quality and coffee taste from various smallholder coffee plantations on Halmahera Island, especially in Bale Village, need to be studied as an attempt to set the quality status of local coffee beans in the area. This is a way to gain an initial illustration that will be used as a basis to develop the local coffee of North Maluku comprehensively. This encourages efforts to generate local coffee beverages with unique tastes that are widely known, favored by many people, and have the potential to be a Geographical Indicator (GI) of Halmahera coffee. Extensive research on coffee bean quality and coffee taste from coffee plantation centers will allow the finding of coffee plants with good bean quality and unique taste.

2. Material and methods

2.1. Coffee Bean Samples

The coffee bean samples were green beans collected from coffee farmers in Bale Village, Oba Sub-district, Tidore Kepulauan on Halmahera Island. The green bean samples were beans that had their pulp and shell (parchment) removed and ready for the roasting process to enter the testing and analysis stage in the laboratory.

2.2. Quality Analysis of Coffee Beans

Table 1 Characters of Coffee Bean Quality of Interest, Requirements, and Analysis Methods

Character	Requirement	Analysis method
Live Insects	Absent	SNI 01-2907-2008; 7.1
Rotten/Moldy Beans	Absent	SNI 01-2907-2008; 7.2
Moisture Content	Maximum 12.5% mass fraction	SNI 01-2907-2008; 7.1
Foreign Matters Content	Maximum 0.5% mass fraction	SNI 01-2907-2008; 7.4.2
Size of coffee beans	Large, if the beans do not pass through a 6.5 mm sieve (Sieve No. 16), a maximum pass of 5% mass fraction. Small, if the beans pass through a 6.5 mm sieve and do not pass through a 3.5 mm sieve (Sieve No.9), a maximum pass of 5% mass fraction.	SNI 01-2907-2008; 7.4.1
Defect Numbers	Quality 1, maximum defect of 11 Quality 2, defect of 12 to 25 Quality 3, defect of 26 to 44 Quality 4a, defect of 45 to 60 Quality 4b, defect of 61 to 80 Quality 5, defect of 81 to 150 Quality 6, defect of 151 to 225	SNI 01-2907-2008; 7.4.2

The analysis of coffee beans quality and coffee taste was conducted at the Laboratory of Coffee and Cacao Research Center in Jember, East Java. The coffee bean quality was determined following the Indonesian National Standard (SNI) of Coffee Bean Commodity SNI 01-2907-2008 which includes observation of general requirements and special requirements [15]. The general requirements consist of characters of the existence of live insects, rotten and moldy beans, moisture content, and foreign matter content. The special requirements comprise the size of coffee beans and defect numbers.

2.3. Coffee Taste Testing

The coffee taste testing was conducted using a hedonic test of the Cup Testing method. The testing employed 6 (six) certified expert taste panelists. The coffee bean samples (green beans) were taken randomly of 300 grams and roasted at a temperature of 175–200°C until medium-roasted coffee beans were obtained and then the beans were ground. Assessment of fragrance/aroma was conducted by inhaling the air near the coffee powder in the bowls. Boiled water ($\pm 100^{\circ}\text{C}$) was poured into the bowl and then covered the bowl and allowed to steep for about 3 minutes until it formed, stirring gently while smelling it to evaluate the aroma. The floated coffee particles were removed and waited until the temperature was $\pm 50^{\circ}\text{C}$ and then the flavour assessment was done by tasting the brew using a special spoon, sipping it until the liquid filled the surface of the tongue, holding it for 3–5 seconds until the taste buds catch the various flavours, among others, aftertaste, acidity, bitterness, uniformity, and balance. The coffee body (consistency) was valued by rubbing the tongue on the roof of the mouth. The testing process was conducted 3-5 times to gain the right impression of the coffee. The assessment of the taste profile used a form referring to the Specialty Coffee Association of America (SCAA) Cupping Form [16].

Each coffee taste attribute used scores of 0-10 by grouping the scores into 6.00-6.75, which is a good category, 7.00-7.75 is a very good category, 8.00-8.75 is an excellent category, and 9.00-9.75 is an outstanding category. The coffee taste categories were based on the final score, namely Very Good (80-84), Excellent (85-89), and Outstanding (90-100). The specialty coffee category is a category with a taste final score of ≥ 80.00 .

3. Result and Discussion

No live insects as well as rotten and moldy beans were found in the robusta coffee bean samples from Bale Village Halmahera Island. Moreover, the samples had a foreign matter content of 0% and a moisture content of 11.3%. The moisture content was smaller than 12.5%; thus, the coffee beans met the criteria of the SNI 01-2907-2008.

Table 2 Results of Testing of Robusta (*Coffea robusta*) Coffee Bean Quality from Bale Village

No	Character	Testing/Analysis Result
1	Live Insects	Absent
2	Rotten/Moldy beans	Absent
3.	Moisture Content	11.3%
4.	Foreign Matters Content	0%
5.	Size of coffee beans	Pass through the 6.5 mm sieve, did not pass through the 3.5 mm size.
6.	Defect Numbers	141.9
7.	Caffeine Content**	1.77%
8.	Conclusion According to SNI 01-2907-2008	Quality 5. Small beans

Based on the bean size, Robusta coffee from Bale Village passed through the 6.5 mm sieve and did not pass through the 3.5 mm sieve; hence, the bean samples (dry processed) were in the small bean category. The size, shape, and structure of coffee beans produced are the interaction of coffee plant genotypic factors and environmental factors. The environmental factors include rainfall, soil characteristics, slope, fluctuation, temperature, humidity, and altitude [17]. Coffee bean normality is influenced by genetic factors, altitude, and its interaction [18]. The altitude of the growing location affects Robusta coffee bean size. The higher the growing location, the larger the bean size. Robusta coffee can be cultivated at an altitude of 400-800 asl. The coffee plants grow well in the soil of 5-6.5 and at an average temperature of 21°C-24°C. Smallholder coffee plantations in Oba Sub-district and its surrounding areas are located at an altitude of

18-29 asl; therefore, besides the genetic factors of the coffee seedling, the altitude of the growing location is assumed to be a factor for smaller Robusta coffee bean.

The best rainfall for Robusta coffee plants is between 2000 and 3000 mm/year [19][20]. High rainfall throughout the year causes a decrease in harvest and lack of dry season can limit coffee harvest in lowland tropical areas [21]. North Maluku has an average air humidity of 84% and wind velocity of 31 knot in August. The highest rainfall is in January. The largest sunshine of 89% occurs in September, whereas rain is all year round with varying intensity [22]. Rainfall in the areas around the coffee plantations in Bale Village is approximately 2000-3000 mm/year [23], which is an ideal condition for robusta coffee growth.



Figure 1 Cherry coffee (a), young coffee fruits (b), stalks and fruits (c), bean of Robusta coffee on Halmahera Island

The level of coffee bean quality is determined by the defect number of coffee beans tested. The testing result indicates that the defect numbers of Robusta coffee beans from Bale Village was 141.9, which was in quality 4b according to the SNI 01-2907-2008. The post-harvest bean processing into green beans by farmers uses traditional methods causing many defects in the coffee beans thus decreasing the coffee bean quality.

Defect in the coffee beans is also caused by improper processing of plantation products and physiological disturbances (ripening disorders and uneven maturation) resulting in full or partial black beans, green beans, hallow beans, and cracked beans [24] [25]. The large number of defects from the tested coffee beans in Bale Village were related to uneven maturation of the harvested fruit and poor post-harvest processing. Coffee farmers in Bale Village and Halmahera Island use traditional coffee processing which is a dry process. Sun-drying the coffee cherries causes harder skin. The hulling

process of outer rind, pulp, and parchment is conducted after the drying process using a traditional tool of wooden mortar, which is a dried coffee cherries grinder. The process causes lots of broken coffee beans. Moreover, coffee beans that have been hulled from their outer rind and parchment are not sorted properly in the sorting process.

The results of the Hedonic Test using the Cup Testing method or analysis of Robusta coffee beans from Bale Village Halmahera Island indicate a fragrance/aroma score of 8.13, flavour and bitter/sweet score of 8.00, mouthfeel/body score of 8.13, and clean cup and uniformity score of 10. The final score of the cup testing was 84.62. Referring to the quality scale from the Specialty Coffee Association of America (SCAA) [26], the fragrance/aroma, flavour, bitter/sweet, and mouthfeel/body were in the excellent category, whereas clean cup and uniformity were in an outstanding category.

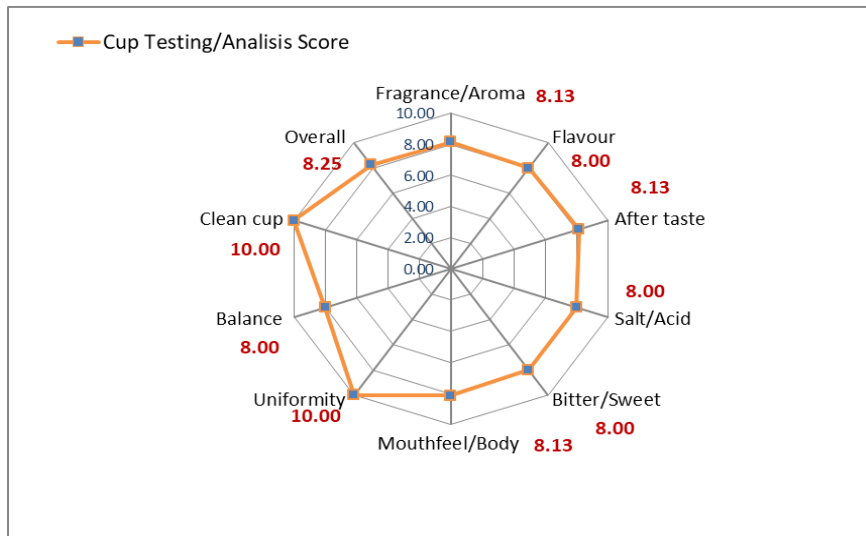


Figure 2 Cup Testing/Analysis Score of Robusta Coffee from Bale Village

Referring to the Q-Grader standard, which is a coffee assessment standard with the Specialty Coffee Association of America (SCAA) method, Robusta coffee from Bale Village on Halmahera Island is in the very good taste category and is included in the specialty coffee category. Coffee taste is affected by geographical location, climate, and soil fertility. The higher the altitude of the coffee growing location, the more delicious the taste. Climate is one of the crucial factors affecting the coffee taste. Fertile land and high altitudes will generate better quality. Additionally, rainfall, air humidity, solar radiation, and temperature are the environmental factors affecting coffee taste [27][28].

Coffee taste is determined by the content of volatile and non-volatile compounds in coffee beans. Approximately 900 volatile compounds are found in coffee yet less than 20 compounds are identified. Volatile compounds are coffee aroma compounds [29]. They are compounds with low molecular weight (100-500 Dalton), volatile, and generally emit a characteristic odor [30]. Aroma is an attribute in sensory variables that affects the attractiveness of coffee drinks [31]. The compounds are affected by certain factors, namely growing environment, physiology, harvesting method, post-harvest process, and roasting process [32].

Robusta coffee from Bale Village Halmahera Island has a unique taste of caramelly, a sweet aroma, and vanilla. Caramelly taste is associated with furaneol content and vanilla taste is related to Vanillin content [29]. The sweet aroma of coffee is due to natural sugar contained in the coffee beans. When coffee beans are roasted, the natural sugar becomes more complex substances and gives a sweet taste to coffee. Moreover, amino acids and protein contribute to a distinctive sweet taste of coffee. The sweet aroma of coffee varies depending on the type of coffee, roasting levels, and serving methods. Organic compounds contained in coffee, such as caffeine, chlorogenic acid, and terpenes affect its aroma. Various organic compounds that give a sweet aroma to coffee include tryptophan, methionine, and phenylalanine. The sweet aroma of coffee is assumed to be one of the significant characteristics of high-quality coffee.

The cup quality characteristics of coffee drinks are organoleptically multifactorial and very complex. Cultivation methods, plant maintenance, and the post-harvest process have a significant influence. The quality of coffee taste is determined by production technology, coffee bean hulling technology (dry, wet, or washed and semi-washed), roasting and fermentation, water percolation method and its duration, and percolation water temperature and are accumulated in determining drink quality [33]. Different rainfall also affects the plant's physiological process and fruit (red cherry) ripening and will specify the results of cup testing [5]. Coffee agroproduction technology affects 40% of the attributes

of coffee drink cup quality, whereas the remaining 60% of the quality attributes are determined by post-harvest processing technology. Several studies explained that there were significant differences in bean classes and sensory attributes produced based on the coffee genotypes. The studies suggest that in addition to factors of cultivation, plant maintenance, and post-harvest process, genetic factors also determine the organoleptic characteristics of coffee drinks during cup testing.

4. Conclusion

Robusta coffee beans from Bale Village Halmahera Island contain no live insect, rotten/moldy beans, and foreign materials and the moisture content of the beans has met the general requirement of SNI 01-2907-2008. The quality testing result of the robusta beans from the village is in the criteria of Quality 4b of the SNI 01-2907-2008, with the bean size category being small. The attributes of the Robusta coffee taste consisting of fragrance/aroma, flavour, bitter/sweet, and mouthfeel/body are in the excellent category, whereas clean cup and uniformity are in the outstanding category. The final score of the cup testing was 84.62, which is in the specialty coffee category.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no competing financial interests and no personal conflict that could affect the work reported in the article.

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