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Physical and Chemical Characteristics of Chosen Genotype of Robusta Coffee from Curahpoh Village Bondowoso East Java

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Abstract

The identity of coffee is significant for consumers mostly in relation to the characteristics of the end result product taste and quality. Robusta coffee varieties are widely grown by farmers in Bondowoso Regency in east Java, Indonesia using planting materials of unknown origin. The objective of this work was to identify the physical and chemical occurrence of Robusta cherries harvested from seven chosen genotypes grown in Curahpoh Village, Bondowoso. Samples of Robusta coffee cherries of seven selected genotype plants were harvested from Curahpoh Village, Bondowoso at three levels of maturity. Some physical and chemical factors were assessed as follows: sphericity, bean density, weight per bean, moisture content, total dissolved solids, to elicit differences in the genotypes. Analyzing the results obtained, the authors pointed to rather serious differences in these characteristics between various genotypes. The sphericity of fresh coffee fruits ranged from 0.82 to 0.93, with average density values between 1.00 and 1.11 g/cm³. The moisture content of green beans varied widely from 4.46% to 22.79%, while total dissolved solids ranged from 2.67% to 5.27%. These studies suggest the possibilities of genotypes selection in order to produce a superior genotype that would improve the quality as well as the marketability of Bondowoso Robusta coffee. These data contribute to the enhancement of the current agricultural practices, and the proposal of new varieties of coffee adapted to the specifics of their environment.

Introduction

Bondowoso Regency is one of the coffee producers in East Java Province which is called as the "Coffee Republic". Based on statistical data, Bondowoso Regency has a Robusta coffee cultivation area of 3,914 ha and a production of 1,764 tons. Robusta coffee has better disease resistance than Arabica coffee (Campuzano-Duque & Blair, 2022). With a characteristic taste that is more bitter, slightly sour, and a higher caffeine content than Arabica, Robusta coffee must be processed properly (Budi et al., 2020; Rosyidi et al., 2020; Sunarharum et al., 2020). There are many factors influencing the quality of coffee, such as the fruit ripening at harvest (Costa et al., 2020), processing and drying methods applied (Banti & Abraham, 2021; Eshetu et al., 2022; Ghosh & Venkatachalapathy, 2014; Rosyidi et al., 2020; Sinaga et al., 2021; Soeswanto et al., 2021; Sunarharum et al., 2020), the storage and packaging method (Aung Moon et al., 2022) as well as the roasting process (Dippong et al., 2022; Priantari & Dharmawan, 2022; Tesfa et al., 2020) and the brewing method (Pradipta & Fibrianto, 2017) used for consuming coffee. The self-incompatible nature of Robusta coffee requires that in its cultivation it is necessary to plant several clones in one garden with a certain pattern (Moraes et al., 2018; Sousa et al., 2022). Farmers generally plant random clones of robusta coffee in their land, not using clones that are recommended due to their good performances, thus it will give impact to the characteristics of robusta coffee which also unknown. These practices may

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lead to the appearance of the new clones which are unidentified in prior. The growth of new clones in local farmers lands is profitable because it saves time and costs for breeding plantation crops which conventionally require a long time and large areas of land. The existing chosen genotypes are potentials whose characteristics and quality must be identified. Some of the potential chosen genotypes of Robusta Coffee in Bondowoso Regency were found in Curahpoh Village, Curahdami District, Bondowoso. Data and information related to Robusta Coffee have not yet been found, so the research is needed regarding the physical and chemical characteristics of the coffee cherries. Physical characteristics such as size, color, imperfect beans are important because they affect the quality of the coffee (Rincon-Jimenez et al., 2021). The physical characteristic of agricultural material is a measurable property which describes a physical state of agricultural material at any given condition and time (Marek et al., 2020). Chemical characteristic of coffee determined by variety, origin, and harvest season of coffee which react chemically during roasting (Saud & Salamatullah, 2021).

Based on SNI 01-2907-2008 the quality of coffee beans is determined by the absence of live insects, the number of beans/ molds smelling and the content of impurities, and the moisture content below 12.5%. Data and information from Robusta coffee are expected to become a potential source of locally based food. Coffee cherries from seven chosen genotypes Robusta coffee plants in the local farmers' garden in Curahpoh Bondowoso Village were harvested and identified. The purpose of this study was to determine differences in the characteristics of robusta coffee fruits and beans obtained from seven chosen genotypes coffee trees in Curahpoh village, Bondowoso regency. The physical characteristics to be observed are the level of maturity, sphercity, mass density, and weight per bean. The chemical characteristics to be exmined are moisture content and total dissolved solids. The benefit of this research is to provide basic information for determining good physical and chemical characteristics of fruit to be harvested, determining proper processing, and in developing new varieties with good production potential.

Methodology

The Robusta Coffee sample obtained from the Coffee Plantation of local farmers which was located at Curahpoh District, Bondowoso Regency. Observations and measurements were carried out at two laboratories: (1) the Harvest and Post-Harvest Technology Laboratory and, (2) the Botany and Ecophysiology Laboratory of the Agricultural Science Department, Faculty of Agriculture, University of Jember, Bondowoso Campus. The materials to be used in this research were seven chosen genotypes of Robusta Coffee, water, distilled water. The equipment needed for the implementation of this research were plastic bags, digital calipers, digital scales, tarpaulins, drying floors, hand refractometer, oven, and measuring cups. This study used a completely randomized design (CRD) which consisted of plant factors of Robusta Coffee fruit consisting of seven chosen genotypes (CG), namely CG1, CG2, CG3, CG4, CG5, CG6, and CG7. Each treatment was repeated 3 times for a total of 21 experimental units. The results of analysis of variance showing significant differences were carried out by Duncan's Multiple Range test (5%).

This research consists of 3 stages. Step I was the stage of harvesting the Robusta Coffee fruit. The coffee cherries from the seven chosen genotypes were all harvested and placed in different containers. Robusta coffee fruit samples were then weighed. Step II was the identification of the physical characteristics of the Robusta coffee fruit. Samples from each tree were sorted based on color which generally indicated the level of maturity (unripe, semi ripe, ripe, and overripe) namely green, yellow, bright red, red, and blackish red or also called the fruit picking test (Hariyadi, 2021). Each color sample of coffee cherries from each tree was weighed.

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Furthermore, the physical characteristics of the coffee beans were identified in the form of maturity level, sphericity, and mass density. Total dissolved solid of coffe fresh peel then examined use hand refractometer. Stage III is the drying and stripping stage. Each coffee cherries were then dried under the sun for 45 days, in which the cherries placed in different trays based on the type of plants and color of coffee cherries. After the coffee dried, the sphericity measurement was carried out again. The dried coffee samples were then peeled to obtain the green bean and then weighed and calculated by weight per bean. Moisture content and total dissolved solids of the green bean coffee then examined. The observational variables for fresh fruit and Robusta green bean were as follows:

Maturity Level

Coffee cherries from each different plant are harvested as a sample. After harvesting, the coffee cherries are sorted based on the maturity level of the coffee (green, yellow, bright red, red and blackish red). The sorting of each color from each tree is then weighed.

$$\text{Percentage of maturity level (\%)} = \frac{\text{weight of coffee cherries for each color category}}{\text{1 kg of mixed coffee cherries}}$$

(Sativa et al., 2014).

Sphericity

Fresh coffee cherries that have been sorted by color (fresh green coffee, fresh yellow coffee, and fresh black coffee) are prepared as much as 100 grams. The diameter of each fruit was measured using a caliper. Coffee cherries are measured in three dimensions, namely major diameter (a), middle diameter (b) and minor diameter (c). For grean bean coffee, based on the color sorting results, 20 beans were sampled to measure, the calculation formula:

$$\text{Sphericity} = \frac{(\text{a.b.c})^{1/3}}{\text{a}}$$

(Sativa et al., 2014)

Mass Density

The mass density of coffee cherries was measured by preparing a 500 ml measuring cup and adding 100 grams of coffee cherries which had been sorted by color (green, yellow and black). The measuring cup is filled with 100 ml of water, changes in the volume of water shown in the measuring cup and the addition is recorded. Mass density is calculated by the formula:

$$\alpha = \frac{mass\ (gram)}{\text{volume}(\text{cm}^3)}$$

(Sativa et al., 2014)

Weight per bean

Yellow Robusta green bean coffee that has been dried, then grinded using a huler to remove the outer skin and epidermis, until it becomes green bean coffee based on the results of color sorting (green, yellow, and black). Determination of weight per bean is calculated by the following formula:

$$\text{Weight per bean} = \frac{\text{100 gram of coffee bean}}{\text{Total amount of coffee bean per 100 gram}}$$

(Winarno & Indah Br PA, 2020)

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Moisture content

Moisture content of robusta coffee green bean examined based on SNI 2907 – 2008. Empty petri dish was prepared and weight (a gram). The sample of 10 grams coffee green bean was put into petri dish and weight (b gram). Sample on the petri dish was oven-dried for 24 hours at 100-105°C. After 24 hours sample put into desiccator for 15 minutes, then weight until reach constant weight (c gram).

$$\text{Moisture content (\%)} = \frac{b - c}{b - a} \times 100\%$$

Total Dissolved Solids

Examination of total dissolved solids Robusta coffee carried out use hand refractometer. Prism of hand refractometer cleaned first with distilled water and dried with tissue. Sample dripped on the prism of hand refractometer and measured the brix degree (Wahyudi & Dewi, 2017).

Results and Discussion

Yields of Robusta Coffee from the seven chosen genotypes (CG) were presented in Table 1. Based on the cherries color, the coffee cherries yields from the seven chosen genotypes are grouped into green, yellow, bright red, red, and blackish red. In general, physiologically ripe coffee cherries are red to blackish red (overripe) (Costa et al., 2020), but some types and varieties are physiologically ripe when they are yellow (Romano et al., 2022) and orange (Srikandi et al., 2019). Differences in the level of maturity in coffee cherries may occur due to differences in genotypes among plants (Nugroho et al., 2016). Genotypes described the hereditary information available in an organism's genome. These definitions can be used for a better interpretation of the phenomenon of coffee quality through the expression of chemical compounds exist in coffee beans (Diego et al., 2016).

Table 1. Percentage of ripeness based on fruit color

Source	Yield of harvest/plant										
	Total (g)	green (g)	%	yellow (g)	%	bright red (g)	%	red (g)	%	Blackish red (g)	%
CG1	1755	181	10,31	194	11,05	104	5,93	1170	66,67	91	5,19
CG2	1275	280	21,96	86	6,75	103	8,08	623	48,86	171	13,41
CG3	1113	106	9,52	92	8,27	103	9,25	747	67,12	47	4,22
CG4	1030	83	8,06	271	26,31	146	14,17	450	43,69	58	5,63
CG5	1432	88	6,15	147	10,27	146	10,20	968	67,60	65	4,54
CG6	1143	125	10,94	169	14,79	155	13,56	420	36,75	258	22,57
CG7	674	84	12,46	76	11,28	70	10,39	402	59,64	27	4,01

Note: CG=Chosen Genotype

Based on the total yield, CG 1 showed the largest yield, followed by CG 5, CG 2, CG 6, CG 3, and CG 7. Of the total yields, each plant showed the largest percentage of red fruit, between 43% and 67 %. This result of total yield of red cherries would be prospective while referring to the industrial standard. The coffee industry tends to pick the ripe red cherries in order to obtain high quality of coffee. Although some high cost consideration could also becoming problem when picking red cherries compared to the mixed maturity level of coffee (Ameyu,

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2017). Ripe coffee cherries tend to produce a coffee brew with strong acidity and a positive impression (Abubakar et al., 2023). The highest percentage of yellow fruit color was from CG 4 and the smallest was from CG 2 with range of 6,75-26,31%. Genotype is one of the things that can affect plant performance, bean yield, and coffee quality.

Based on the research of (Rakocevic et al., 2023) the genotype factor impacted practically all observed variables such as protein (PRO), caffeine (CAF), lipids (LIP),sucrose (SUC), total soluble sugars (TS), total chlorogenic acids (CGA), and total phenolic components (PC) in four genotypes of *Coffea arabica*. However besides genotypes, environmental factor also influenced the quality of coffee. It is also reported that one of the four observed genotypes (Catuai 99) in the 2^{nd} harvest year had the lowest initial berry moisture (53.8-66.8%) which indicating its advanced fruit maturation. The maturity level of the coffee cherries is an important factor because it will greatly affect the quality of the processed beverage produced. High quality coffee with excellent flavor will be obtained by processing the ripe coffee cherry (Abubakar et al., 2023). Flavor of coffee mostly is influenced by genetics and environmental factors(Akbar et al., 2022). Moreover, the riper the coffee cherries, the higher the anthocyanin content in coffee, the more suitable it is for consumption (Hariyadi, 2021). It is reported in another study that anthocyanin contents in orange-colored Arabica berries were lower than those in red fruits, while no anthocyanins were found in yellow colored Arabica coffee fruit (Esquivel et al., 2020). The maturity of coffee bean also affected the caffeine content. Ripe coffee bean showed a tendency of increasing caffeine after roasting. The increasing in caffeine levels occurs because of coffee mass loss during roasting process, because ripe coffee beans experienced the most optimum Maillard reaction and pyrolysis (Muhari et al., 2023).

Furthermore, there is a correlation between coffee bean ripening stages and flavor active differential metabolites in the coffee bean before it is processed. Based on the research result of (Bi et al., 2024) on comprehensively analyze the metabolite changes that occur during the ripening of Coffea arabica coffee cherries. The researchers identified a total of 1078 metabolites and found 46 core differential metabolites through a Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway analysis. At the early green fruit to red orange fruit stage, amino acid synthesis and metabolism dominated, with increases in compounds like O-acetyl serine, N formyl L methionine, and L cystine that contribute to sweetness and freshness. In the transition from the red-orange fruity stage to the brown ripe fruit stage, there was a significant decrease in nucleotides and derivatives like xanthosine, guanosine, and cytidine, which act as flavor-presenting compounds. This reduction in presenting nucleotides enhances the development of other flavor precursors like acidity, bitterness and tartness during cherry ripening. The brown ripe fruit stage to pink ripe fruit stage showed rapid increases in the synthesis of various saccharides (glucose, fructose, mannose) and flavonoids (quercetin, limo citrin) that contribute to sweetness, acidity, and aroma after roasting.

This suggests the pink ripe fruit stage is the optimal harvesting period for high-quality coffee. In the final pink ripe fruit stage to purple black fruit stage, secondary metabolite pathways involving terpenoids, caffeine and plant hormones were enriched. Compounds like eniposidic acid, shanzhiside and theophylline were significantly increased, which could impact the final flavor and aroma of the coffee. Correlation analysis identified 46 core differential metabolites that were strongly linked to taste indicators like sugars, amino acids and chlorogenic acids. This indicates these metabolites have potential as markers for assessing coffee quality and maturity. Overall, this study provides valuable insights into the complex metabolic changes underlying coffee cherry development and how these impact the final quality of roasted coffee beans. Based on the explanation above, the colour of maturity of different coffee cherries will

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give rise to different flavours of robusta coffee products and will be the hallmark or uniqueness of the taste of robusta yellow coffee which needs to be the subject of further research. Around 80% of coffee exports are in the form of coffee green bean (Fitriani et al., 2021). The demand for green bean coffee in international trade makes the physical characteristics of coffee beans a determinant of selling value. Physically, of course importers and consumers prefer to select beans that are large and flawless (Sinaga & Julianti, 2021). Fruit sphericity measurements were carried out to determine fruit dimensions related to coffee bean size (Kuala et al., 2019; Yuwana et al., 2015). The results of the analysis of variance showed a very significant difference from the interaction between the plant source of coffee cherries and the color of the coffee sphercity with an f-count of 2.39. The results of Duncan's multiple range test (5%) the effect of the interaction of plants and cherries color were presented in Table 2.

Table 2. The results of Duncan's multiple range test (5%) the effect of the interaction of chosen genotype (plants) and cherries color on the observed variables of Robusta Coffee Cherries sphericity

Source	**Sphericity of robusta coffee cherries**				
	Green	**Yellow**	**bright red**	**Red**	**blackish red**
CG 1	0,86 (b)	0,87 (ab)	0,88 (ab)	0,84 (c)	0,84 (bcd)
	A	A	A	A	A
CG 2	0,86 (ab)	0,85 (b)	0,91 (a)	0,88 (bc)	0,83 (cd)
	B	B	A	AB	B
CG 3	0,88 (ab)	0,91 (a)	0,86 (abc)	0,93 (a)	0,88 (ab)
	BC	AB	C	A	BC
CG 4	0,88 (ab)	0,88 (ab)	0,86 (abc)	0,88 (bc)	0,87 (abc)
	A	A	A	A	A
CG 5	0,85 (b)	0,89 (ab)	0,84 (bc)	0,85 (bc)	0,82 (d)
	AB	A	B	AB	B
CG 6	0,87 (ab)	0,87 (ab)	0,83 (c)	0,87 (bc)	0,90 (a)
	AB	AB	B	AB	A
CG 7	0,90 (a)	0,87 (ab)	0,90 (a)	0,90 (ab)	0,88 (abc)
	A	A	A	A	A

Notes: CG = Chosen genotype

Numbers followed by the same capital letter (horizontal) showed no significant differences in the Duncan test at the 5% level of the simple effect of fruit color at the same chosen genotype. Numbers followed by the same lowercase letters indicate not significantly different from the simple effect of chosen genotype on the same level of fruit color.

The cherries sphericity of Robusta Coffee was greater than that of Liberika Coffee and Arabica (Khansa & Bintoro, 2021). The coffee fruit sphericity from CG 1, CG 4, and CG 7 showed no significant differences with green, yellow, bright red, red, and blackish red cherries harvested. The fruit sphericity of CG 2, CG 3, CG 5, and CG 6 showed no significant differences between the yellow and red fruits. The red fruit from CG 2 showed the highest sphercity. Coffee cherries harvested on different color level showed sphericity value with no significant difference. The highest sphericity of green coffee cherries was obtained from CG 7 and significantly different from those from CG 1 and CG 5. The yellow coffee cherries showed the highest sphericity values from CG 3 and were significantly different from the CG 2 coffee cherries.

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The bright red coffee cherries of CG 2 showed the highest sphericity value and was significantly different from the coffee cherries from CG 5 and CG 6. The sphericity of red coffee cherries was the highest from CG 3 and not significantly different from the coffee cherries sphericity from CG 7. The sphericity of red-black coffee fruit was the highest from CG 6 and significantly different from the fruit from CG 1, CG 2, and CG 5. Sphericity describes shape of beans. Small size of coffee bean having higher sphericity than coffee bean with bigger size (Asoegwu et al., 2006). The mean mass density of fresh robusta coffee fruits having color varied from green, yellow, bright red, red and blackish red showed the value from 1.00-1.11 gram/cm^3 (Figure 1). Density is defined as the mass or weight per unit volume, while specific gravity is the ratio of the density of a material to the density of water. As the fruit ripened, the value of mass density will be closer to 1 (Sativa et al., 2014). There is no significant difference between the plant source of coffee cherries and the color of Robusta coffee from Curahpoh Village.

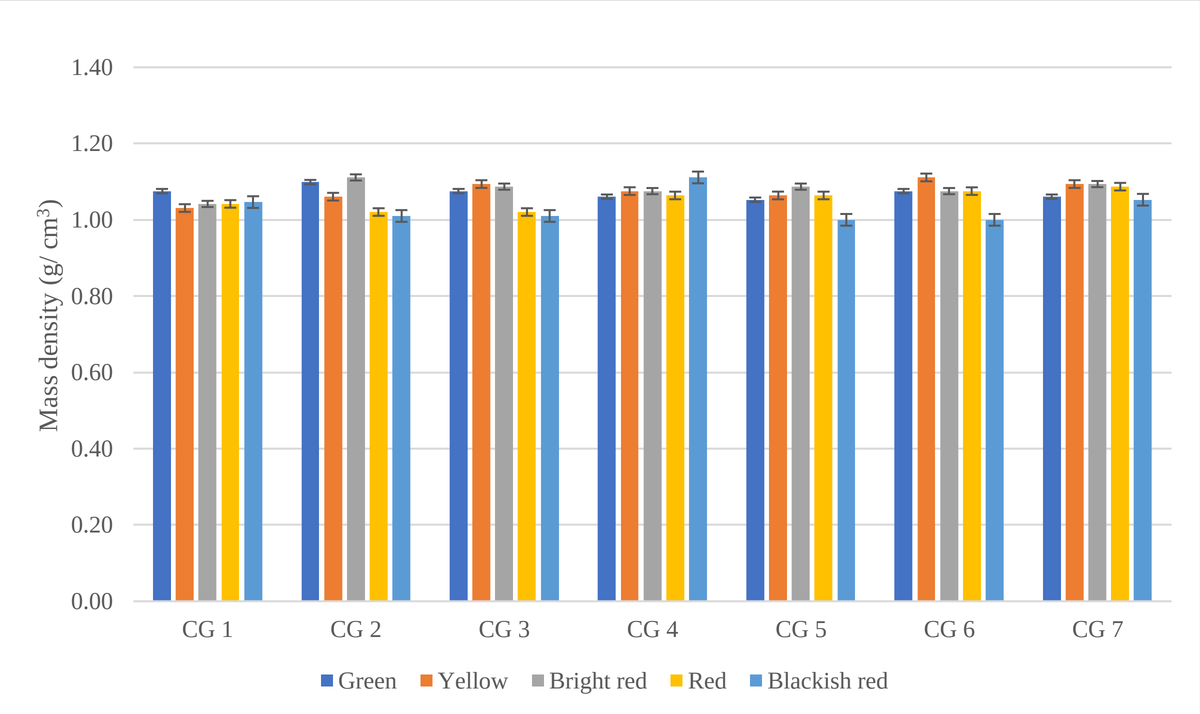

Figure 1. Mean mass density of fresh Robusta coffee fruits

Figure 2 showed the weight per bean of robusta coffee obtained from Curahpoh village, Bondowoso regency. Based on these results, CG 1 having weight per bean for yellow fruit of 0.169 gram and red fruit of 0.190 gram. CG 2 having weight per bean for green fruit 0.256 gram and red fruit 0.254 gram. CG 3 having weight per bean for red fruit 0.204 gram. CG 4 having weight per bean for yellow fruit 0.171 gram and bright red fruit 0.176 gram. CG 5 having weight per bean for yellow fruit 0.202 gram and red fruit 0.166 gram. CG 6 having weight per bean for yellow fruit 0.229 gram and red fruit 0.226 gram. CG 7 having weight per bean for red fruit 0.240 gram. The highest weight per bean obtained from green fruit of CG 2 and the lightest weight per bean obtained from red fruit of CG 5. Based on these results the yellow fruits of robusta coffee from CG 5 and CG 6 showed the heavier weight compared to others.

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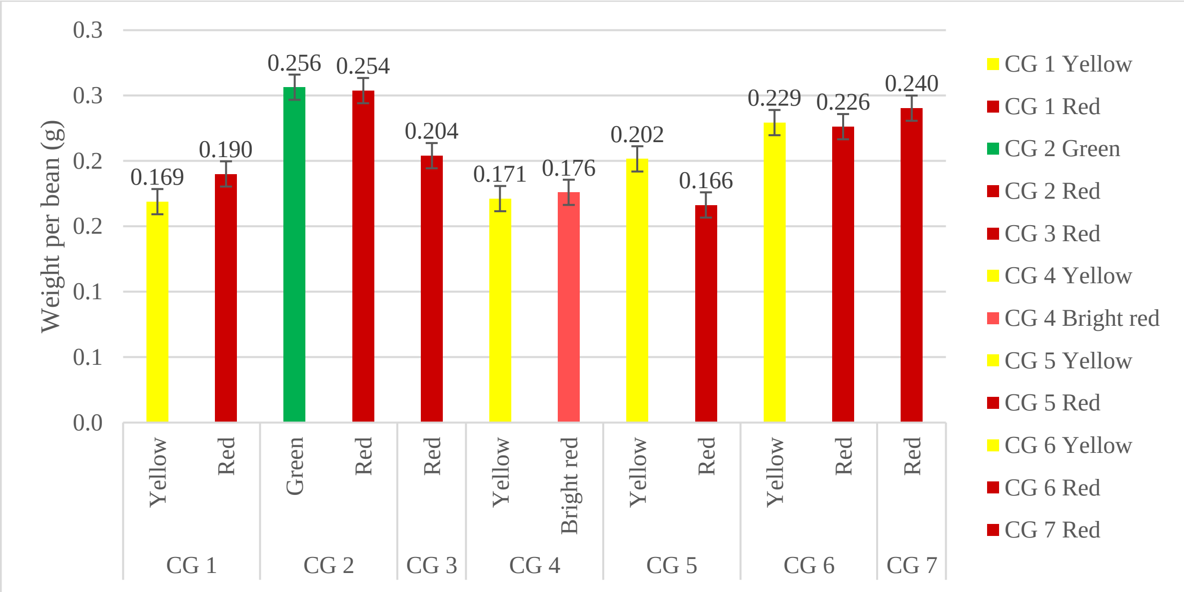

Figure 2. Weight per bean of Robusta coffee

The results of the analysis of variance showed a very significant interaction between the source of the chosen genotype and the color of the coffee fruit on the moisture content variable with F-count value of 3.69. The results of Duncan's multiple range test for coffee moisture content variables are presented in Table 3. The moisture content of coffee beans from CG 1 that meets SNI or Indonesian National Standard (maximum 12.5%) are green, yellow and red fruit is significantly different from seeds from bright red and blackish red. Fruit from CG 2 and CG 6 shows that fruit of all colors show moisture content that is not significantly different but those that meet the standards in CG 2 are red and green fruit while all fruit from CG 6 meets SNI. Fruit from CG 3 showed a moisture content that did not meet SNI for blackish red fruit, yellow fruit was not significantly different from bright red, red and green fruit. The moisture content of CG 4 fruit that meets SNI is yellow and bright red fruit and is significantly different from fruit of other colors. Fruit from CG 5 meets the moisture content standards for all fruit colors. The moisture content of CG 7 fruit in all colors does not meet the standard, it is closest to red fruit and is not significantly different from green and yellow fruit.

According to Kembaren & Muchsin (2021), moisture content of green bean coffee that safe to be stored is about 12-16%. The fulfilment of requirement for maximum moisture content of coffee affects shelf life of green bean coffee. It is reported in another study that the natural processed green bean coffee with initial moisture content of 11% will remain stable in quality (average water activity of 0.40–0.59) during 12 months of storage in -10°C and 10°C chambers compared to those stored in 20°C chamber (Blaszkiewicz et al., 2023). Moisture content of coffee bean is affected by many factors, such as weather condition, drying duration, drying container, thickness of coffee spread while drying, reversal frequency, and the height of drying container from floor surface. Moisture content of fresh coffee bean decreased due to bean maturity; this is consistent with research of (Wahyuni et al., 2020) that showed that coffee moisture content decreased according to the level of coffee maturity. Otherwise, there is no significant difference in moisture content between different roasting temperature and the maturity of coffee beans (Muhari et al., 2023). Higher moisture content of coffee generally caused bigger dimensions (length, width and thickness), however, at different moisture content levels showed insignificant difference ($P<0.05$) to sphericity of coffee bean (Niwagaba, 2019).

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Furthermore, (Muhari et al., 2023) investigated the relationship between coffee maturity level and moisture content, as well as the effect of roasting temperature on robusta coffee bean quality, and discovered that ripening coffee beans have higher moisture content than cherry coffee. This chemical feature will influence the duration and temperature of the roasting process, resulting in the optimum procedure. The roasting process for coffee beans with perfect ripeness (ripe) is carried out at various temperatures, giving different temperature changes; for ripe coffee beans (ripe) at 190℃ and 200℃ in the first minute, there is evaporation of water content is endothermic, so the temperature of the system reduces. At minute 4, there was a little increase in temperature, which was practically consistent. During the roasting process at 210℃, after water evaporation, the temperature rises in the 4th and 8th minutes, indicating pyrolysis between coffee bean compounds (exothermic). Observations of the roasting process revealed that the first and second cracking phases occurred at temperatures of 200℃ and 210℃, respectively, whereas the second crack phase was not accomplished at 190℃. This suggests that the roasting process will proceed smoothly at a temperature of at least 200℃. The second cracking process is significantly smoother than the first, resulting in a very low water content in the coffee. It is at this point when the oil from the coffee beans appears, as seen by its slightly glossy surface. The sour and distinctive taste of coffee is fairly modest, but it has a substantial bitter flavor.

Table 3. The results of Duncan's multiple range test (5%) the effect of the interaction of chosen genotype (plants) and cherries color on the observed variables of Robusta Coffee moisture content

Source	**Moisture content (%)**				
	Green	**Yellow**	**Bright red**	**Red**	**Blackish red**
CG 1	8,32 (cd)	8,95 (c)	13,11 (b)	8,79 (bc)	15,26 (c)
	B	B	A	B	A
CG 2	11,65 (bc)	12,83 (ab)	13,30 (b)	11,57 (ab)	12,84 (cd)
	A	A	A	A	A
CG 3	12,38 (b)	9,39 (bc)	8,83 (c)	8,54 (bc)	15,82 (c)
	B	BC	C	C	A
CG 4	16,32 (a)	9,76 (bc)	8,78 (c)	13,77 (a)	19,35 (b)
	AB	CD	D	B	A
CG 5	8,42 (cd)	8,61 (c)	6,96 (c)	6,22 (c)	10,56 (d)
	AB	AB	AB	B	A
CG 6	7,87 (d)	4,46 (d)	7,00 (c)	5,82 (c)	5,38 (e)
	A	A	A	A	A
CG 7	14,86 (ab)	15,38 (a)	17,96 (a)	13,43 (a)	22,79 (a)
	BC	BC	B	C	A

Notes: CG = Chosen genotype

Numbers followed by the same capital letter (horizontal) showed no significant differences in the Duncan test at the 5% level of the simple effect of fruit color at the same chosen genotype. Numbers followed by the same lowercase letters indicate not significantly different from the simple effect of chosen genotype on the same level of fruit color.

Total dissolved solids (TDS) indicate the amount of dissolved sucrose per 100 ml of solution. According to Mahardhika et al. (2022), TDS of Arabica Coffee is higher than Robusta Coffee. The highest TDS of green cherries was from CG 3 and showed insignificant different with green coffee cherries of CG 2, CG 4, and CG 7 (Table 4). Yellow coffee cherries showed the

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highest TDS was from CG 3 and showed insignificant different with yellow cherries of CG 1, CG 2, CG 4, and CG 6. Bright red color of coffee cherries showed that the TDS from CG 3 was significantly different with CG 5. The TDS of red color of coffee cherries from CG 3 was significantly different with CG 1 and CG 5. Blackish red of coffee cherries showed TDS value of CG 4, CG 6, CG 7 was not significantly different with CG 2. Value of TDS is one the most important factor that affect the flavour of coffee (Washington, 2016).

Table 4. The results of Duncan's multiple range test (5%) the effect of the interaction of chosen genotype (plants) and cherries color on the observed variables of fresh Robusta Coffee Cherries total dissolved solid

Source	**Total Dissolved Solid**				
	Green	**Yellow**	**Bright red**	**Red**	**Blackish red**
CG 1	3,39 (c)	4,76 (abc)	4,30 (ab)	3,16 (bc)	2,67 (c)
	ABC	A	AB	BC	C
CG 2	4,38 (abc)	4,32 (abc)	5,27 (ab)	4,21 (a)	5,59 (ab)
	A	A	A	A	A
CG 3	5,59 (a)	5,66 (a)	5,78 (a)	5,97 (a)	3,31 (bc)
	A	A	A	A	B
CG 4	5,46 (ab)	5,53 (ab)	4,51 (ab)	4,51 (ab)	5,07 (a)
	A	A	A	A	A
CG 5	3,73 (c)	3,79 (c)	3,86 (b)	2,78 (c)	3,14 (bc)
	A	A	A	A	A
CG 6	3,99 (bc)	4,49 (abc)	4,73 (ab)	4,94 (a)	4,99 (a)
	A	A	A	A	A
CG 7	4,83 (abc)	4,04 (bc)	5,39 (ab)	4,84 (a)	4,84 (a)
	A	A	A	A	A

Notes: CG = Chosen genotype

Numbers followed by the same capital letter (horizontal) showed no significant differences in the Duncan test at the 5% level of the simple effect of fruit color at the same chosen genotype. Numbers followed by the same lowercase letters indicate not significantly different from the simple effect of chosen genotype on the same level of fruit color.

Information obtained from the physical and chemical characterization of the Robusta coffee cherries originating from the seven selected genotypes in Curahpoh Village contributes to understanding the possibility of using these genotypes in producing quality coffee. In lapse identified above, every characteristic analyzed maturity level, sphericity, mass density, weight per bean, moisture content and TDS has profound implications both for Robusta cultivation and the coffee on the market. One of the findings being presented here is the variability in the maturity levels of the cherries across the different genotypes, a factor that puts into perspective the impact of timing in harvesting. More specifically, greater biological maturity which as discussed by Costa et al. (2020), determines the degree to which the intended flavoured compounds are released as the ultimate determinant of coffee quality. From the study, there is evidence of both early and late maturing genotypes, which points to the possibility of harvesting during separate time intervals in order to maximize both the total amount and quality of the coffee.

Furthermore, the findings given in this research correlate with Bi et al. (2024) on finding out that the ripening stages of coffee cherries are important developmental phases that facilitate accumulation of flavor-active metabolites. Given that genotypes mature at different rates,

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farmers could plant various with different traits to ripen at a given time and hence produce a variety of coffee products that suit the regional consumer palate in the specialty coffee market. Roundness of coffee cherries referred to as sphericity is therefore very vital when it comes to roasting and the resulting flavor of the coffee beans. Variability degree is related to the ability to improve sphericity by selection, thus indicating dissimilarities of the genotypes under consideration in this aspect. Rincon-Jimenez et al. (2021) & Yuwana & Sidebang (2015) concluded that it is crucial to maintain bean size and shape because non-homogeneous roasting produces off flavor characteristics. Since the sphericity values are significantly higher in genotypes such as CG 3 and CG 7, it may be concluded that these genotypes may be well suited to produce well roasted coffee beans with better sphericity thus improving the overall quality and marketability of the final product.

This trait may be particularly useful in industrial production of coffee or any other product, whereby regularity is paramount in ensuring consumer satisfaction. The mass density of the coffee cherries is an important physical characteristic which determines the structural quality and the ability of the beans to develop the right flavors. In this study, the variability of mass densities is between 1.11 g/cm^3 suggests the uniformity of strength, which is a major factor influencing the beans' suitability for different processing methods. Higher mass density as seen in the genotypes CG 2 and CG 5 leads to enhanced bean density and tough beans that can handle the ordeal of industrial processing and still retain the enhanced flavor (Nugroho et al., 2016). This characteristic is essential for the coffee intended for use in quality niches as the physical sturdiness of the beans may influence the effectiveness of the supply chain and the organoleptic properties of the coffee.

Also, mass density can affect the fineness of grind and how fine the coffee should be which is very important when brewing coffee. The moisture content of coffee beans is one of the most crucial aspects that determine not only the shelf stability but also the taste of prepared coffee. The variation in moisture content observed from 4.46% to 22.79% clearly indicate that there is a possibility of selecting right genotypes to suit post-harvest processing and storage requirement. According to Kembaren & Muchsin (2021), it is also important that the moisture content should be kept within the range of 12-16% especially when storing the green coffee beans since high moisture promotes mold formation and other degradative processes. As demonstrated by the data presented in Table 3, genotypes possessing values within this range, including CG 5 and CG 6, will be preferred for storage or export due to their higher tolerance to quality deterioration which is typically associated with storage.

Additionally, Muhari et al. (2023) describes how moisture content influenced the roasting behaviour, thereby stressing the need to monitor the amount of moisture to attain the preferred level of roasting. Excess moisture hinders even heat distribution across the beans and hinders formation of the desired flavors, especially for light roast beans due to the heightened sensitivity to flavor variations. TDS is one of the most important parameters that indicate the concentration of soluble solids in coffee which in turn contributes to its flavor intensity and the richness in the flavor. The TDS values revealed in the course of this study ranging from 2. 67% to 5. 27% gives indications on the competence of the different genotypes in producing the desired flavoured coffee. Higher TDS values specifically in the genotypes like CG 3 and CG 4 depicted a higher concentration of flavour compounds, which goes hand in hand with improved taste profile that is rich and complex in taste (Washington, 2016).

This characteristic is most useful in specialty coffee market since consumers are on the lookout for coffees with robust and unique tastes. The possibility to choose genotypes with higher TDS may thus provide a competitive edge in generating coffee that fits the demands of choosy

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clients. Also, the correlation between TDS and other quality parameters like acidity and sweetness shows that TDS plays vital role in quality of coffee (Mahardhika et al., 2022). The fact that the seven different genotypes of Robusta coffee differ in physical and chemical properties show clearly that genotype selection is key to better quality and marketable crop. Since sphericity, moisture content, and TDS can be predetermined by genotype, coffee producers can select the beans that meet the requirements of a particular market. This approach fits well in the current world trends of precision agriculture whereby decisions on crop production and quality are arrived at based on the available data (Moraes et al., 2018). Besides, the findings derived from this study can help in developing new breeds of Robusta coffee that will have all these desirable attributes with a view of improving the Indonesian coffee to meet the international markets. In a broader perspective, they support the existing discussions about the contribution of genetic diversity in agriculture its and ability to build and maintain resilience, especially in the face of climate change and other forms of environmental stress (Sousa et al., 2022).

Conclusion

It is revealed from the present study that much variation exists in the physical and chemical traits of Robusta Coffee cherries from seven selected genotypes grown in the Curahpoh Village of Bondowoso. Thereby, the results have also pointed out that the correct type of genotype selection for each of the investigated Arabicas, so that desirable organoleptic properties can be preserved and enhanced, as well as coffee's potential on the market, is critical for coffee quality. These differences in maturity levels of the genotypes make it possible to use selective harvesting to obtain a specific type of coffee flavor which will suit the market. It could therefore be argued that since the maturity of the genotypes varies, then selective harvesting could be used to produce coffee of different qualities to suit various markets. Altogether, the variation in sphericity and mass density, which has been revealed in the frame of the study, suggests that there are specific genotypes (e.g., CG 3 and CG 7) that may be more suitable for constant roasting and Industry processing and, accordingly, improve the quality of a finished product. Conservation becomes a priority for long-term storage, and one of the decisive factors fixing the quality preservation became the moisture content. Due to the proximity of Genotypes CG 5 and CG 6 to the preferred moisture content, these are most suited for long term storage thus suitable for exportation. This research also revealed that higher TDS values on genotypes such as CG 3 and CG 4 could produce more complicated and richer cup quality, which are essential in exotic markets of speciality coffee. Such results present realistic recommendations about the cultivation and subsequent processing of the compound. Through the utilization of these genotypes, the local farmers and coffee producers will be able to improve on the quality as well as the marketability of the Robusta coffee in the national as well as the international market. Further studies should be carried out on genotype selection on long run impacts and genotype by processing techinque interactions that will help in enhancing cooks better.

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