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Bantaeng Geographical Indication Arabica Coffee Coffea Arabica: Does Altitude Affect the Quality of the Coffee Bean?

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Abstract: Indonesia has a wide variety of coffee varieties, and is the 4th largest coffee exporter in the world. This study aims to discover about the difference of coffee bean quality from different altitude. In this study Coffee samples *Coffea arabica* L. which will be used is taken from Bantaeng Regency, South Sulawesi. The selected sample is coffee beans that are red and have matured at every altitude where they grow. Station I is between 800-1000 masl, station II is between 1000-1200 masl and station III is between 1200-1400 masl. The quality test including Physical test, Bean weight, volume, and smell test (rotten aroma) as in SNI 01-2907-2008. The result shows that the quality from each station is different. Thus this research conclude that the altitude will affect the bean quality of *Coffea arabica* from Bantaeng Geographical Indication area.

Keywords: Arabica; Altitude; Bantaeng geographical indication; Physical quality

Introduction

Coffee *Coffea* sp. is a tree-shaped plant that belongs to the family *Rubiaceae* and genus *Coffea.* Coffee plants grow upright and branched and if left unchecked will reach 12 meters in altitude. Coffee plants have reproductive branches, primary branches, and secondary branches. Coffee has a very distinctive taste, and the taste of coffee is greatly influenced by varieties (Syakir et al., 2017). *Green bean* Coffee is raw coffee beans that have not been roasted and are usually green in colour. *Green bean* Coffee is processed from ripe coffee cherries and goes through a drying stage using certain techniques to maximize its flavours. *Green bean* has a different shape according to the coffee variety. *Green bean* arabica coffee *Coffea arabica* L. has a larger size, oval shape and has a pale green colour. *Green bean* coffee contains chlorogenic acid that can reduce body weight, increase body metabolism, and fatty acid oxidation (Harahap et al., 2020). The farming of arabica coffee also come with profit based on its feasibility (Nangameka et al., 2023).

Protection of Geographical Indications is also a matter of great importance in obtaining legal protection for a biological product, bearing in mind that geographical indications are a national potential that can become superior commodities, both in domestic and international trade. Geographical indications are an exclusive right granted by the state to registered geographic indication rights holders, if the reputation, quality, and characteristics that form the basis for the protection of these geographical indications still exist (Medeiros et al., 2016). According to Haritsah et al. (2017), Bantaeng Regency is a geographical indication area because it has the potential to become a center for planting, developing and processing coffee based on a very supportive environment and agro-climatology. Geographical indication rights can only be granted to areas that meet the quality requirements in that region and not in other areas.

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Altitude greatly affects the growth of coffee, where arabica coffee plantations grow well at altitudes between 800-1500 masl. The higher the location of Arabica coffee plantations *Coffea arabica* L., the taste and character of the coffee produced is getting better and tastier. Meanwhile, Robusta coffee plants grow optimally at altitudes between 400-700 meters above sea level (Gumulya et al., 2017). Altitude affects air temperature and rainfall. The higher the place, the lower the air temperature, the higher the rainfall and the more loose/fertile the soil. Changes in these two climatic factors have an impact on the process of decomposition of organic matter, chemical composition in the soil and fruit ripening (Supriadi et al., 2016). The effectiveness of coffee plant growth depends on the altitude where coffee is grown and how it is processed (Cerda et al., 2017). Differences in environmental factors due to differences in altitude affect vegetative and generative growth of plants.

Differences in plant growth also occur due to differences in the intensity of sunlight, which greatly affect the efficiency of photosynthesis and fruit formation. Increasing temperature has an impact on increasing length, fruit diameter, and number of fruit and time of appearance of the first fruit (Rinaldi, 2022). In the other hand, altitude also affect the growth of the coffe desease like wilt by *Fusarium xylaroides* (Zhang et al., 2023). Change of temperature e not only afect growth and production of crop plants directly (Tubiello et al., 2007) but also, indirectly, by infuencing the infectivity and pathogenicity of crop diseases (Newbery et al., 2016).

This research is important as the coffee farmer usually plant their coffee not by its characterisation, like how suitable the coffee plant species to the environment of their land but looking at how well the coffee sold in the market. In another hand if the coffee plant is not suitable for the environment especially the altitude. By knowing which altitude id the best match for *Coffea arabica* in Bantaeng we hope the famer can decide what kind of coffee they want to gorw. But the data of this kind of problem is only a few, thus this research was inisiated. The purpose of this study was to determine the physical quality characteristics of Arabica coffee fruit and beans *Coffea arabica* L. cultivated based on altitude from sea level (masl) in Bantaeng Regency.

Method

Coffee samples *Coffea arabica* L. which will be used is taken from Bantaeng Regency, South Sulawesi. The selected sample is coffee beans that are red and have matured at every altitude where they grow, wheredetermined three elevation stations. Station I is between (800-1000) masl, station II is between (1000-1200) masl and station III is between (1200-1400) masl. At each station, three sampling points were determined. Altitude data is taken using an altimeter.

Dry Sample Processing

Coffee cherries that have been harvested are subjected to a sorting process, namely separating the coffee cherries from the damaged ones. The coffee cherries will be spread over the surface of the plastic mat and then dried in the sun. The coffee cherries must be turned over so that the coffee dries evenly. After drying, the coffee skin is peeled to take the seeds using ae*holes* machines. The drying process lasts for 3-4 weeks to produce *green bean* arabica coffee *Coffea arabica* L.

Physical Quality Test

The physical quality test includes observing the aroma of the beans (rotten smell), the coffee passing the sieve and the value of defects. Physical character testing of *green bean* arabica *Coffea arabica* L. will be adapted to SNI 01-2907-2008.

Seed Weight Test

This test is carried out by calculating the total number of coffee beans in 100 grams, and furthermore the average weight of Arabica coffee beans was measured *Coffea arabica* L. use the formula and record the results of these measurements. Data from the results of weight measurements arabica coffee *Coffea arabica* L. is calculated using the following formula (Barlaman, 2013).

$$\text{Seed Weight} = \frac{\text{100 grams of coffee beans}}{\text{The total amount of coffee beans in 100 grams}} \quad (1)$$

Seed Volume Measurement

This is done by measuring the length of the coffee, the width of the coffee and the altitude of the coffee using a caliper and calculating volume (V). Volume measurements (V) were carried out using the formula and the results of the measurements of each sample were recorded. Volume measurement arabica coffee *Coffea arabica* L. is calculated using the following formula (Sutrisno, 2020):

$$V = \frac{\pi \times P \times L \times T}{3} \quad (2)$$

Result and Discussion

The results of the physical quality test of Arabica coffee grown at different altitudes (asl) in Bantaeng Regency can be seen in the table 1. According to (Novita et al. (2010), physical quality is the ability to describe the inherent characteristics of a product. Coffee characteristics include properties that can be directly observed, measured and are important quality elements.

Table 1. Quality Test Result

Altitude (masl)	Seed scent (smelly)	Coffee Size (mm)	Defect value
800-1000	No rotten smell	Medium Seed	31.9
1000-1200	No rotten smell	Medium Seed	9.15
1200-1400	No rotten smell	Big Seed	28.95

Scent of Seeds

Test the aroma of the coffee beans*Coffea arabica* L is carried out using the organoleptic method through the sense to smell good coffee beans, and visual foresight to assess the bright color of the coffee beans, not contaminated with foreign materials, which can either cause discoloration or smell. Good quality seeds have a fresh smell, uniform, and bright color. Coffee bean quality standards are indispensable as benchmarks in quality control and are one of the criteria in marketing tools. The arabica coffee known containing some organic acid that can affect the aroma and taste (Panggabean, 2019). The groups of volatile compounds that contribute most to the formation of coffee aroma are furans, thiols, pyrazines, furanones and phenolic compounds (Sunarharum et al., 2019). The phenolic acid will make the aroma more fragrant in roasting process (Langi et al., 2023).

The Indonesian National Standard for coffee beans has been issued by the National Standardization Agency, namely SNI 01-2907-2008, namely the smell of the coffee beans is distinctive and does not show the beans smelling rotten, smelling of mold or other foreign smells, where the smell of the beans is caused by mold or odor. musty as a result of storing coffee beans with high water content for too long (Pramono et al., 2018).

Results of the physical quality test of Arabica coffee*Coffea arabica* L based on the altitude above sea level as shown in the table above. Of the three differences in altitude where Arabica coffee grows*Coffea arabica* L, apparently did not show any difference in the aroma of the seeds produced. This shows that coffee*Green bean* arabica*Coffea arabica* L. from Bantaeng Regency, is in accordance with the general quality requirements based on SNI 01-2907-2008 which was ratified by a government regulation in 2012. The coffee bean quality requirements that are applied are the absence of bean aroma (rotten smell) on the coffee beans. In addition, according to Handayani (2013), the requirements for the physical quality of the coffee bean sample are that no live insects are found and the seeds do not smell bad, because smell is one of the determining parameters of the quality of the coffee beans.

Sieve Passing Coffee

The size test of coffee beans passing the sieve was carried out using a multilevel sieve (mess) method to determine the size of the coffee beans with the criteria of bean size, large (L), medium bean size (M) and small bean size (S). Coffee beans that do not pass the 7 mm sieve are classified as large coffee beans (L), those that do not pass the 6 mm sieve are classified as medium coffee beans (M), while the coffee beans that do not pass 5 mm are classified as small coffee beans (S), based on SNI SNI 01-2907-2008 (Sutrisno et al., 2020). For the quality of the size of coffee beans*Coffea arabica* L in Bantaeng Regency, which grows at an altitude between 1200-1400 has a larger size, but has a relatively high disability value. Meanwhile, Arabica coffee beans grow at an altitude of 1000–1200 meters above sea level, even though the seeds are of medium size, the level of seed defects is relatively low. This shows that all samples of coffee beans*Green bean* arabica*Coffea arabica* L. at different altitudes (masl) according to Bantaeng Regency, it is included in the physical quality requirements of the category coffee beans. Bean size is an important character in determining the quality of coffee beans. In general, the size of the coffee bean is influenced by the variety, the conditions of the cultivation site, the altitude above sea level, and the type of soil where it grows (Priantari et al., 2022).

Defective Value

The value of defects in coffee beans is one of the characteristics that will affect the quality of the brewed coffee. Classification of coffee defects based on SNI 01-2907-2008, includes criteria for the presence or absence of foreign bodies not originating from coffee, the presence of non-coffee bean foreign bodies such as pieces of coffee skin, visually abnormal coffee bean shape and abnormal beans which cause taste defects (Novita et al., 2010).

Defective grades of Arabica coffee beans*Coffea arabica* L at each altitude (masl) in Bantaeng Regency as shown in the table. Defect value of coffee beans*Green bean* at an altitude of 800-1000 masl of 31.9%, and the coffee bean defect value *Green bean* at an altitude of 1200 -1400 masl of 28.95%, so both are included in quality category 3, based on the requirements of SNI 01-2907-2008. As for the altitude of 1000-1200 masl, the coffee bean defect value *Green bean* namely 9.15%, including quality category 1.

Following are the requirements for coffee quality classification based on the value of defects determined by SNI 01-2907-2008. Criteria for coffee bean defects are based on SNI 01-2907-2008.

Table 2. Total Devective Valie of Coffee Bean

Stop	Total Defective Value (%)
End 1	1-11
End 2	12-25
End 3	26-44
End 4	44-80
End 5	81-150
End 6	151-225

The value of broken seed defects can also be caused during the skin stripping process using a machine. Another cause of seed defects is caused by insect attacks, namely coffee berry borer pests. Coffee cherries attacked by powder pests will dry on the stalks and will appear pale reddish yellow like ripe coffee cherries, so that after processing they will produce black bean defects (Novita et al., 2010). Furthermore, according to Priantari et al. (2022), the criterion for the type of defect that most determines the value of the defect is if the coffee beans are partially black and the coffee beans are broken. Broken coffee beans are a type of defect caused by processing or after harvesting coffee (Yulianti et al., 2023).

IV.2 Seed Weight

Seed weight*Green bean* coffee arabica*Coffea arabica* L. is the weight per unit of Arabica coffee beans. The weight of a coffee bean is obtained from the results of dividing 100 grams of Arabica coffee beans that have been weighed. Results of weighing Arabica coffee beans*Coffea arabica* L., based on the altitude where it grows which is different from Bantaeng Regency, can be seen in the figure below.

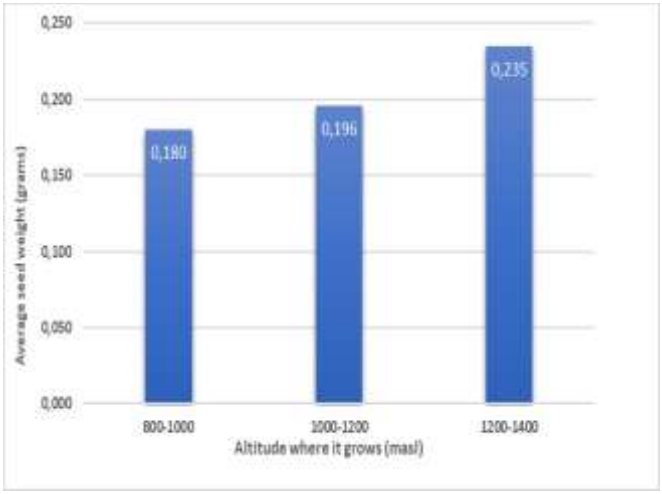

Figure 1. Average seed weight from different altitude

In the picture above, you can see the results of weighing the coffee beans*Green bean* arabica*Coffea arabica* L. from the three altitudes where it grows, produces different seed weights. Coffee beans grown at an altitude of 1200 - 1400 masl have the highest weight with an average of 0.235 gr and the lowest at an altitude of 800 - 1000 masl with an average seed weight of 0.180 gr.

According to Supriadi Supriadi et al. (2016), the weight of 100 coffee beans will increase with increasing altitude. Lower temperatures at higher altitudes will slow down the ripening process of the coffee cherries so that the coffee beans are more perfect and fuller. The results of the correlation analysis of soil chemical properties with altitude also indicate that the higher the location, the better the chemical properties of the soil so that the quality and seed production will also be better. In addition, at higher altitudes the organic matter content is higher than at lower altitudes.

Arabica coffee *Coffea arabica* L. will be suitable to grow on land with an altitude above 1000 meters above sea level. An increase in altitude will be followed by a decrease in air temperature and humidity. Air temperature will affect the physiological processes of plants, and for Arabica coffee types in these environmental conditions will suppress plant respiration rates. The process of respiration and the speed of the plant's photosynthesis process will be greatly influenced by the air temperature of the plant's environment. Air temperature conditions that are not optimal will have a negative impact on plant production where flower fall or nipple fall will occur, causing a decrease in yield (Cahyadi et al., 2021).

Volume Beats

Coffee bean size is very important as an assessment, because there is a correlation between bean size and quality. One of the physical characteristics of coffee beans is their volume. Volume is a measure of how much space a material can occupy.

The results of measuring the average length, width, altitude, volume of Arabica coffee beans*Coffea arabica* L. from Bantaeng Regency based on the altitude of the place can be seen in the following figure.

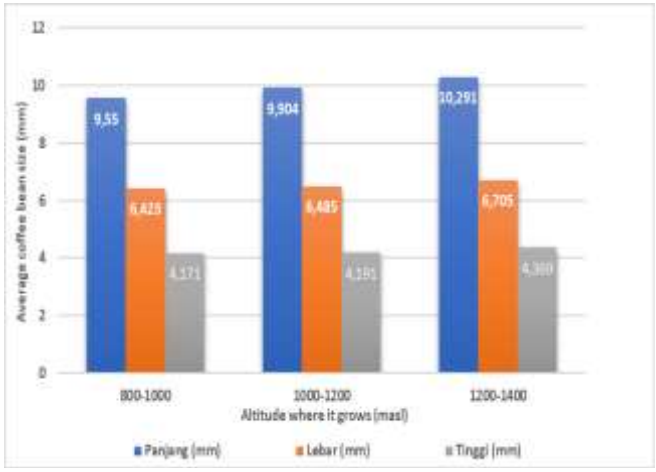

Figure 2. Average size of *Coffea arabica* from difference altitude in Length (Panjang), Wide (Lebar), and Tall (Tinggi)

In the picture above, you can see the volume of coffee beans*Green bean* arabica*Coffea arabica* The largest L. from an altitude of 1200-1400 meters above sea level with a volume of 333.059 mm^3 (rate-rate 315.53 mm^3) and the lowest from a altitude of 800-1000 with a volume of 262.604 mm^3 (rate-rate 267.65 mm^3). From the results of measuring the volume of Arabica coffee beans, it is known that the higher the coffee plant grows to a certain extent, the larger the volume of coffee beans will be produced. This is because there is a correlation between seed size and volume, the larger the seed size, the larger the seed volume will be followed. According to Putri et al. (2018), coffee volume is influenced by the size and shape of the coffee, the larger the bean size, the greater the volume of the coffee beans.

The altitude where coffee plants grow above sea level affects the growth and development of Arabica coffee*Coffea arabica* L. The altitude where it grows also affects rainfall, the higher the place from sea level, the higher the rainfall. The combination of rainfall and temperature is very influential on the process of photosynthesis. Likewise, differences in local climatic conditions due to variations in the altitude of the planting location will affect the quality and size of the coffee beans (Ramadhani et al., 2019). Meanwhile Arabica coffe e*Coffea arabica* L is generally developed in the highlands between 800-1500 meters above sea level, so it really determines the quality and taste.

The higher the place where Arabica coffee grows*Coffea arabica* L., from sea level (up to a certain limit) the size of the seeds produced will be even greater, in the range of altitudes where it grows 1200 - 1400 meters above sea level provides the highest volume of quality seeds, this is due to suitability with environmental factors or the local climate. According to Rinaldi (2022), the factor that influences the difference in coffee bean size is the environment in which coffee grows. Altitude and climate play an important role through temperature, availability of light and water during the ripening process. Altitudes above 1000 meters above sea level can improve the production and quality of Arabica coffee beans *Coffea arabica* good L. Lower temperatures with less fluctuation at high altitudes promote slower and more uniform fruit ripening, resulting in larger, denser seeds. Shaded condition in plantation also affect the taste of coffee, which is better than in unshaded place (Siahaan et al., 2023). The higher the place where coffee grows, the larger the bean size, the physical quality of the coffee beans also better than in the lower altitude (Mintesnot et al., 2018).

Conclusion

Based on quality research *Green Bean* arabica coffee *Coffea arabica* L. based on the altitude of the place in Bonto Tangnga Village, Uluere District, Bantaeng District, Bantaeng Regency, South Sulawesi. In the physical quality test, all samples met the requirements based on SNI 01-2907-2008 (coffee beans do not smell bad, have a uniform size, and the number of defects is included in the SNI quality criteria). At 1200-1400 masl, coffee tree produces a greater weight of coffee than at an altitude of 800-1000 masl and 1000-1200 masl The higher the location where coffee grows, the greater the volume of coffee beans. So it can be concluded that quality *Green Bean* arabica coffee *Coffea arabica* L. is influenced by the altitude where it grows.

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Author Contributions
A.I.L and T.D.P collects data and provide research facilities, T.D.P processes and analyzes data, M.R.U and A.I.L supervising and submitting article.

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Conflicts of Interest
The authors declare no conflict of interest.

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