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The Effects of Processing Methods on the Quality of Arabica Kintamani Green Beans

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Abstract

The coffee of Arabica Kintamani is one of the most popular coffees in the world due to its specific taste. The quality of coffee beans depends on the post-harvest and processing method. Dry processing and wet processing are the most popular methods used and each process produces different quality coffee beans. The objective of this research was to study and analyze various processing methods of coffee beans and to determine the best processing method to apply by the farmers and processors. This research consisted of three processing methods for the coffee namely dried processing (natural); wet processing; and semi-wet processing (honey). The research used a randomized complete design with one factor and five replications. The study showed that dry processing (natural) produced good quality coffee beans compared with wet or semi-wet processing, with significantly higher polyphenols content of 40.80 ± 0.053 mg GAE g^{-1}, approximately the same caffeine content (1.19 ± 0.016 %), significantly higher antioxidant activity (% DPPH) 89.53 ± 0.229 % with an EC_{50} equal to 102.44 ± 0.130 mg L^{-1}, similar lightness 13.63 ± 8.281 and a significantly lower moisture content of 7.54 ± 0.474 %. This indicated that dry processing could be used as an alternative processing method by farmers and processors due to it being easier, cheaper, with more efficient water use as well as giving a product contained the highest levels of polyphenols and antioxidant activity that are good for human health.

Keywords: Arabica coffee; Processing; Quality; Kintamani

1 Introduction

Coffee is one of the most traded commodities and popular drinks nowadays as well as the most widely consumed and traded beverage in the world after water (Jeon et al., 2019). Indonesia's position is considered quite strategic in the international coffee world because Indonesia is the fourth largest coffee exporting country after Brazil, Vietnam, and Colombia (International Coffee Organization, 2019). Coffee contains significant amounts of phenolic compounds such as chlorogenic and hydroxycinnamic acids and antioxidants including caffeine, melanoidins, and other Maillard reaction products and volatile compounds (Kwak et al., 2018). Traditionally, green beans are produced in two ways, namely the wet processing method and the dry method (Sulistyaningtyas, 2017). The physical quality, coffee taste, and chemical composition of cof-

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fee beans are determined by the cultivar, the environmental condition, agricultural management, (Ahmed et al., 2021; Happyana et al., 2021), processing, fermentation, and roasting process (Azuan et al., 2020; Tarigan & Towaha, 2017). According to Rodriguez et al. (2020) and Duguma and Chewaka (2019), post-harvest processing is to be a key factor contributing to the high quality of coffee. One of the stages of the primary processing process that greatly determines the quality of coffee taste is fermentation. The functionality of food products can be increased by fermentation. The phenolic compounds and antioxidant activity of green beans also can be increased by fermentation (Kwak et al., 2018). During the fermentation process, several precursor compounds are formed, namely organic acids, amino acids, and reducing sugars (Hatiningsih et al., 2018). The type and amount of flavour compounds formed in the roasting process are highly dependent on the variation of precursor compounds (Samantha & Almalik, 2019). The fermentation of coffee is known as coffee cherry fermentation and effectively removes the mucilage layer before the drying process to obtain green coffee beans. Therefore, the primary objective of coffee cherry fermentation is to improve the ease of obtaining green coffee beans rather than to increase the functionality of the coffee beans. Green coffee beans can gain higher functionality with additional processing steps such as soaking in fruit extracts and fermentation (Hatiningsih et al., 2018). As the fermentation of tea products increases their antioxidant activity and the number of phenolic compounds, the antioxidant activity and phenolic compounds in green coffee beans could also be increased by fermentation (Kwak et al., 2018). According to Mangku et al. (2019), increased chlorogenic acid concentration during dried fermentation is due to the higher temperature and the longer fermentation time. The fermentation process carried out at a temperature of 40 ± 1 ^{o}C for 20 hours is better than at temperatures of 20 ± 1 ^{o}C and 30 ± 1 ^{o}C (Mangku et al., 2019). The objective of this research was to assess the effect of different processing and drying methods on the physicochemical quality of green beans.

2 Materials and Methods

2.1 Materials

The material used in this study was the Arabica coffee cherry of the "Sigararutang" variety that grows 1200 m above sea level. The coffee cherries were harvested from farmers at "UPP. Catur Paramitha", Catur Village, Kintamani District, Bangli. The maturity level of coffee cherries was optimally ripe with a red skin color of 95 %.
The specialist equipment used in coffee processing included pulper machine Type Horja, huller MPK 2500, Starcom Coffee Grinder model SCG-017, moisture tester Wile 55, aluminum pan (size: l x w x h: 40 x 20 x 5 cm), and aluminum foil packaging size 12 x 22 mm, etc. Instruments for chemical and physical analysis included Colorimeter CS-280, Soxhlet fat extractor, Memmert incubator, and UV-Vis double beam spectrophotometer Libra S 60.

2.2 Experimental design

This research used a complete randomized design that consisted of three treatments, namely: dried processing (natural process); semi-wet processing (honey process); and wet processing. This research was replicated three times thus giving nine sample units.

2.3 Processing of green beans with the dried processing (natural processing)

The drying process is the simplest method that is usually used by most farmers in the village and also the low-cost production is the other reason although the time used for drying is longer than the other methods. The process for producing green beans began with the sorting of coffee cherries manually to get those with optimum maturity (the red color minimum 95 %) and then continued to sort using clean water in a plastic basket to obtain superior coffee cherries. After sorting the coffee cherries (1000 g) were sun-dried for 45 days to get to a moisture content of 12.5 %. The temperature of the drying process was around 22-27 ^{o}C depending on the weather and

ambient temperature. After the drying process was finished, the dried skin layer of the cherries was removed using a huller machine type MPK 2500. The green beans were used to analyze the physical-chemical quality.

2.4 Processing of green beans with the wet processing (full wash)

Full wash is wet processing that is usually done by farmers to produce coffee beans with higher acidity and lower bitterness. This process needs a fermentation step and is more difficult to apply by the farmers due to most arabica coffee in Bali being processed with dry processing. The fermentation process will give the coffee beans a good aroma, flavour, and higher quality than the dried processing. The wet processing consisted of harvest at an optimum maturity with a red colour minimum 95 %, with manual sorting. To get superior coffee cherries, they were soaked in clean water so that the superior cherries floated, leaving the inferior ones at the bottom. 1000 g superior coffee cherries were then pulped, and from this process we obtained 500 g coffee beans that continued on to be washed and then dry-fermented. The fermentation was conducted by putting the coffee beans in an incubator with a set temperature of 40 ± 1 ^{o}C for 20 hours; after the fermentation, the coffee beans were washed to remove the mucilage layer. The cleaned coffee beans were dried in the sun for 14 days to reach 12.5 % of moisture content. The length of the drying process was affected by the temperature, relative humidity, and environmental conditions.

2.5 Processing of green beans with semi-wet processing (honey processing)

The coffee cherries were harvested with a red colour minimum of 95 % then sorted manually and then with water in basket plastic to get superior coffee cherries. About 1000 g of coffee cherries were pulped with a pulper machine type Horja to remove the outer skin and pulp from the beans. The coffee beans were then dried using sun drying for 30 days to 12.5 % moisture. The moisture content was measured every week using a moisture tester. After the coffee beans had reached a moisture content of 12.5 %, the hard skin was removed to produce coffee beans using a huller machine. The temperature for drying the coffee beans fluctuated and was not stable, being between 22-27 ^{o}C depending on the ambient temperature. After drying and hulling, the coffee beans were used for the analysis of physical-chemical quality.

2.6 Physicochemical analysis procedure of the green beans

The physicochemical quality of green coffee beans was evaluated through moisture content, caffeine, polyphenols, degree of lightness, and antioxidant activity (% DPPH).

Moisture content

The moisture content of coffee beans was analyzed using the gravimetric method (Kyaw et al., 2020). Firstly, the dish and its lid were dried in the oven at 105 ^{o}C for 3 h and then transferred to the desiccator to cool. The dish and lid were weighed after cooling. Secondly, 3 g of the coffee sample was weighed and placed in the dish. The dishes with the samples were placed in the oven and dried at 105 ^{o}C for 3 h. After drying, the dish, partially covered with a lid, was transferred to the desiccator to cool. The dish and sample were re-weighed after cooling, and the moisture content of the samples was calculated by Equation 1.

$$\%Moisture = \frac{W1 - W2}{W1} \times 100 \qquad (1)$$

Where W1 = weight of the sample before drying (g) W2 = weight of the sample after drying (g)

Caffeine content

The caffeine content of coffee beans was determined by a spectrophotometric method (Shao & Zhang, 2019). Exactly 2 g of coffee beans powder sample was weighed. 20 mL of distilled water was added to the sample which was then boiled for 10 mins. A total of 2 g of sodium carbonate

was added to each sample to precipitate tannins. Samples were filtered and filtrates were concentrated to 5 mL by evaporation and transferred to a separation funnel. Caffeine was extracted by adding 5 mL of chloroform to the separation funnel with shaking for a few minutes. The lower caffeine-containing layer was separated and analyzed for caffeine content with a UV/Vis spectrophotometer as follows. A sample of the extract (0.1 mL) was mixed with 10 mL of chloroform and placed in a quartz cuvette. The wavelength at which caffeine absorbs maximum was determined by scanning the range of 190-400 nm. The wavelength at which caffeine absorbed maximumally was found to be 274 nm. Absorbance was measured at 274 nm. A standard curve was made with increasing concentrations of caffeine (0,2,4,6,8,10, and 12 ppm). The concentration of caffeine c (μg/mL) was calculated from the absorbance of the sample by reference to the standard curve.

Polyphenol content

The polyphenol content of coffee beans was determined spectrophotometrically using the Folin-Ciocalteu method with some modification (Mehari et al., 2021). Before determination, a 100 μL portion of the soluble polyphenol extract was diluted to 1.6 mL by adding distilled water, whereas the extract corresponding to the cell wall-bound polyphenols was used directly for analysis. A 10 μL aliquot of the extract was mixed with 100 μL of Folin-Ciocalteu reagent, which had been diluted by a factor of 10 with distilled water, and kept for 5 min. Subsequently, 100 μL of 10 % Na_2CO_3 was added to the mixture and incubated for 90 min at room temperature in the dark. The absorbance of the resulting mixture was measured at 760 nm against a blank sample, comprising 10 μL of the extraction solvent treated with all the reagents and incubated for the same period, under identical conditions to the samples. Each sample was extracted in triplicate and each of these extracts was submitted to the Folin-Ciocalteu assay in triplicate, thus a total of nine measurements corresponded to each sample. Results were expressed as average values, together with the associated standard deviations. The analysis was performed by using 96-microwell reaction plates and an absorbance microplate reader (Spectra max 190, China). A total of 9 different samples together with six blank samples were analyzed on a single plate. Gallic acid was used as the reference standard. For this, a stock solution of gallic acid (500 mg L^{-1}) was prepared by dissolving 50 mg of gallic acid powder in 100 mL of 5 % aqueous methanol. A series of standard solutions were then prepared by appropriate dilution from the stock solution with distilled water. A calibration curve was constructed in the range of 10 - 100 mg L^{-1} of gallic acid after treatment with the Folin-Ciocalteu reagents as described. The regression coefficient (R^2) of the calibration equation was 0.998. The results from the analyses of the samples were expressed as milligrams of gallic acid equivalents per gram (mg GAE g^{-1}) of dry mass.

Lightness (L*)

The colour, mainly the degree of lightness, of coffee beans was analyzed using colorimeter type PCE-CSM 1, represented in the coordinates L*, a*, and b* (Commission Internationale de l'Éclairage, CIE). Coffee beans (2 g) were put into a small Petri dish for measurement. Lightness (L*) value is 0 - 100 (black-white); redness to green (a*) value is +100 - (-100); yellow to blue (b*) value is -100 - (-100) (Kwak et al., 2018).

Antioxidant activity

The antioxidant activity of coffee beans was analyzed according to the DPPH method (Avila et al., 2018; Kurang & Kamengon, 2021). Standard DPPH solution (6x10-5 M) was made by dissolving. 1.182 mg of DPPH in 50 mL of methanol. 500 ppm test solution was made and diluted to 100 ppm, 50 ppm, 25 ppm, and 12.5 ppm. The test solution (33.33 μL) was pipetted into a tube protected from light, and then 1 mL of DPPH was added. The solution mixture was stirred by using a vortex mixer for 10 seconds or until homogeneous. Next, the solution was incubated at 30 ^{o}C for 30 minutes. The DPPH radical solution changed its colour from purple to pale yellow during the reduction process by antioxidants. The decrease in absorbance was measured by a UV-

Vis spectrophotometer at a wavelength of 515 nm (As). The blank solution consisted of methanol (1 mL) and DPPH (33.33 μL). A sample of this solution (up to 1 mL) was measured at the same wavelength (Ab). Ascorbic acid was used as a positive control. The treatment was repeated three times. The percentage of reduced DPPH (% DPPH) was calculated using Equation 2.

$$\%DPPH = \frac{\text{Absorbance of control - Absorbance of sample}}{\text{Absorbance of control}} \times 100 \quad (2)$$

A curve was drawn of the antioxidant capacity of the extract against its concentration. Linear regression of the data gave the regression equation that was used to calculate the EC_{50} (Faria et al., 2022). All the analyses were compared with the control extract that was taken from coffee beans without using heat and the extraction was done at room temperature (26 ^{o}C). The free radical scavenging activity was expressed as the concentration required to inhibit 50 % of free radicals (EC_{50}). To obtain the EC_{50} values (concentration of extract necessary to reduce 50 % of the DPPH radical) of the extracts, the antioxidant activity in different concentrations was calculated using Equation 3.

$$EC_{50} = \frac{\text{Concentration of sample (mg/mL)}}{\text{\% reduce of DPPH of the sample}} \times 50\% \quad (3)$$

2.7 Statistical Analysis

The experiments were replicated three times and the data obtained from the physical-chemical analysis was submitted to Analysis of Variance (ANOVA) with a confidence level of 95 %. The analysis was continued using the t-test to determine if the different processing methods were significantly different.

3 Results and Discussion

The result of the coffee beans after processing with different methods is shown in Figure 1 and the analysis of coffee beans from various processing in this study showed in Table 1 below.

3.1 Lightness (L*)

The lightness is one of the parameters of the coffee beans used as a quality attribute. The increasing lightness value means that the coffee beans look clear and bright, while the lower value of lightness indicates the green coffee beans look dark in colour. The dried process produced a higher lightness value (L*) of 13.63 ± 8.281 and the lowest L* value was produced by the semi-wet process (9.75 ± 4.850). However the lightness of the coffee beans was not significantly different (Table 1). The study showed that the colour of coffee beans in the dried process was brighter, whereas both the wet processing and the semi-wet processing produced a darker colour (Figure 2). The difference in the lightness level was probably due to the phenol content in the wet processing and semi-wet processing being higher and during drying the phenols would oxidise thus making the colour of the coffee beans darker. According to Rodriguez et al. (2020), the semi-dry processing method presented higher values of lightness than the wet processing method; this is because the beans had dried with adhering mucilage, enhancing the values of the colour coordinates; these differences were therefore attributable to the processing method.

3.2 Moisture Content

Moisture content is another attribute that is used for indicating the quality of the coffee beans and contributes to the growth of molds as well as the formation of the aroma and flavour of coffee products. According to the Indonesian National Standard (SNI-01-2907-2008) (Badan Standar Nasional [BSN], 2008), the maximum moisture content of coffee beans is 12.5 %. This study showed that the moisture content of coffee beans from all processing methods was lower than the standard 7.54 ± 0.474 % to 8.71± 0.119 %, indicating the coffee beans to have fulfilled the Indonesia National Standard (SNI) (Figure 3). This means that moisture content of 12.5 % or lower will prevent the growth of mold, increase the shelf-life of the coffee beans as well as produce good quality coffee products.
The dry processing had a lower moisture content of 7.54 ± 0.474 % and the wet processing gave higher moisture content of 8.71 ± 0.119 % and the semi-wet processing was 8.64 ± 0.053 %. Both the dried and wet processing showed sig-

Figure 1: a) Coffee beans with natural processing; b) Coffee beans with wet processing; c) Coffee beans with honey processing

Table 1: Physicochemical characteristics of coffee beans in various processing methods

Processing Methods	Lightness (L*)	Moisture content (%)	Polyphenols (mg GAE g-1)	Caffeine (%)	Antioxidant activity (% DPPH)
Dry processing (natural)	13.63 ± 8.281^{a}	7.54 ± 0.474^{b}	40.80 ± 0.053^{a}	1.19 ± 0.016^{ab}	89.53 ± 0.229^{a}
Wet processing (fullwash)	11.47 ± 6.654^{a}	8.71 ± 0.119^{a}	$36{,}20 \pm 0.015^{b}$	1.13 ± 0.003^{b}	87.32 ± 0.153^{b}
Semi-wet processing (honey)	9.75 ± 4.850^{a}	8.64 ± 0.053^{a}	24.10 ± 0.017^{c}	1.26 ± 0.008^{a}	86.70 ± 0.153^{c}

Meanse ± standard deviation with different superscript letters in the same column were significantly different ($p < 0.05$).

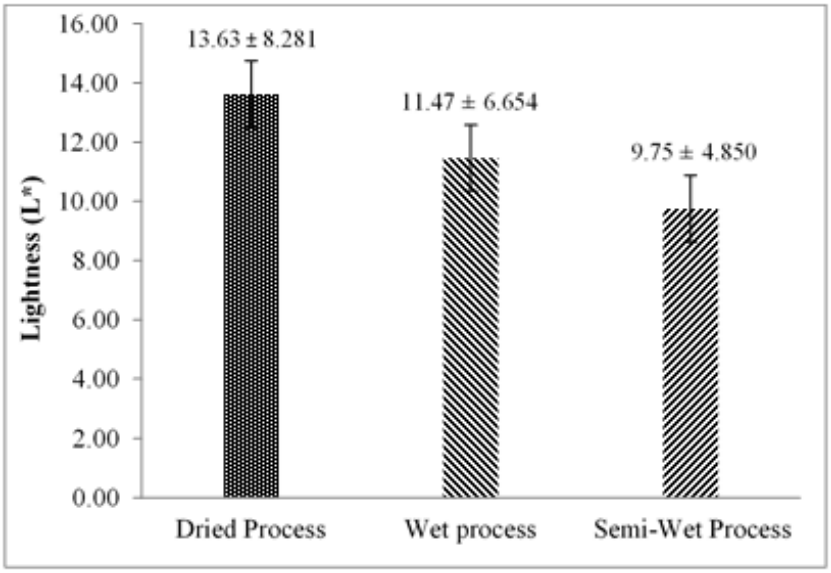

Figure 2: The Lightness (L*) of coffee beans in various processing method

nificant differences ($p < 0.05$) (Table 1). In line with previous research (Tadesse et al., 2016), the moisture content of the coffee processed in the wet method was higher than in the dry methods are 11.20 % and 10.80 % respectively. According to Tadesse et al. (2016), moisture content higher than 12.5 % will accelerate the growth of mold that can decrease the quality of coffee beans, therefore, can reduce self-life.

3.3 Polyphenols content

Chlorogenic acids (CGA) are the main phenolic compounds found in coffee beans. CGA have an important role in determining the quality of coffee beans and beverage taste, and aroma and are a key contributor to the radical scavenger activity of coffee brews (Awwad et al., 2021). The result of studied showed that the polyphenols content of the coffee beans for all process methods was 24.10 ± 0.017 mg GAE g^{-1} to 40.80 ± 0.053 mg GAE g^{-1} and between the treatments process showed significant differences ($p < 0.05$) (Table 1). The higher polyphenols content of 40.80 ± 0.053 mg GAE g^{-1} was given by the dried method and followed by the wet process of 36.20 ± 0.015 mg GAE g^{-1} and the lowest polyphenols content was 24.10 ± 0.017 mg GAE g^{-1} was produced by the semi-wet process method (Figure 4). The lower polyphenols content of coffee beans with the wet process and semi-wet process was due to fermentation during the process that caused the breakdown of phenol compounds such as chlorogenic acid to smaller compounds that reduced the concentration of phenol content in the coffee beans.
According to Mangku et al. (2019), the chlorogenic acid content can be increased by the wet process method with control of the temperature and time of the fermentation process. The chlorogenic acid content of the arabica coffee beans Kintamani was between 4.69 to 11.21 %. The increasing fermentation process would probably decrease phenol content, therefore the fermentation period has to control in optimum conditions.

3.4 Caffeine

Rosita et al. (2016), states that caffeine is one of the important indicator qualities of coffee. Caffeine and chlorogenic acid are the main compounds in coffee beans and both compounds have antioxidant activities (Affonso et al., 2016). The caffeine content of coffee beans due to various processing methods was 1.13 ± 0.003 % to 1.26 ± 0.008 %. There was a significant difference ($p < 0.05$) between caffeine content in producing both wet processing and semi-wet processing (Table 1). The higher caffeine content of 1.26 ± 0.008 % was given by the semi-wet processing followed by the dried processing at 1.19 ± 0.016 % and the lower caffeine content of 1.13 ± 0.003 % was given by the wet processing (Figure 5). Arabica coffee had twice the antioxidant activity of a cup of green and black tea (Kwak et al., 2018).
The wet processing provides good conditions for microorganisms to grow during the fermentation, which then decreases the caffeine content due to the degradation of caffeine compounds and dissolution in the surrounding water. Increasing the fermentation time tends to decrease the caffeine content of arabica coffee beans. In fermentation of up to 20 hours the caffeine content of coffee beans is still relatively high then it tends to decrease after fermentation for 30 and 40 hours (Mangku et al., 2019).

3.5 Antioxidant activity

The bioactive compounds in coffee give benefit to human health; chlorogenic acid is a phenolic compound, which with caffeine, can provide physiological effects on the human body. Affonso et al. (2016) found that a certain amount of available caffeine compounds in coffee beans is needed because it is a bioactive compound and is an antioxidant that can provide physiological effects on the human body. The main compounds found in coffee beans are caffeine and chlorogenic acid, and caffeine is known to have antioxidant properties. The antioxidant activity is affected by the caffeine and phenol content of the coffee beans. This study found that the antioxidant activity of coffee beans that were produced by three dif-

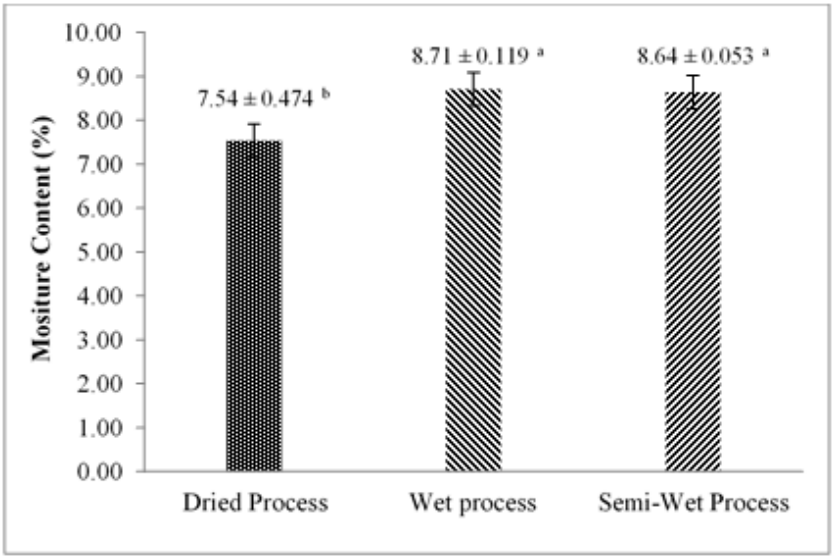

Figure 3: Moisture content (%) of coffee beans from the various processing methods. Means with different superscripts were significantly different ($p < 0.05$).

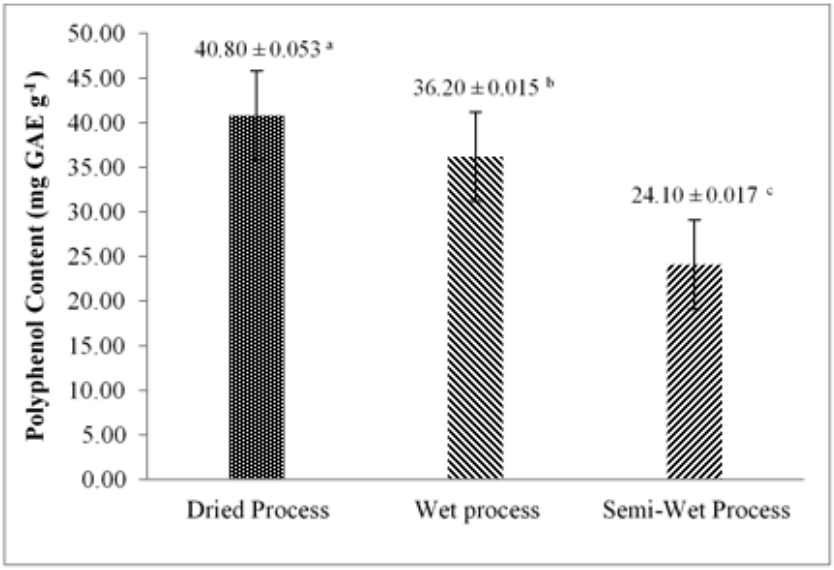

Figure 4: Polyphenols content (mg GAE g^{-1}) of coffee beans in various processing methods. Means with different superscripts were significantly different ($p < 0.05$).

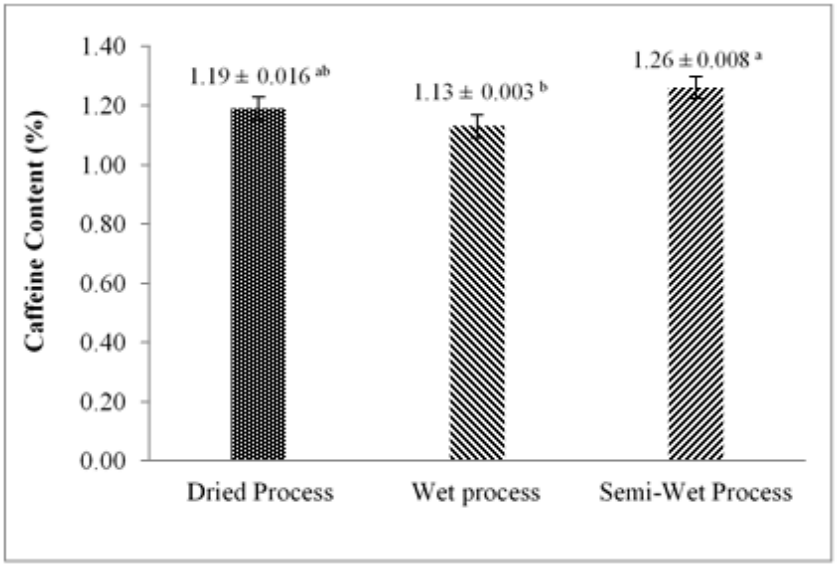

Figure 5: Caffeine content (%) of coffee beans in various processing methods. Means with different subscripts were significantly different ($p < 0.05$)

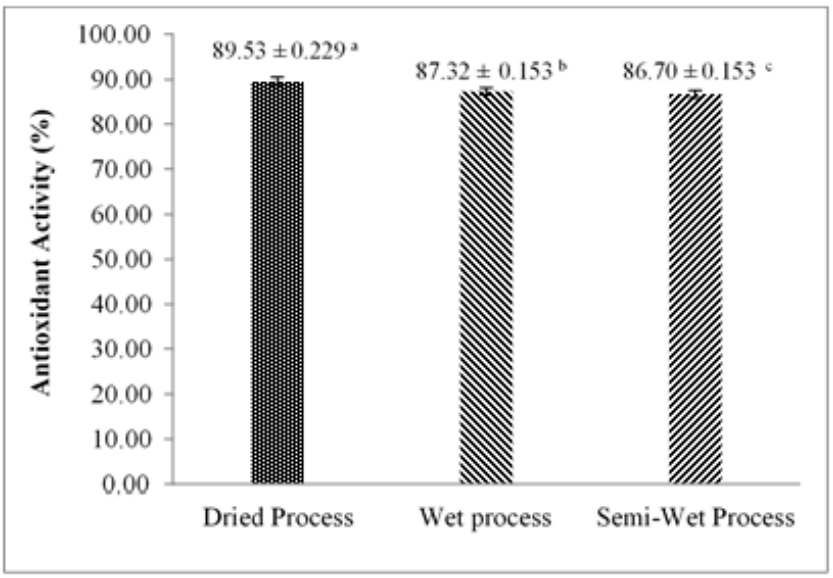

Figure 6: Antioxidant activity (% DPPH) of coffee beans in various processing methods. Means with different superscripts were significantly different ($p < 0.05$).

ferent processing was between 86.70 ± 0.153 % to 89.53 ± 0.229 % and the value of antioxidant activity for all processing methods gave significant differences ($p < 0.05$) (Table 1). The highest antioxidant activity of 89.53 ± 0.229 % with an EC_{50} equal to 102.44 ± 0.130 mg L^{-1} was given by the dried processing (Figure 6) followed by the wet processing with 87.32 ± 0.153 % and an EC_{50} equal to 108.00 ± 0.188 mg L^{-1} and the lowest antioxidant activity was given by the semi-wet processing at 86.70 ± 0.153 % with an EC_{50} equal to 111.69 ± 0.35 mg L^{-1}. The higher antioxidant activity for the dried processing was due to a higher content of phenolic compounds. The dried processing had a higher polyphenol content of 40.80 ± 0.053 % than the wet processing and semi-wet processing (Table 1). On the other hand, the caffeine content in coffee beans also contributed to increasing the antioxidant activity. Online research conducted by Kwak et al. (2018) and Mangku et al. (2019) found that the availability of caffeine and phenolic compounds in coffee beans is needed up to a certain level due to both compounds being bioactive and antioxidants that can provide physiological effects on the human body.

4 Conclusions

The different processing methods of the coffee did not affect the degree of lightness but did affect the moisture content, caffeine, polyphenol content, and antioxidant activity of the coffee beans. Dry or natural processing can be used as alternative coffee processing due to it giving higher polyphenol content (40.80 ± 0.053 mg GAE g^{-1}), caffeine content (1.19 ± 0.016 %), antioxidant activity (89.53 ± 0.229 % DPPH with an EC_{50} equal to 102.44 ± 0.130 mg L^{-1}), more lightness, and having the lowest moisture content of 7.54 ± 0.474 %. In addition, this method is easier, cheaper for farmers or processors, and is more efficient of water use.

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References

Affonso, R. C. L., Voytena, A. P. L., Fanan, S., Pitz, H., Coelho, D. S., Horstmann, A. L., Pereira, A., Uarrota, V. G., Hillmann, M. C., Varela, L. A. C., do Valle, R. M. R., & Maraschin, M. (2016). Phytochemical Composition, Antioxidant Activity, and the Effect of the Aqueous Extract of Coffee (Coffea arabica L.) Bean Residual Press Cake on the Skin Wound Healing. *Oxidative Medicine and Cellular Longevity*, *2016*, 1–10. https://doi.org/10.1155/2016/1923754

Ahmed, S., Brinkley, S., Smith, E., Sela, A., Theisen, M., Thibodeau, C., Warne, T., Anderson, E., Van Dusen, N., Giuliano, P., Ionescu, K. E., & Cash, S. B. (2021). Climate Change and Coffee Quality: Systematic Review on the Effects of Environmental and Management Variation on Secondary Metabolites and Sensory Attributes of Coffea arabica and Coffea canephora. *Frontiers in Plant Science*, *12*(october), 1–20. https://doi.org/10.3389/fpls.2021.708013

Avila, O. V., Montero Fernández, I., da Costa, H. N. R., dos Santos, R. C., Ribeiro, P. R. E., Melo, V. F., de Melo, A. C. G. R., Duarte, E. D. R. d. S., & de Melho Filho, A. A. (2018). Phytometal Availability, Evaluation of Antioxidant Activity and Total Phenolic Compounds of Genipa americana L. (Rubiaceae) Fruits. *Journal of Agricultural Science*, *10*(5), 150. https://doi.org/10.5539/jas.v10n5p150

Awwad, S., Issa, R., Alnsour, L., Albals, D., & Al-Momani, I. (2021). Quantification

of Caffeine and Chlorogenic Acid in Green and Roasted Coffee Samples Using HPLC-DAD and Evaluation of the Effect of Degree of Roasting on Their Levels. *Molecules*, *26*(24), 7502. https://doi.org/10.3390/molecules26247502

Azuan, A. A., Mohd Zin, Z., Hasmadi, M., Rusli, N. D., & Zainol, M. K. (2020). Physicochemical, antioxidant and sensory characteristics of cookies supplemented with different levels of spent coffee ground extract. *Food Research*, *4*(4), 1181–1190. https://doi.org/10.26656/fr.2017.4(4).058

Badan Standar Nasional [BSN]. (2008). *SNI 01-2907-2008*. https://slidepdf.com/reader/full/sni-29072008-biji-kopi

Duguma, H., & Chewaka, M. (2019). Review on Coffee (Coffea arabica L.) Wet Processing more Focus in Ethiopia. *Acta Scientific Agriculture*, *3*(11), 11–15. https://doi.org/10.31080/ASAG.2019.03.0676

Faria, T. d. S., Reis, M. H. M., Reolon Schmidt, V. C., & Cardoso, V. L. (2022). Influence of extraction methods on phenolic compounds from pulp and peel of genipap (Genipa americana L.) fruit. *International Journal of Food Studies*, *11*(april), 38–50. https://doi.org/10.7455/ijfs/11.1.2022.a4

Happyana, N., Pratiwi, A., & Hakim, E. H. (2021). Metabolite Profiles of the Green Beans of Indonesian Arabica Coffee Varieties (D. Suhandy, Ed.). *International Journal of Food Science*, *2021*, 1–9. https://doi.org/10.1155/2021/5782578

Hatiningsih, S., Antara, N. S., & Gunam, I. B. W. (2018). Microbiological And Physicochemical Changes Of Green Coffee (Coffea Arabica) Fermentation In Kintamani, Bangli, Bali. *Media Ilmiah Teknologi Pangan*, *5*(2), 123–138. https://ojs.unud.ac.id/index.php/pangan/article/view/51477

International Coffee Organization. (2019). ICO Coffee Development Report 2019 Overview. *ED-2318/19*. https://www.ico.org/documents/cy2018-19/ed-2318e-overview-flagship-report.pdf

Jeon, J.-S., Kim, H.-T., Jeong, I.-H., Hong, S.-R., Oh, M.-S., Yoon, M.-H., Shim, J.-H., Jeong, J. H., & El-Aty, A. M. A. (2019). Contents of chlorogenic acids and caffeine in various coffee-related products. *Journal of Advanced Research*, *17*, 85–94. https://doi.org/10.1016/j.jare.2019.01.002

Kurang, R. Y., & Kamengon, R. Y. (2021). Phytochemical Test and Antioxidant Activity of Methanol Extract in Arabica Coffee Leaves by Using DPPH Method (1,1-Diphenyl-2-Picrylhydrazyl). *Walisongo Journal of Chemistry*, *4*(2), 113–118. https://doi.org/10.21580/wjc.v4i2.8032

Kwak, H. S., Jeong, Y., & Kim, M. (2018). Effect of Yeast Fermentation of Green Coffee Beans on Antioxidant Activity and Consumer Acceptability. *Journal of Food Quality*, *2018*, 1–8. https://doi.org/10.1155/2018/5967130

Kyaw, E. M., Budiastra, I. W., Sutrisno, & Samsudin. (2020). Estimation of moisture content in Liberica coffee by using near infrared spectroscopy. *IOP Conference Series: Earth and Environmental Science*, *542*(1), 012013. https://doi.org/10.1088/1755-1315/542/1/012013

Mangku, I. G. P., Wijaya, I. M. A. S., Putra, G. P. G., & Permana, D. G. M. (2019). The Bioactive Compounds Formation of "Kintamani" Arabica Coffee Bean during Dry Fermentation. *Journal of Biological and Chemical Research*, *36*(2), 45–52.

Mehari, B., Chandravanshi, B. S., Redi-Abshiro, M., Combrinck, S., McCrindle, R., & Atlabachew, M. (2021). Polyphenol contents of green coffee beans from different regions of Ethiopia. *International Journal of Food Properties*, *24*(1), 17–27. https://doi.org/10.1080/10942912.2020.1858866

Rodriguez, Y. F. B., Guzman, N. G., & Hernandez, J. G. (2020). Effect of the postharvest processing method on the biochemical composition and sensory analysis of arabica coffee. *Engenharia Agrícola*, *40*(2), 177–183. https://doi.org/10.

1590/1809-4430-eng.agric.v40n2p177-183/2020

Rosita, R., Budiastra, I. W., & Sutrisno. (2016). Prediksi Kandungan Kafein Biji Kopi Arabika Gayo dengan Near Infrared Spectroscopy. *Jurnal Keteknikan Pertanian*, *4*(2), 179–186. https://doi.org/10.19028/jtep.04.2.179-18

Samantha, R., & Almalik, D. (2019). Analisis aktivitas antioksidan dengan metode dpph serta tingkat penerimaan kopi arabika koya asrul. *Tjyybjb.Ac.Cn*, *3*(2), 58–66. http://www.tjyybjb.ac.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=9987

Shao, J., & Zhang, Y. (2019). Determination of caffeine content in tea beverages. *IOP Conference Series: Earth and Environmental Science*, *330*(4), 042056. https://doi.org/10.1088/1755-1315/330/4/042056

Sulistyaningtyas, A. (2017). Pentingnya Pengolahan basah (Wet Processing) Buah kopi Robusta (Coffea var. robusta) untuk menurunkan resiko kecacatan biji hijau saat coffe grading. *Jurnal Ilmu Keperawatan Dan Kesehatan*, *9*(6), 90–94.

Tadesse, F. T., Jemal, Y., & Abebe, H. (2016). Effect of Green Coffee Processing Methods and Roasting Temperatures on Physical and Cup Quality of Sidama Coffee, Southern Ethiopia. *Journal of Nutritional Ecology and Food Research*, *3*(1), 44–50. https://doi.org/10.1166/jnef.2016.1119

Tarigan, E. B., & Towaha, J. (2017). Pengaruh tingkat kematangan buah, serta lama fermentasi dan penyangraian biji terhadap karakter fisikokimia kopi Robusta. *Jurnal Tanaman Industri dan Penyegar*, *4*(3), 163–170.