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PHYSICOCHEMICAL CHARACTERISTICS OF WINE COFFEE, A RECENT POPULAR COFFEE PRODUCT FROM GAYO HIGHLAND-INDONESIA

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ABSTRACT
Wine coffee processing is currently very popular in the Gayo Highlands. This study aims to analyze commercial wine coffee's physicochemical characteristics. Wine coffee samples were collected from 9 active producers in Central Aceh and Bener Meriah. Analysis was carried out on coffee beans and brewing, including analysis of bean size, moisture content, color, pH, total dissolved solids (TDS), and total phenolic content (TPC). The results found that Gayo arabica wine coffee has a medium size, moisture content of 8.53%-11.67%, and yellow to brown color. Physicochemical characteristics of brewed wine coffee also showed varying results. The pH of coffee wine brewing ranges from 4.68 to 4.95, TDS 3.93- 4.5 °Brix, and TPC 12.82 to 30 GAE mg/g. Further research is needed to analyze the more complex chemical components of wine coffee (volatile and non-volatile) and their correlation with brewing quality to obtain more comprehensive scientific information on wine coffee quality.

Keywords: Coffee Bean Size, Color, Gayo Highland, Moisture Content, Total Phenolic Content, Wine Coffee.
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INTRODUCTION

Indonesia is a coffee producer and exporter country, ranking fourth in the world behind Brazil, Vietnam, and Colombia. Coffee productivity has increased over the last three years, from 752.511 tons in 2019 to 765.415 tons in 2021.[1] The Gayo Highlands, which encompasses Central Aceh, Bener Meriah, and Gayo Lues Regency, is one of Indonesia's coffee-producing regions. The coffee that comes from the Gayo Highlands is dominated by arabica coffee and generally comes from community plantations. The majority of arabica coffee in Indonesia originated from Central Aceh and Bener Meriah with an average production of 65,122 tons from an area of around 99,050 Ha.[2] Coffee processing is one of the most essential aspects of coffee production that has an impact on the end product's quality. Coffee processing aims to obtain high-quality coffee beans focusing on increasing the selling price. Coffee processing is known to be carried out by several methods. In the Gayo Highlands, coffee processing is generally done by semi-wet processing. However, recently coffee processing methods have developed with various experimental variations (modifications), one of which is a coffee processing method that produces a product called wine coffee. This method is a modified dry processing method by fermenting whole coffee fruit in a closed space for a long time.[3,4] The fermentation process in wine coffee production mimics the process of fermenting grapes into wine, which was first adopted in coffee fermentation by Sasa Sestic, a 2015 world barista championship winner. The process of preparing coffee wine is done by fermenting coffee cherries in a closed tank accompanied by CO_2 gas injection; the process is known as carbonic maceration.[1] Coffee farmers in Indonesia have adopted this technique as an alternative method of processing wine coffee with a simpler process. Coffee fruits are placed in plastic, without or submerged in water, and then tied firmly to maintain an anaerobic atmosphere. In the absence of added CO_2 gas, this process is more accurately referred to as semi-carbonic maceration and farmers in Indonesia recognize the name of the product as wine coffee.[5]

The presence of wine coffee products is one of the main attractions for producers and consumers, especially coffee lovers. The fact of wine coffee certainly adds to the vibrant specialty coffee produced by farmers in the Gayo Highlands. Some specialty coffees already exist in the Gayo Highlands, including honey coffee, wild civet coffee, and captive civet coffee.[6,7] Coffee wine processing is currently very popular in the Gayo Highlands as well as in Indonesia. It is increasingly common to find coffee shops serving wine-coffee variants. The results of a wine-coffee business feasibility analysis support these findings.[3] Until now, wine coffee has not had a standardized quality standard. As a product with a relatively new processing method, studies on the quality of wine coffee are still very limited. This study aims to analyze the quality of commercial coffee wine, especially its physicochemical quality.

EXPERIMENTAL

Materials

The wine coffee green bean as a raw material used in this study was obtained from 9 wine coffee producers in the Gayo Highlands. Analytical materials used for analysis include distilled water, methanol 60%, folin-ciocalteu reagent, gallic acid, sodium carbonate (Na_2CO_3), oxalic acid 0.01 N, phenolphthalein (pp) indicator 1%, and NaOH 0.01 N.

A sampling of Green Bean Wine Coffee

A sampling of commercial wine coffee beans was conducted from nine wine coffee producers in Aceh Tengah and Bener Meriah districts. The producers were determined purposively by considering that the producers processed wine coffee actively and continuously. Each wine coffee bean was taken as much as 1 kg. Samples were put into glass containers that had been coded and tightly closed.

Physicochemical Quality Analysis

The quality analysis of wine coffee green beans includes green bean analysis: coffee bean size, moisture content, and coffee bean color. Coffee bean size was analyzed by stratified sieving method, the moisture content was carried out using a cerra tester type 10810TPP No. III/V6 and coffee bean color were determined by visually comparing the color of wine coffee green beans with coffee beans in the Specialty Coffee Association of America (SCAA) green bean classification system.[8,9] Chemical analysis was carried out on brewed wine coffee beans that had been roasted, including measurement of pH, total dissolved solids (TSS), and total phenolic content (TPC). The pH value was determined with a pH meter. 1 g of the roasted coffee bean sample was weighed and mashed, then dissolved in 100 ml of distilled water, homogenized for 10 minutes, and later the pH of the sample was measured. Measurement of TSS was carried out with a hand refractometer (OSK 7954S-28 Ogawa Seiki, Japan). 1 gram of the sample was weighed, dissolved with 5 ml of distilled water, and homogenized using a stirring shaft. Then the coffee brew was dripped on a hand refractometer and read the soluble solids content using the °Brix scale.[10] TPC was analyzed by the Folin-Ciocalteu method. A total of 0.5 ml of coffee extract was added to 0.5 ml of follin-ciocalteu reagent, then vortexed. After 5 minutes, 1.5 ml of 20% Na_2CO_3 was added to the test tube and homogenized again with a vortex before incubating at room temperature for 60 minutes in a dark room. A UV-Vis spectrophotometer (Shimadzu model UV-1900i) was used to detect the absorbance at 760 nm. TPC was expressed as mg gallic acid equivalent/ml (mg GAE/ml) using the gallic acid solution as the reference.[11]

Data Analysis

Data were obtained from 9 samples (nine wine coffee producers in the Gayo highlands). Each sample was analyzed with 3 repetitions. One-way Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) at a 5% level with Microsoft Excel Office 2021 were used for statistical analysis. The data presented was the average value ± standard deviation.

RESULTS AND DISCUSSION

Green Bean Characteristics of Wine Coffee

Green beans of wine coffee analyzed size bean, moisture content, and color of wine coffee bean can be seen in Table-1. Bean size is an essential indicator in figuring out coffee bean quality and will influence the selling price.[12] The smaller the size of the beans, the lower the selling price. Wine coffee beans from the Gayo highlands are all classified as medium-sized based on the percentage of passed beans. Green beans with large sizes, according to national quality standards[8], are green beans that remain on a sieve with a diameter of 6.5 mm (sieve number 16) with a maximum number of passes of 5%. Green beans of medium size may tolerate a 6 mm diameter sieve (sieve number 15) with a maximum of 5% of passes over a 6.5 mm sieve.

Table -1: Quality of Wine Coffee Beans

Sample	Screening size			Size bean category	Moisture content (%)	Color
	>6,5 mm	6 mm	5 mm			
KW1	61,8%	33,4%	4,8%	Medium	8,53±0,09[a]	yellowish
KW2	75,7%	22,9%	1,4%	Medium	8,4±0,16[a]	brownish
KW3	70,2%	28,0%	1,8%	Medium	9,4±0,16[b]	brownish
KW4	77,2%	21,7%	1,1%	Medium	10,3±0,16[c]	brownish
KW5	68,8%	27,5%	3,7%	Medium	9,33±0,21[b]	brownish
KW6	65,1%	31,9%	3,0%	Medium	11,67±0,05[e]	yellowish
KW7	59,3%	37,6%	3,1%	Medium	9,5±0,08[b]	brownish
KW8	61,4%	36,6%	2,0%	Medium	10,8±0,08[d]	brownish
KW9	71,0%	28,1%	0,9%	Medium	9,3±0,16[b]	brownish

Because the percentage of green beans that can pass through a sieve with a diameter of 6.5 mm is greater than 5%, the complete sample is classed as medium bean size. These wine coffee beans are the same size as standard Gayo Arabica coffee, which is medium. These findings suggest that processing wine coffee with lengthy fermentation does not affect bean size.[13] Coffee bean size is more influenced by coffee varieties rather than by the processing method.[14] Furthermore, Table-1 illustrates that the moisture content of wine coffee ranges from 8.4%-11.67%, meeting the quality standards of coffee beans set by the Indonesian National Standard (SNI) and SCAA, which is lower than 12-12.5%. Higher moisture content is undesirable because it is susceptible to microorganism attack, so the moisture content of green beans must be controlled between 8-12.5%.[15,16] The moisture content of this wine coffee is lesser than the average moisture content of Gayo arabica coffee in the previous study[17], presumably due to differences in processing methods. Gayo arabica coffee is generally handled with semi-wet processing and the drying process is not as intensive as in the processing of wine coffee beans. The color of the wine coffee beans obtained in this study diverse from yellowish to brownish. SNI requires the color of coffee beans to be normal, without a foul or moldy odor. The color of this wine coffee is dominated by a brownish color, quite different from regular Gayo Arabica coffee with a greenish color.[17] The greenish bean color will provide a well-balanced flavor, between acidity and body, and does not leave a disturbing aftertaste.[5] The color appearance of wine coffee bean samples can be viewed in Fig.-1.

Fig.-1: The color of Wine Coffee Beans

The darker color of wine coffee beans is related to the processing process, which uses whole coffee cherries in the process. The coffee cherries are fermented without stripping the skin and carried out over a long period.[3] The coffee fruit consists of 6 parts, namely the outer skin layer (exocarp), the pulp (outer mesocarp) which is combined with the outer skin known as the pulp, mucilage (inner mesocarp), parchment, epidermis, and the innermost part, namely the coffee bean (endosperm). The chemical content of each part varies, consisting of alkaloids, phenolic compounds, lipids soluble compounds, carbohydrates, amino acids/proteins, and organic acids).[18] In the fermentation process, these chemical components certainly change. The fermentation process will decompose the components in each layer of the coffee fruit. Pigments in the coffee fruit skin, phenolic compounds, and sugars contained in the mucilage will break down to become more dilute and soak the coffee fruit for a long period according to the length of the fermentation process carried out. This reddish-brown liquid will enter the coffee beans and affect their color. This process is very different from the processing of regular Arabica coffee, where the coffee fruit is fermented after stripping the skin and the fermentation is also quite short, only 12-24 hours.

Brewed Characteristics

The physicochemical characteristics of brewed wine coffee, showed varying results as shown in Table-2.

Table-2: Physicochemical Characteristics of Brewed Wine Coffee

Sample	pH	Total Dissolved Solid (°Brix)	Total phenol GAE (mg/g)
KW1	4,69±0,01[a]	4,07±0,05[b]	21,82±2,27[b]
KW2	4,82±0,03[d]	4,17±0,05[b]	19,85±0,84[b]
KW3	4,95±0,01[f]	3,93±0,09[a]	17,22±2,24[ab]
KW4	4,68±0,01[a]	4,17±0,05[b]	12,82±0,69[a]
KW5	4,82±0,01[d]	4,4±0,08[c]	30,29±2,95[c]
KW6	4,87±0,01[e]	4,2±0,08[b]	24,13±0,57[bc]
KW7	4,74±0,01[b]	4,57±0,05[d]	21,03±0,17[b]
KW8	4,89±0,01[e]	4,43±0,05[cd]	28,99±4,09[c]
KW9	4,78±0,01[c]	4,47±0,05[cd]	28,77±3,05[c]

Table-2 describes that the pH of coffee wine brewing ranges from 4.68 ± 0.01 to 4.95 ± 0.01. This result is not much different from the pH value of coffee wine studied by Sunarhanum and Farhan,[19] which is 4.9. However, the pH is slightly lower than the regular arabica coffee, which is between 5.10-5.20[20], as well as the results of arabica coffee studied by Pereira *et al*.[21] ranging from 5.07-5.14. The lower pH value is thought to be related to the length of the fermentation process so that higher acids are produced. It is known that during fermentation, microorganism activity will break down coffee mucilage as a substrate into organic acids, which causes a decrease in pH, along with the increase in organic acids produced. The length of fermentation will affect the decrease in pH of the coffee beans from 5.29 to 4.38.[22] The organic acids produced during coffee fermentation consist of lactic acid, acetic acid, and other carboxylic acids.[23,24,25,26] Some of the acid-producing bacteria detected during coffee fermentation are lactic acid bacteria and acetic acid bacteria. Lactic acid-producing bacteria identified as dominant in coffee fermentation are *Leuconostoc, Lactococcus, and Lactobacillus.*[27] Carbohydrate metabolism by lactic acid bacteria is carried out through two pathways, namely glycolysis (Embden-Meyerhof pathway) with the main product being lactic acid (homofermentative) and the pentose phosphate pathway which produces ethanol, CO_2, and other acids besides lactic acid (heterofermentative).[28,29] The acetic acid bacteria identified as dominant in coffee fermentation are *Acetobacter* and *Gluconobacter*.[27] The total soluble solids of wine coffee ranged from 3.93 to 4.5 °Brix, higher than the results of Sunarhanum and Farhan[19], which were 0.94-1.74%. The total dissolved solid content is related to the content of metabolites such as glucose and fructose produced during coffee fermentation due to the activity of microorganisms and the enzymes produced. At the beginning of fermentation (0 hours of fermentation), the total dissolved solid content of coffee is 5.3 °Brix, increasing during fermentation until it stabilizes around 8 °Brix at the end of fermentation (48 hours).[30] This result was supported by Perez [22] with a similar pattern; an increase in total dissolved solid content during coffee fermentation. This outcome is due to the action of hydrolytic enzymes that break down pectin, cellulose, sucrose, and other complex carbohydrates of coffee pulp, into glucose and fructose monomers, resulting in an increase in total dissolved solid content and stabilizing at the end of fermentation. In wine coffee processing, the fermentation time is much longer than regular coffee, which is only 24-48 hours, which will affect the amount of total dissolved solid content produced. It is suspected that further decomposition of glucose and fructose and other metabolites occurs with continued fermentation, resulting in lower total dissolved solid content. Total phenol in this research ranged from 12,82±0,69 to 30,29±2,61 GAE mg/g, which is higher compared to Alnsour *et al.* [31] who reported that the total phenolics of regular arabica coffee averaged 14.92-16.55 GAE mg/g. Wine coffee has a higher TPC compare to regular one, which is believed to be related to the intensive fermentation process. The longer fermentation time will result in higher total phenol content. When fermentation takes place, microorganisms will produce metabolites that can break down complex phenol bonds into active, simple, and easily absorbed ones. Then the fermentation process will also weaken the bonds of phenol compounds so that they are easier to extract.[32] During fermentation, proteolytic enzymes from the budding organisms hydrolyze the phenolic complexes into free soluble simple phenols and more biologically active and absorbable forms.[33] The results of Rochin-Medina *et al.*[34] corroborate that fermentation can increase total phenol content. Fermented coffee beans have a higher total phenol content (10.51 GAE mg/g) than coffee beans without fermentation (7.74 GAE mg/g). The phenolic compounds in coffee beans are mostly chlorogenic acids. Other phenolic compounds in small amounts are simple free volatile and non-volatile compounds such as caffeic, vanillic, ferulic, p-coumaric, and p-hydroxybenzoic acids, and small amounts of more complex phenolic compounds such as anthocyanins and tannins.[35,26] Furthermore, the existence of phenolic compounds in coffee beans can be proven by the detection of several flavonoid compounds in coffee grounds obtained after making coffee drinks. Coffee grounds still contain phenolic compounds such as gallic, chlorogenic, caffeic, ellagic, cumaric and ferulic.[36]

CONCLUSION

Gayo Highland wine coffee has diverse physicochemical and sensory characteristics. The green bean wine coffee from Gayo Highland is medium in size with moisture content meeting national and SCAA standards with a range of 8.4%-11.67%. The color of wine coffee green beans varies from yellowish to brownish, in contrast to the regular Gayo Arabica, which is generally greenish. The pH value of brewed wine coffee ranged from 4.68 to 4.95, lower than regular coffee, which averaged above 5. The total phenol of wine coffee ranged from 12.82±0.69 to 30.29±2.61 GAE mg/g. Further research is needed to analyze the more complex chemical components of wine coffee (volatile and nonvolatile) and their relation to the sensory quality to obtain more comprehensive scientific information.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing, and approved the final draft for publication. The research profile of the authors can be verified from their ORCHID ids, given below:

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