Advances in Engineering Research, volume 172
4th International Conference on Food and Agriculture Resources (FANRes 2018)

Effect of Roasting Profiles and Brewing Methods on the Characteristics of Bali Kintamani Coffee

Kiki Fibrianto
Sensory and Applied Food Science Research Group, Faculty of Agricultural Technology
Universitas Brawijaya
Malang, Indonesia
kiki.fibrianto@ub.ac.id

Khoirul Umam
Sensory and Applied Food Science Research Group, Faculty of Agricultural Technology
Universitas Brawijaya
Malang, Indonesia
khoirulumam@gmail.com

Eka Shinta Wulandari
Sensory and Applied Food Science Research Group, Faculty of Agricultural Technology
Universitas Brawijaya
Malang, Indonesia
ekashintaw@gmail.com

***Abstract*— Roasting profile has been considered as one of important factors governing the quality of coffee. Kintamani coffee is popular because it has strong notes of citric acid and brown sugar sweet. Those sensory characteristics are attributed by different roasting profiles and brewing methods. Cold brew is a coffee brewing method that brews coffee in cold, full immersion or slowly dripping within 16 up to 24 hours of extraction. Unlike hot brewing techniques which are more commonly used, cold brewing is less popular due to its complexity. In this current study, the sensory attributes of cold brew coffee will be compared to that of French Press (hot brew) coffee by applying RATA (Rate-All-That-Apply) method. The result shows that light-roasted Kintamani is more fruity (flavor) and acidic (taste and flavor) than that of dark-roasted. Meanwhile the dark-roasted Kintamani is more roasty (flavor), more bitter (taste) and thicker. In terms of brewing techniques, hot brewing tends to enhance the thickness, acid taste/flavor and bitter taste. Those sensory perceptions are attributed to higher caffeine, total phenolic content and lower pH of hot brewed coffee. On the other hand, cold brewing tends to enhance sweet flavor and balance taste.**

Keywords—Brewing, Roasting, Kintamani Arabica Coffee

I. INTRODUCTION

Coffee is a complex beverage that contains more than 1000 compounds which are responsible for the pleasant taste, aroma and flavor [1]. It has been reported in 2015, that as much as 72,96% or 466.492 tons of Robusta cofee was produced in Indonesia, while the remaining 27,04% or 172.919 tons was Arabica coffee [2]. However, Arabica is more superior in terms uniqueness. Kintamani coffee is a type of Arabica coffee grown in Indonesia and quite famous due to its lemon or orange aroma when brewed [3].

Coffee consumption in Indonesia is increasing by 6-8% per year along with the increasing trend of drinking coffee in cafes and coffee shops. According to the International Coffee Organization, in 2017, coffee consumption in Indonesia increased by an average of 4,9% over the past 5 years. It also shows that coffee consumption in Indonesia has reached up to 4.500.000 bags of 60 kg within the 2015-2016 period. It seems that, coffee drinking has becoming a trend and part of society's life style for many Indonesians.

The roasting process is very important on the taste of coffee produced [4]. Dark roasting tends to produce more intense bitternes and give a burnt flavour compared to other roasting levels. It is also suggested that different roasting profiles will produce different physical, chemical and sensory characteristics [5-11].

Besides the roasting profile, the brewing process is also very influential on coffee flavor. Conventionally, people always consume coffee by brewing it at high water temperatures. This brewing process may make the coffee bitter and cause it to lose some volatile compounds from the coffee beans. To overcome this weakness, cold brewing technique has been developed to preserve the taste and flavour of coffee. The cold brew process is a coffee brewing method using low temperature over a long period of time. It is expected that the resulting coffee has a much richer character than conventionally brewed coffee [12]. The cold brew method provides a more aromatic and flavorful coffee product because at low temperatures volatile compounds are retained better than at high temperatures. A high temperature increases volatility, causing loss of many aromatic compounds from the coffee products [13]. In this current study, a modified French Press method with the addition of a filtration process using filter paper in the final step was also used as a comparison.

Generally Arabica coffee, which is normally grown in the highlands, has a sharper aroma, and a higher acidity and is sweeter than Robusta coffee which is widely consumed in the market. As previously discussed, the brewing process and roasting profile is very influential on coffee flavor, particularly on the acidity level. It has been reported that roasting profile affects coffee acidity [14] and this study showed that coffee acidity increased when roasted using the LTLT (Low Temperature Long Time) method. Kintamani coffee has a medium to high coffee acidity characteristic, therefore Kintamani coffee was investigated in this study.

The main purpose of this study is to compare the characteristic of Kintamani Arabica coffee brewed by cold and hot brewing techniques. The results of this study are expected to be used as a reference in coffee product development.

II. METHODS

This study was conducted at Food Sensory Laboratory and Chemical Laboratory, Agriculture Product Technology Department, Universitas Brawijaya, from February 2017 until July 2017.

A. Tools and Materials

A coffee roaster (drum type with 1 kg capacity) was used in this study. For the French Press coffee brewing process a 600 ml French Press was used while 1 L water container and coffee paper filter were used for cold brewing. Other tools such as thermometer, timer, coffee grinder, water heater and digital scales were also required. For this current study, 3 kg of coarse grounded Arabica Bali Kintamani coffee were supplied by Apresio Kopi, Malang. A commercial demineralised water was used for brewing the coffee as well as for palate cleansers.

B. Chemical Tests

The acidity of the coffee was measured using pH meter at room temperature.

The amount of caffeine content was measured by a spectrophotometric method. The organic solvent, chloroform was used to extract the caffeine from the brewed coffee.

The Total Phenolic Content (TPC) carried out using the Folin-Ciocalteau method using UV-Vis Spectrophotometer at a wavelength of 750 nm. The TPC was calculated as milligrams equivalent to gallic acid (GAE= Gallic Acid Equivalent) per gram sample (mg GAE/ g sample).

C. Sensory Test

The RATA (Rate-All-That-Apply) method was applied to determine the intensity of sensory attributes involving 110 untrained panelists to ensure that compiled data was normally distributed. The literature suggests that the minimum number panelists involved for a RATA study should be 70 people or around 50 and 100 people [15-16].

Panelists were asked to score from 1 to 5 (lowest to highest intensity) on 29 sensory attributes. A preference rating test was also conducted on all sensory attributes using structured scale questionnaires.

D. Experimental Design and Statistical Analysis

A Completely Randomized Block Design was applied by modifying 2 factors; roasting level and brewing method. There were 3 levels of roasting; light, medium and dark and 2 types of brewing; hot (French Press) and cold brewing were used. While preference rating test was analyzed by Friedman test, the rest of data were analyzed by General Linear Model (GLM) on Minitab-16.

III. RESULTS AND DISCUSSION

A. Effect of Brewing Method and Roasting Profile on the pH of Brewed-coffee

It was observed that the pH of the brewed coffee does is not affected by the brewing method (p-value>0.05). However, the roasting profile significantly affects to the value of coffee pH (Table 1). The longer roasting times tend to be more alkaline compared to those of medium and dark roasts. The increasing pH value might result from the evaporation of some of the acidic components when the coffee is roasted. Coffee beans naturally contain various types of volatile compounds such as aldehydes, furfural, ketones, alcohols, esters, formic acid and acetic acid which are also volatile by nature. The compounds forming the acid flavour or taste, such as tannins and acetic acid, will volatilize, while the other volatile compounds will react with amino acids to form melanoidin compounds that contribute to the brown color [17].

Coffee pH does not always represent the sour taste perceived by coffee consumers [18]. The sourness or perceived acidity mostly affected by the presence and composition of organic acids, such chlorogenic acid and quinic acid, rather than by the pH solely. Table 1, indicates that coffee with lighter roasting profile tended to have the higher acidity.

Table 1. The pH of brewed Kintamani Arabica coffee for different roasting profile

Roasting Profile	pH
Dark	5.38 ± 0.12^{a}
Medium	5.1 ± 0.09^{b}
Light	4.85 ± 0.02^{c}

Note: Means in the same column/row with different superscript differ significantly (P<0.05)

B. Effect of Brewing Method and Roasting Profile on Total Phenolic Content of Brewed-coffee

This study shows that roasting levels and brewing methods have significant effects on the TPC of brewed coffee, as shown in Table 2. It has been suggested that the TPC in green beans is influenced by species and its origin, while in brewed coffee the TPC is more influenced by the brewing method, as suggested by Trandafir et al [19] who demonstrated this for eight types of coffee beverages. As observed, the hot brewing method tended to have a higher content of TPC than that of the cold one (Table 2).

Table 2. Total Phenolic Content of brewed Kintamani Arabica coffee at different brewing methods and roasting profiles

Parameter	Treatment	Total Phenolic Content (mg GAE/g)
Roasting	Light	24.09 ± 0.02^{a}
	Medium	19.74 ± 0.01^{b}
	Dark	16.04 ± 0.02^{c}
Brewing	Hot Brew	20.77 ± 0.02^{a}
	Cold Brew	19.13 ± 0.01^{b}

Note: Means in the same column/row with different superscript differ significantly (P<0.05)

Light-roasted coffee tended to have a higher TPC than the medium and dark-roasted ones. The longer roasting process decreases the level of phenol compounds in brewed coffee. This is because phenolic compounds are not stable to high temperatures. Chlorogenic acid, one of the dominant phenol compounds in coffee, is unstable at the high temperatures used in the roasting process. It is degraded into phenol derivatives. During the roasting process, chlorogenic acid will be isomerized and turned into quinolacton [20]. It was reported that the highest chlorogenic acid contents are found in light to medium roasted coffee [21].

C. Effect of Brewing Method and Roasting Profile on Caffeine Content of Brewed-coffee

As can be seen in Table 3, medium roasting produces the highest caffeine content. This is due to the roasting process

degrading caffeine at the high temperatures used in the roasting process [22].

Table 3. Caffeine Content of brewed Kintamani Arabica coffee at different brewing methods and roasting profiles

Parameter	Treatment	Caffeine (%)
Roasting	Medium	2.59 ± 0.01[a]
	Dark	2.30± 0.01[b]
	Light	2.21± 0.01[b]
Brewing	Hot Brew	2.85± 0.01[a]
	Cold Brew	1.89± 0.01[b]

Note: Means in the same column/row with different superscript differ significantly (P<0.05)

However, hot brewed coffee tended to have higher caffeine contents than the cold brewed one. Similar result was also reported by Nhan and Phu [23] who investigated caffeine contents in Arabica and Robusta coffee who showed that high-temperature brewed coffee had higher caffeine contents than low-temperature brewed coffee. At higher temperatures, the extraction process of caffeine will be quicker as its dissolution process is enhanced by heat. The free more easily diffuses though the cell wall and dissolves in the solvent [24].

D. Effect of Roasting Level on Kintamani Coffee Sensory Characteristics

As shown inTable 4, roasting levels changes the dominant sensory attributes of brewed-coffee. Light roasted coffee tends to be enriched by fruity flavors and sour taste. While the medium roast is more dominated by an intensive body feel in the mouth. As predicted, bitter taste was profound in the dark-roast. Fruity aromatic is defined as lightly sour and sweet aromatics are associated with several fruit flavors [25]. Fruit flavors in coffee are contributed by ester compounds, such as ethyl-2-methylbutyrate [26]. Considering the volatility of ester compounds, the lighter roasting profile should retain the fruit flavor in coffee better [27].

Table 4. The effect of roasting profile on Kintamani Arabica coffee sensory profiles

Attributes	Roasting Profile	Intensity
Fruit Flavor	Light	0.8±0.1[a]
	Medium	0.6±0.1[b]
	Dark	0.5±0.1[b]
Acid Flavor	Light	2.4±0.2[a]
	Medium	2.0±0.2[b]
	Dark	1.5±0.2[c]
Roasty Flavor	Dark	2.7±0.2[a]
	Medium	2.2±0.2[b]
	Light	1.8±0.2[b]
Citric Acid	Light	1.5±0.2[a]
	Medium	1.4±0.2[a]
	Dark	1.0±0.2[b]
Bitter Taste	Dark	3.0±0.1[a]
	Medium	2.6±0.1[b]
	Light	2.5±0.1[b]
Body	Dark	2.2±0.1[a]
	Medium	2.6±0.1[ab]
	Light	2.4±0.1[b]

Note: Means in the same column/row with different superscript differ significantly (P<0.05)

Sour flavor in coffee is mainly related to aliphatic acid compounds such as citrate, malate, and formate resulting from carbohydrate degradation which is related to the length of the roasting process. Even though the longer roasting produces more acid compounds, the sourness was perceived to be more intensive by the panelists in light roasted coffee. It might be attributed to the bitterness masking the other attributes. During the roasting process, a bitter taste in coffee is produced by chlorogenic acid, which will be split into quinine acid, quinine lactic acid acid , chlorogenic acid lactones and ferulic and caffeic acids, which have a characteristic strong bitter taste. The increased bitter taste of coffee often also leads to panelists having difficulties in identifying the other flavors in coffee, such as sour or sweet. It has been suggested that dark roasting is the most efficient way to reduce acid content and sourness in coffee [27].

Roasted coffee with dark roast levels will have a stronger roasty taste due to the formation of furan compound. This compound is generated by the Maillard reaction which is enhanced with the length of roasting [28].

Caffeine, a nitrogenous secondary metabolite, is expected to influence the perceived strength, body and bitterness of brewed coffee [27]. In addition, alkaloids also contribute to the bitter taste of coffee [29].

Sensory attributes in coffee related to texture, density and viscosity is often called body. In the mouth body is often described as the smoothness while density is related to the sensation perceived on the surface of the tongue. The body perception of brewed coffee is caused by the presence of lipid and dissolved polysaccharides compounds [30].

It also has been reported that more complex aromas in coffee are formed at a medium roasting level, while a light roast produces sweet, cocoa and nutty aromas and dark roasting is responsible for burnt/acrid, ashy/sooty, sour, pungent, coffee and roasted characteristics [31].

E. Effect of Brewing Method on Kintamani Coffee Sensory Characteristics

Compared to the cold brewing method, the hot method tends to be more intensive in terms of sourness, sweetness, bitterness, body and balance (Table 5). Sourness is defined as an excessively sharp, biting and unpleasant flavor. It is sometimes associated with the aroma of fermented coffee. Methylbutyric acid is an aromatic compound found in both green and roasted coffee.

Table 5. The effect of brewing method on Kintamani Arabica coffee sensory profiles

Attributes	Brewing Method	Intensity
Acid Flavor	Hot	2.2±0.1[a]
	Cold	1.7±0.1[b]
Sweet Flavor	Cold	0.6±0.1[a]
	Hot	0.4±0.1[b]
Citric Acid	Hot	1.5±0.1[a]
	Cold	1.1±0.1[b]
Bitter Taste	Hot	3.0±0.1[a]
	Cold	2.5±0.1[b]
Body	Hot	2.8±0.1[a]
	Cold	2.5±0.1[b]
Balance	Cold	2.8±0.1[a]
	Hot	2.4±0.1[b]

Note: Means in the same column/row with different superscript differ significantly (P<0.05)

Extraction of various compounds is a critical factor affecting the character of coffee. Higher brewing temperatures will increase the content of dissolved compounds in coffee. Thus, hot brewed coffee was found to have more bitterness, sourness and a thicker body. On the other hand, cold brewed coffee had a more sweet character and a better balance taste.

F. Panelist Assessment on The Sweetness of Kintamani Coffee

As sweetness has been closely attributed to Kintamani coffee, panelist assessment of sweetness was considered to be important. Carbohydrate compounds such as glucose and fructose are mainly found in immature beans while higher amounts of sucrose accumulate in mature beans and contribute to perceived coffee sweetness [32, 33]. It has been suggested that furanone groups such as sotolone and abhexone may contribute to the sweet note in coffee [27].

In this study, it was found that sweetness of the cold brew coffee was more intense than that from the hot brew (Table 5). This type of brewing was also preferred by the panelist, particularly when light roasted coffee was used.

IV. CONCLUSION

This study shows that the roasting profile and brewing methods change the sensory profile of coffee. Light roasted coffee, which is cold brewed, tended to intensify the sweetness of Kintamani coffee. Even though the hot brew produced more intense sensory attributes, the cold brewing method is more suggestive of the sweet overtones because of the profound sweetness that inherent in the light-roasted Kintamani coffee.

REFERENCES

[1] Meija E G D, Ramirez-Mares M. Impact of affeine and coffee on our health. Trend in Endocrinology and Metabolism. 2014; 25, 10: 489-492

[2] Slette J and Wiyono E. Indonesia Coffee Annual. USDA Foreign Agricultural Service; 2012

[3] Mawardi S Establishment of Geographical Indication Protection System in Indonesia, Case in Coffee Worldwide Symposium on Geographical Indications 2009

[4] Baggenstoss J, Poisson L, KaegiR, Perren R, Escher F.Coffee roasting and aroma formation: application of different time-temeprature conditions. Journal of Agricultural and Food Chemistry. 2008; 56(14), 5836-5846

[5] Perez-Martinez M, Caemmerer B, De Pena M P, Cid C,Kroh L W.Influence of brewing method and acitiy regulators on the antioxidant activity between green and roasted coffee eans using molecular methods. Molecular Medicine Reports. 2010; 12: 7293-7302.

[6] Zhang C, Linforth R, Fisk I D. Cafestol Extraction Yield from Different Coffee Brew Mechanisms. Food Research International. 2010; 49, 27-31.

[7] Sridevi V, Giridhar P, Ravishankar G A.Evaluation of roasting and brewing effect on antinutritionalditerpenes-cafestol and kahweol in coffee. Global Journal Medical Research. 2011; Vol 11, Issue 5.

[8] Amanpour A,Selli S.Differentiation of volatile profiles and odor activity values of Turkish coffee and french press coffee. Journal of Food Processing and Preservation. 2015; ISSN 1745-4549.

[9] Arisseto A P, Vicente E, Ueno M S, Tfouni S A V,Toledo M C D F.Furan levels in coffee as influenced by species, roast degree and brewing procedures. J. Agric. Food. Chem. 2011; 59, 3118-3124.

[10] Alves R C, Casal S,Oliveira M B P P.Tocopherols in coffee brews: influence of coffee species, roast degree and brewing procedure. Journal of Food Composition and Analysis. 2010; 23, 802-808.

[11] Caporaso N, Genovese A, Canela M D, Civitella A,Sacchi R.Neapolitan coffee brew chemical analysis in comparison to espresso, moka and American brews. Food Research International. 2014; 61, 152-160.

[12] Fomer, B. The Craft and Science of Coffee. Elsevier. London; 2017

[13] Lane S, Palmer J, Christie B R, Ehlting J, Le C H Can cold brew coffee be convinient? A pilot study for caffeine content in cold brew coffee concentrate using high performance liquid chromatography The Arbutus Review 2017; 8, 1

[14] Gloess A N, Vietri A, Wieland F, Smrke S, Schönbächler B, Lopez J A Z, Yeretzian C. Evidence of different flavor formaiton dynamics by roasting coffee from different origins: On-line analysis with PTR-ToF-MS. International Journal of Mass Spectrometry. 2014; 365-366: 324-337.

[15] Ares G,Bruzzone F, Vidal L.Evaluation of a rating based variant of Check-All-That-Apply Question: Rate-All-That-Apply (RATA). Food Quality and Preferences. 2014; 36, 87-95

[16] Budryn. Evaluation of Sensory Attributes of Coffee Brews From Robusta Coffee Roasted Under Different Conditions. Polandia: Institute of Chemical Technology of Food, Technical University of Lodz; 2006

[17] Mulato S.Simposium Kopi 2002: Mewujudkanperkopiannasional yang tangguhmelaluidiversifikasiusahaberwawasanlingkungandalampengembanganindustri kopi bubukskalakeciluntukmeningkatkannilaitambahusahatani kopi rakyat. Denpasar: 16-17 Oktober 2002. Pusat Penelitian Kopi dan Kakao Indonesia. 2002

[18] Davids K. Home Coffee Roasting. St. Martin's Press Florida; 2012

[19] Trandafir I, Nour V, Ionica M E.Antioxidant capacity, phenolic acids and caffeine contents of some commercial coffees available on the Romanian market. Arc Lationamnutr. 2013; 63(1):87-94

[20] Trugo, L C. HPLC in coffee analysis. University of Reading, England; 1984

[21] Tfuoni S A V, Carreiro L B, Teles C R A, Furlani R P Z, Cipolli K M V A B, Camargo M C R.Caffeine and chlorogenic acids intake from coffee brew: influence of roasting degree and brewing procedure. Int. J. Food. Sci. Technol. 2014; 49, 747-752.

[22] Crozier T W M, Stalmach A and Lean M E J. Espresso coffees. Caffeine and chlorogenic acid intake: potential helath implications. Food & Function. 2012; ISSN 2042-6496

[23] Nhan, P P, Phu N T.Effect of time and water temperature on caffeine extraction from coffee. Pakistan Journal of Nutrition. 2012; 11 (2): 100-103

[24] Sivetz, M and Desrosier N W. Coffee Technology. The AVI Publ. Inc. : Connecticut; 1979

[25] Kreuml M T L, Majchrzak D, Ploederl B, Koenig J. Changes in sensory quality characteristics of coffee during storage. Food science & nutrition. Wiley Periodicals, Inc; 2013

[26] Czerny, M. and Grosch, W. Potent odorant of raw arabica coffee. Their changes during roasting. Journal of Agricultural and Food Chemistry. 2000;Colombus, v, 48

[27] Sunarharum W B, Williams D J, Smyth H E. Complexity of coffee flavor: a compositional and sensory perspective. Food Research International 62. 2014.

[28] Grosch W, Czerny M, Mayer F, Moors A. Sensory studies on the key odorants of roasted coffee. Am. Chem. Soc. Symp. Ser. 2000; 754, 202-209

[29] Lean M E, Crozier A. Coffee, caffeine and health: What's in your cup? Maturitas. 2012; 72(3), 171-172

[30] Mulato, S and Suhartanto E. Kopi, SeduhandanKesehatan. PusatPenelitian Kopi danKakao Indonesia. Jember; 2012

[31] Bhumiratana N, Adhikari K,Chambers IV E. Evolution of sensory aroma attributes from coffee beans to brewed coffee. LWT-Food Science and Technology. 2011; 44, 2185-2195.

[32] Oestrich-Janzen, S. Chemistry coffee. Oxford: Elsevier; 2010

[33] Wassesman G, Bradburry A, Cruz T,Penson S. Coffee. Kirk-Othmer Encyclopedia of Chemical Technology. John Wiley & Sons, Inc. 2012