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(Research Article)

The characteristic and sensory evaluation of arabica Semendo coffee in high-speed stirring cold brew and common brew

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Abstract

Differences in brewing methods both from extraction time and brewing water temperature can affect the number of chemical compounds dissolved. This study applied the cold brew brewing method with high-speed stirring to Arabica Semendo coffee with extraction times of 15, 30, and 45 minutes at different particle sizes of coffee powder (coarse, medium, and fine) to obtain coffee with better characteristics than the commonly used brewing methods (hot brew and cold brew) and acceptable in sensory evaluation. The pH, viscosity, total soluble solids, total microbes, and sensory evaluation by hedonic tests on taste, color, and aroma were investigated. Coffee with high-speed stirred cold brewing for more than 30 minutes with finer coffee grounds had higher pH, viscosity, and total soluble solids than common brewing as a control. The size of the coffee grounds and the difference in brewing method did not affect microbial contamination. The results of the hedonic test on color, taste, and aroma in the cold brewing method of high-speed stirring produced coffee that was accepted by consumers and was not significantly different from the common brew.

Keywords: Arabica coffee; Cold Brew; Hot Brew; Hedonic Test; Stirring Brew

1. Introduction

Coffee is a drink that has a distinctive taste and flavor that is in demand by all people in the world. There are several types of coffee in the world, but the most widely recognized and cultivated are Robusta coffee and Arabica coffee [1]. Arabica coffee is the most widely consumed in the world. Most of the world's people prefer Arabica coffee, and consumer demand for Arabica coffee products is almost three times that of Robusta coffee [2]. Indonesia is the world's fourth largest coffee producer and exporter, and South Sumatra is the province with the largest coffee production in Indonesia. Semendo is one of the coffee-producing areas with good quality and flavor in South Sumatra Province. Semendo arabica coffee received the title of "Specialty" in 2020 from the Indonesian Coffee and Cocoa Research Center.

The main thing that becomes a consideration for consumer acceptance of coffee is flavor, many factors affect the flavor of coffee drinks, one of which is the brewing process. Brewing using water with different temperatures and brewing times will trigger different chemical reactions and affect the number of chemical compounds dissolved [3]. The particle size, shape, and particle size distribution of coffee grounds also affect the number of chemical compounds dissolved in coffee beverages [4]. The brewing methods commonly used are hot brew and cold brew. The hot brew generally in a short time makes chemical compounds that are responsible for the formation of coffee flavor and aroma not maximally dissolved, besides that high-temperature water can evaporate volatile compounds that make the flavor of hot brew coffee not too strong, while in cold brew a long extraction is carried out (8-12 hours), almost all chemical compounds are maximally dissolved including compounds that form flavor and aroma, coffee become over taste, which is too sour,

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bitter and thick [5]. Long-time extraction, low-temperature water, and higher pH value in the cold brew method allow microbiological contamination and an ideal environment for the growth of pathogenic microbes [6].

The extraction process with high-speed stirring can damage various layers of barriers in the form of wrapping layers and cell walls in an extracted material so that the chemical compounds contained can come out of the material and dissolve in the solvent more quickly and optimally [5]. This research develops a coffee extraction method with the high-speed stirring cold brew technique using the digital stirring machine that does not change the temperature of the solution and the size of the coffee powder at high speed in a relatively short time compared to the general cold brew method, brewing using cold water to keep flavor-forming volatile compounds from evaporating and getting coffee drinks with characteristics that are almost the same as coffee brewed with common methods (hot brew and cold brew) and in microbiologically can avoid contamination and resist the growth of pathogenic microbes.

2. Material and Methods

This study used Arabica Semendo coffee from Rantau Dedap Village processed post-harvest by dry method, coffee beans were ground according to the treatment, namely fine, medium, and coarse sizes. Coffee was extracted using the common brewing methods of hot brew and cold brew, and the new brew method; was high-speed stirring cold brew with different stirring times of 15, 30, and 45 minutes. Quantitatively tested parameters in the form of pH values were measured with a HI 83141 glass electrode pH meter, a digital rotary viscometer (NDJ-5S, Lichen Technology) was used to measure the viscosity of the coffee solution, and a 0# rotor was selected with a rotation speed of 60 rpm, for measuring liquids with viscosities lower than 1 mPa's [5]. Total Dissolved Solids (TDS) analysis was converted from degrees Brix using a Refractometer, coffee TDS was measured following the protocol outlined by [5], °Brix of each brewed coffee was then converted to TDS (Xs) as follows: XS = 0.0087 × °Brix and displayed as % (x 100%). Microbiological analysis was conducted by counting total microbial colonies using the Spread Plate Count method. For Qualitative Parameters, a Sensory Evaluation was conducted in the form of a Hedonic Test on 30 untrained panelists selected from coffee consumers in coffee shops in the Palembang area with the age range of 17 - 50 years old who drink coffee at least 2 times a day every day. The sensory variations tested were general things related to the identity of coffee drinks, namely taste, color, and aroma. Data processing was carried out by ANOVA analysis of the SAS OnDemand for Academic ProcGLM program and if the results of the ANOVA calculation of the p-value <0.05, which indicates a significant effect on the treatment then continued with Tukey's Studentized Range Honestly Significant Different (HSD) from the SAS (Statistical Analysis System) ANOVA Tukey program from SAS OnDemand for Academic production SAS Institute Inc, 2023.

3. Results and Discussion

3.1. pH, Viscosity, and Total Dissolve Solid (TDS)

The pH value of coffee in combination treatment in Table 1 was shown that the pH of coffee brewed with the high-speed stirring cold brew method was higher than Control 1 and Control 2 at the same particle size level of the coffee ground. The extraction process with high-speed stirring could increase the pH value in coffee, the longer the stirring time shows higher pH, Statistical analysis ANOVA shows that particle size, different brewing method, and a combination of it has a significant effect on pH ($P<0.05$), using Tukey's HSD test, the differences in stirring time in this method were not significantly different. In the treatment combination, A1 and A2 coffee powder, combined with B1, B2, and B3 brewing were significantly different from the control methods B0 and B4, while in A2 powder brewing with control, 1 (B0) was significantly different from all other brewing methods and Control 2 (B4) was not significantly different from B1, B2, and B3.

The pH value in hot brew brewing (4.88-4.91) is lower than cold brew (4.90-4.9) and high-speed stirring cold brew (4.94-5.01), this is in line with the previous study that found the pH value of hot brew (4.85 - 5.10) is lower than the pH of cold brew (4.96 - 5.13). The chemical content in hot brew coffee is more diverse and complex than in cold brew, at high temperature brewing more deprotonic acid is extracted than at low-temperature brewing, this acid compound is thought to be responsible for the lower pH value in hot brew coffee [7] [8].

Viscosity measurements followed by ANOVA statistical analysis ($p < 0.05$) can be seen in Table 1, brewing method has no significant effect on the viscosity of coffee drinks ($P = 0.062$, $P > 0.05$), while for coffee powder particle size and treatment, combinations have a significant effect on viscosity ($P < 0.05$) followed by Tukey's HSD test. For the combination, A1B1, A1B2, A1B3 & A1B4 with A2B3 and A2B2 were not significantly different but significantly different from the coffee hot brew, but for A3, the viscosity of coffee in all brewing methods was not significantly different. A1 when combined with high-speed stirring with a long brewing time will increase the viscosity of the solution, Coarse coffee grounds with long-time extraction will have a higher viscosity than fine powder with a shorter time. These show that time extraction has contributed to the viscosity of coffee beverages. The viscosity of coffee with a combination of treatments in this study, for Hot brew, is between 1,273-1,363 mPa's, for cold brew 1,317 - 1,460 mPa's and for high-speed stirring cold brew from 1,310-1,537 mPa's, the viscosity from this study was in the range from the previous study [9] which compared the ratio of coffee and water, the solution viscosity value range is between 0.32 - 2.81 mPa's. Higher viscosity values were also obtained from another previous study which ranged from 2-4 mPa's at a ratio of coffee and water 20%-60, that stated higher viscosity value of the coffee solution is due to the large number of mano oligosaccharide compounds dissolved in coffee [10]. The viscosity of coffee is influenced by complex molecules such as carbohydrates, fats, and proteins that dissolve in coffee during the extraction process, in the longer extraction process the major polysaccharide compounds in the form of galactomannan and arabinogalactomannan dissolve optimum, these compounds are responsible for the binding aroma and can increase the viscosity of the extract solution [11].

Table 1 pH, Viscosity, and TDS of Coffee in Combination Treatments

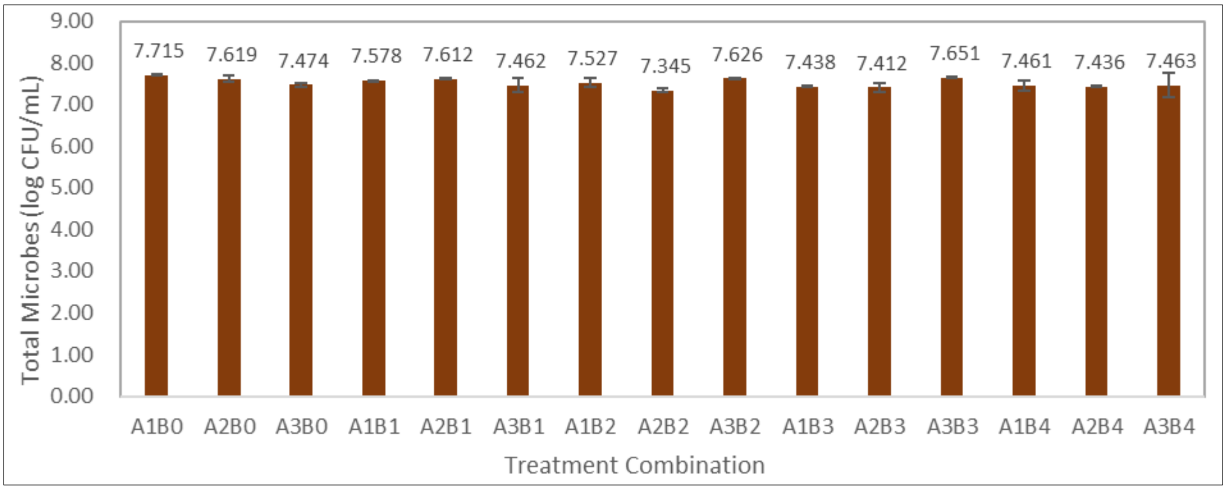
Treatments Combination	**pH**	**Viscosity (mPa's)**	**TDS (%)**
A1B0	4,91 ± 0,01^{ef}	1,353 ± 0,021 ^{bcde}	2,06 ± 0,07^{ef}
A1B1	4,97 ± 0,01 ^{b}	1,423 ± 0,060 ^{abcd}	2,38 ± 0,04 ^{abc}
A1B2	5,00 ± 0,00^{a}	1,443 ± 0,035 ^{abcd}	2,41 ± 0,04 ^{ab}
A1B3	5,01 ± 0,00 ^{a}	1,537 ± 0,031 ^{a}	2,23 ± 0,07 ^{abcde}
A1B4	4,94 ± 0,01 ^{d}	1,460 ± 0,020 ^{ab}	2,18 ± 0,06 ^{cdef}
A2B0	4,90 ± 0,01^{g}	1,363 ± 0,047 ^{bcde}	2,12 ± 0,04 ^{def}
A2B1	4,94 ± 0,01^{cd}	1,310 ± 0,079 ^{de}	2,23 ± 0,04 ^{abcde}
A2B2	4,94 ± 0,01^{cd}	1,397 ± 0,035 ^{abcde}	2,20 ± 0,04 ^{bcde}
A2B3	4,94 ± 0,01 ^{cd}	1,453 ± 0,046 ^{abc}	2,44 ± 0,06 ^{a}
A2B4	4,93 ± 0,01 ^{de}	1,347 ± 0,047 ^{bcde}	2,32 ± 0,09 ^{abcd}
A3B0	4,90 ± 0,01 ^{f}	1,273 ± 0,551 ^{de}	1,97 ± 0,04 ^{f}
A3B1	4,94 ± 0,01^{cd}	1,320 ± 0,035 ^{bcde}	2,06 ± 0.04 ^{ef}
A3B2	4,94 ± 0,01^{cd}	1,310 ± 0,080 ^{de}	2,23 ± 0,07 ^{abcde}
A3B3	4,96 ± 0,01 ^{bc}	1,320 ± 0,017 ^{bcde}	2,26 ± 0,00 ^{abcde}
A3B4	4,90 ± 0,01 ^{f}	1,317 ± 0,040 ^{bcde}	2,18 ± 0,00 ^{cdef}

A1= fine, A2= Medium & A3 =coarse, B0= Hot brew (control 1), B1= High-speed stirring cold brew 15 min, B2= High-speed stirring cold brew 30 min, B3= High-speed stirring cold brew 45 min, B4= Cold brew 12 h (control 2), Values in each category row with the same letter are not significantly different (p >0.05)

The amount of TDS in this coffee drink is calculated based on the degree Brix value of the coffee solution, which is the number of sugar components extracted in water. The highest TDS value was in A2B3 (2,44%) and the lowest was in A3B0 (1,97%). Based on statistical analysis ($P < 0.05$), the treatment of coffee powder particle size ($P = 0.033$, $P < 0.05$), B ($P = 0.0002$, $P < 0.05$), and the combination of both treatments ($P < 0.0001$) all had a significant effect, followed by Tukey's HSD. In the treatment combination, the results of further test calculations can be seen that there was a tendency for TDS to be not significantly different in cold water extraction, the combination of coarser particle size and longer extraction time, with finer particles and shorter extraction time was not significantly different, but would show significantly different combination involving hot water extraction. Hot brew coffee at all sizes of coffee grounds had lower TDS values in the range between 1,97 - 2,18% than cold brews that have TDS in the range between 2,18 - 2,32% and high-speed stirring cold brew coffee 2,05 - 2,44 %. The TDS value of coffee with the high-speed stirring cold brew method showed a tendency to be higher than the TDS value of the control method. A previous study found that TDS coffee in hot brew 1,55 -1,81% and the cold brew with drip an immersion technique had TDS between 2,03 -1,68% [4]. This is also in line with other previous research which states that the TDS value in cold drinks is higher than in hot drinks and the length of extraction time can increase the amount of TDS in the extracted solution [12]. The amount of TDS is higher in coffee drinks extracted with cold water compared to hot water. The TDS value is strongly influenced by the amount of carbohydrates extracted in the coffee solution in this case in the form of simple sugars, fructose in coffee is more soluble in cold water compared to hot water, in the extraction process with cold water fructose has a more optimum solubility than other sugar components such as sucrose and glucose according to [13]. The longer the extraction time make soluble substances will be, and the additional treatment of stirring in the extraction process can accelerate and optimize the solubility of extracting all compounds including sugar into the water.

3.2. Total Colony Microbes

Total microbial colonies were incubated under anaerobic conditions for 48 hours because, during the 24-hour incubation period, the colonies formed were still very small and could not be counted. Data from the calculation of total microbial colonies can be seen in Figure 1. From the statistical analysis using ANOVA; particle size, brewing method, and the combination of treatments had no significant effect on the total number of microbial colonies in coffee drinks so no further tests were needed. The total microbes present in the coffee solution after incubation for 48 hours in all treatments ranged from 7.345-7.715 logs CFU/mL, this number was in the range from the previous study that investigated total microbes in coffee beverages stated that the microbes identified in coffee were bacteria, yeast, and mold, the total microbes incubated for 12, 36 and 48 hours ranged from 6.5 - 8 log CFU/mL [14]. Coffee is considered safe for consumption if the number of colonies based on TPC calculations does not exceed 1 x 108 CFU/mL according to SNI 7388: 2009 standards [15].



A1= fine, A2= Medium & A3 =coarse, B0= Hot brew (control 1), B1= High-speed stirring cold brew 15 min, B2= High-speed stirring cold brew 30 min, B3= High-speed stirring cold brew 45 min, B4= Cold brew 12 h (control 2),

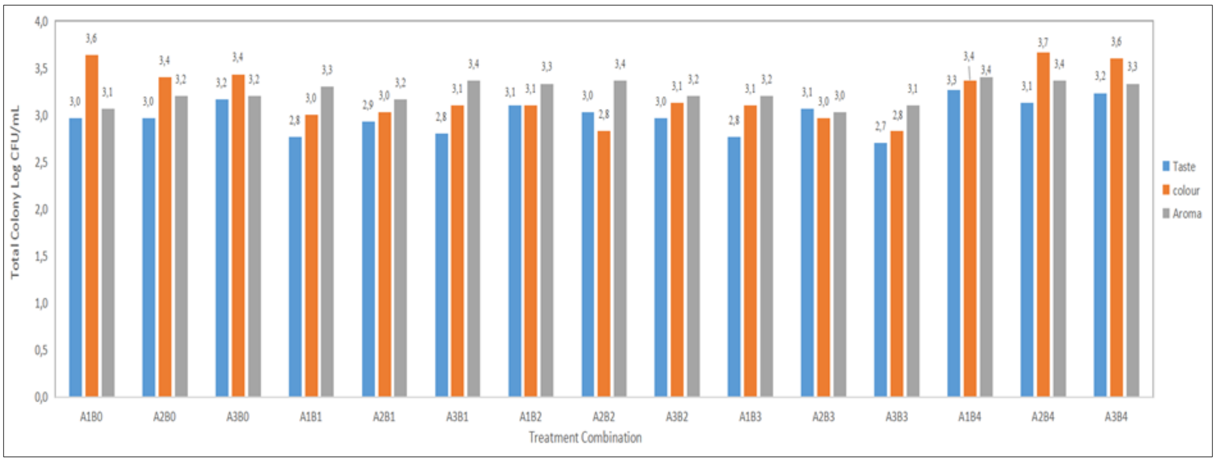
Figure 1 Total Microbes of Coffee Beverages in Treatment Combination

Brewing with high-temperature water did not suppress the number of microbes present in coffee drinks. Brewing using low-temperature water (High-speed stirring cold brew and cold brew) tends to have lower microbial colony counts compared to high-temperature water brewing despite the longer extraction process. The pH value in this method is also higher (4.97 - 5.01) than the pH value of hot brew, the high pH of High-speed stirring cold brew and cold brew coffee does not trigger microbial growth. This is also evidenced by the calculation using the Pearson correlation coefficient.

The correlation coefficient value between total microbial colonies and pH value x= -0.117, which means that the correlation is inversely proportional and very weak or almost had no correlation. The pH of food in the range of 4.6-6 cannot suppress the growth of pathogenic microbes and can damage food, suppressing the number of microbes in coffee due to the content of compounds in coffee that are anti-microbial [16]. Chlorogenic acid which is classified as an antioxidant compound has anti-bacterial properties, chlorogenic acid in roasted coffee is degraded into caffeic acid, quinic acid, and some simple esters that have the antioxidant capacity and can act as anti-bacterial to prevent microbial growth to slow down the process of beverage damage and extend the self-life of the coffee drink itself [17].

3.3. Sensory Evaluation in Hedonic Test

Data results from the hedonic test in Taste, color, and aroma, are shown in Figure 2.



A1= fine, A2= Medium & A3 =coarse, B0= Hot brew (control 1), B1= High-speed stirring cold brew 15 min, B2= High-speed stirring cold brew 30 min, B3= High-speed stirring cold brew 45 min, B4= Cold brew 12 h (control 2).

Figure 2 Hedonic Test in Taste, Color, and Aroma of Coffee Beverages

The main consideration for consumer acceptance of coffee is the flavor of coffee. Non-parametric Cochran-Mantel-Hansel Statistics (Based on Rank Scores) test with the SAS method shows particle size, brewing method and the combination of the two treatments were not significantly different (p value> 0.05) to the consumer preference (hedonic quality) on the taste, color, and aroma of coffee drinks, differences in coffee brewing methods both using conventional brewing methods and high-speed stirring cold brew methods do not significantly affect the level of consumer preference in the taste of coffee drinks produced.

The results of the coffee taste test on all samples were in the range of 2,7 – 3,3 points. In the high-speed stirring cold brew method (B1, B2, and B3), the taste of coffee with medium powder size tends to be preferred over fine or coarse coffee powder, in contrast to the control method 1 where coarse coffee powder is preferred while in control 2 coffee with fine coffee powder is preferred. The 30-minute high-speed stirring cold brew method has a favorability value of >3 in all sizes of coffee powder just like control methods 1 and 2, while at a stirring time of 45 minutes, only the medium powder size has a value of more than 3.

Differences in color in the brewed coffee due to differences in extraction time and brewing method also gives a difference in color preference, the color of hot brew coffee tends to be clear reddish black due to the short extraction time, while conventional cold brew with an extraction period of 12 hours tends to be dark black. Coffee with the high-speed stirring cold brew method is dark brown in color.

Both control treatments have hedonic values that tend to be the same with values >3 in all sizes of coffee powder. The 15-minute high-speed stirring cold brew coffee has a value of >3 at all particle sizes, although it has a hedonic value lower than the control, the color from this method is still accepted by consumers, and the average value tends to reach 3 (Moderate like). Although the physical color of coffee is different, it does not affect panelist preference for coffee color, this means that the color of coffee produced by the high-speed stirring cold brew method of 15, 30, and 45 minutes is still preferred and acceptable to consumers.

The highest value of the coffee color hedonic test is in coffee with control method 2, this indicates that consumers tend to prefer coffee that is solid black in color. The deep black color of coffee is influenced by the length of the extraction process so that all chemical compounds that form the color of coffee dissolve optimally in water. The color in coffee drinks comes from chemical compounds in coffee powder dissolved in water. Sensory-forming compounds in coffee such as melanoidin, furans, acrylamide compounds, and other organic compounds formed from Maillard reactions and caramelization of carbohydrates, lipids, and degradation of phenolic compounds in the roasting process will be maximally dissolved with the length of the extraction process [18].

Coffee drinks have a strong and distinctive aroma, this factor is also the attraction of coffee drinks. The sensory test of coffee aroma can be seen in Figure 2. This value is higher than other sensory parameters, all coffees with particle size and brewing method get a value above 3. The stirring time treatment in the high-speed cold brew method has a high value even exceeding Control 1, especially at 15 minutes of stirring with coarse powder and 30 minutes with medium powder. This indicates that this method can produce a coffee aroma that is favored by coffee consumers Coffee consumers still like the aroma of coffee brewed with the high-speed stirring cold brew method of 15, 30, and 45 minutes just as much as the control methods; the hot brew and 12-hour cold brew methods.

The highest value is in cold brew coffee with fine powder, the aroma in this coffee is very strong compared to other coffees so it is preferred because the low brewing temperature with a long and closed extraction time makes all volatile compounds remain in the coffee drink and will smell strong when consumed in cold coffee. The aroma of coffee that comes out of coffee drinks comes from the release of volatile compounds such as aldehydes, alcohols, and ketones as well as non-volatile compounds in the form of sugars, chlorogenic acid, and trigonelline in coffee powder extracted using water [19].

4. Conclusion

- The pH and TDS of coffee high-speed stirring cold brew was higher than common brew.
- The difference in stirring time in this method did not significantly affect the pH of the coffee beverage.
- The particle size of coffee powder, water temperature, and brewing method affects the amount of TDS in coffee beverages.
- The particle size of coffee ground affects the viscosity of coffee drinks and high speed stirred in the high-speed stirring cold brew method can increase the viscosity of coffee.
- Temperature, coffee powder size, high-speed stirring cold brew method, and brewing time did not give significantly affect the total number of microbes in coffee beverages.
- Hedonic test values of taste, color, and aroma of coffee produced by the high-speed stirring cold brew method are not significantly different from other common methods (hot brew and cold brew) which means that it is still preferred or acceptable to consumers.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare there is no conflict of interest with this article

References

[1] H. Etienne, "Somatic embryogenesis protocol: coffee (Coffea arabica L and C canephora P)," SM Jain & P K Gupta Eds Protocol for somatic embryogenesis in woody plant, pp. 167-168, 2005.

[2] H. D. Belitz, W. Grosch and P. Schierberle, Coffee tea cocoa In H-D Belitz W Grosch and P Schieberle Eds Food Chemistry, (4th ed) 938–951 Leipzig Springer , 2009.

[3] N. Z. Rao, M. Fuller, and M. D. Grim, "Physiochemical Characteristics of Hot and Cold Brew Coffee Chemistry: The Effects of Roast Level and Brewing Temperature on Compound Extraction," www.mdpi.com/journal/foods, pp. Foods 2020, 9, 902; doi:10.3390/foods9070902, 2020.

[4] N. Cordoba, M. Fernandez-Alduenda, F. L. Moreno and Y. Ruiz, "Coffee extraction: A review of parameters and their influence on the physicochemical characteristics and flavor of coffee brews," Trends Food Sci. Technol, pp. 96, 45–60., 2020.

[5] M. Vinatoru, T. J. Mason and I. Calinescu, "Ultrasonically assisted extraction (UAE) and microwave-assisted extraction (MAE) of functional compounds from plant materials," Trends in Analytical Chemistry 97, p. 159e178, 2017.

[6] F. L. Moreno, M. Raventós, E. Hernández, N. Santamaria, A. J., O. Pirachican, L. Torres and Y. Ruiz, "Rheological Behaviour, Freezing Curve, and Density of Coffee Solutions at Temperatures Close to Freezing," International Journal of Food Properties, vol. 18, no. DOI: 10.1080/10942912.2013.833221, pp. 426–438, 2015.

[7] N. Z. Rao and M. Fuller, "Acidity and Antioxidant Activity of Cold Brew Coffee," www.nature.com/scientificreports/ 8:16030, pp. DOI:10.1038/s41598-018-34392-w, 2018.

[8] S. Kyroglou, K. Thanasouli and P. Vareltzie, "Process characterization and optimization of cold brew coffee: effect of pressure, temperature, time and solvent volume on yield, caffeine and phenol content," Journal of Society of Chemical Industry, p. (wileyonlinelibrary.com) DOI 10.1002/jsfa.11125, 2021.

[9] J. T. Romero, R. A. F. Cabral, A. L. Gabas and . V. R. N. Telis, "Rheological Properties And Fluid Dynamics Of Coffee Extract," Journal of Food Process Engineering, vol. 24, no. 3 May 2001, pp. 217-230, 2001.

[10] S. B. Erkan, S. Basmak, A. Ozcan, C. Yılmazer, H. N. Gürler, G. Yavuz, M. Germec, E. Yatmaz and I. Turhan, "Mannooligosaccharide production by β-mannanase enzyme application from coffee extract," Journal of Food Processing and Preservation, vol. 00:e14668., no. 1 Juni 2020, p. DOI: 10.1111/jfpp.14668, 2020.

[11] M. Arya and L. J. M. Rao, "An impression of coffee carbohydrates.," Critical Reviews in Food Science and Nutrition, Vols. 47(1), , no. https://doi.org/10.1080/10408390600550315, p. 51–67., 2007.

[12] F. L. Partelli, H. D. Vieira, E. P. B. Ferreira, A. P. Viana, . M. A. Martins and S. Urquiaga, "Chemical and Microbiological Soil Characteristics under Conventional and Organic Coffee Production Systems," Communications in Soil Science and Plant Analysis, Vols. 43:5, , no. http://dx.doi.org/10.1080/00103624.2012.648470, pp. 847-864, 2012.

[13] C. E. Crestani, A. Bernardo, C. B. B. Costa and M. Giulietti, "Fructose Solubility in Mixed (Ethanol + Water) Solvent: Experimental Data and Comparison among Different Thermodynamic Models," Journal of Chemical and engineering data, p. dx.doi.org/10.1021/je400471m, 2013.

[14] R. Nasanit and K. Satayawut, "Microbiological Study During Coffee Fermentation of Coffea arabica var. chiangmai 80 in Thailand," Kasetsat Journal (Naturat Sci), vol. 49, no. 04 February 2015, pp. 32 - 41, 2015.

[15] K. Fibrianto, M. H. Fakhruddin and E. S. Wulandari, "Effect of Mokapot brewing temperature on sensory profiling of Dampit and Tulungagung Ijo coffee," International Conference on Green Agro-industry and Bioeconomy, vol. IOP Conf. Series: Earth and Environmental Science 230, pp. doi:10.1088/1755-1315/230/1/012037, 2019.

[16] R. Kwok, K. L. Ting, S. Schwarz, L. Claassen and D. W. Lachenmeier, "Current Challenges of Cold Brew Coffee—Roasting, Extraction, Flavor Profile, Contamination,and Food Safety," www.mdpi.com/journal/challenges 11, 26, p. doi:10.3390/challe11020026, 2020.

[17] A. Farah, T. De Paulis, L. C. C. Trugo and P. R. Martin, "Effect of Roasting on the Formation of Chlorogenic Acid Lactones in Coffee," Journal of Agricultural and Food Chemistry, Vols. 53,, no. 10.1021/jf048701t, p. 1505–1513, 2005.

[18] G. Angeloni, L. Guerrini, P. Masella, M. Innocenti, M. Bellumorib and A. Parentia, "Characterization and comparison of cold brew and cold drip coffee extraction methods," J Sci Food Agric, pp. (wileyonlinelibrary.com) DOI 10.1002/jsfa.9200 391 -399, 2018.

[19] D. N. Yusianto, "Mutu Fisik dan Citarasa Kopi Arabika yang Disimpan Buahnya Sebelum di-Pulping," Pelita Perkebunan, pp. 30(2) : 137-158, 2014.