Brewing time and temperature optimization of Robusta Dampit Coffee on several drip techniques

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Abstract. This study aims to optimize brewing temperature and time for 5 different drip techniques specifically to obtain optimum total phenol content and antioxidant activity. These are including Kalita Wave, Chemex, Woodneck Drip Pot, Vietnam Drip and V60. Optimization was conducted due to variability of brewing procedure among barista/coffee brewer. In addition, sensory profiling was also carried out. The optimum time and temperature for Kalita Wave and Vietnam Drip were observed at 100°C for 180 s. Meanwhile, Chemex and V60 were optimum for 150 s brewing at 100°C and 90°C consecutively. The optimum temperature of Woodneck Drip Pot brewing was the lowest as 80°C for 180 s. Sensorially, Chemex and Kalita Wave tend to be similar, while the other three tend to be distinctive.

1. Introduction
Coffee is the most popular beverage in the world that has been produced by people for centuries. According to the International Coffee Organization, in 2016-2017, coffee consumption by people in the world increased by 1.9% from 2015-2016 period. Coffee is popular because of its distinctive taste and aroma. In addition, coffee is also popular as coffee which contains antioxidants that can be used for body healthy.

Physical, chemical and sensory characteristics of coffee brewing are not only influenced by the type of coffee, but also influenced by brewing techniques and brewing conditions such as particle size, ratio of ground coffee and water, brewing time, and brewing temperature [1-2]. It has been commonly known that brewing temperature and brewing time have an important role in the quality of brewing coffee produced. The time and temperature that is too low or too high causes the coffee brewing to be under-extracted or over-extracted. Thus, the phenolic compounds which have antioxidant activity in coffee [3] are not extracted optimally.

Drip brewing method is one type of brewing method that is commonly done. More recently, the drip brewing method has been the subject of increased attention. This technique is carried out by the principle of passing water on ground coffee in the filter. Filter material can be made of paper, metal or fabric. Water id poured slowly into the powder and dissolves the coffee flavoring compound in ground coffee and penetrates the filter pores. The coffee solution will drip and be stored in a glass, cup or kettle. The dregs left in the filter [1].
The purpose of this study is to optimize the brewing conditions, namely brewing temperature and brewing time in the filter drip brewing technique namely Kalita wave, Chemex, V60, Woodneck drip pot and Vietnam drip. The optimization response observed was antioxidant activity and total phenolic compounds through application of Response Surface Methodology. In addition, sensory characterization of each brewing technique was also carried out using the Quantitative Descriptive Analysis (QDA) method.

2. Materials and Methods

2.1. Materials

The raw material used in this study was Robusta Dampit coffee with semi-washed processing. Robusta Dampit coffee was obtained from UPH Sekar Rindu. In addition, mineral water was used as a palate cleanser and as a coffee solvent.

2.2. Method

The method used to determine the optimization of brewing temperature and brewing time was Response Surface Methodology (RSM). The response parameters were antioxidant activity and total phenol. In the sensory characterization, each brewing technique was also carried out using the Quantitative Descriptive Analysis (QDA) method.

The optimization data obtained was analyzed using Design Expert 7 software. Whereas the results of sensory evaluation were analyzed using GLM ANOVA in the Minitab 17 software with a 95% confidence interval. Principal Component Analysis (PCA) was analyzed by Sensehub software.

3. Results and Discussion

3.1. Results of optimization of brewing temperature and brewing time using RSM

Optimized data were analyzed using Design Expert 7. From the results of the analysis, the optimum point was obtained as follows.

| Brewing Techniques   | Brewing Temperature (°C) | Brewing Time (seconds) | IC50 (ppm) | Total Phenolic Content (mg GAE/g) |
|----------------------|--------------------------|------------------------|------------|----------------------------------|
| Kalita Wave          | 100                      | 180                    | 49.03      | 4.91                             |
| Chemex               | 100                      | 150                    | 39.67      | 4.56                             |
| Woodneck Drip Pot    | 80                       | 180                    | 65.35      | 4.82                             |
| Vietnam Drip         | 100                      | 180                    | 48.71      | 6.25                             |
| V60                  | 90                       | 150                    | 28.88      | 29.72                            |

As shown in Table 1, it was observed that each brewing technique has a specific optimum brewing condition (temperature and brewing time) even though they are categorized as the same filter drip group. In Kalita brewing techniques, Chemex and Vietnam drip have optimum points at 100° C. While the Woodneck drip pot and v60 were optimum at 80° C and 90° C respectively. At those optimum temperature, the optimum brewing time was 180 seconds for Kalita wave, Woodneck drip pot and Vietnam drip. Meanwhile Chemex and V60 were optimum when brewed for 150 seconds.

One method used to test the activity of antioxidant compounds used the DPPH method. The antioxidant activity of the sample is expressed in IC50 or the concentration of the sample which has an inhibition against the radical DPPH of 50%. The smaller the IC50 value indicates that the antioxidant activity in the extract is higher [4]. In this study IC50 was obtained at 28.88-65.35 ppm at optimum
brewing conditions. Ludwig et al [5] stated that a longer contact time between water and ground coffee in the drip filter method can improve the extraction efficiency of antioxidant compounds. Antioxidant activity in coffee is associated with the content of chlorogenic acid, ferulic acid, caffeic acid and n-coumaric acid. In roasted coffee beans, melanoidin is a powerful antioxidant. Caffeine and trigonelin are also associated with antioxidant activity in coffee [6].

Reblova [7] stated that temperature is one of the most important factors affecting antioxidant activity. In general, heating can cause an acceleration of the initiation reaction which can lead to a decrease in antioxidant activity. Research conducted by Reblova [7] shows that the higher the temperature used, the lower the total phenol content. Cheng et al [8] stated that phenolic compounds are unstable at high water temperatures and for a long time. Research conducted by Afify et al. [9] suggests that water temperature affects the total phenol content in coffee. The higher the temperature of the water used, the lower the total phenol content.

3.2 The results of sensory characterization
After obtaining the optimum brewing conditions, sensory characterization for all samples was carried out. Characterization method used in this study is the Quantitative Descriptive Analysis (QDA) method. The QDA method is one of the descriptive analysis methods used in describing the characteristics of the sensory attributes of food products. Product description is based on verbal perceptions of trained panellists on the product. The QDA method includes formal selection and training, the development and use of sensory language and repeated product appraisal to obtain an overall quantitative descriptive product [10].

Table 2 shows that 21 out of total 26 sensory attributes are influenced by the brewing techniques used. There are 4 attributes including brown sugar aroma, burnt aroma, sour taste, saltiness and cocoa flavour which are not influenced by brewing techniques. Brown sugar aroma is associated with sweet aroma detected by panelists with medium intensity. Compounds that contribute to the aroma of brown sugar include furaneol, 2,3-butane-dione and 2,3-pentane-dione compounds [11]. These compounds are formed during the roasting process [12] and therefore, it is not directly related to brewing techniques. Unlike brown sugar aroma, burnt aroma, acid taste and cocoa flavour were not affected by applied brewing techniques as they were consistently rated at low intensity.

| Sensory Attributes | P-Value |
|--------------------|---------|
| Aroma              |         |
| Brown Sugar        | 0.192   |
| Musty              | 0.038*  |
| Burnt              | 0.524   |
| Vegetative         | 0.000*  |
| Nutty              | 0.000*  |
| Cocoa              | 0.000*  |
| Black Tea          | 0.001*  |
| Fermented          | 0.000*  |
| Sweet              | 0.000*  |
| Taste              |         |
| Sweet              | 0.021*  |
| Sour               | 0.326   |
| Salty              | 0.353   |
| Bitter             | 0.000*  |
| Mouthfeel          |         |
| Body               | 0.014*  |
| Strength           | 0.001*  |
| Flavor             |         |
| Cocoa              | 0.132   |
| Burnt              | 0.000*  |
Table 3 shows that 21 sensory attributes are influenced by the use of different brewing techniques in making coffee. Not only affected by brewing temperatures and time, the differences in attributes intensity may also be contributed by the different filter used. It can be seen in Figure 1 that shows the fifth drip techniques are located in different quadrants and have different dominant sensory attributes.

| Sensory Attributes | Chemex | Kalita Wave | Woodneck Drip Pot | Vietnam Drip | V60 |
|--------------------|--------|-------------|-------------------|--------------|-----|
| Aroma              |        |             |                   |              |     |
| Musty              | 4.73<sup>a</sup> | 2.94<sup>b</sup> | 5.09<sup>a</sup> | 4.48<sup>ab</sup> | 2.94<sup>b</sup> |
| Vegetative         | 327<sup>a</sup> | 1.89<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 1.88<sup>b</sup> |
| Nutty              | 0.00<sup>b</sup> | 4.27<sup>a</sup> | 3.29<sup>a</sup> | 0.00<sup>b</sup> | 3.76<sup>a</sup> |
| Cocoa              | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 2.64<sup>a</sup> |
| Black Tea          | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 2.16<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> |
| Fermented          | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 3.45<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> |
| Sweet              | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 2.89<sup>a</sup> |
| Taste              |        |             |                   |              |     |
| Sweet              | 2.93<sup>ab</sup> | 2.14<sup>b</sup> | 2.78<sup>ab</sup> | 3.62<sup>c</sup> | 2.50<sup>b</sup> |
| Bitter             | 6.48<sup>ab</sup> | 6.99<sup>a</sup> | 7.05<sup>a</sup> | 4.03<sup>c</sup> | 5.28<sup>bc</sup> |
| Mouthfeel          |        |             |                   |              |     |
| Body               | 6.87<sup>a</sup> | 6.61<sup>ab</sup> | 6.92<sup>a</sup> | 4.44<sup>c</sup> | 5.04<sup>bc</sup> |
| Strength           | 0.00<sup>b</sup> | 7.88<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> |
| Flavor             |        |             |                   |              |     |
| Burnt              | 2.89<sup>a</sup> | 4.17<sup>a</sup> | 3.05<sup>a</sup> | 3.66<sup>c</sup> | 0.00<sup>b</sup> |
| Chemical           | 4.45<sup>a</sup> | 5.46<sup>a</sup> | 3.84<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> |
| Vegetative         | 2.79<sup>a</sup> | 1.95<sup>a</sup> | 1.47<sup>a</sup> | 0.00<sup>b</sup> | 2.23<sup>a</sup> |
| Musty              | 4.44<sup>a</sup> | 3.88<sup>a</sup> | 4.99<sup>a</sup> | 0.00<sup>b</sup> | 3.46<sup>a</sup> |
| Nutty              | 4.23<sup>ab</sup> | 3.32<sup>bc</sup> | 2.63<sup>c</sup> | 5.32<sup>a</sup> | 3.52<sup>bc</sup> |
| Citrus Fruity      | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 3.2<sup>a</sup> | 0.00<sup>b</sup> | 2.07<sup>a</sup> |
| Fermented          | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 3.05<sup>a</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> |
| Brown Sugar        | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 2.15<sup>a</sup> | 0.00<sup>b</sup> | 2.66<sup>a</sup> |
| Aftertaste         |        |             |                   |              |     |
| Pleasant           | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 0.00<sup>b</sup> | 5.69<sup>a</sup> |
| Unpleasant         | 4.60<sup>ab</sup> | 6.26<sup>a</sup> | 5.30<sup>ab</sup> | 3.49<sup>b</sup> | 0.00<sup>b</sup> |

As can be seen in the plot (Figure 1), the five samples are located in different quadrants. Only Chemex and Kalita Wave are located in the same quadrant. This can be confirmed in Table 3 which shows that Chemex and Kalita Wave techniques have similarities on 18 sensory attributes out of 21 attributes. Samples located in the same quadrant indicate that the characteristics of the sample tend to
be the same. While the samples located in different quadrants show that the samples have different characteristics.

**Figure 1.** Principal component analysis of brewing technique influences on sensory properties of Robusta Dampit coffee.

4. Conclusion
In this study the optimum brewing temperature and brewing time were obtained for Kalita wave, Chemex, Woodneck drip pot, Vietnam drip and V60 brewing techniques were 100°C and 180 s; 100°C and 150 s; 80°C and 180 s; 100°C and 180 s; and 90°C and 150 s in a row, with IC\textsubscript{50} and total phenol content of 49.03 ppm and 4.91 mg GAE/g; 39.67 ppm and 4.56 mg GAE/g; 65.35 ppm and 4.82 mg GAE/g; 48.71 ppm and 6.25 mg GAE/g; 28.88 ppm and 29.72 mg GAE/g for Kalita wave, Chemex, Woodneck drip pot, Vietnam drip and V60 techniques respectively. Kalita wave, Chemex, and Woodneck drip techniques have sensory characteristics such as bitter taste, thicker body, burnt flavor, chemical flavor, vegetative flavor, musty flavor, and unpleasant aftertaste. While Vietnam Drip and V60 have sensory characteristics of musty aroma, low bitter taste, and low to medium body.

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