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FULL PAPER

Optimization of roasting temperature and time of the durian seed (*Durio zibethinus* L.) as coffee substitution and its flavour profile

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Abstract

Durian seeds are known for their ability to produce the same flavour and aroma as regular coffee beans if it goes through the roasting process. Hence, in this research, optimization of roasting treatment will be carried out at a certain temperature (200-240°C) and roasting time (30-60 mins) to obtain a comparable aroma and taste with the Robusta and Arabica coffee. The optimization was done by using Response Surface Methodology (RSM) method from the program Design Expert 11.1.0.1Ò. The optimization results showed that the optimum temperature and roasting time for durian seeds are 240°C and 47.63 mins for it to be comparable with the Robusta coffee and 229.48°C for 52.27 mins for it to be comparable with the Arabica coffee, both having a similarity level of 69%. The flavour profile from the optimized product was then determined using the Quantitative Descriptive Analysis (QDA) consisting of 6 attributes (sweet, bitter, sour, fruity aroma, fruity flavour, and roasted flavour). The Robusta coffee substitute has low caffeine content (0.26±0.00%), lightness value of 34.05±0.43, °Hue value of 38.01±0.10, pH of 6.40±0.02, moisture content of 2.18%±0.05, ash content of 3.84±0.10%, fat content of 1.41±0.07%, protein content of 9.71±0.06%, and carbohydrate content of 85.04±0.30%, while the substitute for the Arabica coffee also has a low caffeine content of 0.24±0.00%, a lightness value of 35.23±0.17, °Hue value of 39.88±0.60, pH of 5.67±0.01, moisture content of 2.22±0.05%, an ash content of 3.75±0.07%, a fat content of 1.34±0.09%, protein content of 9.63±0.00%, and a carbohydrate content of 85.28±0.23%.

1. Introduction

Coffee is one of the most popular beverages in the world. Coffee is processed from coffee beans (*Coffea* spp.) (BSN, 2008). Coffee can be consumed both in the morning as an energizer and also at night to prevent sleepiness (Fajriana and Fajriati, 2018). In general, coffee can also be called an energy drink that stimulates and reduce fatigue in our body (Alsunni, 2015). Apart from being a stimulant, coffee also has a unique aroma and antioxidant content (CGA). However, the presence of caffeine in coffee brings negative health impacts. Moreover, excessive caffeine consumption can lead to hypertension, anxiety, and tachycardia (Bae *et al*., 2014). Coffee with 97% extracted caffeine content called decaffeinated coffee can be used as an alternative to avoid these negative impacts. Although decaffeinated coffee has lower caffeine content (1-5 mg/150 mL) than coffees in general (60-180 mg/150 mL), decaffeinated coffee has less taste, aroma, and body which makes it not as preferable as regular coffee (Caballero *et al.,* 2016).

Coffee substitution is a non-caffeine product that is used to replace coffee beverages without reducing the taste of coffee in general (Gajić *et al.,* 2017). The utilization of snake fruit (*Salacca zalacca*) or roasted corn and rice powder as coffee powder alternatives are many examples of coffee substitution (Lestari *et al.,* 2017). The roasting process carried out on coffee substitution is important to obtain similar aroma and flavour characteristics as coffee (Caballero *et al.,* 2016).

Durian (king of fruits) is a tropical fruit with a more dominant flavour and smell compared to other fruits. In a single durian, 70% of the fruit is not consumable including the seeds (20-25%). The content of 100 g of durian seeds consists of carbohydrate (43.6 g), protein (2.6 g), and fat (0.4 g), therefore has the potential to be developed into food products (Amid *et al.,* 2012). In previous research, it was found that durian seeds can produce a flavour and aroma comparable with commercial coffee through certain temperatures and times of roasting, which showed its aptitude as a coffee

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substitution product. In this research, the focus will be on optimization of the roasting temperature and time to obtain coffee substitution with flavour and aroma that is comparable with the Robusta and Arabica coffee using a statistic technique, called Response Surface Methodology (RSM) (Youn and Chung, 2012). Furthermore, the flavour profile and caffeine content in coffee substitution products will be analyzed.

2. Materials and methods

2.1 Materials

The material used for durian seed coffee is durian seed (*Durio zibethinus* L.) from "Rumah Durian Harum, Indonesia". The materials used for the analysis are Robusta coffee, Arabica coffee, sugar, salt, caffeine, citric acid, water, crackers, $CaCO_3$, K_2SO_4, selenium, chloroform, hexane, 0.2 N HCl, H_2SO_4, NaOH 35%, H_2O_2 35%, boric acid 4%, pH 4 and pH 7 buffer, and distilled water.

2.2 Roasted durian seed powder

The process of making roasted durian seed powder was based on the method from Nusa *et al.* (2014), Prayogo *et al.* (2016), Lokaria and Susanti (2018), Varelis *et al.* (2018) with modification. Durian seeds obtained from "Rumah Durian Harum" were cleaned, peeled, and later boiled at 90ºC for 60 mins. The boiled water will turn reddish-brown which indicates the toxic component inside was removed. Drained durian seeds were then cut into small sizes. The process of drying was done using a cabinet dryer with a temperature of 50°C for 24 hrs. Dried durian seeds then proceeds to be roasted to bring out the aroma and flavour from the seeds using a coffee roaster. Roasting was carried out at different temperatures and times based on an experimental design by RSM, which were 200°C, 220°C, and 240°C, for 30, 45, and 60 mins. Roasted durian seeds were then ground to reduce the size and sieved with mesh 80 to produce homogenous roasted durian seed powder.

Optimization of roasting temperature and time was done by using the Multiple Comparison Test to compare the brewed roasted durian seed coffee with the brewed Robusta and Arabica coffee. Brewing was done by pouring 150 mL of 85-95°C water into a filter cloth that contains 8.25 g of sample powder and coffee powder (Brown, 2015; SCA, 2018 with modification).

2.3 Experimental design

The experimental design that was used in this research is Response Surface Methodology (RSM) with Central Composite Design (CCD) as the design using Face centred model. CCD consists of a factorial design of 2^2 with roasting temperature and time as the factors. The factors were coded to 2 levels (-1 and +1) and 4 centre points (0). The independent variables were inserted into a program called Design Expert 11.1.0.1^{Ò} resulting in 12 different trial runs. The dependent variable (responses) that was used was from the sensory evaluation of the Multiple Comparison Test. Response data was then inserted to Design Expert 11.1.0.1^{Ò} and analyzed by ANOVA. The results of optimization from Design Expert 11.1.0.1^{Ò} were later verified to ensure that the optimal treatment suggested by the program produces the responses that match the actual responses. Optimization results were accepted if the actual responses were in the range of Confidence Interval (CI) or Prediction Interval (PI).

2.4 Method of analysis

The analysis conducted in this research includes chemical, physical, and sensory evaluation. Chemical analysis that was done is proximate analysis (AOAC, 2005), caffeine content (Arwangga *et al.,* 2016), and pH value (AOAC, 1995). Physical analysis that was done on coffee substitution products is colour (Guiné *et al.,* 2018). Sensory evaluation was carried out using the Multiple Comparison Test and Quantitative Descriptive Analysis (QDA) involving semi-trained panellists and trained panellists who have passed the selection and training process (Meilgaard *et al.,* 2016).

3. Results and discussion

3.1 Taxonomical verification

The durian seeds used in this research were identified by Lembaga Ilmu Pengetahuan Indonesia (LIPI) and showed that the durian seeds used were indeed *Durio zibethinus* L.

3.2 Chemical characteristics of fresh durian seed

Chemical characteristics of fresh durian seed that was used (Table 1) indicated that the seeds have a proximate content that was not much different from the theory of Djaeni and Prasetyaningrum (2010), Srianta *et al*. (2012), and Kumoro *et al*. (2020). The differences in the content of fresh durian seeds can be caused by environmental factors, such as climatic and geographical conditions.

The carbohydrate content in durian seeds is dominated by monosaccharides such as galactose (48.6%), glucose (37.1%), arabinose (0.58%), and xylose (0.3%) (Mulyati *et al.,* 2019). The high carbohydrate content is one of the precursors of forming a distinctive taste and aroma in coffee (Caballero *et al.,* 2016). In comparison, the carbohydrate content in green coffee beans reaches 60%, and there are 10% of which around 6 -12.5%, are soluble carbohydrates such as galactose, glucose, arabinose, sucrose, and xylose. This indicated a similarity in the carbohydrate composition of durian seeds and green coffee beans, which shows the possibility to produce a flavour and aroma similar to coffee.

Table 1. Chemical characteristics of fresh durian seed

Parameter(s)	Fresh durian seed	Fresh durian seed*
Moisture (%, wb)	43.37±1.24	54.9
Ash (%, db)	3.86±0.06	4.08
Fat (%, db)	0.37±0.06	0.41
Protein (%, db)	7.37±0.42	7.54
Carbohydrate (*by difference*) (%, db)	88.41±0.40	86.54

*Djaeni and Prasetyaningrum (2010), Srianta *et al.* (2012), Kumoro *et al.* (2020)

Fatty acids and amino acid content of the seeds are other contributing factors to the distinctive flavour and aroma of coffee. The main fatty acid content in green coffee beans includes palmitic acid (25-35%), also amino acid content, such as glutamic acid, aspartic acid, lysine, and alanine (Folmer, 2007; Caballero *et al.,* 2016). These contents share a similar profile with the fatty acids and amino acids in durian seeds, which are dominated by saturated fatty acids such as palmitic acid, stearic acid, and arachidic acid, along with 12 types of amino acids including glutamic acid (5.57%), aspartic acid (6.10%), lysine (6.04%), and alanine (5.24%) (Amid *et al.,* 2012). Therefore, those contents may play a role in the formation of a similar flavour and aroma to durian seeds with Robusta and Arabica coffee.

3.3 Optimization of roasting temperature and time of durian seed

Optimization was carried out twice to compare the durian seed coffee with Robusta (*Coffea canephora*) and Arabica (*Coffea arabica*). Different species of coffee all have their own flavour and aroma. Robusta coffee is known to have a more roasted flavour and aroma, while Arabica coffee has a more sour and fruity flavour and aroma (Caballero *et al.,* 2016). Roasting was done at the temperature of 200°C as the lower limit and 240°C as the upper limit, for 30 mins as the lower limit and 60 mins as the upper limit. Range determination of roasting temperature and time was done based on the trial and error activity using a coffee roaster. The organoleptic Multiple Comparison Test results involving 25 panellists were inserted as optimization response data. The response data results of temperature and time towards the level of similarity to commercial coffee were shown in Table 2 (a) and (b).

Response data of the optimization obtained were based on the assessment of the Multiple Comparison Test consisting of 7 scales, with the details of 1 = Extremely less than R, 2 = Less than R, 3 = Slightly less than R, 4 = Comparable with R, 5 = Slightly more than R, 6 = More than R, dan 7 = Extremely more than R. The relation between roasting temperature and time with the response data of Robusta and Arabica, shown as a quadratic model in the Design-Expert program. The response data results were analyzed by ANOVA and can be seen in Table 3. Based on Table 3, the p-value of both the Robusta and Arabica response model has a value of less than 0.05 ($p<0.05$). This indicated that the temperature and time as factors have a significant effect on the similarity of roasted durian seed powder with Robusta and Arabica coffee. The closer the R-squared value to 1, the more accurate the response data is with the regression prediction. An adequate precision value of more than 4 is desired. The value of adequate precision data for the Robusta dan Arabica responses in Table 3 shows a value of more than 4, indicating that the model can be used to predict the optimum temperature and time of roasting.

Table 2 (a). The response data of Robusta optimization

Run	Factor(s)		Response
	Temperature (°C)	Time (Mins)	Multiple Comparison Test
1	220	30	1.80±0.70
2	220	45	2.84±0.75
3	220	45	2.64±1.07
4	240	30	2.12±0.97
5	240	45	2.80±1.12
6	220	45	2.56±0.92
7	200	45	2.04±0.98
8	200	60	2.52±0.96
9	220	60	2.24±1.20
10	200	30	1.28±0.54
11	220	45	2.76±1.16
12	240	60	2.60±0.91

Table 2 (b). The response data of Arabica optimization

Run	Factor(s)		Response
	Temperature (°C)	Time (Mins)	Multiple Comparison Test
1	240	60	2.60±0.87
2	200	45	1.76±0.97
3	220	45	2.68±1.07
4	200	60	2.44±0.83
5	240	30	1.76±0.78
6	220	45	2.76±0.73
7	240	45	2.88±0.97
8	200	30	1.36±0.50
9	220	30	1.72±0.84
10	220	45	2.72±0.84
11	220	45	2.84±0.90
12	220	60	2.56±0.96

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Table 3. ANOVA Response Surface Methodology

Response	Model	*p-value*	Standard deviation	*R-squared*	*Adequate precision*
Robusta	Quadratic	0.0054	0.1986	0.903	11.3591
Arabica	Quadratic	0.0067	0.2333	0.8954	9.2438

3.4 Analysis of multiple comparison test responses

Responses data from the sensory evaluation were analyzed using interaction analysis of variance (ANOVA). Figure 1 shows the interaction between roasting temperature and time factors with the Robusta Multiple Comparison Test response data.

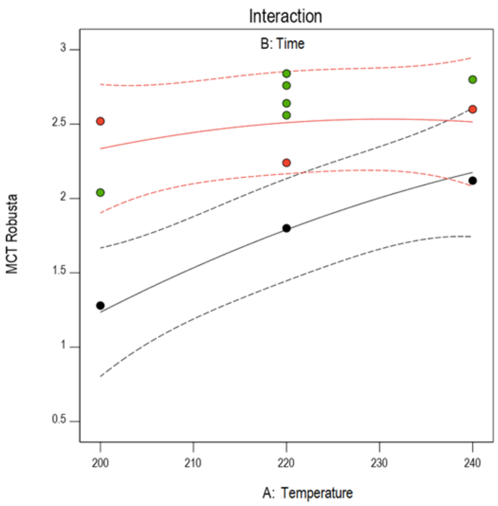

Figure 1. Model graph of Robusta Multiple Comparison Test response. Black, green, and red dots indicate the time of roasting for 30, 45, and 60 mins

The equation for Multiple Comparison Test Robusta response was described as:

$$Y = 2.64 + 0.2800A + 0.3600B - 0.1900AB - 0.0850A^2 - 0.4850B^2$$

Where Y = Multiple Comparison Test Robusta organoleptic results, A = Temperature (°C), B = Time (Mins)

Through Figure 1, it is known that durian seeds that were roasted at the temperature of 240°C for 45 mins have a better similarity to the commercial Robusta coffee. Roasting temperature and time will affect the sensory characteristics of coffee beans, resulting in a certain roasting temperature and time that will produce coffee with a preferred flavour profile (Anisa *et al.,* 2017). Roasting that was done at the temperature of 240°C for 45 mins showed a higher response value than for 60 mins. Prolong roasting process will reduce the aroma due to the large number of volatile compounds that evaporated (Purnamayanti *et al.,* 2017).

The equation for Multiple Comparison Test Arabica response was described as:

$$Y = 2.69 + 0.2800A + 0.4600B - 0.0600AB - 0.2650A^2 - 0.4450B^2$$

Where Y = Multiple Comparison Test Arabica organoleptic results, A = Temperature (°C), B = Time (Mins)

Figure 2 shows the analysis of the interaction between roasting temperature and time factors with the Arabica Multiple comparison response data. Roasting done at the temperature of 220°C and 240°C yielded fairly similar response data at 30, 45, and 60 mins. However, the roasting time of 30 mins at 200°C, 220°C, and 240°C resulted in lower response data. Shortened period of roasting time will not sufficiently induce the Maillard reaction, which lessens the volatile and non-volatile compounds formed, resulting in less flavour (Purnamayanti *et al.,* 2017). The factors and responses summary for the optimization can be seen in Table 4.

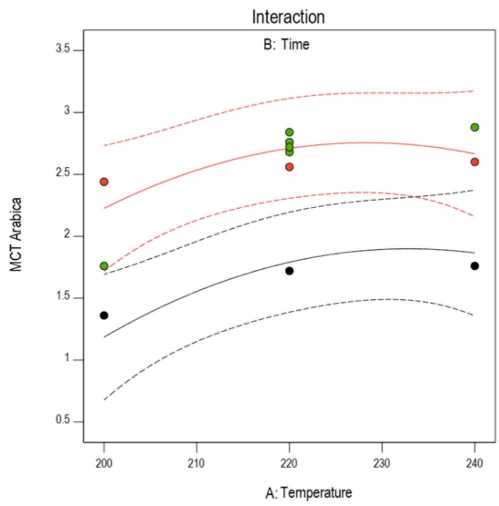

Figure 2. Model Graph of Arabica Multiple Comparison Test response. Black, green, and red dots indicate the time of roasting for 30, 45, and 60 mins

Table 4. The factors and responses summary for the optimization

Factors dan responses	Goal	Lower limit	Upper limit	Importance
Temperature	is in range	200	240	3
Time	is in range	30	60	3
MCT Robusta	maximize	1.28	4	5
MCT Arabica	maximize	1.36	4	5

The result of the optimization response will be in the range of 200°C as the lower limit and 240°C as the temperature upper limit, and the time factor in the range of 30 and 60 mins as the lower and upper limit. The lower limit was determined by the results of the organoleptic Multiple Comparison Test, while the upper limit was determined as the value of 4 (Comparable with R). The goal used in responses is to maximize, with the aim that the predicted temperature and time factors can produce a product with a response close to a value of 4 (Akbar and Murtini, 2018). The degree of importance of

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the factors was set to number 3, while the response of MCT Robusta dan Arabica was set to number 5, as the objective of the optimization is to obtain roasted durian seed powder that most closely resembles the commercial Robusta and Arabica coffee. The optimized factors and responses were predicted by the Design Expert 11.1.0.1ò software is shown in Table 5.

Table 5. Prediction by Design Expert

Optimum	Temperature (°C)	Time (Mins)	MCT Response
Robusta	240	47.632	2.845
Arabica	229.480	52.271	2.873

The desirability value obtained from the predicted solution was 0.575 for Robusta and 0.573 for Arabica. The closer the desirability value to 1, indicating the more ideal the predicted solution is to produce the optimum response. From Table 5, it can be seen that the durian seeds that showed the most similarity with the Robusta coffee were the durian seeds that were roasted at a high temperature (240°C). The Robusta variance is known to have a stronger roasted aroma flavour compound than the Arabica coffee, which is shown in this result, that a higher roasting temperature will produce a higher roasted aroma (Sasongko and Rival, 2018). The durian seeds that showed similarity with the Arabica coffee was the one that roasted at 229.480°C, which was a lower temperature shown than the one that produces similarity with Robusta coffee, albeit the similarity in the roasting time. Arabica coffee is known to have a sourer flavour and aroma than Robusta coffee, and durian seeds that were roasted at a lower temperature tend to have a more sour aroma and taste. The results of the roasting optimization prove that both time and roasting temperature affected the aroma and flavour characteristic of the coffee substitution, with a higher roasting temperature will produce more roasted flavour and less sour flavour.

3.5 Verification stage

Verification of prediction produced by the program called Design Expert 11.1.0.1Ò was done. The value of the actual Robusta optimum and Arabica optimum obtained from the sensory evaluation of the verification stage was in the 95% CI range. This indicated that the prediction of the optimum solution produced by the Design Expert was correct and acceptable. A comparison of the predicted with the actual value obtained can be seen in Table 6.

3.6 Comparison of optimum product and commercial product

The comparison of the optimization results with commercial products can be seen in Table 7. The Coffee substitutes product shows around 70% similarity with commercial products for both Robusta and Arabica coffee. However, the statistical analysis showed that the commercial products and the substitution products were significantly different ($p<0.05$). This showed that the substitution coffee was still not able to produce a similar level to the commercial coffee. Coffee has many different species and varieties with different flavours and aromas. Coffee itself has up to 124 species, including the Robusta and the Arabica coffee, which are divided into various varieties depending on where the coffee plants are grown. Arabica coffee can be divided into various types, such as "Typica", "Bourbon", "Caturra", "Tico", and "Catuai", while Robusta coffee can be divided into "Robusta", "Uganda", and "Conilon" (Belitz *et al.,* 2009; Caballero *et al.,* 2016; Davis *et al.,* 2019). Robusta coffee is famous for its more earthy, roasted (smoky, tobacco) and cocoa flavour and aroma, while Arabica coffee has an aroma and flavour that is more sweet or caramel-like, sour, spices, bitter, fruity (Caballero *et al.,* 2016; Kim *et al.,* 2016; Davis *et al.,* 2019). Therefore, it is possible that the Robusta and Arabica coffee used in this study did not accurately represent coffee as a whole. Moreover, the coffee roaster used could have affected the roasting temperature due to the different heat flow rates for each machine, as a result affecting the flavour and aroma formed.

Table 7. The comparison of the optimization results with commercial products

Optimization	Commercial product	Optimum product	MCT optimum product interpretation (%)
Robusta	3.88±0.33^{b}	2.76±0.60^{a}	69
Arabica	3.72±0.46^{b}	2.76±0.66^{a}	69

Values with different superscripts within the column are significantly different ($p<0.05$).

3.7 Flavour profile

Flavour profile determination was carried out by Quantitative Descriptive Analysis (QDA) with a total of 10 selected panellists. The total attributes used can be divided into 3 parameters (taste, flavour, and aroma). The taste parameters are sweet, bitter, and sour, the flavour attributes are fruity and roasted, while the aroma attribute is fruity. The selection was done based on the Sensory Lexicon reference from World Coffee Research

Table 6. Point prediction and confirmation of response verification

Optimum	Predicted Mean	Observed Mean	Std. Dev.	SE Mean	SE Pred.	95% CI Low	95% CI High
Robusta	2.8449	2.76	0.198578	0.140106	0.243029	2.50207	3.18772
Arabica	2.87281	2.76	0.23331	0.106807	0.256595	2.61147	3.13416

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(2017). The scoring test was carried out twice on QDA with 15 intensity scales. Representation of the comparison of flavour profile between Robusta coffee substitute and Robusta commercial coffee were depicted in the form of spider web graphs. A comparison of flavour characteristics and intensity attributes between Robusta commercial coffee and the substitute can be seen in Figure 3.

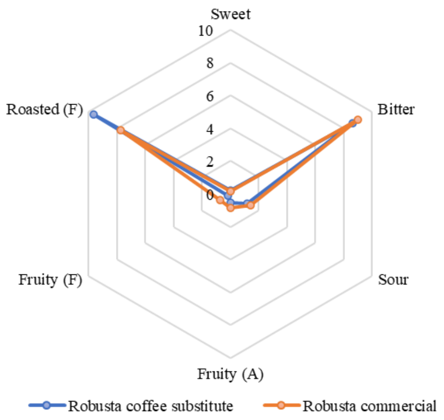

Figure 3. Flavour characteristics comparison of Robusta

The dominant attributes of the Robusta coffee substitute according to Figure 3, were roasted (flavour) and bitterness. The results of the statistical analysis show that there was a significant difference ($p<0.05$) in the attributes of fruity (flavour) and roasted (flavour). The roasting process of the durian seeds was done at 240°C, which is included in the dark roast category (240-250°C). The dark roast category means having a roasted flavour that is stronger than the other categories with a lower roasting temperature (Sasongko and Rivai, 2018). Roasting done at a higher temperature will increase the bitter taste of a drink (Radi *et al.,* 2016). Representation of the QDA results of Arabica commercial coffee and the substitute were depicted in the form of spider web graphs and can be seen in Figure 3 and Figure 4 shows a comparison of flavour characteristics and intensity attributes.

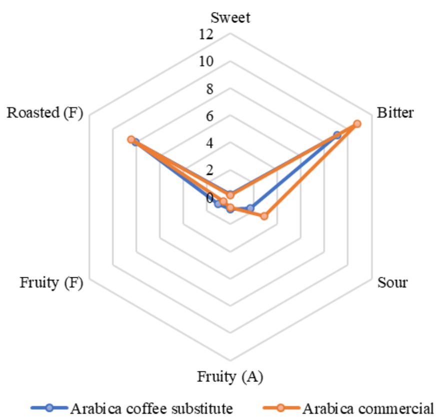

Figure 4. Flavour characteristics comparison of Arabica

In Figure 4, the sour attribute of the Arabica coffee substitute has a fairly detectable intensity. Roasting at low temperatures tends to produce products with higher acidity (Reineccius, 2013). The resulting flavour profile from the substitution product is dominated by the bitter and roasted (flavour) attributes. The statistical analysis results showed that there was a significant difference ($p<0.05$) in the bitter and sour attributes. Based on Figure 3 and Figure 4, it can be said that commercial coffee and the substitution products have a fairly similar flavour profile as a whole, with only a slight difference in the flavour and aroma intensity formed.

3.8 Caffeine content

The measurement of the absorbance value of caffeine was carried out at the maximum absorption wavelength generated by the spectrophotometer, which was 273 nm. The caffeine content of coffee substitution and commercial coffee was shown in Table 8. Statistical analysis showed a significant difference ($p<0.05$) in caffeine content between coffee substitution and commercial coffee, where coffee substitutes have a lower caffeine content than commercial Robusta dan Arabica coffee.

3.9 Proximate

In Table 8, it can be seen that there is no significant difference ($p>0.05$) between Robusta and Arabica coffee substitutes in moisture, ash, fat, protein, and carbohydrate content. The moisture content of the 2 coffee substitutes meets the quality standards for ground coffee in SNI 01-3542-2004, where the maximum moisture content for ground coffee is 7% (BSN, 2004). The ash content in the coffee substitutes powder are minerals such as calcium, potassium, iron, sodium and phosphorus which is not losable (Lim, 2012). The quality standards required for ash content according to SNI 01-3542-2004 is a maximum of 5% (BSN, 2004). The roasting process and the high temperature applied can increase the fat content in coffee beans (Endeshaw and Belay, 2020). Powdered coffee substitutes have a lower fat content if compared to commercial coffee (Robusta and Arabica).

Table 8. Proximate content of coffee substitution products

Parameter(s)	Robusta coffee substitute	Arabica coffee substitute
Moisture (%, wb)	2.18 ± 0.05^a	2.22 ± 0.05^a
Ash (%, db)	3.84 ± 0.10^a	3.75 ± 0.07^a
Fat (%, db)	1.41 ± 0.07^a	1.34 ± 0.09^a
Protein (%, db)	9.71 ± 0.06^a	9.63 ± 0.00^a
Carbohydrate (*by difference*) (%, db)	85.04 ± 0.30^a	85.28 ± 0.23^a

Values with different superscripts within the row are significantly different ($p<0.05$).

A Maillard reaction will occur during the roasting process which produces melanoidin. Apart from contributing to the brown colour, melanoidin also contains nitrogen. In this research, the determination of protein content was carried out using the Kjeldahl method which measures the amount of nitrogen (Belitz *et al.,* 2009; Wei and Tanokura, 2015). Therefore, the protein in the coffee substitutes powder was higher compared to the protein content of the fresh durian seeds analyzed at the beginning of this research (7.37±0.42). The roasting process will reduce the carbohydrate content as big as 20-37%. The higher the roasting temperature, the bigger the decrease of the carbohydrate content in the product (Oosterveld *et al.,* 2003).

3.10 Lightness

The lightness value in Table 9 showed that each coffee powder (coffee substitutes and commercial coffee), has a significant difference ($p<0.05$). The roasting process affected the lightness value to be lower (Bicho *et al.,* 2012). The occurrence of a Maillard reaction during roasting will produce 25% of melanoidin compounds that contribute to the colour brown (Caballero *et al.,* 2016). The carbon atom that formed from the pyrolysis reaction could also affect the physical changes of the beans into a more brown and darker colour (Fisdiana and Fitriyadi, 2018).

3.11 °Hue

The statistical analysis of the coffee substitute powder and commercial coffee in °Hue value shown in Table 9, resulted in a significant difference ($p<0.05$). Overall, all of the coffee powders were included in the category of red colour with an °Hue value ranging from 18-54° (Hutchings, 1999).

3.12 pH

The statistical analysis results of pH value between coffee substitute and commercial coffee in Table 9, showed a significant difference ($p<0.05$). Roasting conducted at a lower temperature and relatively short time will result in a higher acidity level (Reineccius, 2013). The roasting process will lead to the evaporation of volatile compounds such as carboxylic acids and chlorogenic acids (CGA). The evaporation of CGA which contributes to the acidity will lead to an increase in the pH value of the coffee powder. As the temperature increases during the roasting process, the acidity of the coffee will be lower (Fadri *et al.,* 2019).

4. Conclusion

The process of roasting at a certain temperature and time has a notable effect on coffee substitution products made from durian seeds. According to the optimization results from Design Expert 11.1.0.1^{Ò} program, the optimum roasting temperature and time obtained from the results of the Multiple Comparison Test to resemble a Robusta coffee was 240°C, 47.63 mins and 229.48°C, 52.27 mins for Arabica coffee, both with a similarity level of 70%. Both of the coffee substitutes have a flavour profile consisting of sweet, bitter, sour, fruity (aroma), fruity (flavour), and roasted (flavour) as attributes that are similar to Robusta and Arabica coffee. The coffee substitution products from durian seeds also have a low caffeine content (0.24±0.00% – 0.26±0.00%).

Conflict of interest

The authors declare no conflict of interest.

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Table 9. Physicochemical Difference between the coffee substitutes and coffee

Proximate	Robusta coffee substitute	Robusta Coffee	Arabica coffee substitute	Arabica coffee
Lightness	34.05±0.43^{c}	26.61±0.22^{b}	35.23±0.17^{d}	25.55±0.48^{a}
Hue	38.01±0.10	32.81±0.01^{b}	39.88±0.60^{d}	24.27±0.30^{a}
pH	6.4±0.02^{d}	5.60±0.02^{b}	5.67±0.01^{c}	5.24±0.04^{a}
Caffeine content	0.26±0.00^{b}	2.65±0.03^{d}	0.24±0.00^{a}	2.14±0.01^{c}

Values with different superscripts within the row are significantly different ($p<0.05$).

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