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Tengger *Herbal* (concocted) coffee formulation with fennel seed (*Foeniculum vulgare*) and ginger (*Zingiber officinale*) extract

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KEYWORDS

Antioxidant
Fennel Seed
Ginger
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ABSTRACT

Coffee is a drink suitable for consumption in cold areas. Bromo tourist area is a producer of fennel plants that can be used as a drink to warm the body. This study used Robusta coffee, fennel seed and ginger extract as the basic ingredients for making *herbal* coffee. The study aimed to obtain a herbal coffee formulation based on fennel seed and ginger extract to enhance and sustain food diversity in Bromo. This study employed the Response Surface Methodology (RSM) method with two factors (i.e. the proportion of Robusta coffee and the proportion of fennel seed and ginger extract) and three responses (i.e. pH, TSS, color L). Selection of the best treatment was carried out by using the effectiveness index method. The best treatment results and optimal solutions for RSM were then tested for antioxidant activity by using DPPH method. The results showed that optimal formulation of coffee (based on RSM) in a proportion of Robusta coffee of 12.50 g (proportion of fennel seed and ginger extract of 10.00 g) has a pH of 5.93, total soluble solids of 12.00 °Brix and L value of26.56 with IC_{50} value of 75.50 ppm. Whereas, the best organoleptic result was found from the first treatment, in the proportion of 14.00 g Robusta coffee (with fennel seed and ginger extracts of 10.00 g with a pH value of 5.73, total soluble solids of 13.00 °Brix, L * value of 25.06 and IC_{50} of 69.50 ppm).

Introduction

Coffee is very popular to both local and international people due to its distinctive aroma. Indonesia is listed as the fourth largest coffee producer after Brazil, Vietnam and Colombia (Center for Data and Agricultural Information Systems, 2016). In 2013, the International Coffee Organization (ICO) estimated that the world coffee powder needs around 8.77 million tons (ICO, 2015). Based on the Agriculture Data and Information System Center (2016), Indonesian coffee production in 2014 was 643,857 tonnes, with 473,672 tonnes (73.57%) of Robusta coffee.

The Bromo Tengger Semeru National Park (TNBTS) covers a massive area of 800 square km in the center of East Java. This is the largest volcanic region in the province. The most suitable product to be developed in the Bromo area is coffee. Coffee is commonly served hot as a very suitable consumption in highland areas with cold temperatures such as in Bromo Tengger Semeru National Park. Beside coffee, wild plants such as fennel (*Foeniculum vulgare*) plant is also found in Bromo area, which is traded internationally. Fennel grows wild and massive in the TNBTS area at an altitude of 2100-2200 meters above sea level (Kurniawati and Wahyuningsih, 2014). According to FAO data (2013), the export of fennel seed along with coriander and ginger from Indonesia in 2009 was 612 tonnes and it dropped to 62 tonnes in 2011. Fennel is cultivated as a spice plant and medicinal plant in Indonesia (Sastrawan et al., 2013). Although fennel seed is rich of its antioxidant attribute, the utilisation of fennel remains low. Thus, food product development is required especially for Bromo typical products which using raw materials from fennel plant. Another ingredient which is often used as an enhancer of flavor in a beverage is ginger, due to its distinctive spicy taste from the gingerols. Indeed, ginger offers good benefits for health due to its antioxidant content (Uhl, 2000).

Exploration and formulation of coffee drinks based on fennel seed and ginger extract becomes an effort to utilise and increase food diversity in Indonesia, especially in Bromo

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region. This study aimed to obtain a herbal coffee formulation based on fennel seed and ginger extract to enhance and sustain food diversity in Bromo.

Research Methods

Materials

The main material used for this study was Robusta coffee originating from Dampit Malang. Fennel seeds were obtained from fennel plants that grow around the Ngadas Village which is located in the Mount Bromo area. The ginger used was the type of empirical ginger and obtained from the big market in Malang. Materials for the analysis of antioxidants include aquadest, methanol and DPPH.

Methods

This study uses Response Surface Methodology (RSM) with the design of Central Composit Design (CCD) by using Design Expert 7.1.5 Trial Version software. The design of *herbal* coffee formulation is depicted in Table 1. Factors used in this study were as follows:

X1 = proportion of Robusta coffee (g)
X2 = proportion of fennel seed and ginger extract (g)
Y1 = pH
Y2 = TSS
Y3 = L*

Table 1. Formula design of *herbal* coffee

No	Variable Code		Independent Variables		Responses		
	X1	X2	Robusta Coffee (g)	Fennel Seed and Ginger Extract (g)	pH	TSS	L*
1	1.000	1.000	14.000	10.000	Y1	Y2	Y3
2	1.000	-1.000	14.000	6.000	Y1	Y2	Y3
3	-1.000	1.000	8.000	10.000	Y1	Y2	Y3
4	-1.000	-1.000	8.000	6.000	Y1	Y2	Y3
5	1.414	0.000	15.240	8.000	Y1	Y2	Y3
6	-1.414	0.000	6.760	8.000	Y1	Y2	Y3
7	0.000	1.414	11.000	10.830	Y1	Y2	Y3
8	0.000	-1.414	11.000	5.170	Y1	Y2	Y3
9	0.000	0.000	11.000	8.000	Y1	Y2	Y3
10	0.000	0.000	11.000	8.000	Y1	Y2	Y3
11	0.000	0.000	11.000	8.000	Y1	Y2	Y3
12	0.000	0.000	11.000	8.000	Y1	Y2	Y3
13	0.000	0.000	11.000	8.000	Y1	Y2	Y3

The process of *herbal* coffee making is accomplished through several stages, started from making: Robusta coffee powder, fennel seed powder, fennel seed and ginger extract, and is then mixed to obtain *herbal* coffee powder.

Coffee Powder Making Process

The process of making Robusta coffee was as follows: coffee beans were sorted to obtain uniform seeds and to remove impurities or foreign objects contained in the seeds. Coffee beans were washed with clean water to remove dirt attached to the seeds, then dried in the sun to remove water from the washing. Coffee beans were weighed then roasted at 190 ^{o}C for 20 minutes, resulted a brownish color coffee bean. Coffee beans were cooled for 30 minutes, then mashed to coffee powder. Coffee powder was sifted using a 60 mesh sieve.

Fennel Seed Extract Making Process

The process of making fennel seed powder was as follows: fennel is obtained from the area of Bromo Tengger Semeru National Park in the form of old fennel seeds. Old seeds are grayish green. Fennel seeds were sorted to remove impurities and obtained uniform fennel seeds. Fennel seeds were washed with clean water, then dried to remove the water. Fennel seeds were weighed and mashed until the fennel powder was obtained

The Process of Making Ginger Extract

The process of making ginger powder is as follows: Ginger is obtained from the big market in Malang. Ginger is washed with clean water until there is no dirt left. The ginger root is peeled clean and then weighed 200 g. The rhizome of ginger is sliced small with a size of 1 cm, then the ginger slices are smoothed using a blender. 300 ml of water and 100 g of fennel powder are added in a blender to be mixed with ginger that has been mashed to become mush. Ginger porridge and fennel are filtered with a filter cloth to separate the pulp, then deposited for 60 minutes to precipitate starch. The ginger juice and fennel obtained are cooked at 100 ^{o}C for 20 minutes. In the cooking process 300 g of sugar is added with continuous stirring. After crystallization the cooking is stopped and still stirred until powder forms. Ginger and fennel powder are sifted on 60 mesh and powder that does not pass the sieve is mashed using a blender, then sifting again so that the ginger and fennel extract powder is obtained. The process of *herbal* coffee making is presented in Fig. 1.

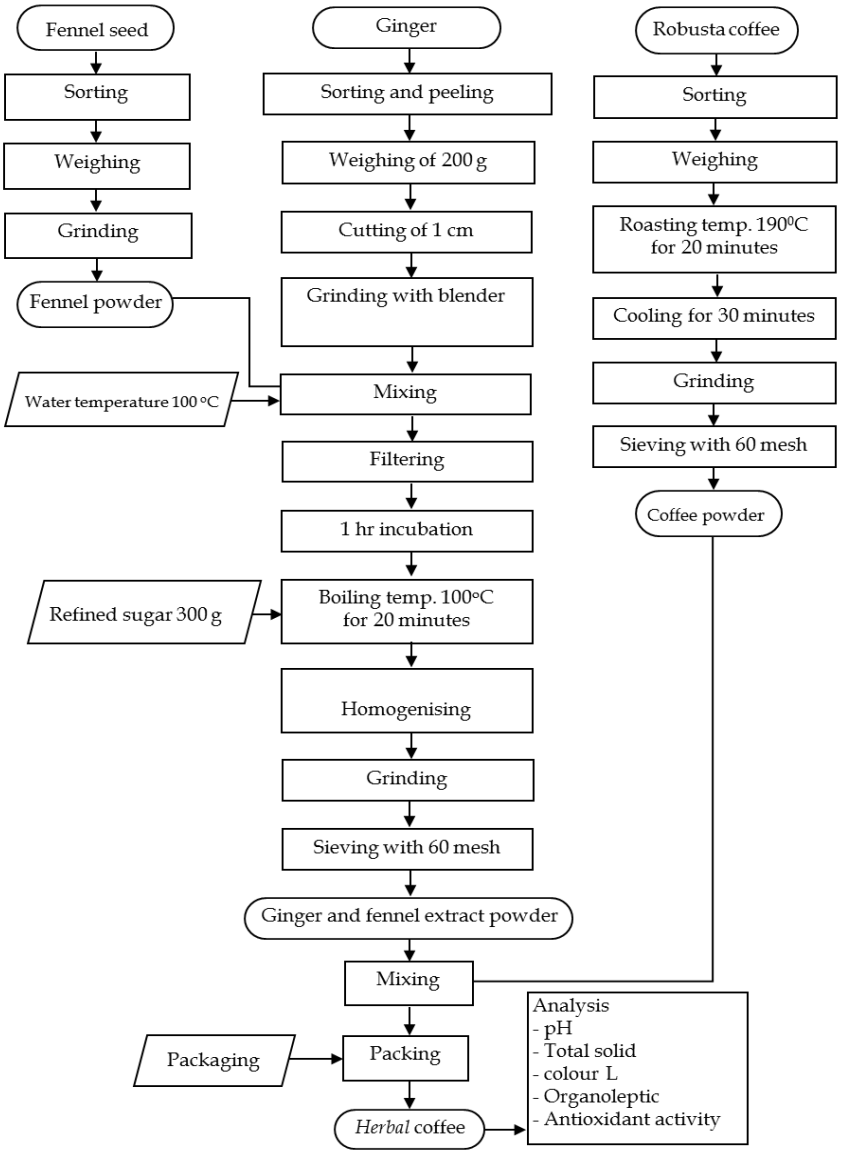

Figure 1. *Herbal* coffee making process

Analysis

Tests carried out on coffee powder, include: pH testing by using a pH meter (Chintya and Fithri, 2015), testing of total dissolved solids (TSS) by using a refractometer (Muchtadi et al., 1989), and L color testing by using color reader (Fardias, 1992). The selection of the best treatment was conducted by organoleptic test (color, aroma, taste) by using index effectiveness method (De Garmo et al., 1984). Analysis of pH, TSS and L color data was

accomplished by using Software Design Expert 7.1.5 Trial Version. Meanwhile, the organoleptic test data analysis wass processed with SPSS Stastistics 17.0 software. The results of RSM optimal solution and best selection were tested by antioxidant activity by using the DPPH method.

Result and Discussion

Result of pH response, TSS and L color of *herbal* coffee is depicted in Tabel 2.

Table 2. pH response, TSS and L color of *herbal* coffee

No	Variable Code		Independent Variable		Response		
	X1	X2	Robusta Coffee (g)	Fennel Seed and Ginger extract (g)	pH	TSS	L*
1	1.000	1.000	14.000	10.000	5.730	13.000	25.060
2	1.000	-1.000	14.000	6.000	5.870	9.800	25.560
3	-1.000	1.000	8.000	10.000	6.030	12.000	26.550
4	-1.000	-1.000	8.000	6.000	6.200	10.000	26.920
5	1.414	0.000	15.240	8.000	5.770	12.000	25.170
6	-1.414	0.000	6.760	8.000	6.270	9.600	26.980
7	0.000	1.414	11.000	10.830	5.900	11.800	26.700
8	0.000	-1.414	11.000	5.170	6.130	8.000	26.120
9	0.000	0.000	11.000	8.000	6.100	9.800	26.820
10	0.000	0.000	11.000	8.000	6.070	9.800	26.760
11	0.000	0.000	11.000	8.000	6.130	9.800	26.880
12	0.000	0.000	11.000	8.000	6.030	9.600	26.860
13	0.000	0.000	11.000	8.000	6.070	9.600	26.900

pH Response

The quadratic model was selected to test pH response. Table 2 presents that pH value of *herbal* coffee was in the range of 5.730 - 6.270. The result of ANOVA analysis on *herbal* coffee pH variety is illustrated in Table 3.

Table 3. Analysis result of pH variance response

Source of Variance	P-Value	Note
Model	<0.0001	Significant
A-Proportion of Coffee	<0.0001	Significant
B-Proportion of Extract	0.0009	Significant
A^2	0.0091	Significant
B^2	0.0074	Significant
Lack of Fit	0.1614	Not Significant

The model used in Table 3 is significant with p value of <0.0001. This result explains that it is less than 0.01% the likelihood of interference with the model. Based on the result of variance analysis, the proportion of Robusta coffee mixed with fennel seed and ginger extract significantly influenced pH value. The acids found in coffee have an effect on pH and contribute to the acidity in coffee (Wayan et al., 2015). An increase in the addition of fennel seed and ginger extract may reduce the pH value of *herbal* coffee, making it more acidic. This was possibly due to organic acid component (malate, oxalate, lauric acid) in fennel seed and ginger extract (Mujim, 2010). The equation obtained from the model is as follows:

$$Y = 5.481 + 0.068X_1 + 0.176X_2 + 1.250E - 0.03X_1X_2 - 6.111E - 0.03X_1^2 - 0.014X_2^2$$

Where,
Y = pH
X_1 = Robusta coffee powder
X_2 = fennel seed and ginger extract

The results of the study are illustrated in the form of contour plots marking the interaction between the proportion of Robusta coffee and the proportion of fennel seed and ginger extract to pH value of *herbal* coffee as shown in Fig. 2.

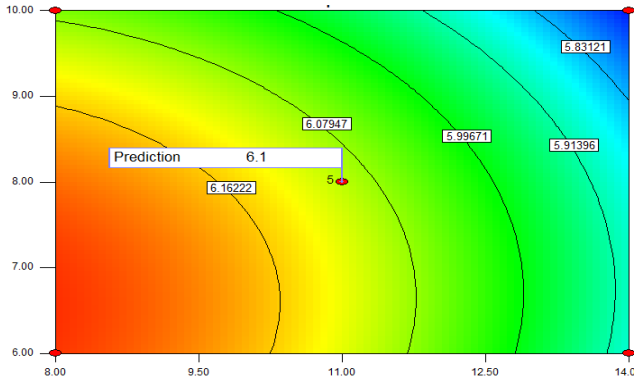

Figure 2. *Plot Contour* of pH response

The outermost curved line on the contour presents the lowest pH value and the deeper the line shows the highest pH value. Likewise, the blue to red changes indicate that pH value gets higher. In contrast, if the red color goes to blue, pH value gets lower. The color change in Fig.2 illustrates that the addition of the proportion of Robusta coffee has a significant effect on the pH value of coffee. While the addition of fennel seed and ginger extract also shows a significant effect on pH value of coffee. The addition of similar proportion of fennel seed and ginger extract in Robusta coffee will bring significant color changes.

Total Response of Solid Solution

The model chosen for the TSS response is the quadratic model. The results of the analysis of the variance in TSS ANOVA can be seen in Table 4.

Table 4. Results of variance analysis of TSS responses

Source of Variance	P Value	Note
Model	0.0023	Significant
A-Proportion of Coffee	0.0372	Significant
B-Proportion of Extract	0.0003	Significant
A^2	0.0109	Significant
B^2	0.2099	Not Significant
Lack of Fit	0.0008	Significant

The analysis of the total dissolved solids of *herbal* coffee ranges from 8.000 to 13.000 ^{0} Brix. Based on Table 4, it is apparent that the proportion of Robusta coffee mixed with the proportion of fennel seed and ginger extract has a significant effect. Robusta roasted coffee beans have sugar content consisting of galactose, mannose and pentose which have an effect on the value of TSS in coffee. When added sugar in the making of ginger and fennel extract, it will increase the total value of dissolved solids in ginger and fennel extract. This is in accordance with the statement of Osundahusi et al. (2007) pointing out that the addition of sugar can have an effect on higher dissolved solids components.

Ginger has a sugar component consisting of glucose, fructose, galactose and sucrose. Whereas for fennel seed extract, it is thought that it only gives a small contribution to TSS coffee due to other dominant components in fennel seeds such as crude fiber, protein, fat and carbohydrate content (Ibrahim and Ayman, 2013). The equation obtained from the model is as follows:

$$Y = 21.860 - 2.060X_1 - 1.099X_2 + 0.050X_1X_2 + 0.083X_1^2 - 0.756X_2^2$$

Where,
Y = TSS
X_1 = Robusta coffee powder
X_2 = fennel seed and ginger extract

The results of the TSS response are described in the form of contour plots from the response surface that show the relationship between the two factors to the response. The contour plot of the interaction between the proportion of Robusta coffee and the proportion of fennel seed extract and ginger to TSS coffee is shown in Fig. 3.

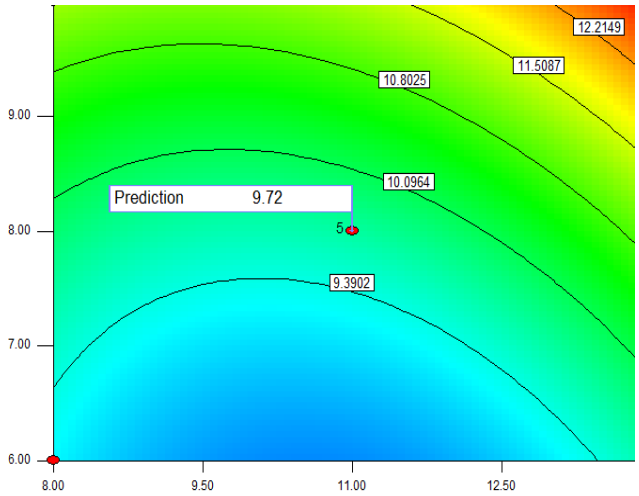

Figure 3. *Plot contour* of TSS response

Fig. 3 shows that the outermost curved line on the contour is the highest TSS value, and the innermost line shows the lowest value of TSS. The blue to red indicates higher TSS value, while the red color goes to blue, the TSS gets lower.

The addition of the proportion of Robusta coffee has a significant effect on TSS coffee. Furthermore, fennel seed and ginger extract also have a significant effect on TSS coffee formulations. Graphical color changes in fennel seed and ginger extract with similar proportion of Robusta coffee, shows significant color changes.

L Color Response

The analysis of the L value in Table 2 shows that the L value of *herbal* coffee ranges from 25.060 to 26.980. The model chosen for the L color response is the quadratic model. Variance analysis result of ANOVA in L color *herbal* coffee can be seen in Table 5.

Table 5. Variance analysis result of ANOVA in L color

Source of Variance	P Value	Note
Model	0.0011	Significant
A-Proportion of Coffee	0.0002	Significant
B-Proportion Extract	0.9481	Not Significant
A^2	0.0030	Significant
B^2	0.0285	Significant
Lack of Fit	0.0012	Significant

The ANOVA result in Table 5 shows that the proportion of Robusta coffee has a significant effect. While the proportion of fennel seed and ginger extract do not significantly influence the response of L color value. The process of color formation in coffee is caused by Maillard reaction when roasting coffee beans. Primadia (2009) explains that maillard reactions involve carbonyl compounds (reducing sugars) and amino groups (amino acids). This is in accordance with the explanation of Fauzi et al. (2016) that the process of roasting the hydrolysed hydrocarbon compounds into carbon elements is followed by the formation of non-volatile melanoidin compounds due to the polymerisation of sugars and amino acids which plays a role in giving color to roasted coffee.

The *herbal* coffee color is dominated by Robusta coffee powder due to its black color; therefore, concoction of fennel seed and ginger extract does not have a significant effect on coffee color. Fennel seed and ginger extract has a yellowish brown color which comes from the color of ginger and fennel seeds. Ginger has a yellow color and fennel seeds have a green color when they are unripe and turn to grayish green when they are ripe (Aspan, 2008). In the cooking process, fennel seed and ginger extract are oxidised, causing the color of the extract to become yellowish brown. The equation obtained from the model is as follows:

$$Y = 8.610 + 0.892X_1 + 1.144X_2 - 0.03X_1X_2 - 0.048X_1^2 - 0.068X_2^2$$

Where,
Y = L color
X_1 = Robusta coffee powder
X_2 = fennel seed and ginger extract

The results of the L color response are depicted in the form of contour plots from the response surface marking the relationship between the proportion of Robusta coffee and the proportion of fennel seed and ginger extract to L color of coffee as shown in Fig. 4.

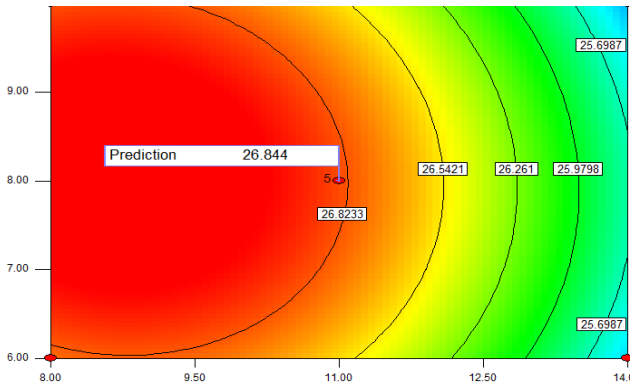

Figure 4. *Plot Contour* of L Color Response

The outermost curved line on the contour is the lowest L color value and the innermost line shows the highest L color value. The color change from the contour represents the change in L value as shown in Fig. 4. The blue to red color indicates that the L value is higher, whereas if the red one goes to blue, the L value is lower. A low L value indicates that the coffee color is getting darker.

The L color change in the contour plot graph appears when adding Robusta coffee with similar proportion of fennel seed and ginger extract showing a significant change. Thus, the addition of Robusta coffee proportion brings a significant effect on the L color of coffee. Again, fennel seed and ginger extract do not have a significant effect on L color of coffee. This result is based on non-significant color changes in fennel seed and ginger extract with the same proportion of Robusta coffee.

Verification of Optimisation Result

Response optimisation aims to obtain the most optimal results based on the desired limitation of factors as limits of response shown in Table 6. Optimal treatment is obtained in the equal

proportion of Robusta coffee and proportion of fennel seed and ginger extracts of 10.000 g (with prediction results of pH response of 5.860; total dissolved solid of 11.940 and L value of 26.100). The choice of the optimal solution is based on the highest desirability value or which is close to 1 (one) and is equal to 0.789. The lowest and highest prediction results produced by the program are used as a limitation of verification result through the conducted research. The results of the verification and the predicted response values can be seen in Table 7.

The results of the optimal solution suggested by the program as in Table 7, are re-verified to ensure the predictions of the computational results which are in accordance with the actual response of the study. The value of the verification results for each response is still in the range of the lowest and highest predictive values; therefore, predictive results can be received with a confidence level of 95%.

Table 6. Response optimisation

Criteria	Name	Aim	Lower Line	Upper Line
Factor	Proportion of Robusta coffee (g)	In Range	8.000	14.000
Factor	Proportion of fennel seed and ginger extract(g)	In Range	6.000	10.000
Response	pH	In Range	4.000*	9.000*
Response	TSS	Maximize	8.000	13.000
Response	Color	In Range	26.190**	27.640**

Source: *Farida et al. (2013)
**Febryana (2016)

Table7. Verification result and prediction of optimal solution

Parameter	*Design Expert* Prediction	Lowest Predictive Value	Highest Predictive Value	Verification Result
Robusta coffee (g)	12.500			
Fennel Seed and Ginger Extract (g)	10.000			
pH	5.860	5.760	5.980	5.930
TSS (^{o}Brix)	11.940	10.370	13.520	12.000
L Color	26.100	25.390	26.810	26.560

Organoleptic Test Result

Organoleptic testing is defined as a test using the human senses as an instrument. The hedonic test (reception) is one of the most preferable type of organoleptic tests. The average results of panelists' preference for *herbal* coffee are shown in Table 8.

Table 8. Average panelist preference to flavor, color and taste of *herbal* coffee

Proportion		Flavor	Color	Taste
Robusta Coffee (g)	Fennel Seed and Ginger Extract (g)			
14.000	10.000	6.000	5.330	5.670
14.000	6.000	4.670	5.670	5.330
8.000	10.000	4.330	4.330	4.330
8.000	6.000	4.330	4.330	4.000
15.240	8.000	5.670	5.670	5.000
6.760	8.000	4.000	4.000	3.000
11.000	10.830	4.670	4.330	4.330
11.000	5.170	4.330	4.670	4.000
11.000	8.000	4.670	4.000	4.670
11.000	8.000	4.670	4.000	4.330
11.000	8.000	4.330	4.000	4.330
11.000	8.000	4.330	4.000	4.000
11.000	8.000	4.000	4.000	4.000
		Significantly Different	Significantly Different	Significantly Different

Flavor of Herbal Coffee

According to SNI 01-3542-2004 good coffee quality standards have a normal flavor, namely the flavor of coffee. Panelists' favorite scores on the aroma of coffee using a preference scale of 1-7 (very disliked to very fond) obtained results of 4.67-6.00. The average panelist preference score can be seen in Table 8.

Good coffee quality standards according to SNI 01-3542-2004 mentions that it has a normal aroma, which is flavored with coffee. The panelist favorite score on the coffee aroma uses a preference scale of 1-7 (very dislike to very fond) and the results are 4.670-6.000 (neutral to like). According to Buffo and Freire (2004), the aroma of coffee comes from volatile compounds (such as aldehyde, ketone and alcohol) contained in coffee beans. Coffee aroma formation occurs during roasting, which causes physical and chemical changes in coffee beans as well as the formation of a distinctive aroma in coffee.

The distinctive aroma produced by *herbal* coffee is derived from fennel seed and ginger extract. The *zingiberen* and *zingiberol* components of ginger when brewed with coffee will give a distinctive aroma of ginger and coffee. While the distinctive aroma of fennel seeds comes from fenchone compounds. Kurniawati and Wahyuningsih (2014) explained that fenchone is a type of ketone having a distinctive camphor-like odor.

Color of Herbal Coffee

The sense of sight becomes the main tool for qualifying the quality of coffee through the appearance of the color and texture of the liquid surface (Tarigan et al., 2015). The Friedman test results on the color of *herbal* coffee indicate that there are differences in the coffee color of each treatment.

The main factor influencing the coffee color is derived from the Robusta coffee powder. Fennel seed and ginger extract have no effect on the color of *herbal* coffee, because the color of coffee powder is already thicker (black); therefore, the black coffee color dominates the color of fennel seed and ginger extract. According to Somporn et al. (2011), the level of roasting of coffee beans has an influence on the coffee bean color as well as the amount and type of volatile compounds which will be produced later. The color change of *herbal* coffee is related to the protein content in coffee. Melanoidin is a protein derivative compound (the result of the Maillard reaction) which is responsible for the color characteristics of coffee (Tarigan et al., 2015).

Taste of Herbal Coffee

Taste attributes play an important role in determining the quality of a product by using taste buds. The average panelist preference score for coffee flavor obtained is from 4.330 to 5.670. The average panelist preference level for the taste of *herbal* coffee can be seen in Table 8. Based on the results of the Friedman test conducted on the taste of *herbal* coffee, it shows that there are real differences in the taste of coffee for each treatment.

The panelists stated that the flavor of *herbal* coffee in each treatment had different flavor arising from the fennel seed and ginger extract. When brewing volatile ginger compounds, it gives a spicy sensation when consumed. The spicy characteristic and aromatic taste is due to the added content of oleoresin in the ginger extract. The main components which contribute spicy flavor to ginger are *gingerol* and *shogaol*. Gingerol content in ginger ranges from 14% to 25% and shogaol is between 2.8% to 7.0%. In addition, fenchone compounds of 13.99% in fennel seed extract give a bit of bitter taste to the coffee produced (Kurniawati and Wahyuningsih, 2014).

The taste of coffee is formed during the roasting process especially from sucrose, amino acids and chlorogenic acid contained in coffee beans. The taste of coffee produced comes from non-volatile organic compounds such as caffeine, chlorogenic acid, trigonelin and dissolved solids content (Fauzi et al., 2016). Panelists state that there is little sour taste in coffee due to acidic compounds in cofee bean such as: formic acid, acetic acid, oxalic acid, citric acid, lactic acid, malic acid (Wayan et al., 2015).

The Best Treatment

Determination of the best treatment is performed by comparing the product value (NP) from each treatment using the effectiveness index. De Garmo et al. (1984), explained that deciding the best treatment was determined by the highest average value of the product. The results of the best treatment in coffee formula is the formula 1 treatment having the highest product value. The value analysis results of the best product selection for *herbal* coffee can be seen in Table 9.

Based on the organoleptic test result of the 13 treatments, the coffee with the highest product value was coffee with treatment 1 with a product value of 0.920. While the lowest product value is found in

treatment 6 with a product value of 0.000. The higher the value of the product shows that *herbal* coffee is more preferred by the panelists. In contrast, lower result value shows panelists tendency to dislike the *herbal* coffee.

IC_{50} Antioxidant

Antioxidants are antidotes to free radicals which play a role in inhibiting the oxidation process. The antioxidant activity test was carried out on the results of the selection of the best treatment and the optimal solution results using RSM. The results of testing the antioxidant activity of racic coffee can be seen in Table 10.

Based on Table 10. The highest antioxidant activity is found in treatment 1, which is IC_{50} value of 69,500 ppm. While the lowest antioxidant activity is found in the RSM optimization treatment which is IC_{50} value of 75,500 ppm. A higher addition of the proportion of Robusta coffee powder may produce better IC_{50} value of *herbal* coffee

Antioxidant activity of treatment 1 and optimization of RSM are classified as strong antioxidant. This is consistent with the explanation of Zuorro and Roberto (2013) that Robusta coffee has high antioxidants. Antioxidants in coffee beans come from polyphenol compounds such as chlorogenic acid and cafeic acid. Antioxidants in *herbal* coffee formulation are also influenced by the content found in fennel seed and ginger extract. Ghasemzadeh et al. (2010) stated that the antioxidants in ginger have a relationship with the total phenolic content, as higher total phenols and flavonoids show higher antioxidant activity in ginger. In contrast, the antioxidant content in fennel seeds is classified as weak as a study conducted by Shahat et al. (2011) explained that fennel seeds from vulgare varieties had significantly small levels of antioxidant activity.

Tabel 9. Best *herbal* coffee selection

Treatment	Proportion		Product Value
	Robusta Coffee (g)	Fennel Seed and Ginger Extract (g)	
1	14.000	10.000	0.920
2	14.000	6.000	0.680
3	8.000	10.000	0.240
4	8.000	6.000	0.210
5	15.240	8.000	0.880
6	6.760	8.000	0.000
7	11.000	10.830	0.310
8	11.000	5.170	0.290
9	11.000	8.000	0.250
10	11.000	8.000	0.230
11	11.000	8.000	0.160
12	11.000	8.000	0.140
13	11.000	8.000	0.060

Tabel 10. Antioxidant activity of *herbal* coffee

Treatment	Proportion		IC_{50} (ppm)
	Robusta Coffee (g)	Fennel Seed and Ginger Extract (g)	
1	14.000	10.000	69.500
RSM Result	12.500	10.000	75.500

Conclusions

The difference in the proportion of Robusta coffee mixed with fennel seed and ginger extract will significantly influence the pH parameters, but does not have a significant effect on the parameters of total dissolved solids and *herbal* coffee color.

The optimal coffee solution obtained from RSM produces a proportion of Robusta coffee of 12.500 g with 10.000 g of fennel seed and ginger extract having a pH of 5.930; total dissolved solids of 12.000 and L values of 26.56 with IC_{50} value of 75.500 ppm. While the selection of the best treatment based on organoleptic test in this study is *herbal* coffee which has the highest product value (NP) of 0.920, which is treatment 1 with a proportion of 14.000 g of Robusta coffee mixed with

proportion of fennel seed and ginger extracts of 10.000 g. *Herbal* coffee treatment 1 has a pH value of 5.730, total dissolved solid of 13.000 and an L color value of 25.06 with an IC_{50} value of 69.500 ppm.

Conflict of interest

The authors declare that there is no conflict of interest in this publication.

References

Aspan, R. (2008) *Taksonomi koleksi tanaman obat kebun tanaman obat Citeureup*, BPOM RI, Jakarta [In Indonesian]

Buffo, R.A. and Freire, C.C. (2004) 'Coffee flavour: an overview', *Journal Flavour and Fragrance*, 19, pp. 99-104

Chintya, R.S. and Fithri, C.N. (2015) 'Pengaruh daya lampu dan lama iradiasi ultraviolet terhadap karakteristik sari buah murbei (*Morus alba* L.)', *Jurnal Pangan dan Agroindustri*. 3(2), pp. 610-619 [In Indonesian]

De Garmo, E.P., Sullivan, W.G. and Canada, J.R. (1984) *Engineering Economics*, New York: Mc. Millan Publishing Company.

Farida, A. Evi, R.R. and Andri, C.K. (2013) 'Penurunan kadar kafein dan asam total pada biji kopi Robusta menggunakan teknologi fermentasi anaerob fakultatif dengan mikroba nopkor MZ-15', *Jurnal Teknologi Kimia dan Industri*, 2(3), pp. 70-75 [In Indonesian]

Fauzi, M., Yuli, W. and Ayu, P. (2016) 'Karakteristik organoleptik hasil blending dari berbagai tingkat sangrai kopi luwak *in vitro'*, *Prosiding Seminar Nasional Apta*, Universitas Jember

Febryana, Y.S. (2016) 'Pengaruh teknik penyeduhan dan ukuran partikel kopi bubuk terhadap atribut sensori seduhan kopi Robusta Dampit Menggunakan Metode RATA', *SKRIPSI*, Universitas Brawijaya [In Indonesian]

Ghasemzadeh, A., Jaafar, H.Z.E. and Rahmat, A. (2010) 'Antioxidant activities, total phenolics and flavonoids content in two varieties of Malaysia young ginger (*Zingiber officinale* Roscoe)', *Molecules*, 15(6), pp. 4324-4333

Ibrahim, F.Y. and Ayman, Y.E. (2013) 'Effect of herbal beverages of *Foeniculum vulgare* and *Cymbopogon proximus* on inhibition of calcium oxalate renal crystals formation in rats', *Annals of Agricultural Science*, 58(2), pp. 221–229

International Coffee Organization (ICO) (2015) *ICO Annual Review 2013-2014*, London: International Coffee Organization.

Kurniawati, A. and Wahyuningsih (2014) 'Karakterisasi morfologi, analisis minyak atsiri dan kapasitas antioksidan adas (*Foeniculum vulgare* Mill.) di Taman Nasional Bromo Tengger Semeru', *Prosiding Seminar dan Pameran Industri Jamu 2014*, Institut Pertanian Bogor [In Indonesian]

Muchtadi, Tien R. and Sugiyono. (1989) *Petunjuk Laboratorium Ilmu Pengetahuan Bahan Pangan*. Bogor: IPB-Press. [In Indonesian]

Mujim, S. (2010) 'Pengaruh ekstrak rimpang jahe (*Zingiber officinale rosc*.) terhadap pertumbuhan *Pythium Sp*. penyebab penyakit rebah kecambah mentimun secara *In Vitro'*, *Jurnal Hama Penyakit Tanaman Tropika*. 10(1): 59-63

Osundahunsi, O.F., Amosu, D. and Ifesan, B.O.T. (2007) 'Quality evaluation and acceptability of soy-yoghurt with different colours and fruit flavours', *American Journal of Food Technology*, 2(4), pp. 273-280

Primadia, A.D. (2009) 'Pengaruh peubah proses dekafinasi kopi dalam reaktor kolom tunggal terhadap mutu kopi', Institut Pertanian Bogor [In Indonesian]

Sastrawan, I.D., Meiske, S. and Vanda, K. (2013) 'Skrining fitokimia dan uji aktivitas antioksidan ekstrak biji adas (*Foeniculum vulgare*) menggunakan metode DPPH', *Jurnal Ilmiah Sains*, 13(2), pp. 110-115 [In Indonesian]

Shahat, A.A., Ibrahim, A.Y., Hendawy, S.F., Omer, E.A., Hammouda, F.M., Rahman, A.F.H. and Saleh, M.A. (2011) 'Chemicalcomposition, antimicrobial dan antioxidant activities of essential oils from organikally cultivated fennelcultivars', *Journal Molecules*, 16, pp. 1366-1377

Somporn, C., Kamtuo, A., Theerakulpisur, P., Siriamompun, S. (2011) 'Effects of roasting degree on radical scavenging activity, phenolics and volatile compounds of arabica coffee beans', *International Journal Of Food Science And Technology*, 46, pp.2287- 2296

Tarigan, E.B., Dibyo, P. and Tajul, I. (2015) 'Tingkat kesukaan konsumen terhadap kopi campuran Robusta dengan arabika', *Jurnal Teknologi dan Industri Pertanian Indonesia*, 7(1), pp. 12-17 [In Indonesian]

Uhl, S.R. (2000) *Handbook of spices, seasonings and flavoring*, Lancaster-USA: Technomic Publishing.

Wayan, A., Komang, A.N. and Ni, L.A.Y. (2015) 'Kajian kandungan kafein kopi bubuk, nilai pH dan karakteristik aroma dan rasa seduhan kopi jantan (*pea berry coffee*) dan betina (f*lat beans coffee*) jenis Arabika dan Robusta' *SKRIPSI*, Universitas Udayana [In Indonesian]

Zuorro, A. and Roberto, L. (2013), 'Influence of extraction conditions on the recovery of phenolicantioxidants from spent coffee groundsantonio', *American Journal of Applied* Sciences, 10(5), pp. 478-486