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Sensory Analysis of Butterfly Pea (*Clitoria ternatea* L.) Flower Tea Drink Using Central Composite Design

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ABSTRACT

Butterfly pea (*Clitoria ternatea* L.) flower tea is a functional drink that is helpful in improving nutrition and health. The level of preference for the tea drink needs to be studied; thus, the accurate product formula can be obtained in its postharvest handling and processing. This research aimed to optimize the microwave-dried pea flower tea drink using the central composite design (CCD) method. The treatment factors studied were microwave power and drying time, with the treatment response as a sensory test of butterfly pea flower tea, including colour, aroma, taste, and aftertaste. The results of CCD analysis show that microwave power and drying time significantly affect the colour, aroma, and taste of butterfly pea tea but have no significant effect on the aftertaste. The optimum sensory formula was obtained at microwave power (X_1) of 180 watts and drying time (X_2) of 17 minutes, with a prediction of colour of 5.8 ≈ 6 (likes), aroma of 5.1 ≈ 5 (somewhat like), taste of 5 .03 ≈ 5 (somewhat like) and aftertaste of 4.05 ≈ 4 (neutral).

1. INTRODUCTION

Butterfly pea flower (*Clitoria ternatea* L.) contains numerous antioxidants and bioactive compounds that function to reduce stress, antiproliferative, and anti-inflammatory activities [1-4]. The flower is used in functional drinks, such as ready-to-serve drinks, syrups, and powders [5].

Tea is a popular functional beverage in the community [6, 7]. Tea has health benefits [8, 9] as it has various active components of high antioxidant and mineral contents [5]. Serving this drink is relatively straightforward: boiling or brewing [5]. Tea processing generally involves the process of oxidizing ingredients and molecules, stopping oxidation, and forming tea through a drying process [4].

Drying is essential for food processing and storage [10]. Drying is one of the processes that affect the tea produced [11, 12], starting in terms of colour, aroma, taste, and active compounds contained in the tea [10, 11]. Optimal drying conditions are essential for quality maintenance during food processing [11]. Drying is one of the stages of post-harvest handling, as it helps prevent the breakdown of enzymes and the growth of microorganisms while preserving the essential characteristics of plant products [13]. Drying also aims to remove moisture content up to 95-97% to maximize shelf life [14]. Drying using microwave ovens has very successful applications in food processing, especially in maintaining the quality of foodstuffs [15-17]. Even the usage of microwaves is considered to minimize energy consumption [17, 18].

The consumer's acceptance of the butterfly pea flower tea drink can be determined through sensory tests. Sensory tests are useful and help improve the quality of final products [19]. The sensory analysis is a test that uses the five senses (sight, smell, taste, touch, and hearing) of panellists to examine the characteristics of food (texture, taste, taste, appearance, smell, etc.) [20, 21].

Based on the background, it is necessary to determine the optimum condition of the parameters that affect the sensory parameters of butterfly pea flower tea drink dried using a microwave. One of the optimization methods that can be used to determine the quality of food products is the central composite design (CCD) method [6, 22-27]. Therefore, sensory optimization of butterfly pea flower tea drinks using CCD should be done to determine the optimal condition of the microwave power and drying time treatment factors.

2. MATERIALS AND METHODS

2.1 Research tools and materials

The equipment utilized comprised a 20L Samsung ME731K microwave, a desiccator, a watch glass, an analytical balance, a pot, a heater, a tray, a measuring cup, heat-resistant gloves, a camera, and several sensory tools (stationery, questionnaires, and code paper). In addition, butterfly pea blossoms, distilled water, crackers, and tissues were utilized.

2.2 Research procedure

The steps in this research were divided into several stages, including sample preparation, drying, production of butterfly pea flower tea drinks, sensory tests, and data analysis using the CCD method. The sensory analysis of flower tea drinks with CCD was conducted using MINITAB 19 software.

The harvested butterfly pea flowers were then sorted, washed, and drained. The flowers that had been sorted and cleaned were placed on the shelf and left to wither for 4 hours at room temperature. Furthermore, the flowers are dried using a microwave with various microwave power of 100, 180, and 300 watts, with various times of 7, 12, and 17 minutes, according to the prescribed treatment. Each treatment used a sample of 10g of butterfly pea flowers.

Furthermore, 1 gram of dried butterfly pea flowers was brewed using 250 ml of boiling water (100℃) for 7 minutes, then filtered and prepared as a sample for sensory test. The sensory test method used is the hedonic test, which is a sensory analysis test method that can determine the level of preference [21] and differences in the quality of a product [28]. The sensory test of the flower tea drinks was carried out sensorily to determine the level of liking and difference in the quality of tea drinks obtained based on differences in microwave power treatment and drying time determined based on a numerical scale of colour, aroma, taste, and aftertaste characteristics. The scales used (in numeric) were very like (7), like (6), somewhat like (5), neutral (4), somewhat dislike (3), dislike (2), and strongly dislike (1) [6, 29].

Table 1. Levels of variation of treatment factors

Variable (X)	Levels		
	Low	Medium	High
Microwave power, X_1 (watt)	100	180	300
Drying time, X_2 (minutes)	7	12	17

This research used an experimental design of the response surface method with a two-factor CCD design. The aim is to determine the optimal conditions of the effect of microwave power treatment and drying time on the sensory quality of the butterfly pea flower tea produced. The levels of variation of treatment factors and treatment codes are shown in Table 1. The optimum conditions of the treatment response were obtained based on mathematical equations with second-order polynomial models that are generally formed, as shown in Eq. (1) [6, 22].

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2 \qquad (1)$$

where, Y is the value of the treatment response (colour, aroma, taste, and aftertaste), β_o is the intercept/constant, β_1 and β_2 are the linear coefficients, β_{11} and β_{22} are the quadratic coefficients, β_{12} is the treatment interaction coefficient. X_1 represents microwave power, and X_2 represents drying time.

3. RESULTS AND DISCUSSIONS

The research results are optimum sensory quality characteristics of the butterfly pea flower tea drinks assessed based on colour, aroma, taste, and aftertaste. Sensory properties function as an assessment of food ingredients to determine whether a product is accepted [19]. An indicator in determining whether a product is acceptable is the sensation received, including colour, aroma, taste, and aftertaste [20, 23, 30]. The results of sensory analyses performed by panellists for the 13 treatment combinations performed are presented in Table 2.

Table 2. Response value of treatment based on central composite design (CCD)

Treatment	Factor Limits and Levels Treatment (X)		Treatment Response (Y)			
	X_1	X_2	Y_1	Y_2	Y_3	Y_4
1	180	12	5	4	4	4
2	180	12	4	4	4	4
3	300	12	5	3	3	4
4	180	12	5	4	4	4
5	300	17	5	4	3	4
6	300	7	5	4	4	5
7	100	12	4	4	4	5
8	180	12	5	5	5	5
9	180	12	5	4	5	4
10	100	7	3	4	4	5
11	180	7	5	5	5	6
12	180	17	6	5	5	4
13	100	17	5	5	5	4

Note: X_1 = microwave power (watt), X_2 = drying time (minutes), Y_1 = colour, Y_2 = aroma, Y_3 = taste, Y_4 = aftertaste, treatment response score (very like (7), like (6), somewhat like (5), neutral (4), somewhat dislike (3), dislike (2), and strongly dislike (1)).

Sensory analysis is helpful in new product development [19, 20] including butterfly pea flower tea drinks. The CCD method was used to determine the effect of microwave drying treatment factors on sensory characteristics assessed based on the panellists' preference for butterfly pea flower tea drinks. The regression equation, significance, lack of fit, and R^2 value of the CCD method analysis results for each response are shown in Table 3.

3.1 Colour

Colour is an essential factor in determining a food product's quality and level of acceptance [6], including butterfly pea flower tea. Table 3 indicates that the significance value ($p < 0.05$) is 0.016, which means that factors X1 and X1 significantly affect the colour of butterfly pea flower tea. The p-value from the lack of fit test is 0.656, which is more than the α=5% percentile. This indicates that there is no lack of fit, meaning that the data is in line with the projected model. The model's final R^2 value for the colour parameter is 0.818. This indicates that the butterfly pea flower tea's colour is influenced by the treatment parameters X_1 and X_2 by 81.8%.

The Pareto diagram illustrates the absolute magnitude of the standard effect, the highest to lowest effect [31, 32]. The Pareto diagram in Figure 1 was used to investigate whether the treatment factor had a positive or negative effect on the colour of the tea drink. The Pareto diagram shows that the microwave power factor (X_1) has the most effect on the panellists' preference for the colour of the flower tea drink. In contrast, the drying time (X_2) has a minor effect on the panellists' preference for the colour of the flower tea drink.

Table 3. Analysis of CCD models for sensory characteristics of butterfly pea flower tea

Response	Regression Equation (*Uncoded Units*)	Significance (p<0.05)	Lack of Fit (p<0.05)	R^2
Colour (Y_1)	Y_1 = - 0,45 + 0,0476 X_1 - 0,057 X_2 - 0,000077 X_1^2 + 0,01448 X_2^2 - 0,000987 X_1*X_2 (2)	0.016	0.656	0,818
Aroma (Y_2)	Y_2 = 5,10 + 0,0296 X_1 - 0,622 X_2 - 0,000068 X_1^2 + 0,03103 X_2^2 - 0,000461 X_1*X_2 (3)	0.035	0.799	0.767
Taste (Y_3)	Y_3 = 2,70 + 0,0422 X_1 - 0,339 X_2 - 0,000088 X_1^2 + 0,0221 X_2^2 - 0,000987 X_1*X_2 (4)	0.019	0.995	0,668
Aftertaste (Y_4)	Y_4 = 8,53 - 0,0003 X_1 - 0,543 X_2 - 0,000006 X_1^2 + 0,0166 X_2^2 + 0,000066 X_1*X_2 (5)	0.137	0.280	0,636

Note: X_1 = microwave power (watt), X_2 = drying time (minutes).

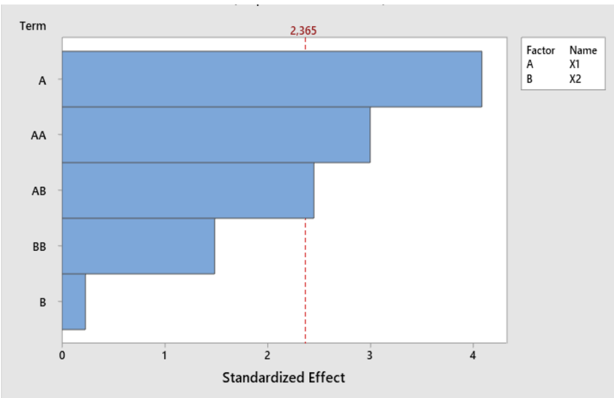

Figure 1. Pareto chart of standardized effects for the CCD model for the colour of butterfly pea flower tea drink (Y_1)

The pattern of consumer acceptance of the butterfly pea flower tea drink colour is shown in Figure 2, where the highest value of the tea drink colour is 5 (somewhat like), and the lowest colour value is 3 (somewhat dislike). The results indicate that panellists prefer the bright blue butterfly pea flower tea drink. The tea's colour will affect the product's appearance as the product's overall appearance is important to attract consumers and develop expectations before consumption [19].

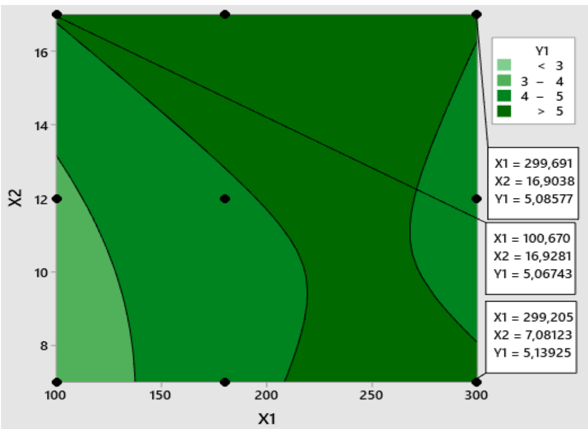

Figure 2. Contour plot of the relationship of the colour of butterfly pea flower tea (Y_1) to variations in microwave power (X_1) and drying time (X_2)

3.2 Aroma

Aroma is one of the most essential sensory factors used to assess a food product's acceptability. Customers can determine the contents of a product and its suitability for eating by smelling it. The human nose's sense of smell can be used to assess a food product's deliciousness based on its scent [33].

Table 3 shows the results of CCD analysis of the aroma of the butterfly pea flower tea, where the model significance obtained is 0.035, smaller than $\alpha = 5\%$ ($p < 0.05$), which means that X_1 and X_2 factors have a significant effect on the aroma of butterfly pea flower tea. While the lack of fit value obtained by 0.799 is larger than α=5% (not significant). The R^2 value of the model of the aroma characteristics of butterfly pea flower tea obtained was 0.767, which means that the treatment factors X_1 and X_2 only have an influence of 76.7% on the aroma of butterfly pea flower tea. Other factors still affect the aroma of butterfly pea flower tea by 23.3%. In addition to microwave power and drying time, other factors can still affect the aroma of butterfly pea flower tea, including tea steeping temperature, the number of butterfly pea flowers used, and various other things.

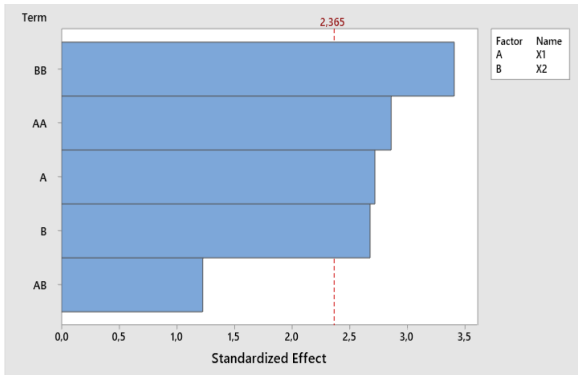

Figure 3. Pareto chart of standardized effects for the CCD model for the aroma of butterfly pea flower tea drink (Y_2)

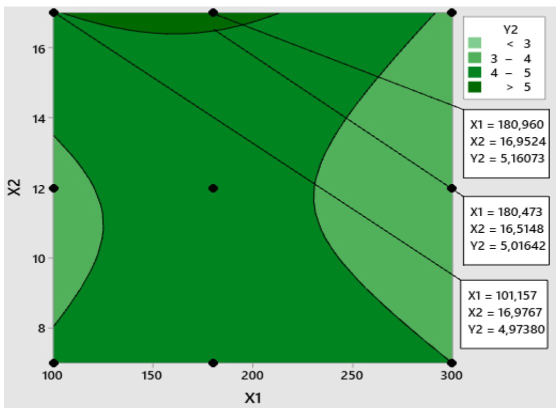

Figure 4. Contour plot of the relationship of the aroma of butterfly pea flower tea (Y_2) to variations in microwave power (X_1) and drying time (X_2)

The Pareto diagram from the CCD model analysis for the aroma of the flower tea drink shows that the quadratic factor of drying time (X_2) has the most significant influence on the panellists' preference for the aroma of the flower tea drink, as shown in Figure 3.

Visualization of contour plots of the highest level of acceptance of the aroma of butterfly pea flower tea was obtained at a score of 5 (somewhat like). In contrast, the lowest level of acceptance of the aroma of the tea was obtained at a score of 3 (somewhat dislike), as shown in Figure 4.

3.3 Taste

Taste determines the panellists' acceptance of the resulting product [6]. The results of CCD analysis of the taste of the butterfly pea flower tea (Table 3) show that the model significance is 0.019, smaller than $\alpha = 5\%$ ($p < 0.05$), which means that factors X_1 and X_2 have a significant effect on the taste of butterfly pea flower tea. At the same time, the lack of fit value obtained is 0.995 (not significant). The R^2 value of the model of the taste characteristics of butterfly pea flower tea obtained was 0.668; this means that the treatment factors X_1 and X_2 have an influence of 66.80% on the taste of butterfly pea flower tea, and there are still other factors that affect the taste of butterfly pea flower tea by 33.20%. In addition to X_1 and X_2 factors, there are still other factors that can affect the taste of butterfly pea flower tea, such as the ratio of the number of butterfly pea flowers and water, brewing time as well as other additives in the butterfly pea flower tea drink, such as sugar, honey, or lemon juice.

The butterfly pea flowers have a slightly bland taste and tend to be slightly sour. A few factors, including chemical compounds, processing temperature, concentration, and other taste component interactions, often affect the product mind of a food product [33].

The results of CCD model analysis for the taste of butterfly pea flower tea drink show that the microwave power factor (X_1) has the greatest influence, followed by the quadratic microwave power factor (X_1^2) and the interaction of microwave power factor and drying time (X_1X_2). Furthermore, quadratic drying time (X_2^2) and drying time (X_2) has the least influence on panelists' preference for the taste of butterfly pea flower tea drink, as shown in Figure 5.

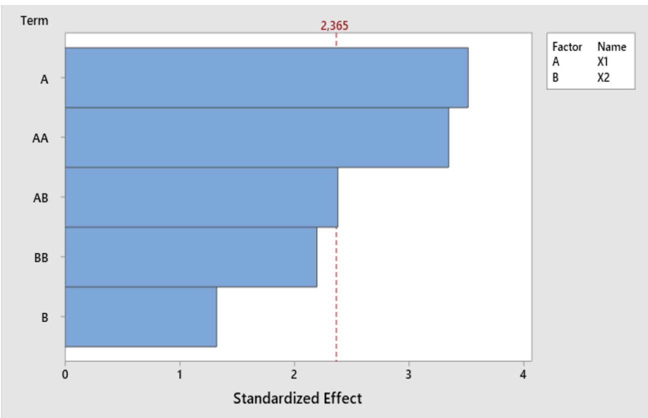

Figure 5. Pareto chart of standardized effects for the CCD model for the taste of butterfly pea flower tea drink (Y_3)

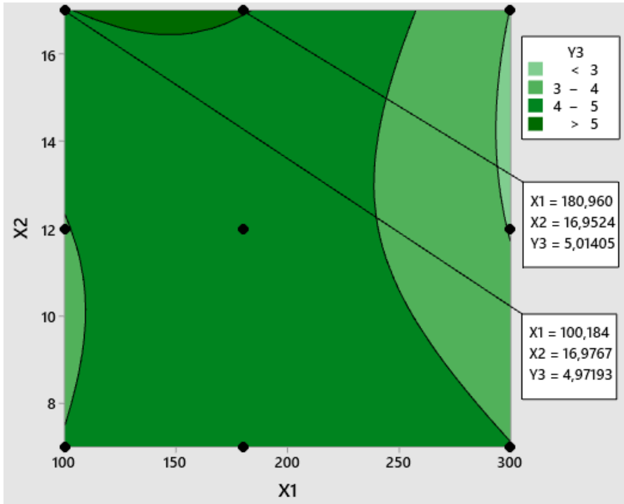

Figure 6. Contour plot of the relationship of the taste of butterfly pea flower tea (Y_3) to variations in microwave power (X_1) and drying time (X_2)

Figure 6 shows that consumer acceptance of the highest taste of butterfly pea flower tea obtained was at a score of 5 (somewhat like), and the lowest score obtained was 3 (somewhat dislike). The results show that panellists preferred the flower tea drink, which was dried at a drying time of ± 17 minutes and microwave power of 100-180 watts. Suppose the microwave power of > 180 watts causes the panellists' preference for the taste of the butterfly pea flower tea drink to decrease. In that case, the drying process of fresh butterfly pea flowers at that temperature causes some of the tips of the petals to be slightly charred. It causes the taste of the flowers to change slightly, resulting in lower consumer ratings. In addition, high microwave power causes high drying air temperatures that can affect the composition of bioactive substances in the flowers.

3.4 Aftertaste

The pleasant taste and aroma that linger in the back of the mouth after the drink is swallowed or spat out is known as the aftertaste [6]. CCD analysis of the aftertaste of butterfly pea flower tea (Table 3) shows that the model significance is 0.137 and larger than $\alpha = 5\%$ ($p < 0.05$), which means that factors X_1 and X_2 did not have a significant effect on the aftertaste of butterfly pea flower tea. While the lack of fit value obtained was 0.280, larger than α=5%, which also means it is insignificant. The flower tea aftertaste model has an R^2 of 0.636. This means that the treatment factor (microwave power and drying time) only has a 63.6% influence on the aftertaste of the flower tea drink. The Pareto diagram (Figure 7) shows that linear and quadratic drying time treatment factors significantly affect the aftertaste assessment of the flower beverage. In contrast, the microwave power treatment factor has a minor effect on the aftertaste value of the flower tea drink. Furthermore, from the results of the contour plot analysis (Figure 8), it was found that the highest aftertaste value obtained was 5.5 ≈ 6 (like), while the lowest aftertaste value obtained was 3 (somewhat dislike).

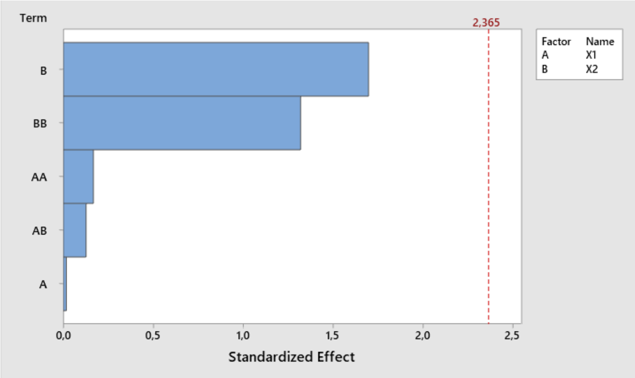

Figure 7. Pareto chart of standardized effects for the CCD model for the aftertaste of butterfly pea flower tea drink (Y_3)

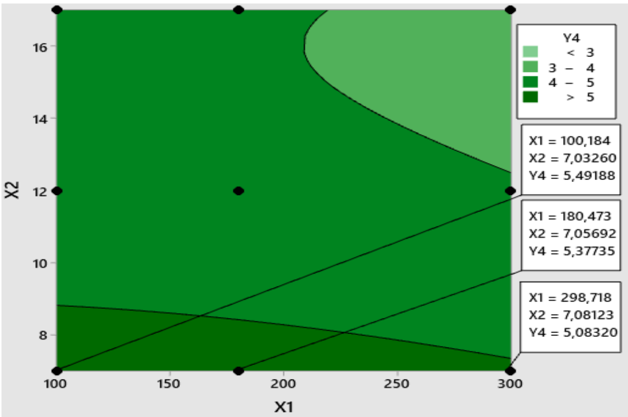

Figure 8. Contour plot of the relationship between the aftertaste of the butterfly pea flower tea drink (Y_4) to the variation of microwave power (X_1) and the variation of drying time (X_2)

3.5 Optimization of butterfly pea flower tea sensory

After obtaining the mathematical model for each response, the optimization was carried out. The optimization aimed to find the best composition of treatment factors X_1 and X_2 for sensory butterfly pea flower tea. The determination of the lower, mean, and upper values for each response is shown in Table 4, and the results of optimizing the composition of each treatment factor for the responses are shown in Table 5, with an average composite desirability value of 0.802. The detailed formula for each response and the desirability level of each response is as shown in Figure 9.

The design of sensory optimization of butterfly pea flower tea was selected on the target colour, aroma, and taste, namely 6 (likes) with a successive level of importance of 4; 4; 5, then the minimum aftertaste response is 4, with an importance level of 3, as shown in Table 4.

Furthermore, the optimal formula obtained includes a microwave power treatment factor of 180 watts, a drying time of 17 minutes, and the optimal response values of colour is 5.8 ≈ 6 (likes), aroma is 5.1 ≈ 5 (somewhat like), taste is 5.03 ≈ 5 (somewhat like), and aftertaste is 4 (neutral).

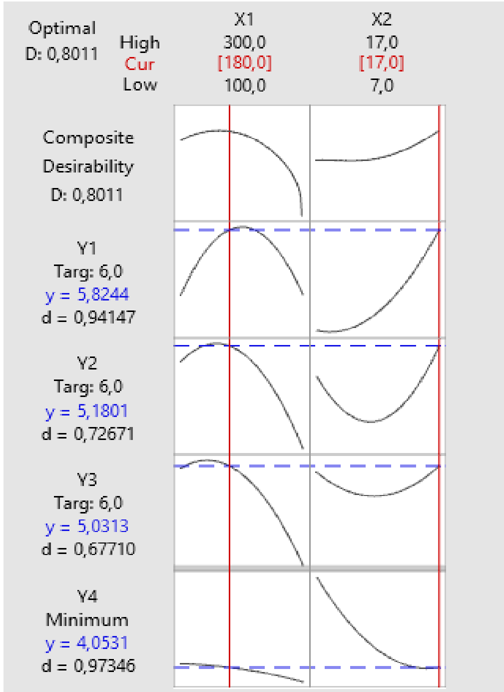

Figure 9. Optimal sensory solution of pea butterfly flower tea

Table 4. The sensory optimization design of butterfly pea flower tea using CCD

Response	Goal	Lower	Target	Upper	Weight	Importance
Y_1	Target	3	6	6.6	1	4
Y_2	Target	3	6	6.6	1	4
Y_3	Target	3	6	6.6	1	5
Y_4	Minimum		4	6.0	1	3

Note: Y_1 = colour, Y_2 = aroma, Y_3 = taste, Y_4 = aftertaste.

Table 5. The optimum sensory formula of microwave-dried butterfly pea flower tea

Solution	X_1	X_2	Y_1 Fit	Y_2 Fit	Y_3 Fit	Y_4 Fit	Composite Desirability
1	180	17	5.82441	5.18013	5.03131	4.05309	0.801089

Note: X_1 = microwave power (watt), X_2 = drying time (minutes), Y_1 = colour, Y_2 = aroma, Y_3 = taste, Y_4 = aftertaste.

The results showed that the optimization data can be applied to the drying of butterfly pea flowers, where the butterfly pea flowers produced not only have good sensory quality, but also have good physical characteristics, well dried butterfly pea flowers, and can be stored for a long time. In addition to sensory quality, drying butterfly pea flowers using a microwave is also expected to be able to maintain its antioxidant content, so further research needs to be carried out to determine the physical and chemical quality of dried butterfly pea flowers produced as raw materials for healthy drinks.

4. CONCLUSIONS

The results of CCD analysis show that microwave power and drying time significantly affect the colour, aroma, and taste of butterfly pea flower tea but do not significantly affect the aftertaste of butterfly pea flower tea. The optimum sensory formula was obtained at microwave power (X_1) of 180 watts and drying time (X_2) of 17 minutes, with predictions of the colour of 5.8 ≈ 6 (likes), aroma of 5.1 ≈ 5 (somewhat like), taste of 5.03 ≈ 5 (somewhat like) and aftertaste of 4.05 ≈ 4 (neutral).

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