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Short Communication
The Optimization of Recipe on the Production of Natural Jam from the Peel of Dragon Fruit (*Hylocereus polyrhizus*)

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Abstract

Background and Objective: Natural jam from the peel of dragon fruit is a product to enhance the economic value of the waste of dragon fruit's peel. The study aimed to optimize a recipe for production a natural jam from the peel of dragon fruit. **Materials and Methods:** A response surface methodology with central composite design was used to investigate the effects of three independent variables; X1: The concentration of the peel of dragon fruit, X2: Processing time and X3: Sugar; on the sensory qualities of the jam such as color and texture. **Results:** The three independent variables had significant effects ($p<0.05$) for all response variables where the optimum recipe of the jam consisted of 1096,55 g of the peel of dragon fruits, 3954 min of processing time and 791.24 g of sugar, theoretically. **Conclusion:** The results suggest that the utilization of the peel of dragon fruit has potential as raw material for the production of a consumer's acceptable functional food.

Key words: Betacyanin, food diversification, functional food, response surface methodology, dietary fiber

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Dragon fruit (*Hylocereus polyrhizus*) is a tropical fruit that is widely grown in Asian countries, including Indonesia. For consumption, the dragon fruit must be peeled to expose the flesh while the skin is not consumed and will be wasted. The waste of peel is traditionally used as fertilizer. However, recent research shows that dragon fruit peels have high beneficial compounds such as dietary fiber (pectin) and phytochemicals (betacyanins)[1,2]. Therefore, this substance must be considered as a good material for the development of functional foods.

Considering of pectin as a soluble dietary fiber, pectin has been widely applied as thickening, gelling and emulsifying agents for jams, soft drinks, fish and meat products, fruit juice, desserts and dairy products. Apart from that, pectin is useful in medicinal applications, in which it helps to lowering serum cholesterol level, removing heavy metal ions from the body, stabilizing blood pressure and restoring intestinal functions and weight reduction[3,4].

In addition to pectin, betacyanin has also recognized as abundant compound in the peel of dragon fruit. Betacyanin is also responsible for the natural red pigment colour instead of anthocyanin. There is a growing interest in the natural red pigments in food science, due to their preventive effects on chronic diseases. However, the stability of betacyanin in food processing could be affected by heat, oxygen, light, pH and moisture as these factors are the main causes for discolouration of this pigment[5,6].

Jam is a pectin derivative product that has a long shelf life because it has a high sugar content. Jams are thick; sweet spreads made by cooking crushed or chopped fruits with sugar. They tend to hold their shape but are generally less firm than jellies. Jam production requires the correct proportions of based fruits, pectin and sugar[7] to get the desired result. Moreover, since the betacyanin is a susceptible phytochemical, the cooking time would also be considered to maintain the functionality of the betacyanins. To date, there are a limited research that has focused on the optimal utilization of dragon fruit peel as the main source of pectin and betacyanin in jam production, where these compounds will affect the sensory properties of jam especially the texture and color of the jam produced. The previous research on the utilization of dragon fruit peel has conducted on the production of jelly and juice[8,9]. This study was designed to optimize recipe for the production of functional jam derived from the skin of the dragon fruit. Response surface methodology (RSM) is used in this study, where RSM is one of the most commonly used optimization techniques in food science[10]. RSM could provides an information for elucidate the aspects affecting the desired response if there are many factors and interactions in the study of food production.

MATERIALS AND METHODS

Materials: The dragon fruits were obtained from the traditional farmers in local area (Bukittinggi, Indonesia). The raw material was prepared by separating the peel from the flesh. The peel was dried in an air-circulated oven (Venticell, Medcenter Einrichtungen GmbH, Germany) at 50°C until constant weight was obtained. The dried peel was then ground manually. The powder obtained was stored at 4°C prior to analysis. Other good quality raw materials such as sugar, salt and citrus were collected form the local market.

Jam preparation: A self-prepared dragon fruits rind was processed into jams according to the Food and Agriculture Organization's guidelines with slight modifications[11].

Experimental design: The response surface methodology (RSM) is a tool that could be used to evaluate the relative significance of several factors in the presence of complex interactions. This is a robust technique for testing multiple variables because more experiments are needed to study one variable at a time. RSM answers the question of how to choose the level for the factors applied to obtain the desired response function value, smallest or largest, in a smaller number of experiments[12]. In this study, the RSM was employed to optimize the conditions like the peel of dragon fruit, processing time and sugar in the production of the jam from the peel of dragon fruit.

The statistical software package "software design exepert 7.1." was used to analyze the experimental data. All variables were taken at a central coded value of zero. Experiments were performed according to the central composite design (CCD) in the RSM. A CCD with three independent variables was applied to investigate the weight of dragon fruits peel, processing time and amount of sugar. The central points were determined by the preliminary experiment where 1000 g of the peel of dragon fruits, 30 min of processing time and 800 g of sugar were indicated.

Upon the completion of experiments, the average maximum sensory evaluation of jam for color and texture was taken as the response. A multiple regression analysis of the data was carried out for obtaining an empirical model that relates the response measured to the independent variables.

With recorded value of colour and texture, the optimization of jam's recipe was based on desirability function. For this purpose, the response optimizer tool was used.

Sensory evaluation: Sensory evaluations were performed by 25 semi-trained panelists aged between 18-25 years. The panelists were the students and staff of Department of Family Welfare Science, Padang State University, Indonesia. The sensory evaluation of jam samples was carried out for the factors colour and texture. Overall acceptability of the jam were evaluated following nine point hedonic scale (9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely).

RESULTS AND DISCUSSION

The central composite design: The present investigation deals with the production of dragon fruits jam using the peel of dragon fruits and sugar with certain processing time. Response surface methodology was used to test the relative importance of sensory outputs and the optimum condition for the best sensory score of the produced jam. Table 1 shows the results obtained from the central composite design regarding the studied variables [The concentrations of the peel of dragon fruits (X_1), processing time (X_2) and sugar concentration (X_3) the sensory properties: colour (Y_1) and texture (Y_2) of the jam]. All studied variables indicated that the sensory properties of produced jam were in the range of 3.4 5.7 which means the interaction of all components affected the sensory characteristics of the products.

Table 2 shows the results of the response surface models for the production of the peel of dragon fruit jam. Data was analyzed using the analysis of variance (ANOVA). The coefficient of regression for the jam production demonstrates that the model is significant due to the low probability (p) value ($p<0.0001$). Generally, a low probability (p-value) indicates a high significance of the regression model[13]. The interaction terms and the quadratic coefficient terms (X_1X_2, X_2X_3, X_1^2, X_2^2 and X_3^2) were also found to be significant factors. In this model, the high $R^2>0.90$ and also that of the adjusted $R^2>0.90$ indicate a close agreement between the experimental results and the theoretical values predicted by the model. The high p-value for the lack of fit test indicates the high level of non-significance of the error and further confirms that the model fits suitably with the experimental data.

Prediction of desirability: Table 3 indicates the desirability functions of response surface modeling that used to determine the optimum conditions for the production of the jam from the peel of dragon fruit. The optimum condition for the production of jam derived from the peel of dragon fruit was achieved with 1095.64 g of the peel of dragon fruit, 38.60 min of processing time and 774.61 g of sugar. This formula has obtained the desired value of 1. The desirability

Table 1: The central composite design for jam production

Level of variables			Variables (X)			Response (Y)	
X_1	X_2	X_3	Quantity of peel of dragon fruit (X_1)	Processing time (X_2)	Sugar (X_3)	Colour (Y_1)	Texture (Y_2)
+1	+1	-1	1100.00	40.00	700.00	5.12	4.52
0	+α	0	1000.00	46.82	800.00	5.72	3.56
0	0	0	1000.00	30.00	800.00	5.24	5.20
0	0	0	1000.00	30.00	800.00	5.28	5.36
-α	0	0	831.82	30.00	800.00	4.40	5.08
0	0	+α	1000.00	30.00	968.18	5.32	4.56
+α	0	0	1168.18	30.00	800.00	5.60	5.32
-1	+1	+1	900.00	40.00	900.00	5.28	3.88
+1	+1	-1	1100.00	40.00	700.00	5.56	3.80
0	0	0	1000.00	30.00	800.00	5.20	5.36
+1	-1	-1	1100.00	20.00	700.00	3.56	5.16
-1	-1	+1	900.00	20.00	900.00	3.72	4.60
0	- α	0	1000.00	13.18	800.00	3.44	5.52
+1	+1	+1	1100.00	40.00	900.00	5.64	4.60
+1	-1	+1	1100.00	20.00	900.00	4.32	5.28
0	0	0	1000.00	30.00	800.00	4.76	5.16
0	0	-α	1000.00	30.00	631.82	4.32	5.08
0	0	0	1000.00	30.00	800.00	5.24	5.12
0	0	0	1000.00	30.00	800.00	5.08	5.16
-1	-1	-1	900.00	20.00	700.00	3.88	5.32

Table 2: Analysis of variance (ANOVA)

	Prob>F	
Sources	Colour (red)	Texture
Model	<0.0001	<0.0001
X_1: quantity of peel of dragon fruit	0.0098	0.1845
X_2: processing time	<0.0001	<0.0001
X_3: sugar	0.0269	0.0700
X_1X_2	0.5010	0.3191
X_1X_3	0.2858	0.0010
X_2X_3	0.6393	0.1564
X_1^2	0.2889	0.3174
X_2^2	0.0086	0.0001
X_3^2	0.0690	0.0027
Lack of fit	0.1559	0.0638
Adjusted R^2	0.8712	0.9056
R^2	0.9322	0.9503

Table 3: Desirability function on the production of dragon fruit jam

	The peel of dragon fruit (g)	Processing time (min)	Sugar (g)	Colour	Texture	Desirability
Prediction	1095.64	38.60	774.61	5.72	4.48	1
Verification	1096.55	39.54	791.24	5.61	4.43	-
Difference (%)				0.11	0.05	-
				1.90	1.10	-

Table 4: Nutritional compositions of the optimized dragon fruit jam

Components	Concentration	Units
Carbohydrate	44.52	%
protein	1.90	%
Moisture	50.54	%
Ash	1.54	%
Vitamin C	47.60	%
IC50	100.00	ppm

function approach is one of the most widely used methods in industry for the optimization of multiple response processes[14]. It is based on the idea that the "quality" of a product or process that has multiple quality characteristics, with one of them outside of some “desired” limits, is completely unacceptable. The method finds operating conditions (X) that provide the "most desirable" response values. Optimization was based on the desirability function

$$D = \frac{d1 \times d2 \times d3 \times ... dn}{n}$$

where, d1 are the desirability indices for each response [d1 = 1 means the most desirable, d1 = 0 means least desirable and n is the number of response used]. The responses may be used as the control parameters to determine the optimum quality characteristics with respect to the concentration of each variable such as the concentration of the peel of dragon fruit, processing time and the concentration of sugar. Thus, present study was first effort for optimizing the recipe of dragon fruit’s jam by using RSM as a tool which gave advantage of not only selecting best recipe but also provided impression of the influence of ingredients used in on its sensory profile. As results, the fact that the linear parameter of all variables was positive; indicates that an increase in these variables within the limits studied in this experiment, contributed to an increase in the acceptance of the jam. The quadratic terms of both variables were negative, thus indicating that the stationary point within the experimental region was the maximum to obtain the best acceptance. The R values for these response variables were higher than 0.80 thus there was a satisfactory correlation between regression models and the experimental data, considering that the response variable is a hedonic measurement, which can often present considerable variation as the panelists were semi-trained

Nutritional composition: Table 4 indicates the nutritional composition of the optimized dragon fruits jam recipe. As expected, the jam contains high amount of antioxidant and high carbohydrates and low amount of fat. The high amount of vitamin C and IC_{50} from the jam may be affected from the main raw material that would contributed to the functional properties of the jam. Therefore, the term “healthy food” may be claimed on the product’s label.

The result of the present study was in line with a previous research conducted by Jalgaonkar *et al.*[9] who also used the response surface methodology to optimize the utilization of Dragon fruit for development of Dragon fruit based ready to serve drink. The optimization of many models including pH, TSS, titratable acidity, ascorbic acid content, colour, total

phenol content and sensory evaluation were found to be statistically valid and provided adequate information regarding the behaviour of the responses upon variation in concentration of Dragon fruit juice and sugar.

CONCLUSION

This study showed that the quantity of peel of dragon fruits follows by processing time and sugar content have strong tendency to affect the quality of produced jam which subsequently will affect the consumers acceptance. The results suggest that the utilization of the peel of dragon fruit has potential as raw material for the production of a consumer's acceptable functional food. Future research on optimizing dragon fruit jam recipe that affect phytochemical characteristics such as betacyanin levels nor antioxidant abilities needs to be conducted.

SIGNIFICANCE STATEMENT

This study will help the researcher and the food producer to enrich the utilization of the waste of dragon fruit peel. The proper utilization of the waste of dragon fruit peel will be able to increase the kind functional food products while also being able to reduce wastage and improve the economy of the community.

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