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Temperature and Time Optimization of Dragon Fruit Peel Powder Drying Using the Response Surface Methodology

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Abstract: The purpose of this study is to obtain the right temperature and time for the manufacture of dragon fruit peel powder and to obtain the optimal total yield and water content. The method used in the spraying process is Foam Mat Drying. The method used for optimization is the Response Surface Method (RSM) with a factorial centralized composite design 22. The factors used are the temperature of 60°C, 70°C, and 80°C and the time is 5 hours, 6 hours, 7 hours. The results showed that the composition of the formula was the best at a temperature of 79,214°C and a time of 5,007 hours. It can be predicted that the optimal formula gets a yield value of 16.109%, and a moisture content of 4.662%. The total powder obtained in 1 day of production is 5000 grams, if the production for 1 week is 35,000 grams, then 150,000 grams will be obtained for 1 month of production. It was concluded that the optimal formula that has been obtained can be used as a model for making powder from dragon fruit peel.

Keywords: Drying, RSM, and Dragon Fruit Peel Powder

INTRODUCTION

Dragon fruit is a fruit that has been cultivated and has good economic value in Indonesia. A tropical climate with good sunlight intensity helps dragon fruit bear fruit all year round. Dragon fruit is one of the recommended by many people because it has a good vitamin content to maintain the body's immunity [1]. East Java Province is the largest producer of dragon fruit in Indonesia with 4,197,037 quintals. Dragon fruit production in Banyuwangi Regency for East Java Province is the first highest production of 2,732,247 quintals, followed by Malang Regency with 52,306 quintals and Jember with 20,103 quintals (Central Statistics Agency, 2022).

Dragon fruit contains protein that can increase the body's metabolism, fiber, prevent colon cancer, diabetes, diet, vitamin B1, vitamin B2, and vitamin C [3]. Dragon fruit has bioactive substances that are beneficial to the body such as antioxidants, ascorbic acid, beta-carotene, and anthocyanins, dietary fiber in the form of pectin, minerals, calcium, phosphorus, iron and vitamins B1, B2, C [4]. Meanwhile, the skin of dragon fruit contains 8.98% protein, 2.60% fat, 18.76% ash and 25.56% fiber [5]. Dragon fruit peel extract contains antioxidants, namely vitamin C, flavonoids, tannins, alkaloids, steroids, and saponins [6].

Dragon fruit peel is one of the parts of the fruit that has a lot of potential but has not been used properly. However, most of the dragon fruit peels are not processed and become waste. Even though 30-35% of the weight of dragon fruit is found in the skin [5]. The skin of dragon fruit contains quite high antioxidants that are able to inhibit free radicals and increase body immunity. However, dragon fruit has a fairly high moisture content, especially in the skin of the fruit at 94.05% [7]. One of the processes carried out to process dragon fruit peels if they are to be used as powder is through the drying process. The main purpose of drying is to reduce the moisture content of food so that it can inhibit the growth of unwanted microbes. Drying is affected by several factors such as temperature and drying time. Drying with high temperatures and a long enough time can reduce the water content in the dried material [8].

High water content, especially in the skin, causes the fruit to have a short shelf life. Therefore, the process of drying dragon fruit peels into powder is one of the innovations to deal with dragon fruit peel waste which has not been optimal so far. Development of dragon fruit skin products can reduce waste so that it has economic added value. Seeing the above conditions, it is necessary to innovate dragon fruit peel into powder and conduct further research related to optimizing temperature and time in the process of making dragon fruit peel powder so as to obtain the optimal yield and water content. One of the methods used in determining the optimum value of a formula is the Response Surface Methodology (RSM) method which is processed with the Design Expert 13.0 application.

METHOD

Place and Time of Research

The research was conducted from March to May 2024 at the Agroindustrial Processing Technology Laboratory of the Agricultural Industrial Technology Study Program, Faculty of Agriculture, University of Muhammadiyah Jember.

Tools and Materials

The tools used to make dragon fruit peel powder include analytical scales (Sartorius), spoons, basins, plastic containers, petromax plastic, *mixers,* blenders, baking sheets, and memmert ovens. Meanwhile, the tools used for analysis include ovens, steam cups, cup clamps, desiccants, spatula spoons, tissue paper. The materials used in this study include dragon fruit and chemicals used for the analysis include aquades, maltodextrin, and *tween 80*.

Research Design

This research was carried out in one stage, namely obtaining dragon fruit peel powder. This research method is an experimental method carried out in the Laboratory of Agroindustrial Processing Technology, Agricultural Industrial Technology Study Program, Faculty of Agriculture, University of Muhammadiyah Jember. The raw material for dragon fruit peels is obtained from Barurejo Village, Siliragung District, Banyuwangi Regency. The optimization method of dragon fruit peel powder used is *Response Surface Methodology* with *a central composite design* (CCD) factorial 2^2. There are two factors in this study, namely temperature (X1) which is 60°C, 70°C, 80°C, and time (X2) which is 5 hours, 6 hours, 7 hours. In both of them, a code is formed (-1,414, -1, 0, +1, +1,414) where the value of -1 is the minimum value, the value of 0 is the middle value and the value of +1 is the maximum value of the factor. The values of -1,414 and +1,414 are generated from the comparison of the values of the two factors. The factors studied and each of their levels are presented in **table 1**. The tests carried out are yield and moisture content analysis.

Table 1. Factors and levels studied in the study

Factor	Unit	Lower limit (-1)	Upper limit (1)
Temperature	°C	60	80
Time	Hour	5	7

In this study, there were 13 treatments, each of which followed the CCD experimental design specified by **Table 2**.

Table 2. Centralized composite design matrix in experimental design

Code		Current		Response	
Std	Run	Temperature (°C)	Time (Hours)	Yield	Water Content
5	1	60	6		
10	2	70	6		
6	3	80	6		
2	4	80	5		
12	5	70	6		
11	6	70	6		
4	7	80	7		
8	8	70	7		
9	9	70	6		
13	10	70	6		
1	11	60	5		
3	12	60	7		
7	13	70	5		

Research Implementation

The process of making dragon fruit peel powder. In the powder making stage, it is carried out with 2 stages, the first of which is the process of making dragon fruit peel porridge presented in figure 1.

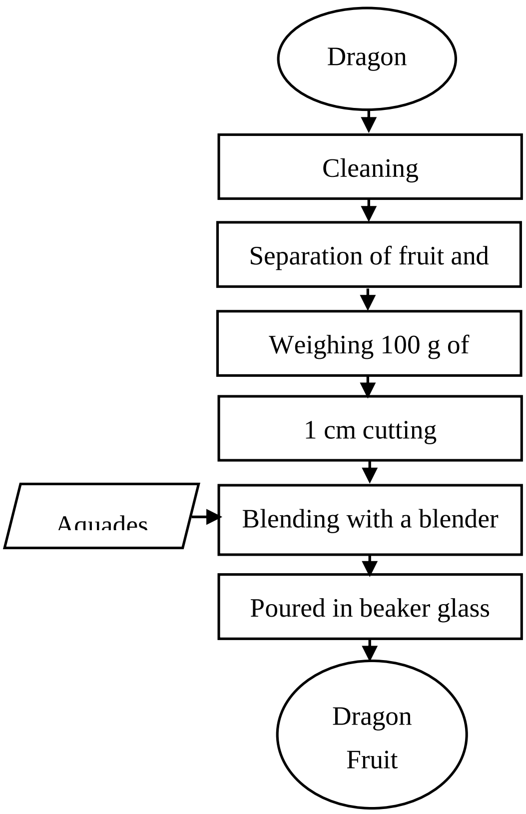

Figure 1. Flowchart of dragon fruit peel pulp preparation

While the second stage is the manufacture of dragon fruit peel powder. The dragon fruit peel that has been made into porridge is then dried using an oven. In this process, there is the addition of filler and foaming materials. The filler used is maltodectrin, while the foaming agent used is *Tween* 80. This process is estimated by the *Response Surface Methodology method*. The flow diagram of making dragon fruit peel powder is presented in figure 2.

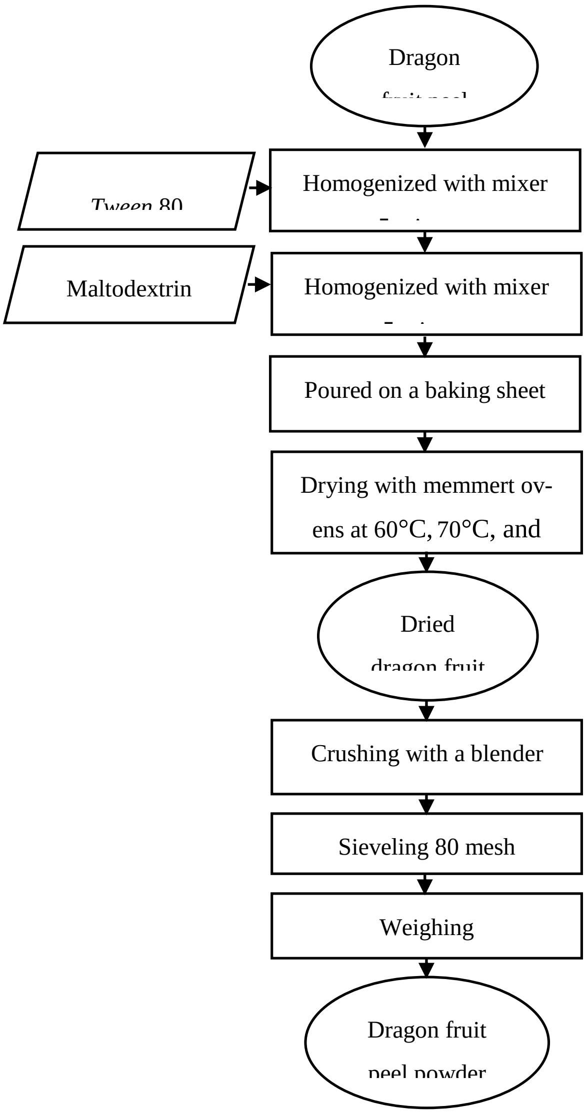

Figure 2. Flowchart of dragon fruit peel powder preparation

RESULTS AND DISCUSSION

RSM (*Response Surface Methodology*) Result Analysis

a. Yield Response Analysis

The economic value of a product can be affected by the yield obtained from the results of powder manufacturing. The larger the yield, the better. Yield is the ratio between the weight of the product obtained to the weight of the raw materials used [9]. The yield can be obtained by calculating the weight of the powder after being in a blender to weigh the liquid before drying. The value of the yield range obtained is around 5-16%. The mathematical equation for the yield response is as follows:

Yield (%) = 14.40 + 3.61* A + 1.69*B – 2.25*A*B – 2.66*(A2) + 0.26*(B2)

Information:

A*Temperature B*Time

The R2 value for the yield response model is 0,8295. This means that the influence of temperature factors and Drying time to the response of powder yield of 82,95% b/v, while the rest is as much as 17,05% b/v is influenced by other factors. Value *predicted R-squared* which is produced by 0,2797, while the value of *adjusted R-squared* as 0,7078. This shows that the predicted data and the actual data for the yield response are covered into a model of 27,97% b/v and 70,78% b/v. Value *predicted R-squared* Supporting value *adjusted R-squared* which is produced because the difference between the two is smaller than 0,2. *Adequate precision* for the yield response is 9,199 which shows the magnitude of the signal against *noise ratio*. Value *adequate precision* that is greater than 4 indicates an adequate signal so that this model can be used as a guideline *Design Space* and qualify as a good model in providing predictions [10].

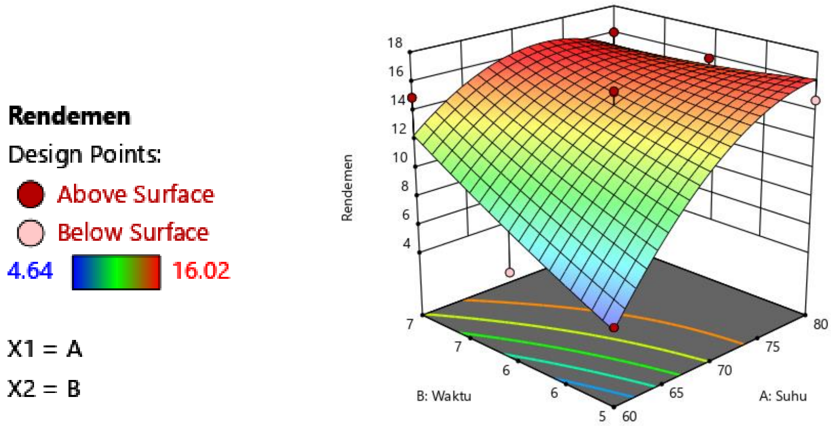

Figure 3. Response of dragon fruit peel powder yield

Different colors on the graph show different response values for each combination between the components of the factor. The low yield value is indicated by the blue area of 5% b/v, while the high yield value is indicated by the red area of 16% b/v. In the graphs model, there are several colors such as red indicating the highest number, yellow indicating the middle value, and blue indicating the lowest value. The 3-dimensional *image of the design expert* in the form of a parabola means that at the starting point (low) the response shows a low yield, then it curves upwards is the optimal point of the response, and it curves down when the yield response decreases so that it forms a parabola.

From the results of further analysis, the factors that have the greatest tendency to change the yield value are temperature and time factors. Increasingly high temperature and the longer it dries, the lower the yield of the material and vice versa if the lower the temperature and the faster the drying, the higher the yield of the material will be [11].

b. Water Content Response Analysis

The moisture content of each sample varies greatly, meaning that the temperature and drying time have a significant influence on the moisture content of dragon fruit peel powder. The higher the temperature and the longer the drying time, the lower the moisture content produced. The value of the moisture content range obtained is around 4-10%. The mathematical equation for moisture response is as follows:

Moisture Content (%) = 8.76 - 1.93* A - 1.18*B + 0.40*A*B – 1.24*(A2) – 1.10*(B2)

Information:

A*Temperature B*Time

The R2 value for the moisture response model is 0,8812. This means that the influence of temperature factors and Drying time to the response of the water content of the powder by 88,12% b/v, while the rest is as much as 11,88% b/v is influenced by other factors. Value *predicted R-squared* which is produced by 0,3465, while the value of *adjusted R-squared* as 0,7963. This shows that the predicted data and the actual data for the moisture content response are covered into a model of 34,65% b/v and 79,63% b/v. Value *predicted R-squared* Supporting value *adjusted R-squared* which is produced because the difference between the two is smaller than 0,2. *Adequate precision* for water content response is 8,954 which shows the magnitude of the signal against *noise ratio*. Value *adequate precision* that is greater than 4 indicates an adequate signal so that this model can be used as a guideline *Design Space* and qualify as a good model in providing predictions [10].

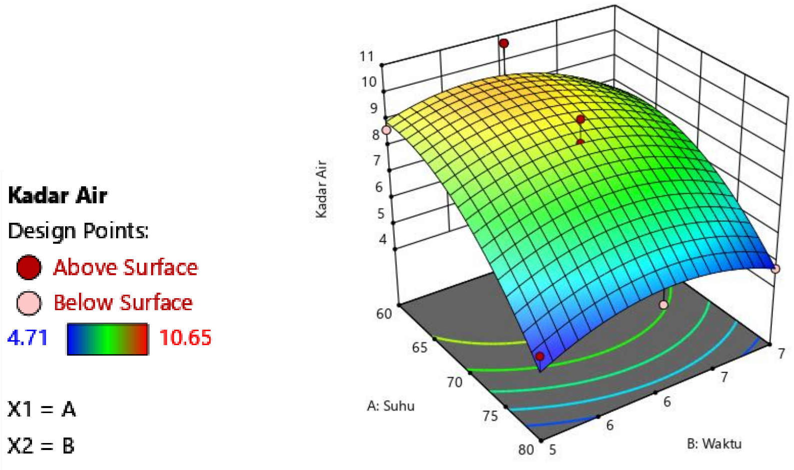

Figure 4. Response to the water content of dragon fruit peel powder

The low moisture content value is indicated by the blue area of 5% b/v, while the high water content value is indicated by the red area of 11% b/v. In the graphs model, there are several colors such as red indicating the highest number, yellow indicating the middle value, and blue indicating the lowest value.

From the results of further analysis, the factor that tends to change the moisture content value the most is the temperature factor. The higher the temperature, the greater the decrease in total water content. This is caused by the evaporation of free water or surface water contained in the [11].

c. Verification of Optimum Conditions of Model Prediction Results

The optimal formula solution for fruit peel powder based on the results of data processing can be seen in Table **3.** The results show that 2 responses have a *Desirability value* of 1,000. The formula obtained from the *Design Expert 13.0.3.0 application* is one solution. The composition of the formula is a temperature of 79.214 and a time of 5.007 with a *desirability* value of 1,000. This optimal formula is predicted to have a yield value of 16.109 per 100 g, and a water content of 4.662%.

Table 3. Optimal formula solution obtained from optimization results

It	Temperature (°C)	Time (Hours)	Yield (%)	Water Content (%)	Desirability	
1	79,214	5,007	16,109	4,662	1.000	Selected

Value *Desirability* It is greatly influenced by the complexity of the components, the range of components, the number of components and the response as well as the target to be achieved in obtaining the optimal formula. The complexity of the component is described from the requirement of the amount of raw materials that are considered important and affect the product. The difference in the hose used in each component affects the value of *desirability*. The wider the hose, the more difficult it will be to get the optimal formula with the value *Desirability* high. Desirability is a function that can be used to select the most optimal experimental conditions [10]. The optimal formula of the selected fruit powder is then verified to find out if the model is recommended by the program *Design Expert 13.0.3.0* can predict the response value well. Based on the results of the verification, it was obtained that the selected formula had a yield value of 16,1091% and moisture content of 4,661%. The actual values of the measurement results and predictions can be seen in the Table **4.**

Table **4.** Comparison of selected response measurement values

Response	**Prediction**	**Verivication**	**95% CI**		**95% PI**	
			Low	**High**	**Low**	**High**
Yield	16,1091	16,1091	12,2996	19,9187	3.53094	28,6874

Water Content	4,66194	4,66194	3,08712	6,23676	- 0.537745	9,86162

The verification results showed that the response value of antioxidant activity met the value of *Confident Interval (CI)*, while the total response of phenol and yield meets the value of *Prediction Interval (PI)* that has been predicted by the program *Design Expert 13*. *Confident Interval* (CI) is a range that shows the average expectation of measurement results at an accurate significance level of 5 %. *Prediction Interval* (PI) is a range that indicates the expectation of future or subsequent response measurement results under the same condition at a significance level of 5 % [10]. It can be said that the results of optimizing the use of temperature and time in the manufacture of dragon fruit peel powder have been verified with the yield value 16,1091% and moisture content of 4,661%.

d. Production Capacity

In the powder manufacturing process, the method used, namely *Foam Mat Drying* , is a process in which a liquid or semi-solid material is made into a stable foam by adding a large volume of air or other gases from the foaming material, which works as a *foam inducer* or stabilizer. In this method, a tool in the form of a dryer is needed for the drying process. The drying tool used in this method is *the Cabinet Dryer* , that is, equipment that is often used for drying fruit. This dryer is simple in structure, low installation cost, and can be used in almost any environmental condition. In conventional cabinet dryers, hot air is usually put under the first tray (lower tray) and then passed on to the other tray normally.

The dryer used in this study was found in the laboratory of Agroindustrial Processing Technology, Agricultural Industrial Technology Study Program, Faculty of Agriculture, University of Muhammadiyah Jember. The maximum temperature that can be used in a cabinet dryer is 800C. The calculation of the production capacity of dragon fruit peel powder with this tool is as follows:

Starting weight	= 100 grams
Final weight	= 20 grams
Resin	= 16,109%
1 day production	= 25,000 grams of dragon fruit skin
	= 25,000 : 100
	= 250 grams
	= 250 x 20 grams
	= 5,000 grams (5 kg)/day
1 week production	= 5,000 x 7 = 35,000 grams (35 kg)/week
1 month	= 5,000 x 30 = 150,000 grams (150 kg)/month

In the calculation above, it can be seen that the initial weight of the porridge before drying is 100 g , then after drying it is 20 g, so the yield is 16.109%. The results were obtained from 1 day of production of 5,000 grams with an initial weight of 25,000 grams. If production is carried out during a week of meals, 35,000 grams of powder will be obtained and if it is produced in 1 month, 150,000 grams of powder will be obtained.

CONCLUSION

In this study, the optimization of the best dragon fruit peel powder with Response Surface Methodology (RSM) and Design Expert 13.0.3.0 obtained optimal results at a drying temperature treatment of 80°C and a drying time of 7 hours with a desirability value of 1,000. The formula is predicted to obtain a yield value of 16.1091% and a moisture content of 4.66194%. Based on the verification of the best formula, the value is equal to the predicted result. The total powder obtained in 1 day of production is 5000 grams, if the production for 1 week is 35,000 grams, then 150,000 grams will be obtained during 1 month of production.

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