Abstract. Purple sweet potato flour can be used as a raw material for cookies. Formula optimization is needed to make cookies based on purple sweet potato flour. This research aimed to obtain the optimal formulation of cookies using the I-optimal mixture design method. The research stages were carried out divided into three stages, including (a) processing of purple sweet potato flour and physicochemical analysis; (b) optimization of the formula cookies based on purple sweet potato flour using the I-optimal mixture design method; (c) analysis of cookies for moisture, protein, anthocyanin level, antioxidant activity, color intensity, hardness, and sensory tests. A combination of purple sweet potato flour (39.47%) and corn starch (4.47%) resulted in optimum cookies for the formulation of purple sweet potato flour. This formulation could provide moisture content 3.95%, protein content 5.60%, anthocyanin level 20.15 mg/100 g, antioxidant activity 204.01 ppm, color intensity 2.31, hardness 1791.19 g, and sensory test for color 5.13, aroma 4.60, texture 4.93, taste 4.60, overall 5.0. The cookies prepared showed the best solution for this combination of variables with a desirable value of 0.847.

1 Introduction

Producing of sweet potato in West Java Province in 2021 could reach 489,920 tons, which is one of the production centers. Producing of various sweet potato varieties that have the potential to be utilized, one of which is purple sweet potato [1]. Purple sweet potato (PSP) contains anthocyanins which are antioxidant compounds [2], one way to increase the shelf life of PSP and maintain the anthocyanin content is to make flour an intermediate product, the shelf life of PSP flour at 20°C can reach 159 days [3]. Products made from purple sweet potato, one of which is cookies, with the consideration of longer shelf life, easy packaging, easy consumption, and liking by children and adults [4]. Cookies are a type of biscuit made from a soft dough, crunchy, and when broken the cross-section appears less dense in texture [5]; cookies are sweet-tasting pastries, usually made of wheat flour as a primary ingredient, with a supporting ingredient of butter or margarine, powder sugar, and eggs mixed then molded and baked until cooked [6]. Cookies made from PSP, which still contain anthocyanins as antioxidants that function as anti-aging, can be consumed by adult women,
which can provide health benefits.

To produce good quality cookies, it is necessary to optimize the formula, which aims to obtain the optimal formula based on the response [7]. One method that can be used to determine the optimal formula for a product is the Design Expert (DE) method of the I-Optimal mixture, which has relatively high accuracy and displays the number of formulas by predetermined limits [8]. Based on this, research was carried out on optimizing the cookie formula based on purple sweet potato flour (*Ipomoea batatas* L.) using the DE application of the I-Optimal Mixture Method. This research aimed to obtain the optimal formulation of cookies using the I-optimal mixture design method.

## 2 Method

### 2.1 Materials and tools used

The ingredients used to make cookies included: PSP obtained from Cilembu Village-Pamulihan District-Sumedang Regency-West Java, citric acid, corn starch, powder sugar, margarine, skim milk, chicken eggs, and salt. Materials used for chemical analysis included: filter paper, 3% HCl, DPPH solution, ethanol, methanol, aquadest, KCl buffer, pH, and Na-citrate buffer pH 4.5.

Tools used include: drum dryer (RCAT), meat grinder (SXL8), steamer (Maspion), slicer (RCAT), cross-beater mill (RCAT), vibrator screen mesh 40 (RCAT), sealer (Everbest), and stove (Rinnai). The analytical tool used is color analysis with L, a, b. chromamater (Minolta type CR 400, Japan), DuMaster Protein Analyzer (Buchi D-480), and glassware for chemical analysis.

### 2.2 The process of making purple sweet potato flour and its characteristics

The process of making PSP flour was carried out through the following stages: the purple sweet potato is washed thoroughly to remove adhering dirt, the skin is scraped off with a knife, then sliced using a slicer with a thickness of ±3 mm, and the resulting slices are soaked in 0.5% citric acid solution for 15 minutes. After 15 minutes, the slices were drained and steamed at 91-93°C for 10 minutes with 1 kg of purple sweet potato/batch. Sweet potato slices, as a result of steaming, were ground using a grinder to form a paste, then dried using a drum dryer at 120-124°C, 2 bar pressure, and 13.6 rpm rotation. The drying results are in the form of flakes, which are then floured using a cross-beater mill and sieved using a vibrator screen with a size of 40 mesh.

### 2.3 Optimization of the formula cookies using the I-optimal mixture design method

The application of DE using the Mixture I-Optimal method [8], to analyze the cookies characteristics by determining the fixed (powdered sugar, margarine, skim milk, egg, egg white, salt) and independent variables (PSP flour 30.93% - 44.19% and corn starch 0% - 13.26%). The formula optimization is obtained based on the specified response needs. The settings in the program include lack of fit point = 5, replicate point = 5, so that 13 formulas must be analyzed. The setting provided test sure the model fit the data across the design space. There are 13 formulations of purple sweet potato flour and corn starch for the cookies sample suggested by the DE 12 Mixture I-Optimal method, presented in Table 1 below.
Table 1. The formula of cookies based on purple sweet potato flour

<table>
<thead>
<tr>
<th>Formula</th>
<th>Purple Sweet Potato Flour (%)</th>
<th>Corn Starch (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>44.19</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>30.93</td>
<td>13.26</td>
</tr>
<tr>
<td>F3</td>
<td>35.35</td>
<td>8.84</td>
</tr>
<tr>
<td>F4</td>
<td>40.875</td>
<td>3.315</td>
</tr>
<tr>
<td>F5</td>
<td>34.245</td>
<td>9.945</td>
</tr>
<tr>
<td>F6</td>
<td>44.19</td>
<td>0</td>
</tr>
<tr>
<td>F7</td>
<td>37.56</td>
<td>6.63</td>
</tr>
<tr>
<td>F8</td>
<td>30.93</td>
<td>13.26</td>
</tr>
<tr>
<td>F9</td>
<td>39.77</td>
<td>4.42</td>
</tr>
<tr>
<td>F10</td>
<td>37.56</td>
<td>6.63</td>
</tr>
<tr>
<td>F11</td>
<td>37.56</td>
<td>6.63</td>
</tr>
<tr>
<td>F12</td>
<td>30.93</td>
<td>13.26</td>
</tr>
<tr>
<td>F13</td>
<td>44.19</td>
<td>0</td>
</tr>
</tbody>
</table>

The process of making cookies through the stages: purple sweet potato flour and corn starch were mixed until homogeneous. The egg white stirred until fluffy, add margarine, powdered sugar, skim milk, salt, then shake and add eggs while shaking for 6 minutes. The resulting dough was added to a mixture of purple sweet potato flour and corn starch while shaking again for 4 minutes until the dough becomes smooth. Then the dough was printed and stored on a baking sheet smeared with margarine and baked for 11 minutes at ± 150°C using an oven [5]. Cookies had been cooked are tempered until reach room temperature and packaged.

2.4 Physical, chemical, and organoleptic analysis of cookies

The chemical analysis included moisture content using the gravimetric method [9], protein content using Buchi-Dumaster [10], anthocyanin content using the pH difference method [11], and analysis of antioxidant activity using spectrophotometry [12]. Physical analysis was conducted on color intensity using a chromameter [13] and hardness using a texture analyzer [14]. Sensory test used hedonic method for color, aroma, texture, taste, and overall of 30 semi-trained panelists, a scale fro, 1 (dislike) to 6 (very like) [15]. Data were analyzed using the variance test (ANOVA) and Duncan test to the presence of significant differences between samples, the data of optimalization were analyzed using the Microsoft Excel program and the application of the Mixture Design method [8].

3 Result and discussion

3.1 Characterization of purple sweet potato flour

The physicochemical characteristics of purple sweet potato flour using the drum drying method can be seen in Table 2.
Table 2. Results of physicochemical analysis of purple sweet potato flour

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analysis Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>28.14%</td>
</tr>
<tr>
<td>Moisture content</td>
<td>5.90%</td>
</tr>
<tr>
<td>Anthocyanin level</td>
<td>38.75 mg/100 g</td>
</tr>
<tr>
<td>Antioxidant activity</td>
<td>15.23%</td>
</tr>
<tr>
<td>Color value (L)</td>
<td>54.29</td>
</tr>
</tbody>
</table>

The analysis results of PSP flour fulfill the recommendations for the quality requirements of sweet potato flour [16]. PSP flour pretreated with steaming prior to drum drying which is conducted by Nevara et al. (2018) give result for yield 24.30%, moisture content 3.21%, color value (L) 45.93 [17] and 56.00 to 57.20 [11], anthocyanin levels of PSP flour 27.68 mg/100 g and antioksidan activity 14.45% [2].

3.2 Optimization of the formula cookies for chemical analysis

Moisture content controls product stability at the storage stage, determining organoleptic quality for taste and texture, while protein content is a determinant of product quality. Based on Indonesian National Standards Number 2973:2018 regarding biscuits [6], cookies quality requirements for maximum moisture content 5% and minimum protein content of 4%. Figure 1a shows that the response of moisture content to 13 cookies formulas based on PSP flour shows that the ratio of PSP flour and corn starch has a significant effect (P <0.05). Meanwhile, the response to protein content can be seen in Figure 1b, indicating that the addition of PSP flour and corn starch had no significant effect (P>0.05) because they are a source of carbohydrates [18]. Analysis results of the lowest moisture content in formula 1 (3.38%) and the highest protein content in formula 11 (5.16%).

PSP flour contains anthocyanin as a bioactive component [2]; anthocyanin levels in PSP flour-based cookies can act as a functional food. Anthocyanins can act as antioxidants inhibiting free radicals and anti-aging [12]. Anthocyanin levels can be seen in Figure 1c, and antioxidant activity in Figure 1d, indicating that adding PSP flour and corn starch had no significant effect (P>0.05) on anthocyanin levels and antioxidant activity. Analysis results of the highest anthocyanin content was in formula 11 (35.96 mg/100 g L), and the highest antioxidant activity was in formula 2 (37.82 mg/100 g with decisive criteria).

Anthocyanin levels of PSP products 6.19–46.14 mg/100g [2], while anthocyanin levels of cookies 37.82–39.56 mg/100g, there is a decrease in anthocyanin levels compared to purple sweet potato fresh, due to the use of heat in the drying and baking process [17].
Fig 1. Contour plot graph of chemical response to moisture content (1a), protein content (1b), anthocyanin content (1c), and antioxidant activity (1d). The blue line signs the 95% confidence interval, and the red dot signs the design point.

3.3 Optimization of the formula cookies for physics analysis

Testing the color intensity of cookies serves to show the effect of adding PSP flour as a main ingredient and natural dyes for cookies. Hardness test to show the degree of crispness and consumer acceptance of cookies. In Figure 2a, it can be seen that the response of color intensity to 13 cookie formulas based on purple sweet potato flour results that the ratio of PSP flour and corn starch has a significant effect ($P<0.0001$). The hardness response can be seen in Figure 2b, showing that adding purple sweet potato flour and cornstarch had a significant effect ($P>0.05$). The highest color intensity test ($\Delta E$) results were in formula 2 (5.303), while purple sweet potato flour 11.87 [17]. The highest hardness test results were in formula 5 (3468.60 g) with highest moisture conten (5.16%). In line with the results of
research Budžaki et al. (2014) that samples with the higher moisture content have significantly affect textural properties [14].

![Fig 2. Contour plot graph of physical response to color intensity (2a) and hardness (2b). The blue line signs the 95% confidence interval, and the red dot signs the design point](image)

### 3.4 Optimization of the formula cookies for sensory test

The results of sensory test for color, texture, taste, and overall attributes of the 13 cookies formula can be seen in Figure 3a-3c-3d-3e, showing that the comparison of PSPflour and corn starch had no significant effect (P>0.005). The most preferred sample of cookies for color formula 4 (4.60); texture formula 12 (4.33); aroma formula 9 (4.43); and the overall attribute formula 13 (4.53).

The results of sensory test for aroma attribute of the 13 cookies formula can be seen in Figure 3b, showing the comparison of purple sweet potato flour and corn starch had a significant effect (P<0.005), and the cookies sample preferred formula 8 (4.57).
Fig 3. The sensory response contour plot graph includes color (3a), aroma (3b), texture (3c), taste (3d), and overall (3e) attributes. The blue line signs the 95% confidence interval, and the red dot signs the design point.

3.5 Optimization and Verification Models

This study aims to obtain the optimal formula for cookies based on purple sweet potato flour. To achieve this goal, numerical optimization was carried out with the response to moisture content and antioxidant activity being minimized, the response to protein content, anthocyanin, color intensity, and all attributes of the sensory test being maximized, and the hardness response being set at a specific range. Then the priority of each response is arranged based on the level of importance. Responses to moisture content, protein content, and all attributes on organoleptic testing were given +5 points, responses to anthocyanin levels and antioxidant activity were given +4 points, and responses to color intensity and hardness were given +3 points. The optimization results show that cookies based on PSP
flour made using PSP flour (39.47%) and corn starch (4.72%) show the best solution based on the desirability value (0.847).

The selected optimal formula sampled and then analyzed again. The analysis result of each response compared with the response value predicted by the design expert 12 application using the model equation. It is predicted that the selected formula will have a moisture content 3.55%; protein content 4.49%; anthocyanin levels 24.35 mg/100 g; antioxidant activity 330.901 ppm; hardness 2159.68 g; color intensity 1.986; attribute for color 4.32; aroma 4.43; texture 3.96; taste 4.19 and overall 4.26. The response values from the analysis and predictions are within the Confidence Interval, Prediction Interval ranges, so that the model can be used to optimize the PSP-based cookies formula.

The analysis results of optimal formula for cookies based on purple sweet potato flour fulfilling the quality requirements of Indonesian National Standards Number 2973:2018 regarding biscuits [6] for moisture content 3.95% and protein content 5.60%. Anthocyanin level 20.15 mg/100 g; antioxidant activity 204.01 ppm (very weak); hardness 1791.19 g; color intensity 2.31; attribute for color 5.13; aroma 4.6; texture 4.93; taste 4.6; and overall 5.0.

Fig 4. Graph of desirability optimization of purple sweet potato flour based cookies formula

4 Conclusion

Selection of optimal formula by the program is purple sweet potato flour 39.47% and corn starch 4.47%. Purple sweet potato cookies based on the selected optimal formula showed the best results with a desirable value 0.847. Based on the selected of optimal formula contains moisture content 3.95%, protein content 5.60%. anthocyanin level 20.15 mg/100 g; antioxidant activity 204.01 ppm (very weak); hardness 1791.19 g; color intensity 2.31; attribute for color 5.13; aroma 4.6; texture 4.93; taste 4.6; and overall 5.0. The next research is suggested to conduct of packaging cookies and determinan of shelf life its product.

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References


