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Optimization of formulation and drying temperature of dried Cassava Getuk with black mulberry (*Morus Nigra L.*) juice using response surface method (RSM)

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Abstract: The purpose of this research is to develop an optimal formulation for producing dried cassava getuk infused with black mulberry juice, utilizing the Design Expert version 13 software and the Response Surface Methodology (RSM). The study evaluates both chemical and organoleptic responses. Chemical responses include moisture content and total carbohydrate content, while organoleptic responses assess color, aroma, taste, and texture. Based on the predictions generated by the Design Expert software, the optimal formulation comprises 65% cassava, 10% black mulberry juice, and a drying temperature of 70°C. The predicted outcomes for this formulation are a moisture content of 27.294%, a total carbohydrate content of 84.033%, and organoleptic scores of 4.00 for aroma, 4.74 for color, 3.59 for taste, and 3.95 for texture. The model's accuracy, indicated by the validation value, is 0.886, demonstrating a high level of reliability in the predicted results.

Keywords: *Design expert, Dried Getuk, Formula optimization, Response surface method (RSM).*

1. Introduction

Innovation in the food sector is one of the most important things that can build competitiveness in the food industry in Indonesia. Innovation is a tool for replacing something outdated with something new. Innovation is an ability to create something new and different from the previous, and also in accordance with ideas, facts, and information that already exist. An innovation product generally has some new natures that are new, has qualities, and is profitable. Thus, innovation essentially is something new and qualitative [1]. Local food is food product that has been produced for a long time, developed, and consume in some particular place or some local communities [2]. Local food product commonly processed from local material, local technology, and also by local knowledge. Local food product usually develops by the local consumer preference. One of the utilizations of local food that have a lot of availability and have potential to be develop in various processed food is cassava.

Cassava (Manihot utilissima) is one of the carbohydrate commodities which is widely cultivated in Indonesia. The reason of why cassava widely cultivated in Indonesia is because cassava can grow well and can be found in climate region and soil type of tropical country [3]. Cassava can be processed into various food product such as tapioca flour, mocaf, and processed food product such as getuk, tiwul, and cassava chips.

Getuk is a traditional semi-moist food that is usually made of cassava and goes through some process such as material preparation, steaming, pulverization, mixing some additional ingredients, and moulding [4]. Getuk, as semi-moist food, has high water content, hence it's easy to get contamination from microbiology or because of some chemical material [5]. Nowadays, it's hard to get getuk in the market. The getuk that is in the market today is easy to get spoiled if it's not directly consumed. With a

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drying process as an innovation for getuk product, it can be easier for the consumer to get getuk that is rarely found in the market.

Dried cassava getuk can be made by adding some food additive like food flavour. Food flavour that can be used is synthetic flavour or natural flavour. Another food material that can be added when making cassava getuk to enhance and varied the taste and colour is fruit juice from black mulberry (Morus nigra L.). Black mulberry (Morus nigra L.) is a perennial plant that originated in China. It is grown mainly because its leaves are the main food for silkworms. Mulberry plants have many species, including Morus alba, Morus multicaulis, Morus nigra, Morus macroura, Morus cathayana, Morus indica, Morus canva, Morus khunpai, Morus husan, Morus lembang [6]. This plant is able to make a major contribution to production, but its utilization in the country is still very limited.

Black mulberry contains several active substances, for example, the active substances anthocyanins as antioxidants, cyanidin, insoquercin, saccharides, linoleic acid, stearate acid, oleic acid, and vitamins (carotene, B1, B2, C) [7]. Anthocyanins are pigments from the flavonoid family that are soluble in water, giving red, violet, purple, and blue colours [8] Flavonoid is a natural organic compound found commonly in plants. Flavonoids have polar properties because they contain hydroxyl groups or sugars, so they dissolve in polar solvents such as ethanol. Methanol, butanol, acetone, dimethylsulfoxide, and water. [9].

Design Expert is a program used for optimization studies. Some examples of applications include the effect of reaction conditions on the physicochemical properties of cationic starch, evaluation of modified rice starch by extruction cooking, and extruction behavior of flint corn and sweet corn grits [9]. Anthocyanins are pigments from the flavonoid family that are soluble in water, giving red, violet, purple, and blue colours [8]. Flavonoid is a natural organic compound found commonly in plants. Flavonoids have polar properties because they contain hydroxyl groups or sugars, so they dissolve in polar solvents such as ethanol. Methanol, butanol, acetone, dimethylsulfoxide, and water [9].

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2. Material and Methods

2.1. Trial and Error dan Model Determination

Before doing the research, trial and error was carried out which can be used as a reference to determine the upper and lower limits.

Table 1.
Trial and Error Formulation of Black Mulberry Fruit Juice Dried Getuk.

Material	**Content (%)**
Steamed Cassava	70
Black mulberry	10
Powder Sugar	13
Material	**Content (%)**
Margarine	6
Vanili	1
Total	100

The determination of the optimum amount consists of four stages, namely the formula planning stage, formulation stage, analysis stage, and optimization stage. The first step is to determine the variables to be combined and their concentrations, then determine the response to be measured which has a function of the components that make up the product.

Choosing a model to get a polynomial equation, there are three models provided by Design Expert software, namely sequential model sum of squares, model based on lack of fit test, based on model

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summary statistic, and ANOVA. The sequential model sum of squares is accepted if the P value is less than 5%, which indicates that the model has a real effect on the response. The P value is a tool to determine the suitability of the model, the smaller the P value, the more significant the model. A P value of less than 5% means that the variables used in the study have a significant effect on the suggested model [10].

2.2. The Making of Dried Getuk

The first stage for making black mulberry juice is making black mulberry juice. Black mulberry fruit that has been sorted is washed using clean water and then drained. The black mulberry fruit that has been washed and drained is then mashed using a blender, then filtered by squeezing using a filter cloth to produce black mulberry juice.

The second stage is the process of making black mulberry juice. Raw cassava is stripped of skin and unnecessary parts, then reduced in size using a knife, this aims to make the cassava cook faster during the steaming process and to remove the middle fiber part of the cassava that cannot be consumed. The cut cassava is then washed using clean water to remove the soil, then the clean cassava is steamed for 30 minutes at 100°C.

2.3. Product Analysis

In the dried cassava getuk with black mulberry juice, the analysis conducted includes chemical and organoleptic responses. The chemical analysis performed on the dried getuk product includes moisture content analysis using the gravimetric method and carbohydrate analysis using the Luff-Schoorl method.

The organoleptic test was conducted based on the panelists' preference levels for the dried getuk product using the hedonic test method. The tested parameters included color, aroma, taste, and texture. This hedonic organoleptic test was carried out to determine the panelists' level of preference for the dried getuk product.

3. Results and Discussion

Based on the analysis using a trial-and-error approach, the determination of the upper and lower limits of the ingredients, and the fixed variables in the production of dried cassava *getuk* with black mulberry juice, the results are presented in Table 2 and Table 3.

Table 2.
Variable Factors in the Production of Dried Cassava Getuk with Black Mulberry Juice.

No	Material	Lower Limits	Upper Limits
1.	Cassava	65%	75%
2.	Black Mulberry Juice	5%	10%
3.	Drying Temperature	60°C	70°C

Table 3.
Fixed Variables in the Production of Dried Cassava Getuk with Black Mulberry Juice.

No.	Material	Content (%)
1.	Powder sugar	13
2.	Margarine	6
3.	Vanili	1

3.1. Mouisture Content

Based on the research results, the moisture content obtained from 20 formulations ranged from 25.52% to 32.40%. According to the analysis conducted using *Design Expert Ver-13*, the polynomial model for the moisture content response was quadratic. The analysis of variance (ANOVA) results indicated that the quadratic model was significant, with a *p*-value (*Prob* > *F*) lower than 0.05, specifically 0.0040.

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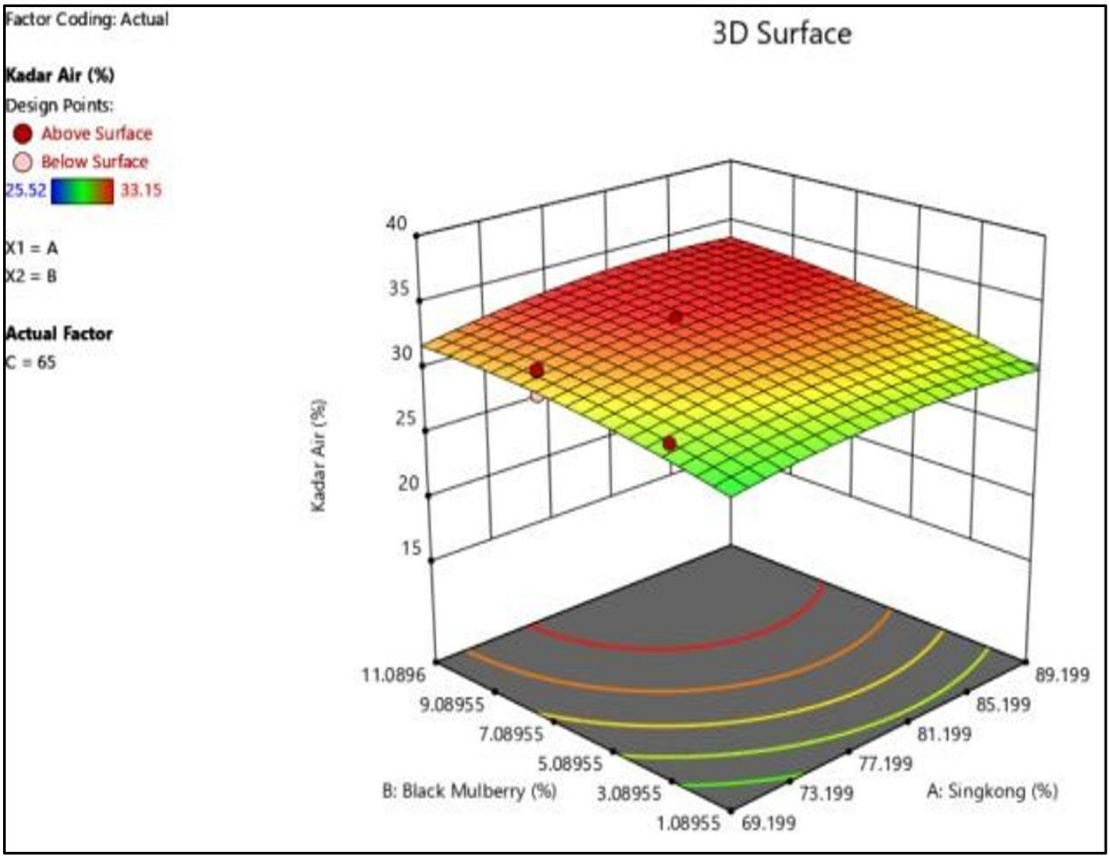

Figure 1.
3D Surface Plot of Variable AB for Moisture Content Response.

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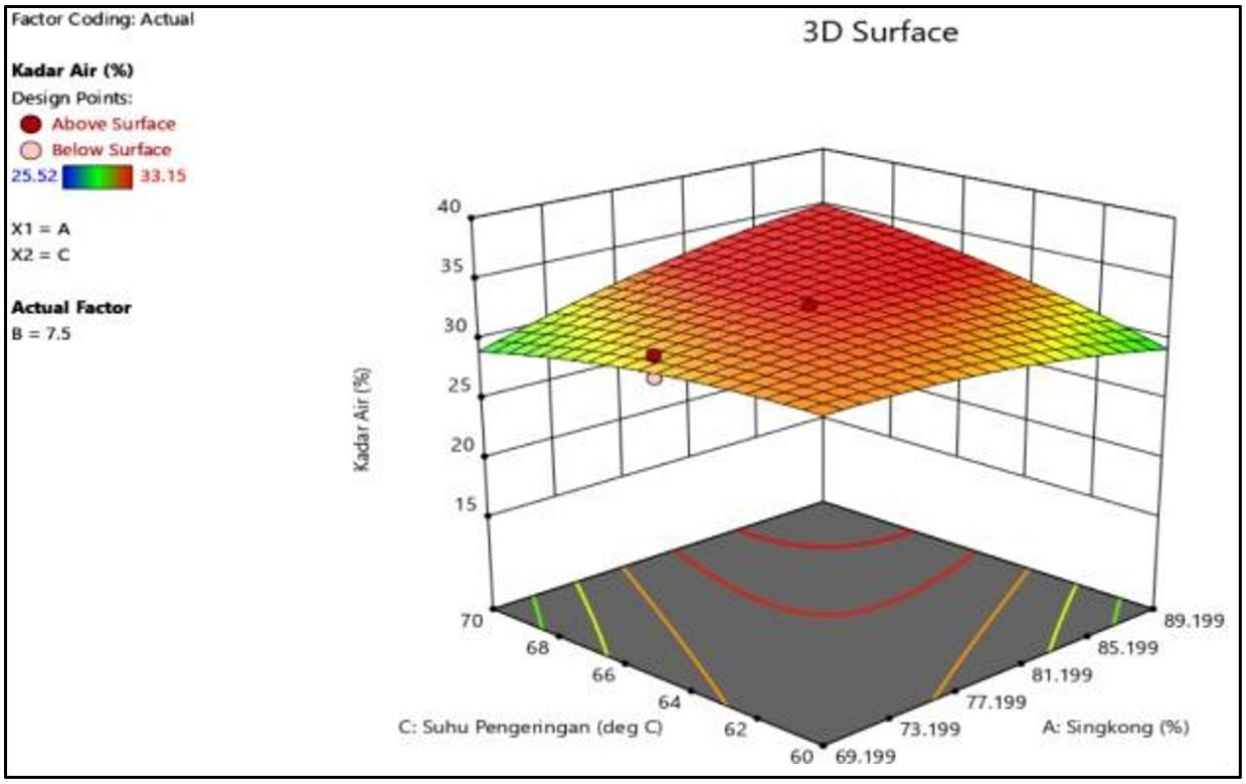

Figure 2.
3D Surface Plot of Variable AC for Moisture Content Response.

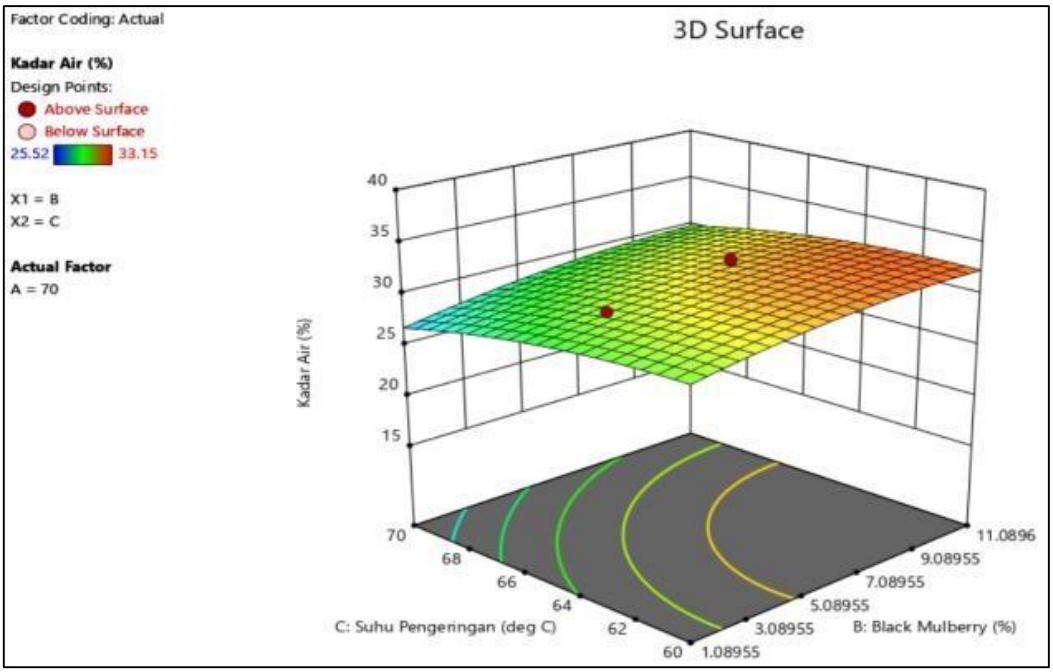

Figure 3.
3D Surface Plot of Variable BC for Moisture Content Response.

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Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that the addition of raw materials increases the moisture content of the product. The higher the proportion of cassava and black mulberry juice used, the higher the moisture content. Conversely, as the drying temperature increases, the moisture content decreases. This finding aligns with the statement by Purwanti, et al. [11] which explains that during the drying process, water evaporates into the air due to the difference in moisture content between the drying chamber's air and the air within the material being dried. The rate of water transfer from the material results in a reduction in moisture content. In addition to reducing moisture content, the drying process also causes shrinkage, leading to changes in the volume or shape of the material.

3.2. Total Carbohydrate Content

Based on the research results, the total carbohydrate content obtained from 20 formulations ranged from 75.50% to 87.58%. According to the analysis conducted using *Design Expert Ver- 13*, the polynomial model for the total carbohydrate response was linear. The analysis of variance (ANOVA) results indicated that the linear model was significant, with a *p*-value (*ProbF*) lower than 0.05, specifically <0.0001.

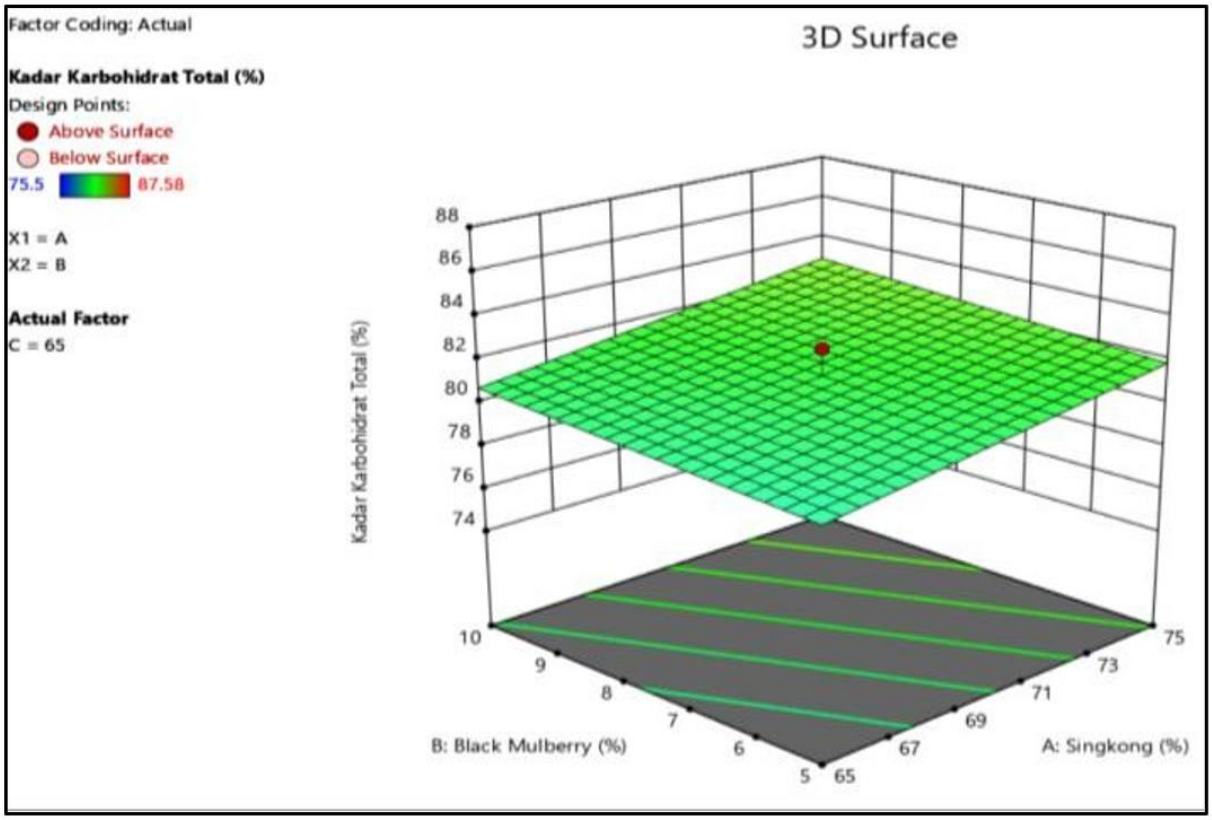

Figure 4.
3D Surface Plot of Total Carbohydrate Content Response.

Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that the higher the proportion of cassava and black mulberry used, the higher the total carbohydrate content. This is because cassava and black mulberry contain high levels of carbohydrates.

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3.3. Aroma

Based on the research results, the sensory evaluation scores for the aroma attribute obtained from 20 formulations ranged from 3.40 to 4.07. According to the analysis conducted using *Design Expert Ver-13*, the polynomial model for the aroma response was linear. The analysis of variance (ANOVA) results indicated that the linear model was significant, with a *p*-value (*Prob > F*) lower than 0.05, specifically 0.0291.

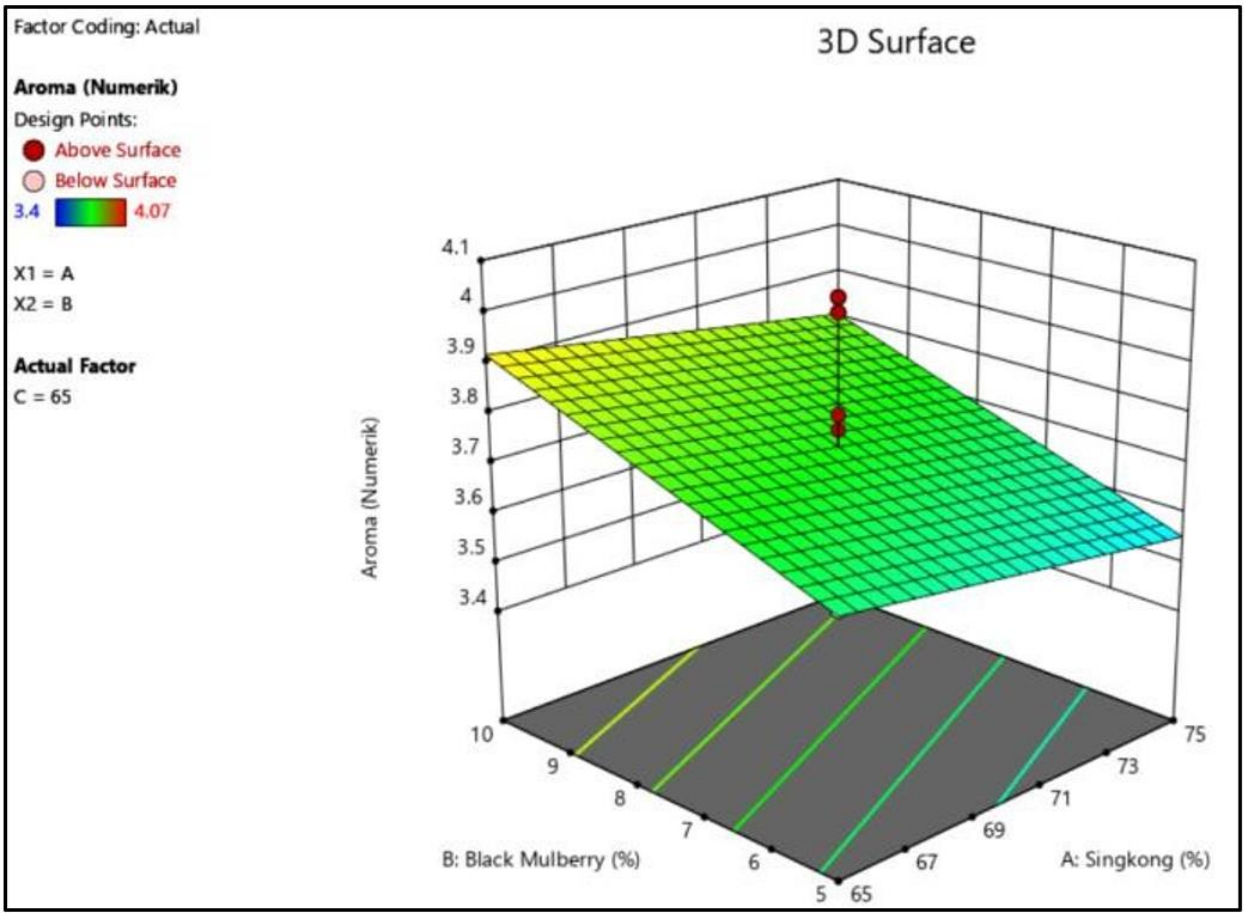

Figure 5.
3D Surface Plot of Organoleptic Response for Aroma Attribute.

Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that a lower proportion of cassava and a higher proportion of black mulberry result in a stronger aroma. This is due to the presence of volatile compounds in black mulberry, which contribute to its distinctive aroma.

3.4. Color

Based on the research results, the sensory evaluation scores for the color attribute obtained from 20 formulations ranged from 2.90 to 5.00. According to the analysis conducted using *Design Expert Ver-13*, the polynomial model for the color response was linear. The analysis of variance (ANOVA) results indicated that the linear model was significant, with a *p*-value (*Prob > F*) lower than 0.05, specifically <0.0001.

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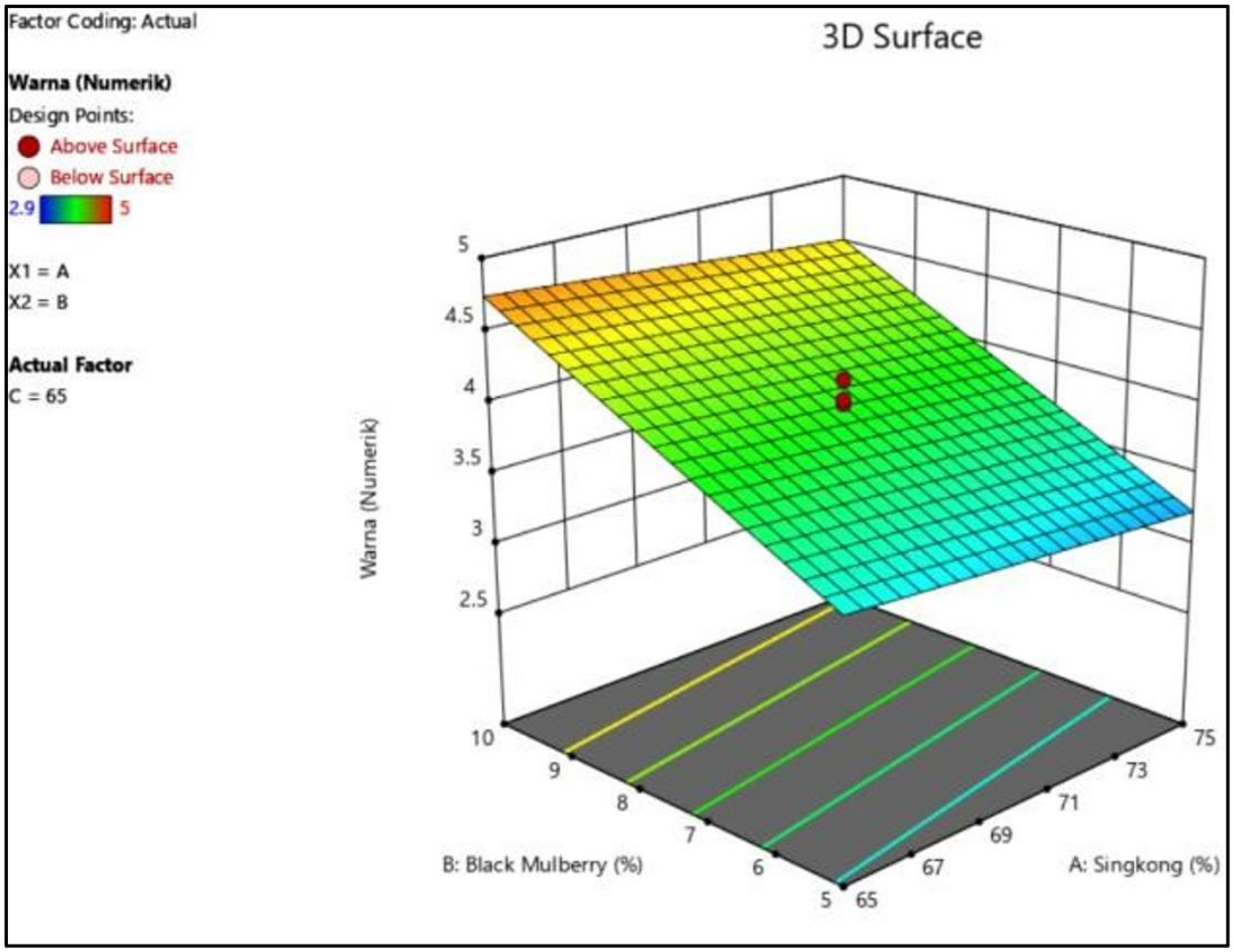

Figure 6.
3D Surface Plot of Organoleptic Response for Color Attribute.

Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that a lower proportion of cassava and a higher proportion of black mulberry result in a higher color attribute score. This is because black mulberry contains active compounds, such as anthocyanins, which act as antioxidants. Anthocyanins are water-soluble pigments from the flavonoid family that produce red, violet, purple, and blue hues [8].

3.5. Taste

Based on the research results, the sensory evaluation scores for the taste attribute obtained from 20 formulations ranged from 3.40 to 4.70. According to the analysis conducted using *Design Expert Ver-13*, the polynomial model for the taste response was 2FI (two-factor interaction). The analysis of variance (ANOVA) results indicated that the model was significant, with a *p*-value (*Prob* > *F*) lower than 0.05, specifically 0.0148.

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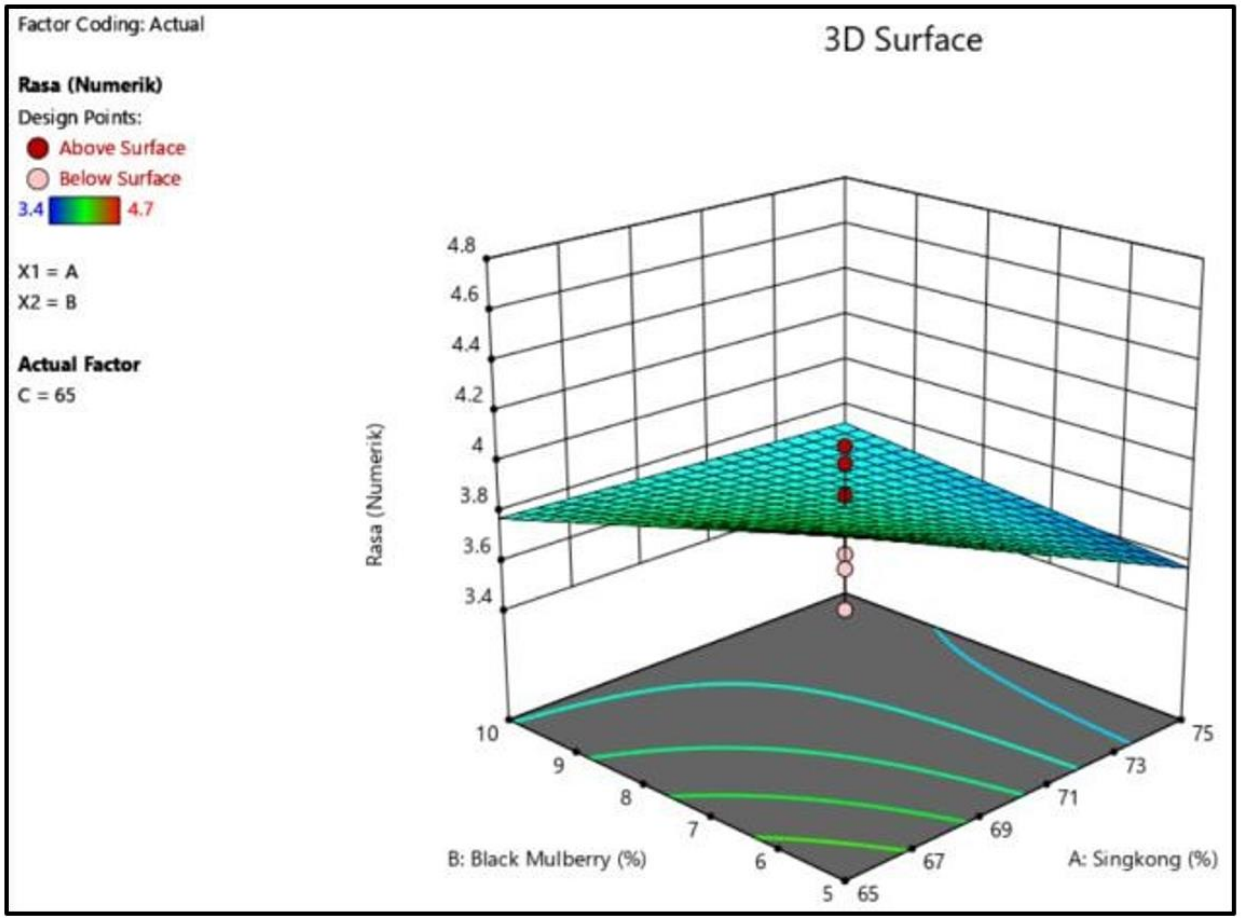

Figure 7.
3D Surface Plot of Variable AB for Organoleptic Response of Taste Attribute.

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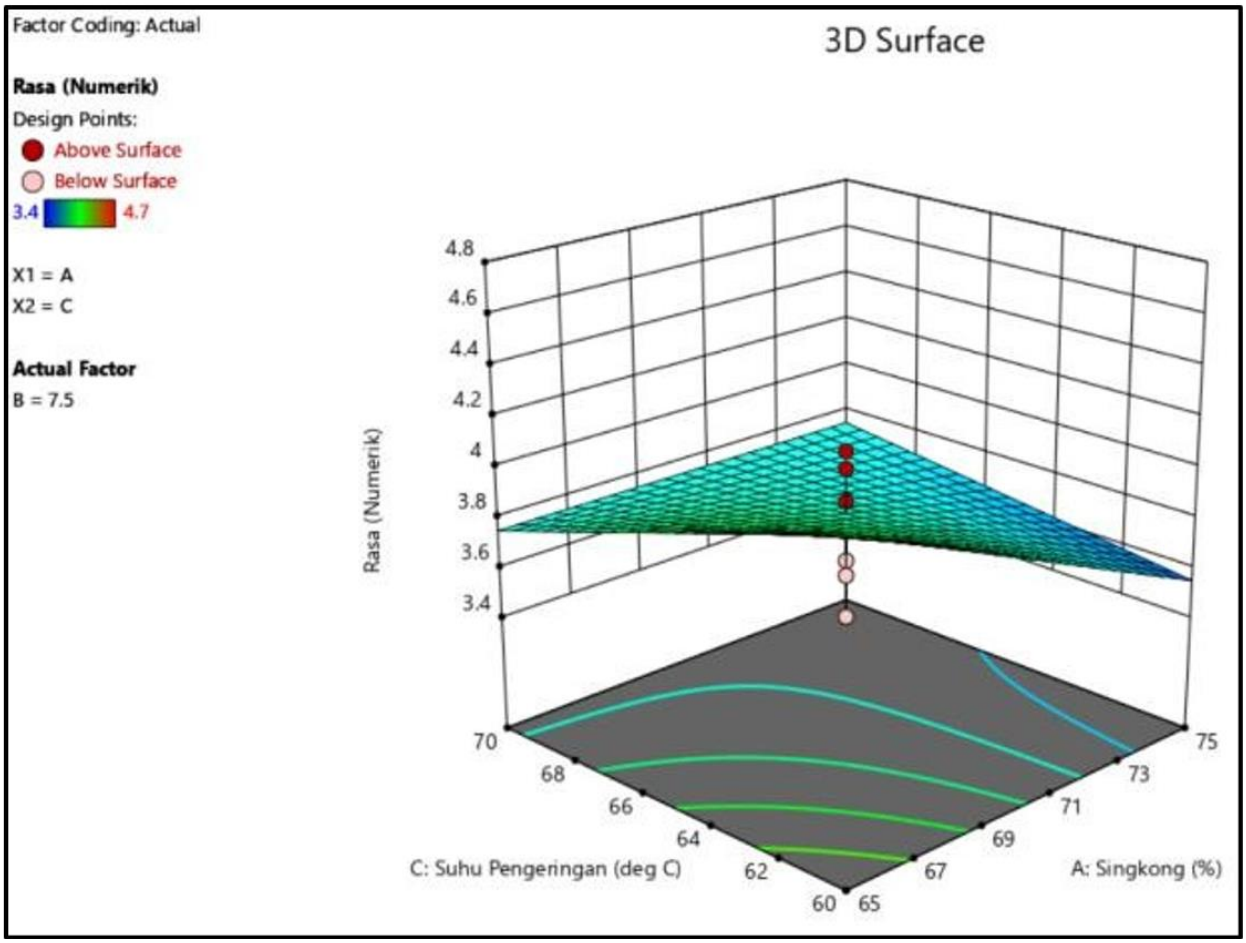

Figure 8.
3D Surface Plot of Variable AC for Organoleptic Response of Taste Attribute.

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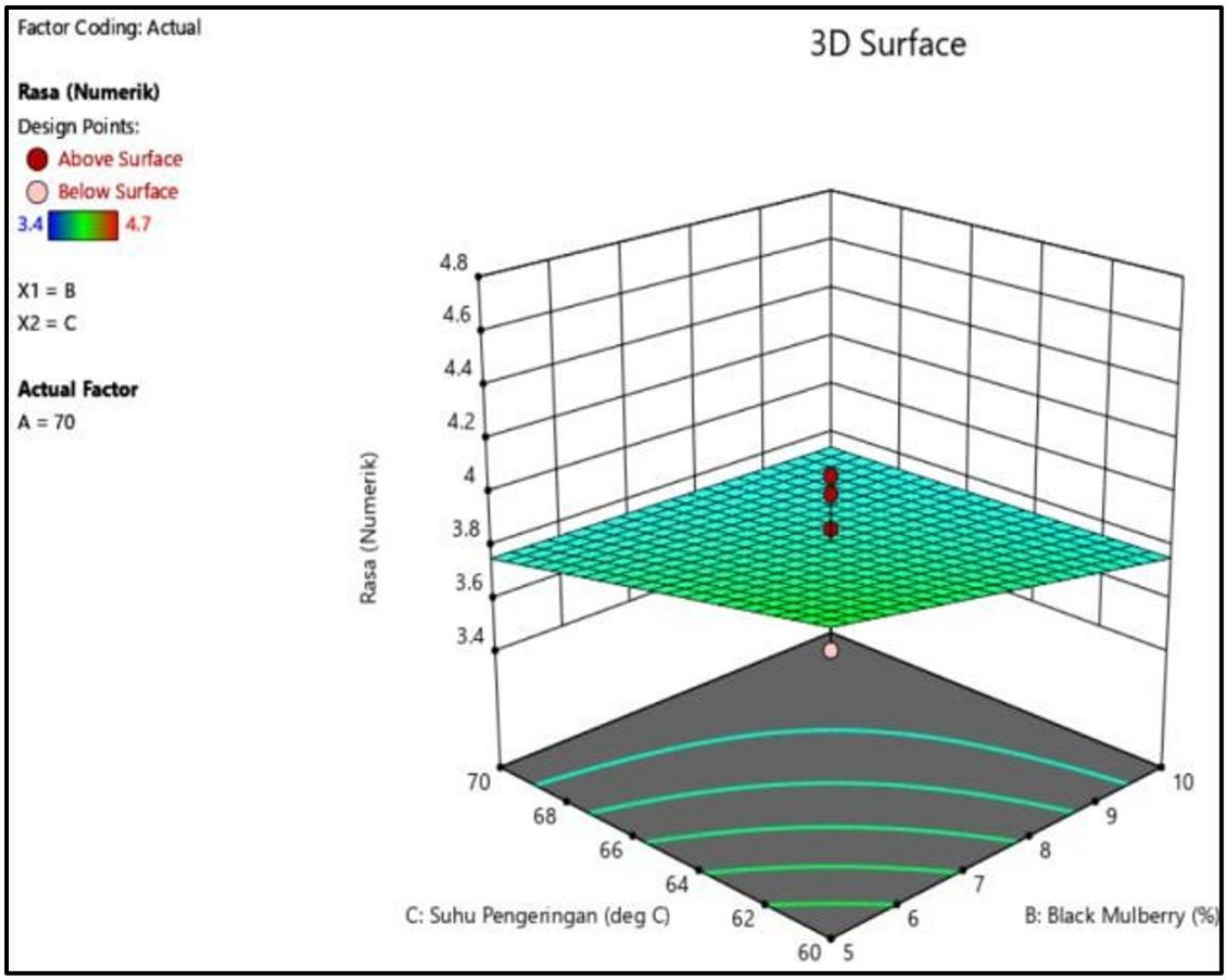

Figure 9.
3D Surface Plot of Variable BC for Organoleptic Response of Taste Attribute.

Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that the interaction between the variable factors has an inverse effect on the taste attribute score. Lower levels of cassava, black mulberry, and drying temperature result in a higher taste attribute score.

3.6. Texture

Based on the research results, the sensory evaluation scores for the texture attribute obtained from 20 formulations ranged from 3.10 to 4.07. According to the analysis conducted using *Design Expert Ver-13*, the polynomial model for the texture response was quadratic. The analysis of variance (ANOVA) results indicated that the quadratic model was significant, with a *p*-value (*Prob* > *F*) lower than 0.05, specifically 0.0003.

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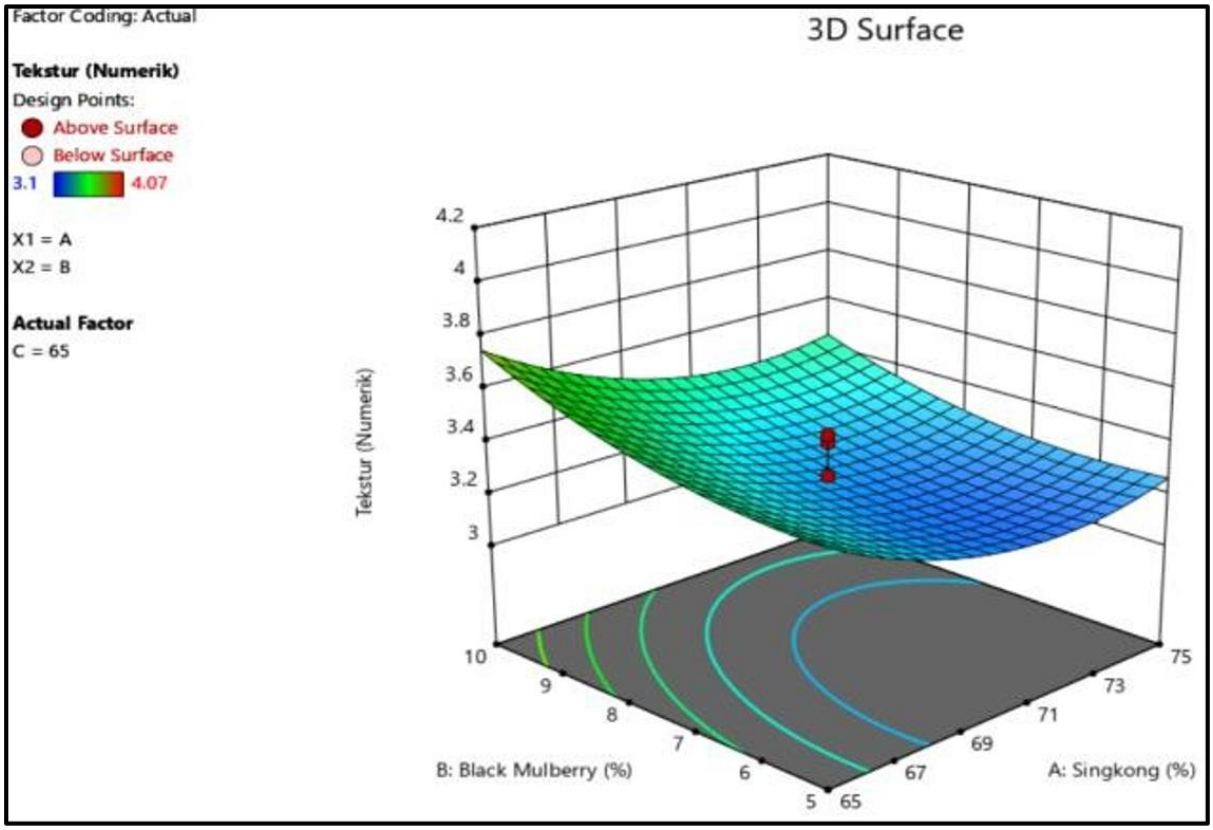

Figure 10.
3D Surface Plot of Variable AB for Organoleptic Response of Texture Attribute.

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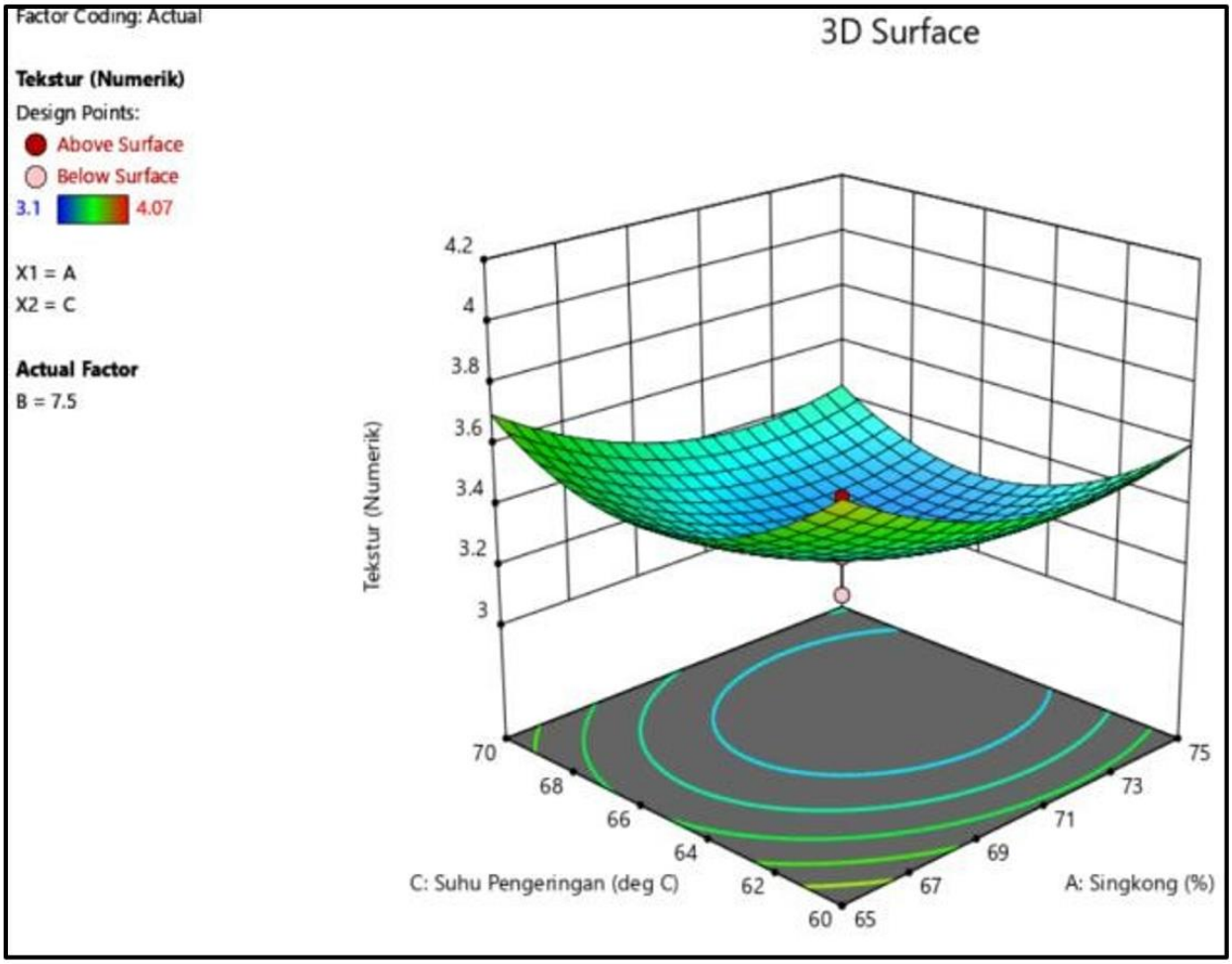

Figure 11.
3D Surface Plot of Variable AC for Organoleptic Response of Texture Attribute.

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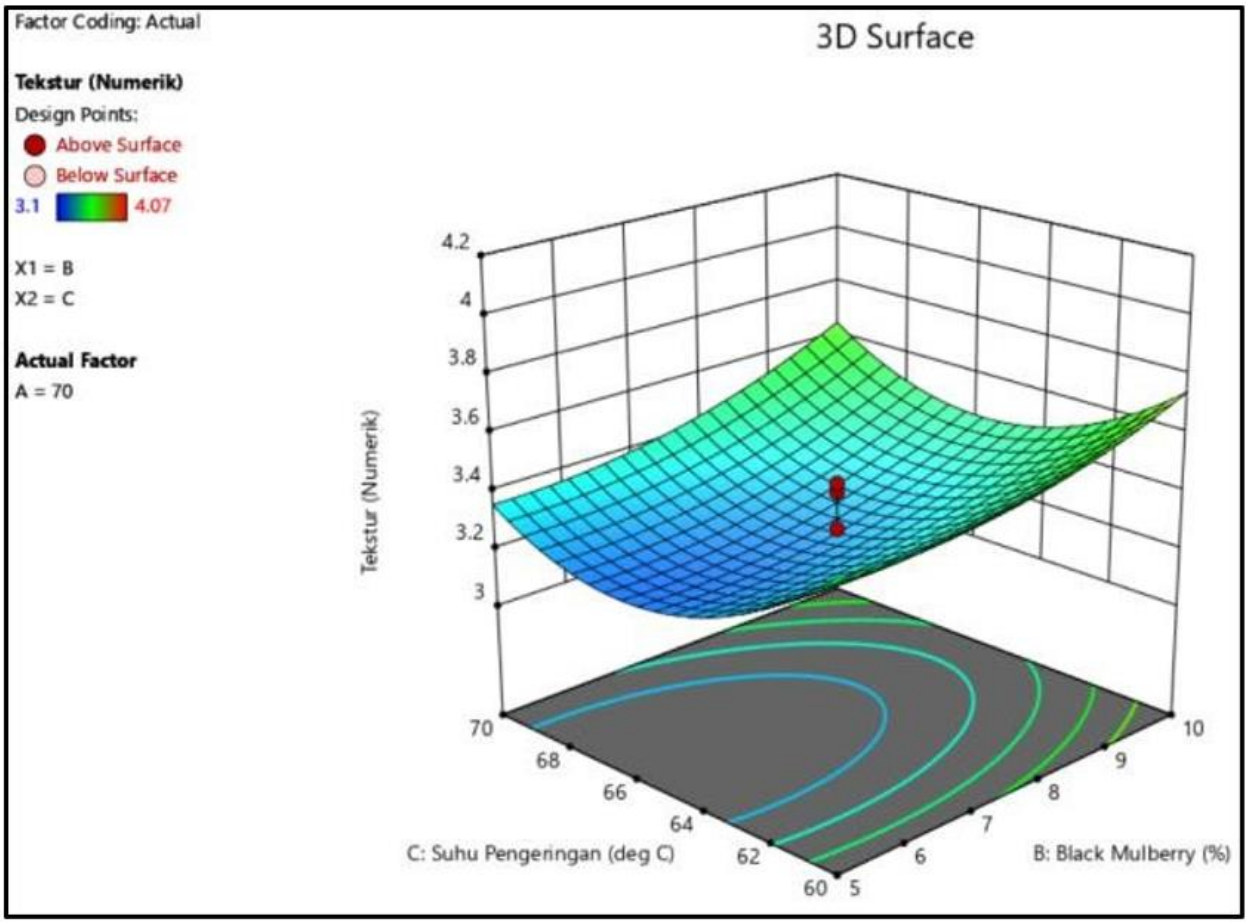

Figure 12.
3D Surface Plot of Variable BC for Organoleptic Response of Texture Attribute.

Based on the statistical analysis provided by *Design Expert Ver-13*, it can be concluded that a higher proportion of black mulberry, a lower proportion of cassava, and a lower drying temperature result in a higher texture attribute score.

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3.7. Optimization Results Using Design Expert Ver-13

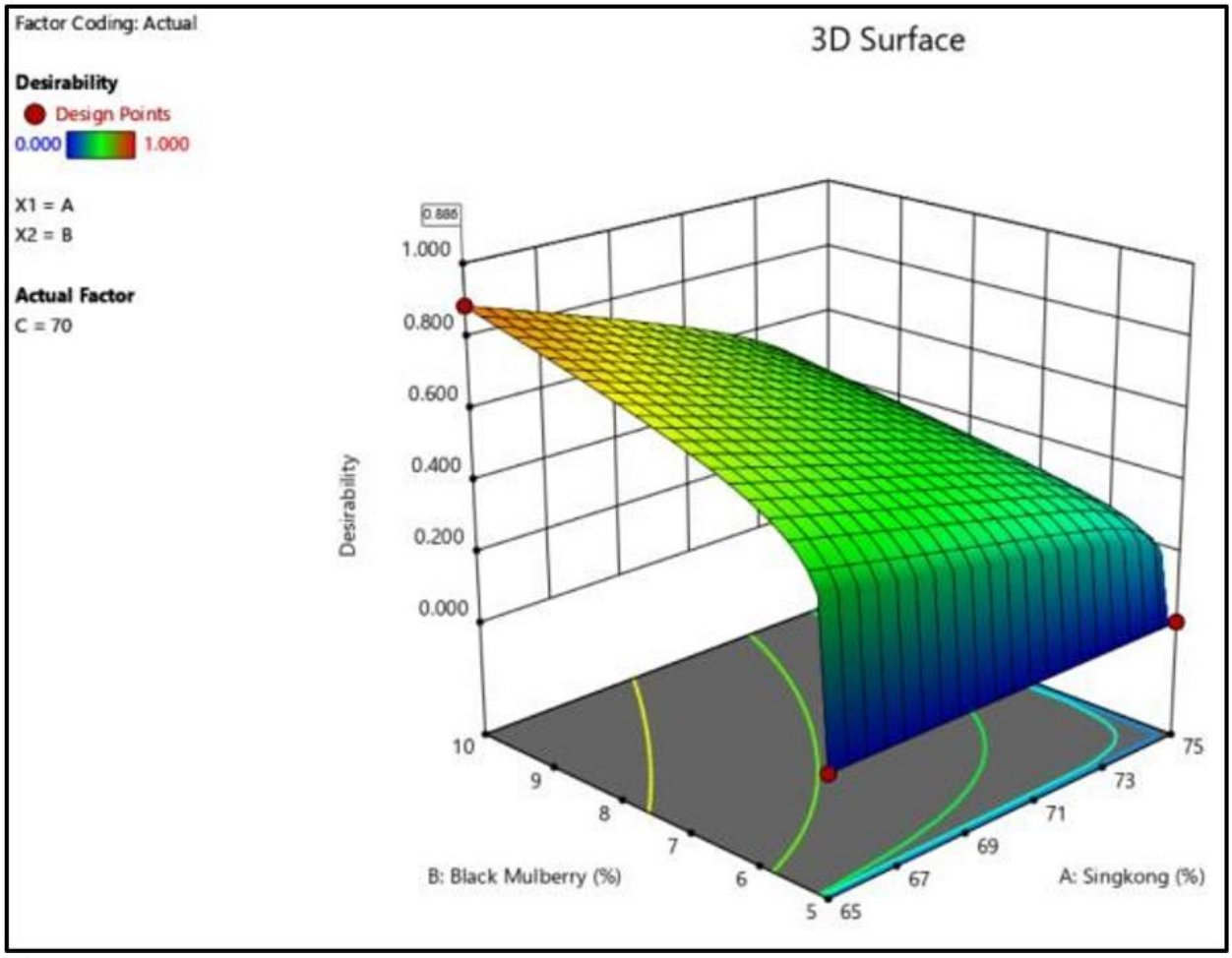

Figure 13.
3D Surface Plot of Desirability Value.

The selected formulation represents the optimum formula, consisting of 65% cassava, 10% black mulberry, and a drying temperature of 70°C. This formulation achieved a desirability value of 0.886, meaning that the formula produced a product with characteristics that met 88.6% of the optimization target. Therefore, *Design Expert Ver-13* recommended this formulation as the selected optimal solution.

Based on the research findings, it can be concluded that the optimal formula can be determined using *Design Expert* software with the Response Surface Method (RSM) and the Central Composite Design (CCD) model. The verification results showed that the selected formula had the following characteristics: moisture content 27.294%, total carbohydrate content 84.033%, sensory evaluation scores of aroma 4.00, color 4.74, taste 3.59, and texture 3.95.

4. Conclusion

Based on the results of the research conducted, it was concluded that the optimal formulation using the Design Expert software with the Response Surface Method (RSM) achieved a desirability value of 0.886. This value indicates the selected formulation and optimal drying temperature that can produce dried cassava getuk with black mulberry juice, meeting the optimization target of 88.6%. The

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selected formulation consists of 65% cassava and 10% black mulberry, with a drying temperature of 70°C. Verification results showed that the selected formulation had a moisture content of 27.40%, total carbohydrate content of 84.08%, aroma attribute of 4.33, color attribute of 4.40, taste attribute of 4.10, and texture attribute of 4.27.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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