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Original Paper

Corn-based Wingko Processing Optimization Using Response Surface Methodology

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Abstract*— *Wingko* is semi-wet food from Indonesia made from grated coconut, glutinous rice flour, sugar and other additives which form a distinctive taste and aroma. The utilization of corn in the form of flour aims to reduce the use of glutinous rice flour as the main composition of *Wingko* because, in addition to being an economic commodity, corn contains fiber which is useful for digestion. This study aims to determine the effect of the proportion of corn flour, sticky rice flour and tapioca on the physical and chemical properties of *Wingko*. This study uses the Response Surface Methodology (RSM) method with the experimental design of the Central Composite Design (CCD) using 3 factors of 5 levels, namely the proportion of corn flour (43.18; 50; 60; 70; 76.82) (w / w), flour sticky rice (23,18; 30; 40; 50; 56,82) (w / w), tapioca flour (6,59; 10; 15; 20; 23,41) (w / w). These factors are analyzed using Design Expert software 7.1.5. The parameters observed were corn flour including water content, ash, starch, amylose, crude fiber and yield. On glutinous rice flour and tapioca, the analysis also focuses on starch and amylose content. To contrast, on *Wingko* products, the analysis includes water content, aw, starch, crude fiber and texture. The results show that corn flour has 7.12% moisture, 0.34% ash, 84.72% starch, 21.22% amylose of the total ingredients, 1.15% crude fiber, and 79.8% yield. Glutinous rice flour has a starch content of 81.98% and 1.02% amylose of the total ingredients. By contrast, tapioca flour has a starch content of 78.71% and 20.63% amylose of the total ingredients. The optimum conditions of *Wingko* products are characterized by the proportion of corn flour: sticky rice: tapioca 50:38:20 (w / w) with 23.46% moisture content, aw 0.881, 50.87% starch, 2.78% crude fiber, and texture of 0.01194 mm / gs with desirability 0.831.

Keywords*— *corn, optimization, response surface methodology, Wingko

I. INTRODUCTION

Wingko is a semi-wet food made from grated coconut, glutinous rice flour, sugar and other additives to form a distinctive aroma (Singgih and Harijono,2015). According to [21], in a long period of time, *Wingko* has experienced a diversification of flavor and presentation variants, but there has not been much development in the diversification of the basic ingredients of *Wingko*. The use of corn in making *Wingko* can reduce the use of glutinous rice flour. It has been confirmed by [21] that *Wingko* with substitution of corn flour up to 60% is still preferred by panelists. Corn contains 21.68% amylose and 57.69% amylopectin of the total ingredients [17]. In addition, it contains fiber which is useful to prevent various degenerative diseases such as diabetes, high cholesterol, obesity, constipation, hemorrhoids [24].

Corn is one of the food crops that is easily grown in Indonesia and is abundantly available at an economical price. According to [14], corn production in 2014 amounted to 19,033,000 tons and experienced an increase of 1.11% over the past 5 years. The use of corn as an industrial raw material will add value to the commodity farming business [22]. Corn is more profitable because it is more flexible, easily processed into a variety of processed foods and longer shelf life [3].

Wingko is traditional food that has the characteristics of a chewy texture. The presence of corn in *Wingko* causes the thickness of *Wingko* to be reduced due to the high amylose content in corn. According to Yu et al., (2009), foods with high amylose content are known to have high hardness values and low adhesiveness, so tapioca needs to be added because tapioca contains 8.06% amylose and 91.94% amylopectin of total ingredients [10].

Response Surface Methodology is a method of solving problems using mathematics and statistics in analyzing the problem. The response to be achieved is influenced by several variables so that the response is at its optimum point [23]. This response surface method is an advanced design that aims to find the optimum point based on the independent variables that have been known to pose influence using the Completely Randomized Design. Experiments with the response surface method were carried out in two stages, namely stage I experiments and stage II experiments. The experimental design used in stage I experiments was a two-level factorial design while the experimental design used in stage II experiments was Central Composite Design (CCD).

First phase experiments are also called preliminary research which can be done with a literature study of previous research [15]. [21], in his research entitled Experiments on Making *Wingko* Using Basic Materials of Sweet Corn Mix with Glutinous Flour, got the best results on the proportion of corn

flour: glutinous rice flour 60:40 on organoleptic responses so that it was used as the center point of research design. Semi-wet food products such as *Wingko* have a major component which needs to be considered, namely water content. The addition of tapioca flour aims to reduce the moisture content of corn-based *Wingko*. According to [29], the addition of tapioca flour by 10% -20% can reduce *Wingko* water content by approximately 19.88-20.30% and produce a more springy texture ranging from 0.093 to 0.109 mm / g.s. The proportion of tapioca flour of 10 gr (w / w) is used as the lower point and 20 gr (w / w) tapioca as the upper point with the midpoint of 15 gr in this study.

This study aims to determine the effect of the proportion of corn flour, sticky rice flour and tapioca flour on the physical and chemical properties of corn *Wingko* Also, it aims to determine the optimum proportion of corn flour, glutinous rice flour and tapioca flour from *Wingko* corn products from the research model. It is also projected to investigate the appropriateness of the real results subsequent to the validation.

II. MATERIALS AND METHOD

A. Material

The materials used in this research were hybrid varieties of BISI 2, grated coconut and coconut water, glutinous rice flour, tapioca flour, eggs, sugar, salt, vanilla and margarine and chemicals including K2SO4, HgO, H2SO4, distilled water , NaOH, H3BO3, HCl, NaCl and diethyl ether.

The tools used in making corn flour included grinding machines and cabinet dryers. Upon making *Wingko*, cales and processing equipment (spoons, bowls, basins, knives, topping, sutures, stoves and molds) are used. The tools used for testing consisted of weighing bottles, porcelain exchange rates, ovens, furnaces, desiccators, analytical balances, penetrometers, aw meters, soxhlets, and hot plates.

B. Method

This research applied RSM (Response Surface Methodology) design method with CCD (Central Composite Design) research design using Design Expert 7.1.5 software. The response variables observed were water content, aw value, starch content, crude fiber and texture, with independent variables / factors:

Proportion of corn flour (X1)	: 50, 60, 70
Proportion of sticky rice flour (X2)	: 30, 40, 50
Proportion of tapioca flour (X3)	: 10, 15, 20

C. Research stage

1) Preliminary research

This stage was carried out before conducting research and was aimed to determine the factors which influenced the response. This objective can be done through literature study [15].

According to [21], the best proportion of corn flour and sticky rice is 60:40 in sensory response (preference) and 80:20 is best in crude fiber response (3,295%) and beta carotene (592.8 µg). In *Wingko* SNI Quality Standard No. 01-4311-1996 the maximum limit of crude fiber is 3%, so the proportion of corn is chosen 60, sticky 40 as the midpoint with corn 50, sticky 30 as the bottom point and corn 70, sticky 50 as the top point in the optimization process.

[29] research on *Wingko* with tapioca flour substitution of 10% generated the best response to hardness (0.093 mm / gs), sensory response (preference) color parameters 5.5 (strongly preferred) and taste 4.8 (preferred), while the proportion of 20% responses The best results are revealed in water content (19.88%), free fatty acids (1,127%) and sensory response of aroma parameters 4.9 (preferred). Each proportion has the best response respectively so that the proportion of tapioca 10 becomes the bottom point, and 20 becomes the upper point with 15 being the midpoint in the optimization process.

2) Corn flour making

The research procedure began with making corn flour. The corn used was corn rice which had undergone a process of grinding and separating grits, epidermis and institutions then soaked in 1: 2 (w / v) water for 1 hour which aimed to facilitate the grinding process. Corn kernels were ground or floured until a fine corn flour was obtained, the results of which were dried with a cabinet dryer with a temperature of 50 ° C for 5 hours. Corn flour was sieved with 80 mesh sieve to obtain fine corn flour. 80 mesh sized cornmeal analyzed includes water content, ash content, starch content, crude fiber and yield.

3) Corn-based Wingko Production

Weighing the ingredients included corn flour, glutinous rice flour, tapioca flour, sugar, grated coconut, salt, coconut water, vanilla and margarine. The first batter was mixed with grated coconut, sugar, salt and vanilla until these ingredients were well blended and the texture became slightly runny. Afterwards, egg yolks were added, and the mixture was stirred until smooth. The next process was to enter sticky rice flour, corn flour and tapioca flour. All ingredients were stirred to achieve well blended mixture. Coconut water was added so that the mixture was runny or slightly runny. The next step was baking the dough on a mold covered with margarine over low heat. Roasting was done at a temperature of 90°C for 15 minutes. The final product analysis included water content, aw, starch content, crude fiber and texture.

4) Testing and analysis

Tests and analyzes conducted on corn flour included analysis of water content, ash, starch, crude fiber and yield. In the *Wingko* product the analysis carried out was water content, aw, starch content, crude fiber and texture. After the product response value was obtained, data analysis was done using Design Expert 7.1.5 software to get the optimum process.

5) Validation

Validation was concerned with assessing the difference in prediction results reported by Design Expert 7.1.5 software with the results of the analysis at the optimum point. The software prediction results were obtained from the program after analysis so that a point was suggested by Design Expert 7.1.5 software as the optimum point. When the difference was less than 5%, the prediction value and the results of the study did not differ much, thus showing the accuracy of the model.

III. RESULTS AND DISCUSSION

A. Raw material analysis

Based on Table 2. there is a difference between the results of the analysis with [17], but no significant difference is evident in the parameters of ash and amylose content. The difference in water content analysis is due to the different flouring processes that are carried out. In [17] corn was roasted overnight, while in this study flour was dried for 5 hours so that the water content in the material was higher but had fulfilled the requirements of SNI 01-3727-1995. Other parameters such as ash content, crude fiber and yield also have also met SNI 01-3727-1995 requirements.

At the starch level, there are differences in the results of the analysis, compared to the findings in [18], due to differences in harvest age, season, climate in the planting land and the process used for the extraction of corn starch. As explained by [8], planting areas can affect the nature and content of materials in plants. [12] also state that different types of starch extraction methods affect the chemical composition and starch properties.

Food starches are generally composed of a quarter of amylose and three-quarters of amylopectin [30]. Amylose content of corn flour is composed of a quarter of the total starch which reaches 21.22%. According to Singh et al. (2005), normal corn contains 15.3-25.1% amylose. The corn used for making *Wingko* is a hybrid corn variety of BISI 2, which is normal corn.

TABLE 1. Research Design at Design Expert 7.1.5

Run	Independent Variables		
	Corn Flour	Sticky Rice Flour	Tapioca Flour
1	50	30	20
2	60	40	15
3	60	56.8179	15
4	50	50	10
5	60	23.1821	15
6	70	50	10
7	60	40	15
8	60	40	6.59104
9	60	40	15
10	60	40	23.409
11	60	40	15
12	50	30	10
13	43.1821	40	15
14	76.8179	40	15
15	60	40	15
16	60	40	15
17	50	50	20
18	70	50	20
19	70	30	20
20	70	30	10

In general. rice flour can be distinguished according to its amylose content. Amylose content 0-2% including glutinous rice flour. 20-25% including normal or medium rice flour and 25-30% including high amylose rice flour [25]. The amylose content of glutinous rice flour is 1.02%. According to [2] the amylose content of glutinous rice flour is less than 5% or almost does not have amylose and contains high amylopectin.

The results of the analysis of tapioca starch content of 78.71% fulfilled the SNI 01-2997-1996 quality requirements as indicated by starch content of 75% (w / w). This finding is in line with Singh et al.. (2006) who state that tapioca flour starch levels range between 72-81%. Also. it is in harmony with the research of [9] which measures the starch content of various tapioca starch varieties. namely around 77%-81%. Amylose content produced was 20.63%. This finding supports the opinion of [16] who contends that the amylose content of tapioca flour is in the range of 20%-27%. According to [9]. the amylopectin content of tapioca flour ranges from 50%-58%. This is consistent with the amylopectin content of tapioca flour produced. which is 58.08%.

TABLE 2. Proximate Analysis of Corn Flour

Parameters	**Corn Flour**		
	Analysis Result	**SNI 01-3727-1995***	**Muhandri (2007)**
Water Content (%)	7.12	max 10	5.23
Ash Content (%)	0.34	max 1.5	0.37
Starch Content (%)	84.72	-	79.37
Amylosa (%)	21.22	-	21.68
Crude Fiber (%)	1.15	max 1.5	-
Yield (%)	79.8	min 70	-

* National Standardization Agency of Indonesia.1995

B. Analysis result of Wingko product

1) Water content

Based on the analysis it is found that the water content between corn-sticky rice flour and corn-tapioca flour is not significantly different. which is around 22.6%-23%. Corn flour is the main factor that influences the low water content in *Wingko*. This is due to corn containing 21.22% greater amylose than 1.02% sticky rice flour and 20.63% tapioca (see Table 3). which demonstrates that the higher the amylose lead to the greater the ability to absorb water. The higher the amylose content is. the ability of starch to absorb water will be. Also. the absorbance becomes more intense because amylose has the ability to form hydrogen bonds which are greater than amylopectin [11].

TABLE 3. Comparing starch content and amylose of flour

Parameter	Corn Flour	Stcky Rice Flour	Tapioca Flour
Starch Content (%)	84.72	81.98	78.71
Amylose (%)	21.22	1.02	20.63
Amylopectin(%)	63.50	80.96	58.08

2) Water activity (Aw)

The lowest aw value is found in the interaction of corn flour and sticky rice where the amylopectin content of glutinous rice flour is the highest compared to the other two flour types. i.e. 80.96%. This circumstance causes the gelatinization process to take longer time to occur. This is consistent with the opinion of [10] which contends that high amount of amylopectin content in glutinous rice flour starch requires high temperatures to reach its gelatinization point. causing free water outside the granules. Also. water which has been bound inside the starch granules will continue to evaporate until the gelatinization point is reached.

Based on Figure 1. it is known that the lowest aw value generated from the interaction of raw *Wingko* materials is around 0.818905-0.829036. *Wingko* made of maize has similar value of aw compared to corn-based *Wingko*. according to [4]. which ranges from 0.6 to 0.8.

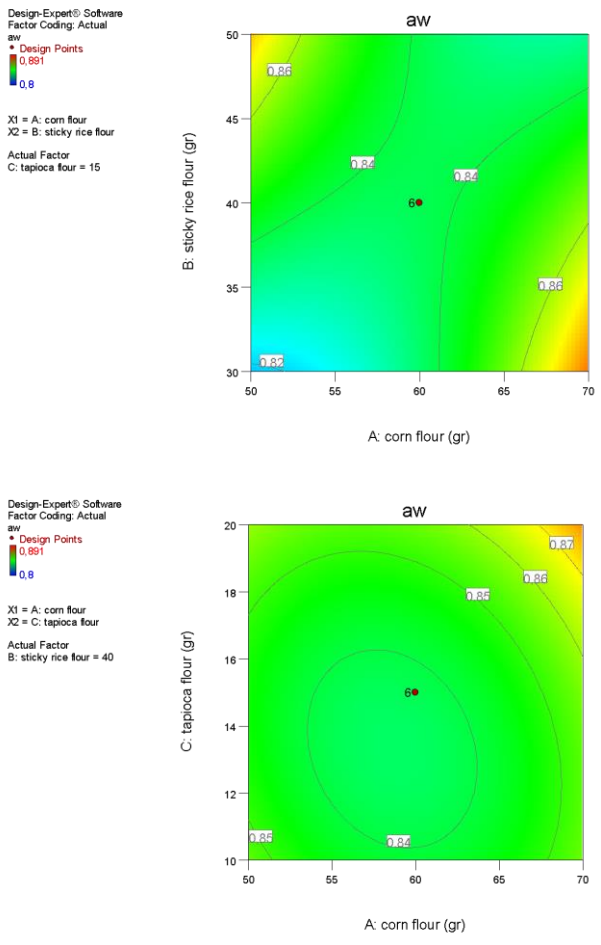

Figure 1. water activity contour : (A) [corn flour: sticky rice flour]. (B) [corn flour : tapioca flour]

3) Starch Content

Based on the three graph models. it was found that each flour interaction produced starch levels ranging from 53% - 54%. This result is greater than *Wingko* starch content with only glutinous rice formulation. which is 45.99% [26]. This is due to the manufacture of corn-based *Wingko* flour formulations which include such ingredients as corn flour. sticky rice and tapioca have a large starch content of 84.72%. 81.98%. 78.71% compared to previous studies which only use sticky rice flour. Total starch content of raw materials affects starch content [26]

4) Crude fiber content

Based on the graph above. it is known that the levels of crude fiber interaction of corn flour and tapioca are higher than that between glutinous and tapioca flour. This is because the levels of crude fiber in corn flour by 1.15% (Table 2) are greater than 0.35% glutinous rice flour [13] and tapioca flour at 0.13% [7]. Raw fiber content has an effect on the crude fiber content of the product. Starch contains less crude fiber than flour because of the process of extracting large amounts of fiber which is wasted with pulp [1].

5) Texture

Based on the three graph models. the highest texture value is obtained in the proportion of tapioca flour 15 (w / w) where the lower the corn flour and the higher the glutinous rice flour with a maximum texture value of 0.0167161 mm / g.s (Figure 2). Products with high amylose content have high hardness value and low adhesiveness because in the post-cooking process. amylose easily undergoes retrogradation where amylose is reunited to form strong amorphous. which causes the texture to become hard. This is in accordance with the opinion of Yu et al. (2009) who contend that texture properties such as hardness and adhesiveness correlate with amylose content and starch retrogradation. [6] also states that high starch amylose content can produce harsh products because the process of starch division occurs limited.

6) Optimization and response validation

Optimization is a process to obtain maximum desirability value by considering all objective criteria. Optimization is done based on the results of the analysis of each response to treatment (formula). Analysis of the model aims to determine whether significant response is evident and it is optimized to get the optimum formula [5].

The optimum conditions are obtained for corn flour by 50 grams. glutinous rice flour by 37.75 grams and tapioca flour by 20 grams with the highest desirability value 0.831. Desirability value of 0.831 or 83.1% means that desires based on the specified optimization criteria can be fulfilled by 83.1%.

After getting the selected proportions validated by making products according to the recommended proportions as the selected proportions (optimum). an analysis of the product characteristics is carried out. The results of the analysis will provide the actual value. while the previous optimization

calculation has estimated the response value (prediction) obtained from the regression coefficient in the regression equation of each response [5].

Table 4 shows that there are differences in the value of real responses compared to predicted response values. Based on the validation results. the difference between the real and predicted values of the response of water content is 4.5%. aw level 3.2%. starch content 0.7%. crude fiber 4% and texture 8.5%. According to Wu et al.. (2006). differences in predictive values and research values of no more than 5% indicate that the model is fairly appropriate for the process to be accepted. Based on the difference between the real value and the prediction of the five responses. the model is proven appropriate in determining the optimum conditions except the texture response.

TABLE 4. Response Value At Optimum Condition

Response	Value (y^)	Real Value (Lab Test)
Water Content (%)	22.429	23.46
a_w	0.853	0.881
Starch Content (%)	51.234	50.87
Crude Fiber (%)	2.896	2.78
Texture (mm/g.s)	0.01306	0.01194

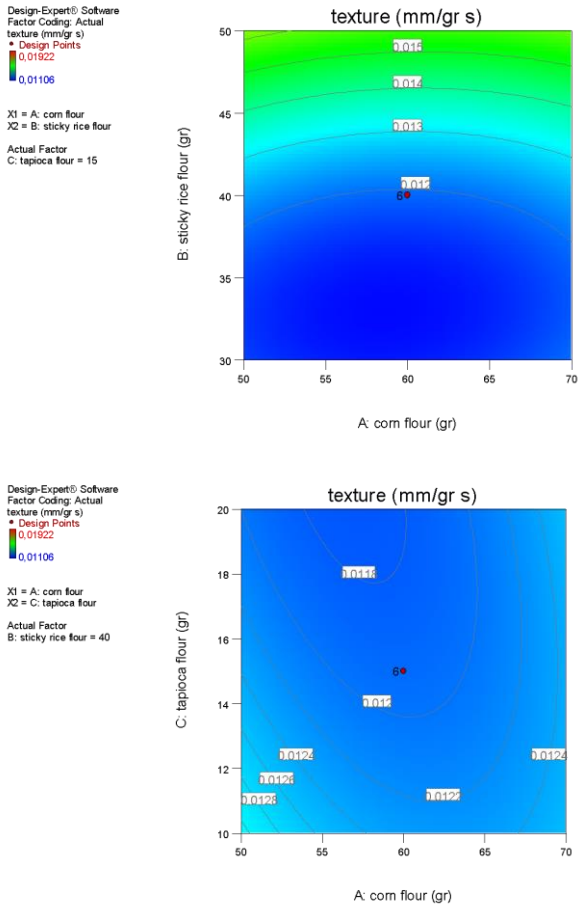

Figure 2. Texture contour : (A) [corn flour : sticky rice flour]. (B) [corn flour : tapioca flour]

IV. CONCLUSION

Corn flour raw material used has fulfilled the requirements of SNI 01-3727-1995. The optimum proportions selected with a desirability value of 0.831 are 50 gr corn flour (w / w). 38 gr glutinous rice flour (w / w) and 20 gr tapioca flour (w / w) with a response of 23.46% water content. aw 0.88. starch content 50.87%. crude fiber 2.78% and texture 0.01 mm / gs. Validation shows that the model is suitable for the response of water content. aw. starch and crude fiber ($\alpha \leq 0.05$). However. the texture response is not appropriate in determining the optimum conditions.

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