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Textural optimization of Ledre: Indonesian crepes-like snack

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KEYWORDS

Crepes
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ABSTRACT

Ledre is a traditional crepes-like snack uniquely made by Indonesian Chinese descendant in Bojonegoro, East Java, Indonesia. However, there is a lot of varieties in terms of formulations, ingredients and techniques. Therefore, this study aimed to optimize the composition of raw materials (comparison of rice flour and tapioca, thickness of coconut milk with the ratio of coconut and water (w/v) and the amount of banana addition) using the response surface method (RSM) to optimize the textural quality of Ledre. It was found that the optimum textural quality of Ledre obtained with a ratio of rice flour: tapioca of 17.5: 1, a ratio of water and coconut milk of 4: 1 and the addition of 4 g bananas. This Ledre was characterized by 428.18 gf of fracturability value, 600.22 gf of hardness, 3.31% of water content, 5.03% of protein content, 1.73% of ash content, 5.27% of fat content, and 43.48 of brightness (L*).

Introduction

Ledre is generally produced by micro, small and medium enterprises (MSMEs). The quality of Ledre products on the market varies depending on the formulation. The initial surveys on 15 MSMEs showed that there is a variability of recipe to make Ledre. The diversity includes ratio of rice flour and tapioca (between 2: 1 to 33: 1), ratio of coconut milk and water (between 1: 2 to 1: 6) and the amount of banana addition (between 3 - 5 g / roll).

Rice flour is an important ingredient for Ledre processing. Rice flour contains 12.2 to 28.6% of amylose (Wani et al., 2012). Cauvain and Young (2006) mentioned that the primary function of using flour in baked products is the gelatinization process between starch and water. The contact of water and starch in conjunction with high temperature during the baking process induces starch swelling and gelatinization. Furthermore, higher amylose in rice flour tends to have denser granules thus lower swelling power and solubility. Consequently, the product becomes harder and denser (Yu et al., 2012).

The addition of tapioca in Ledre processing plays an essential role as according to Sun and Yoo (2015), tapioca affects the viscosity, increases the gel strength and significantly decreases syneresis. Furthermore, tapioca flour simplifies the sheet-forming process ("ngledre"). The application of tapioca in baked products has been carried out by Shittu et al. (2008) as well as other products such as noodles (Eguichi et al., 2014), fruit filling pastry (Agudelo et al., 2014), soups (Wongsagonsup et al., 2014), sauces (Bortnowska et al., 2016), and cassava crackers (Saeleaw and Schleining, 2010).

The primary purpose of adding bananas in making Ledre is to promote a unique banana aroma to the crepes. The banana aroma consists of various volatile components, in which ester and aldehyde groups are the major components. The ester group is included isoamyl acetate and 2-pentanol acetate, while the aldehyde group consists of n-hexanal aldehydes and 3-methyl butanol (Selli et al., 2012; Pino and Febles, 2013). The banana that commonly used for Ledre is over-ripe or fully-ripe “Raja” Banana or *Musa acuminata x Musa balbisiana. The level of maturity of banana can be detected by the presence of brown patches over the yellow skin.* Banana is added directly on the top of the dough sheet and then applied in the form of smoothies with a traditional crushing device ("uleg"), then leveled with “lethok” (tools of rectangular shape wood) until evenly distributed on the entire surface of the Ledre sheet.

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The use of coconut milk in making Ledre is not only used as thinner to produce batter but also a source of fat that improves taste and texture. According to Cauvain and Young (2006), coconut milk is an essential source of fat in providing an excellent mouth-feel sensation. The viscosity of coconut milk used in the manufacture of Ledre affects the quality of the Ledre produced.

This study aims to determine the optimum recipe of Ledre, particularly in terms of rice flour and tapioca proportion and thickness of coconut milk as well as the addition of banana using the Response Surface Methodology (RSM). RSM is very effectively used to reduce the number of experiments needed for complex research (Giovanni, 1983). Furthermore, RSM has been applied for development and optimization in manufacturing bean paste (Badwail et al., 2014) and noodles (Vijayakumar and Boopathy, 2014).

Research Methods

Samples

The samples used in the process of optimizing the composition of the raw materials for Ledre were rice flour of the NE brand and tapioca brand of Bogasari, granulated sugar, coconut, and Raja bananas with a maturity level of 7 (overripe) with physical characteristics of yellowish, brownish spots on the skin.

Sample preparation

Ledre was prepared from mixed raw materials with 17 combinations (Table 1). First, all ingredients were stirred manually until a viscous liquid were formed. Next, the Ledre dough was poured and leveled with "lethok" on a hot pan until a thickness of between 0.22-0.27 mm. Third, the Ledre was added with a banana piece that was already smoothed with "uleg" and flattened on the Ledre surface. After the Ledre sheet became half dry, it was sprinkled with granulated sugar. Cooked Ledre was characterized by changing the color of the edges of the Ledre sheet to brown. Last, the Ledre sheet was taken and rolled manually in hot conditions. Ledre as many as 20-25 rolls were packaged in PP plastic with a thickness of 0.3 mm.

Methods

Chemical testing of Ledre compositions such as water, fat, protein, and ash was analyzed using the AOAC method (1990). Texture parameters (hardness and fracturability) measured using a TA XT Plus texture analyzer (stable microsystems with 50 kg load cell with pre-test speed of 1.0 mm /sec and test 2.0 mm / sec) and repeated three times. Hardness was calculated from the maximum value of the peak force. The greater the maximum value of the peak force, the more complex the sample becomes. Fracturability is the point where the force exerted makes the object break/fracture. Samples with a large force show low fracturability. Brightness analysis on the Ledre surface with L* (lightness) parameters was measured using a Minolta Reflectance Chromameter (CR-400) color reader.

Table 1. Box Benhken experimental design for Ledre formulation format table

Runs	Rice Flour: tapiocca flour ratio	Viscosity (Coconut: Water ratio)	Banana Quantities
1	17.5 : 1	1 : 4	4
2	33 : 1	1 : 6	4
3	33 : 1	1 : 2	4
4	17.5 : 1	1 : 6	5
5	33 : 1	1 : 4	3
6	17.5 : 1	1 : 2	5
7	33 : 1	1 : 4	5
8	17.5 : 1	1 : 4	4
9	17.5 : 1	1 : 4	4
10	17.5 : 1	1 : 2	3
11	17.5 : 1	1 : 4	4
12	2 : 1	1 : 4	3
13	17.5 : 1	1 : 6	3
14	17.5 : 1	1 : 4	4
15	2 : 1	1 : 6	4
16	2 : 1	1 : 4	5
17	2 : 1	1 : 2	4

Design of experiment

The combination of treatments used in RSM was Box-Behnken, with three treatments and three levels. The independent variables used were the ratio between rice flour and tapioca (X1 = 2:1; 17.5:1; 33:1), coconut milk viscosity (comparison between coconut and water; X2 = 1:2; 1:4; 1: 6) and the number of bananas used (X3 = 3; 4; 5). The number of experiments according to RSM was 17, with the composition shown in Table 1.

Data analysis

RSM was conducted on Design Expert 16. The model was validated using the F-ratio and coefficient of determination (R^2) at a significance level of 5%.

Results and Discussion

Model responses optimization

Estimated responses from various independent combinations can be seen in Table 2. The resulting different responses from various

Table 2. Physical and chemical characteristics of different Ledre formulation format table

Runs	Rice Flour:tapiocca flour ratio	Viscosity (Coconut:Water ratio)	Banana Quantities	Fracturability	Hardness	Water Content	Fat Content	Protein Content	Ash Content	Brightness
	(g/g)	(g/ml)	(g)	(gf)	(gf)	(%)	(%)	(%)	(%)	(*L)
1	33 : 1	1 : 6	4	801.91	803.12	1.85	4.89	3.87	1.71	43.9
2	17.5 : 1	1 : 4	4	437.58	562.68	3.29	5.24	5.10	1.78	43.7
3	33 : 1	1 : 2	4	759.84	817.98	2.09	6.23	6.02	1.82	43.5
4	17.5 : 1	1 : 6	5	526.97	424.04	2.59	4.67	3.68	2.12	37.4
5	33 : 1	1 : 4	3	775.04	826.12	1.49	5.16	4.87	1.49	45.4
6	17.5 : 1	1 : 2	5	482.08	608.55	1.69	6.21	5.75	2.06	38.2
7	33 : 1	1 : 4	5	783.01	865.41	2.55	5.23	5.02	1.82	35.9
8	17.5 : 1	1 : 4	4	426.56	639.12	3.40	5.11	4.84	1.65	43.1
9	17.5 : 1	1 : 4	4	488.56	498.45	3.55	5.32	5.09	1.64	44.9
10	17.5 : 1	1 : 2	3	452.11	531.14	1.99	5.96	5.62	1.42	45.3
11	17.5 : 1	1 : 4	4	417.46	692.61	3.04	5.34	5.17	1.68	43.2
12	2 : 1	1 : 4	3	866.76	1148.54	3.59	4.96	4.75	1.75	47.5
13	17.5 : 1	1 : 6	3	506.34	527.24	2.54	3.96	3.28	1.32	46.4
14	17.5 : 1	1 : 4	4	420.75	608.25	3.36	5.21	4.95	1.74	42.5
15	2 : 1	1 : 6	4	956.39	805.2	3.59	4.75	4.11	1.69	43.8
16	2 : 1	1 : 4	5	872.84	703.55	3.34	5.37	5.16	1.86	36.2
17	2 : 1	1 : 2	4	813.17	901.81	1.89	5.98	5.73	1.94	45.9

Table 3. Verification of optimized Ledre formulation format table

Solution	Optimum Level			Prediction Result							Desirability
	X_1	X_2	X_3	Fracturability (gf)	Hardness (gf)	Water Content (%)	Fat Content (%)	Protein Content (%)	Ash Content (%)	Brightness (*L)	
1	17.5	4	4	428.18	600.22	3.31	5.27	5.03	1.75	43.48	1
				T-Test Result							
Mean				432.39	609.84	3.332	5.376	5.123	1.81	45.24	
Sig.(2-tailed)				0.551	0.107	0.749	0.179	0.373	0.49	0.137	

combinations are fracturability 417.46–956.39 gf, hardness 424.04–1148.54 gf, moisture content 1.49–3.59%, fat content 4.67-6.21%, protein content 3.28-6.02%, ash content 1.32-2.12%, and brightness (*L) 35.9-47.5.

Fracturability

The effect of the independent variable on the fracture response is shown in Figure 1. In contrast, the quadratic value determined by the model coefficient value is shown in Table 3. The positive (+) and negative (-) signs and the coefficient value indicate the variable's effect on the response. Table 3 shows that the quadratic fracturability response was significantly ($p<0.05$) influenced by differences in the rice flour: tapioca, coconut milk viscosity, and the amount of banana added.

The ratio of rice flour: to tapioca flour contributed significantly ($p<0.05$) to the fracture. A crisp Ledre is characterized by a low value of fracturability, such as in crisp Chinese sticks (Ma et al., 2013). The ratio of low (2: 1) and high (33:1) rice flour will increase the value of fracturability (Table 2). The high amylose content in rice flour (25–28%) affects the increase in fracture strength of rice crackers from Japan (Senbei and rare) (Nakamura et al., 2012).

The primary function of fat in the batter during the kneading process perform as an air trap (Broker, 1993). The lower air trapped in the dough the stiffer the cookies texture become (Jacob and Leelavanthi, 2007).

The use of bananas in large quantities and the slathering step affect the Ledre to be slightly sticky. These factors affect an increment value of Ledre fracture.

Hardness

Hardness was significantly affected ($p<0.05$) by the ratio of rice flour: to tapioca flour and the interaction between the ratio of rice flour: to tapioca flour and the number of bananas. Tapioca starch has a high swelling ability which is indicated by a high maximum viscosity followed by a decrease in viscosity during heating. Crystalline decay causes the loss of the double helix of the amylopectin chain, resulting in the crystallinity of starch granules (Cookie and Gidley, 1992). The crystalline decay of tapioca starch generates low hardness and springiness values of the formed gel increasing the resulting product’s cripness (Li et al., 2014). The high fracture strength (hardness) value in crackers indicates a low level of crispness (Kusuma et al., 2013).

Textural hardness is related to fracture. The higher the hardness value, the higher the fracture value become (Halek et al., 1989). The optimum hardness illustration level for hardness is displayed in Figure 2. Therefore, the use of more bananas will increase the value of fracture so that it will increase the hardness value as well (Table 2).

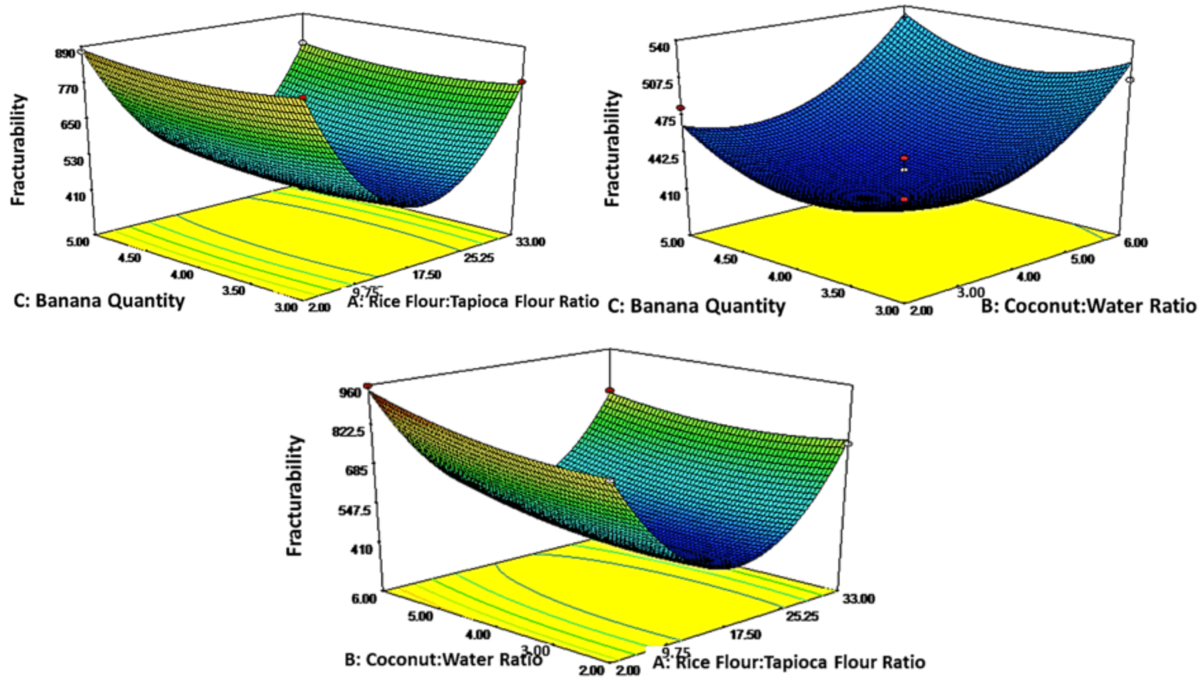

Figure 1. The effect of coconut milk thickness, flour ratio and banana addition to fracturability

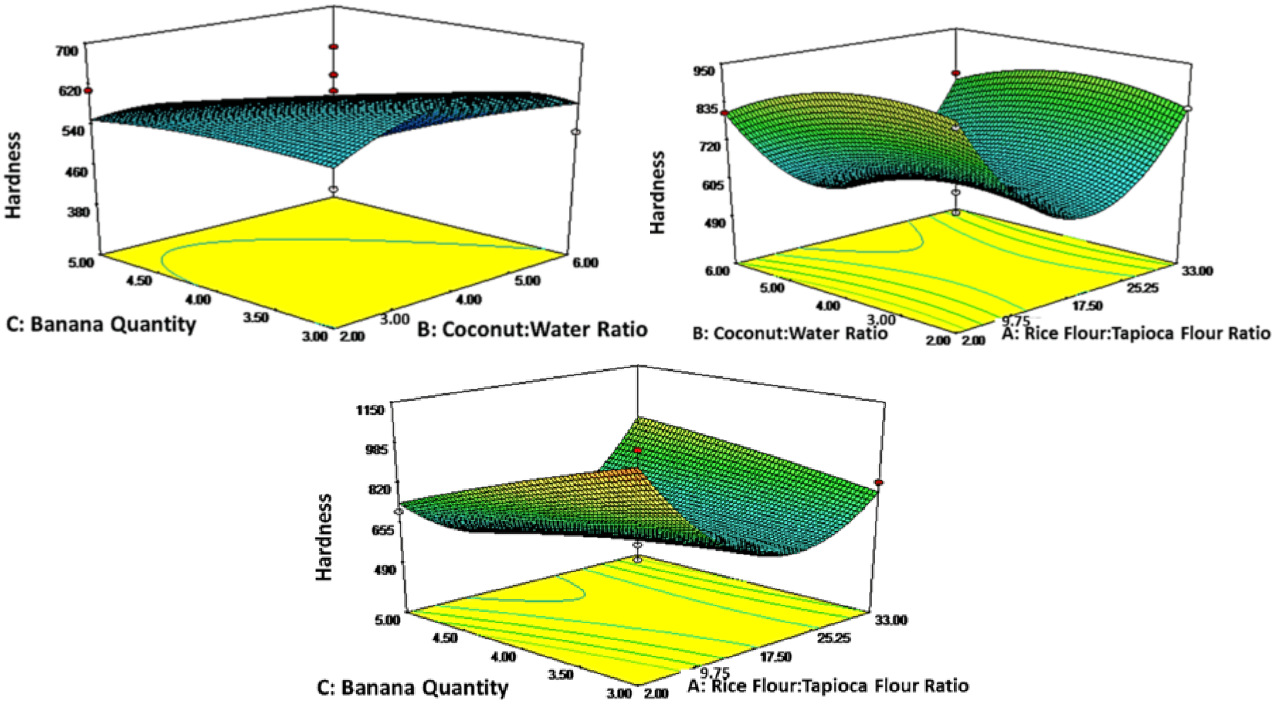

Figure 2. The effect of coconut milk thickness, flour ratio and banana addition to hardness

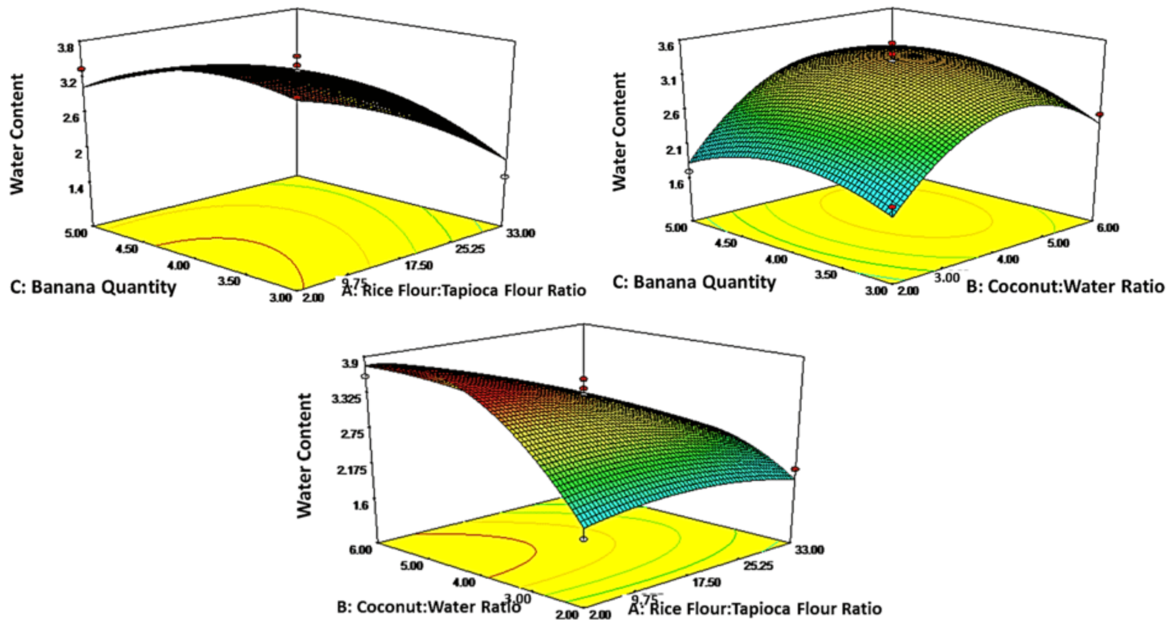

Figure 3. The effect of coconut milk thickness, flour ratio and banana addition to water content

Water content

The quadratic response of Ledre water content was significantly affected ($p<0.05$) by the independent variables of coconut milk viscosity and the number of bananas. Table 2 shows that the water content of Ledre has a value of less than 10%. The low water content of the Ledre affects the brittle texture of the Ledre. Low water content (<10%) makes corn meal extrudates crunchy and break efficiently (Halek et al., 1989).

Table 2 shows the addition of water in the manufacture of high coconut milk (comparison of coconut: water as much as 1:6 and 1:4) increased the value of the water content of the Ledre. Likewise, bananas that were used in a high quantity (4 and 5g) could increase Ledre water content. Bananas have a water content of 3.6% (Ministry of Health RI, 1995). The optimum water content illustration level for hardness is displayed in Figure 3.

Fat content

Ledre fat content was significantly affected ($p<0.05$) by the thickness of coconut milk and the number of bananas. The independent variable coconut milk viscosity negatively correlates with fat content with a coefficient of –0.76, meaning the higher the coconut milk viscosity (comparison of coconut: water is getting smaller) used causes an increase and higher fat content. Coconut milk is a high source of vegetable fat 15.44 ± 1.53% (Alyaqoubi et al., 2015).

On the other hand, the number of bananas was positively correlated with fat content with a regression coefficient of 0.18. The higher the number of bananas added to the manufacture of Ledre, the higher the fat content produced. Bananas contain fat content in relatively small amounts, such as 0.2 g/100 g bananas (Ministry of Health, 1995).

Protein content

The protein content of Ledre was significantly affected ($p<0.05$) by the thickness of coconut milk and the number of bananas (Table 3). Coconut milk contains 3.40 ± 0.59% protein (Alyaqoubi et al., 2015), meanwhile bananas are 1.2% (Ministry of Health RI, 1995).

Ash content

The ash content of the Ledre was only significantly affected ($p<0.05$) by the number of bananas. The independent variable coconut milk viscosity, positively correlates with fat content with a coefficient of 0.24. The higher the number of bananas used, the higher the concentration of coconut milk. Bananas contain several minerals such as Ca, P and Fe with values of 10.22 and 0.8 mg/100 g bananas, respectively (Ministry of Health, 1995) which affect the presence of minerals in the Ledre.

Brightness

The value of the brightness of the Ledre was only significantly affected ($p<0.05$) by the number of bananas added to the manufacture of the Ledre (Table 2). The brightness value (*L) indicates the brownish level of the Ledre. The brown colour of the Ledre is occurred due to the sucrose sugar from bananas and the addition of granulated sugar in the dough. The Maillard process occurs between protein from rice and sugar (Li et al., 2009), which causes the Ledre to have a slightly brownish color. The optimum water content illustration level for brightness is displayed in Figure 4.

Model optimization verification

Some of the optimization responses from the optimum level of each independent variable and the predicted value with maximum desirability are shown in Table 3. For example, the optimum condition of the independent variable for the Ledre formulation was chosen with a minimum fracturability value of 433.39 as the predicted result of the ratio of rice flour and tapioca (17,5: 1), the ratio of coconut: to water (1: 4) with the number of bananas added as much as 4 g.

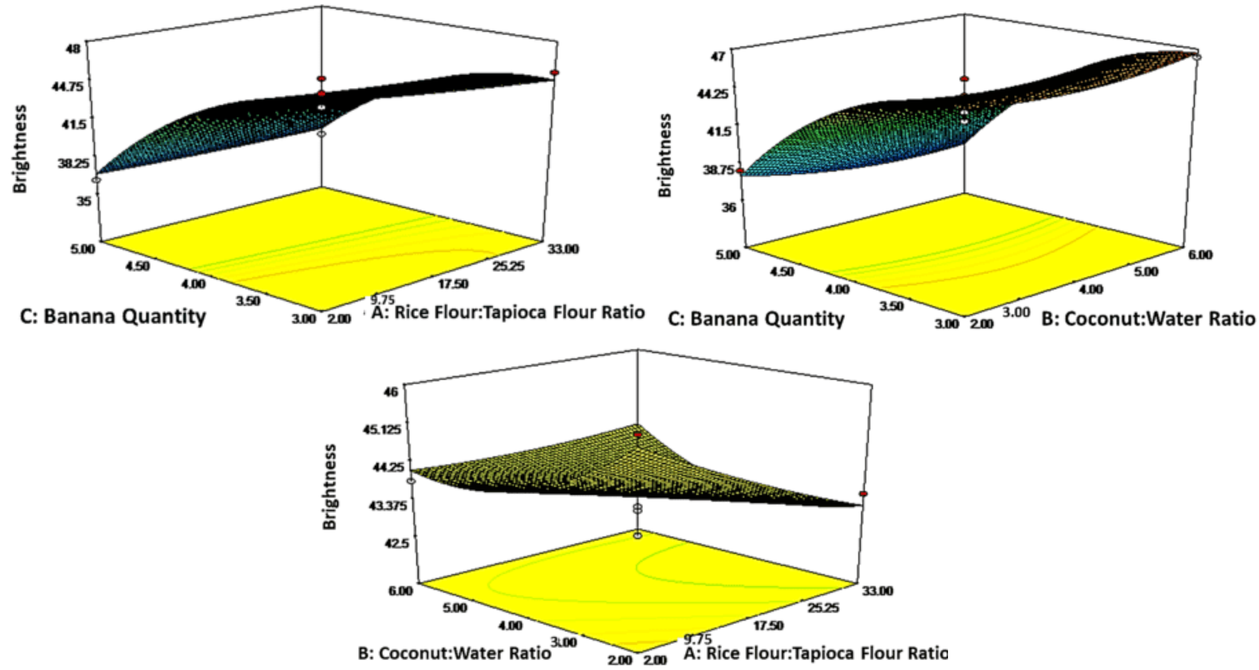

Figure 4. The effect of coconut milk thickness, flour ratio and banana addition to brightness

A verification was carried out to determine the difference between the predicted results (Table 3) and the results of the analysis at the optimum point (comparison of rice flour: tapioca (17.5: 1), the ratio of coconut: water (1: 4) with the amount of banana added as much as four g. The verification process was carried out by making Ledre using the optimum composition of the resulting raw materials. Verification test was done using a one-sample t-test (Sig.2-tailed) on the predicted values and research results.

The optimum point test results were obtained from a ratio of rice flour: tapioca (17.5: 1), a ratio of coconut: water (1: 4) and the number of bananas as much as 4 g, resulting in a fracturability response value of 428.18 gf, hardness 600.22 gf, water content was 3.31%, fat content was 5.27%, protein content was 5.03%, ash content was 1.73%, and brightness (*L) was 43.48. Verification was carried out ten times, with the results shown in Table 3. As the results of Sig (2-tailed) >0.05, thus it was concluded that there was no significant difference between the predicted and the observed results. This indicates that the verification results were acceptable.

Conclusion

The optimum condition of the raw material for Ledre was obtained with a ratio of rice flour: tapioca of 17.5: 1 with a ratio of coconut and water of 1: 4, and the addition of bananas of 4 g. This optimized recipe provided Ledre with a fracturability value of 428.18 gf, hardness 600.22 gf, levels of water content is 3.31%, protein content is 5.03%, ash content is 1.73%, fat content is 5.27%, and brightness (*L) is 43.48. Increase in banana and rice flour: tapioca can elevate the crispness level.

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Declarations

Conflict of interests The authors declare no competing interests.

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