Formula Optimization and Characterization of Physicochemical and Sensory Properties of Gluten-Free Noodles Based on Modified Cassava Flour with Addition of Soybean Flour and Skim Milk

Santi Dwi Astuti[1)*], V. Prihananto[1)], Ali Maksum[1)], Ervina Mela D.[1)], Indah Fitri H[1)]

[1)] Department of Agricultural Technology, Jenderal Soedirman University
*E-mail : santi.astuti@unsoed.ac.id

ABSTRACT

Gluten-free noodles from modified cassava flour had low protein content and a less favorable taste. Besides being able to increase the protein content, the addition of soy flour and skim milk in the noodle formula was intended to reduce the unfavorable flavor. The other ingredients used in the production of noodles were cassava starch, xanthan gum, sodium tripolyphosphate, salt, and egg yolk. This study were aimed to : 1) optimizing the proportion of soy flour and skim milk which had maximum elongation, intensity of preference, springiness, and elasticity; rehydration time, color intensity, cassava flavor, beany flavor, milky flavor in the range value; and cooking loss at the minimum value; 2) examine the effect of addition of soy flour and skim milk on the physicochemical and sensory properties of product; 3) comparing the physicochemical and sensory properties of products with optimum formula and control (products without the addition of soy flour and skim milk). The optimization of the formula was carried out by the response surface methodology (RSM) using a central composite design. The lower and upper limits set for the proportion of soybean flour were 0 and 30%, while for skim milk were 0-20%. With software design expert (V.XIII for trial) using 2 blocks, obtained 14 factor combinations. Sensory test was done by scoring method using intensity scale 1-7. The results showed that: 1) The formula consisting of 8% soy flour and 17% skim milk produced the optimum product with a desirability value of 0.8; 2) The increasing of the proportion of soybean flour causes an increase in rehydration time, cooking loss, color intensity and beany flavor; and cause a decrease in the value of elongation, springiness, elasticity, cassava flavor, milk flavor, and overall acceptibility; 3) The increasing of the proportion of skim milk causes an increase in the intensity of springiness, elasticity, milky flavor, color, and overall acceptibility, as well as a decrease in the rehydration time and intensity of cassava and beany flavors; while the elongation value decreases, and the cooking loss value increases; 4) Compared to the control, the product with the optimum formula had higher intensity for all sensory attributes and elongation values which were not significantly different, but higher rehydration time and cooking loss; 5) The optimum product contains 5.8% wb protein, 1.8% wb fat, 2.7% wb ash, 80.85% wb carbohydrates, and produces 362.8Kcal/100g of energy.

Keywords: modified cassava flour, gluten-free noodles, soy flour, skim milk, response surface methodology

INTRODUCTION

Based on the raw materials used, noodles are grouped into wheat noodles and non-wheat noodles. Wheat noodles are made from wheat flour with a high protein content which is dominated by gliadin and glutenin proteins. These two proteins will form gluten which plays a role in the formation of elastic plastic noodle strands. Non-wheat noodles can be made from starchy ingredients, including various types of tubers such as cassava. The cassava flour used in the present invention was made through biological modification by submerge fermentation using commercial Bimo CF inoculum. This product has characteristics that are suitable for use as a raw material in making noodles compared to natural flour (nativ flour).

Noodles were food source of carbohydrates that were widely consumed by Indonesians besides rice. Usually, noodles were made from wheat which was still imported. Production of non-gluten noodles from modified cassava flour (Mocaf) can be an alternative to reduce wheat, while optimizing the use of cassava. Gluten-free noodles from modified cassava flour had low protein content and a less favorable taste. Besides being able to increase the protein content, the addition of soy flour and skim milk in the noodle formula was intended to reduce the unfavorable flavor. Soy flour and skim milk have a protein content of about 35%.

This study were aimed to : 1) Optimizing the proportion of soy flour and skim milk which had maximum elongation, intensity of preference, springiness, and elasticity; rehydration time, color intensity, cassava flavor, beany flavor, milky flavor in the range value; and cooking loss at the minimum value; 2) Examine the effect of addition of soy flour and skim milk on the physicochemical and sensory properties of product; 3) Comparing the physicochemical and sensory properties of products with optimum formula and control (products without the addition of soy flour and skim milk).

MATERIALS AND METHOD

Materials :

Cassava tuber and local variety of soybean were obtained from Banjarnegara dan Banyumas district. Other ingrediens (Skim milk, xanthan gum, sodium tripoliphosphate, salt, alkaine solution) were obtained from CV. Nuru Jaya Surabaya

The stages of research :

1. Determination of basic formula and process
2. Recruitment of semi trained panelists
3. Formula optimization (skoring test)
4. Physicochemical analysis of product with optimum formula

Basic formula :

The basic formula consists of the main and supporting ingredients, The percentage of supporting ingredients was calculated based on the total of the main ingredients used

Table 1. Basic formula

Type of ingredient	Name of ingredient	Basic value (%)
Main ingredients	Mocaf	82
	Soybean flour	8
	Cassava starch	10
	Total	100
Supporting ingredients	Xanthan gum	1
	Salt	1
	STPP	0.3
	Alkaline solution	1
	Egg	3
	Skim milk	15
	Water	87

Stages in the product manufacturing :

1) Manufacture of modified cassava flour using controlled fermentation technology (submerged method, tuber slice size 1 cm, soaking in 0.2% citric acid solution for 1 hour, followed by

immersion with 0.2% bimo for 48 hours, drying, milling, and sifting 80 mesh); 2) Making soybean flour (soaking the seeds followed by boiling for 20 minutes, separating the epidermis, drying, milling and sifting 80 mesh); 3) Making noodles (gelatinization of cassava starch, mixing with other ingredients, kneading, aging 30 for minutes, sheeting and cutting, steaming 15 minutes, drying at room temperature followed by 60oC using cabinet dryer for 4 hours

Formula optimization

The optimization of the formula was carried out by the response surface methodology using a central composite design. There were 2 optimized factors, i.e. the proportion of HFS and sorbitol. The minimum and maximum proportions for Soybean flour were 0 and 30%; while skim milk were 0 and 20%. The selection of 2 blocks using design expert software (V.XIII for trial) produced 14 factor combinations.

The Stages of formula optimization : 1) Determination of the upper and lower limits; 2) Making products with treatments result from RSM recommendation; 3) Measurement of responses; 4) Verification and validation

RESULT AND DISCUSSION

According to the Indonesian Industry Standard (SII) number 0178-90, dry noodles are noodles that have been dried until the water content reaches 8-10%. Noodles are usually made from wheat flour with the addition of water and other ingredients such as eggs and salt. Wheat noodles are made from wheat flour with a high protein content which is dominated by gliadin and glutenin proteins. These two proteins will form gluten which plays a role in the formation of elastic plastic noodle strands. Eggs function as an emulsifier and salt functions as a texture enhancer and salty taste.

Gluten-free dry noodles made from modified cassava flour have a different composition and manufacturing process than noodles made from wheat. In this invention, noodles from the main ingredient of modified flour are prepared by adding ingredients, namely: tapioca or cassava starch, water, xanthan gum, sodium tripolyphosphate, soda ash solution, salt, and eggs. Cassava starch is used to form a cohesive dough, creating and strengthening the elastic, plastic texture of the noodles when the dough is made and when the noodles are consumed. Water functions as a solvent for the ingredients used in making noodles. Water which is mixed with tapioca at the beginning of making noodles and then heated, will cause gelatinization of tapioca which is characterized by a change in form from liquid to a semi-solid paste, an increase in viscosity or thickness. This gelatinized starch will trap the other components and after kneading the dough will form a cohesive, elastic and plastic dough typical of noodle dough. Xanthan gum is a hydrocolloid that has a high ability to bind water and also functions as an emulsifier, reduces the level of stickiness and stabilizes the cohesiveness of the dough, and minimizes solid loss when the noodles are brewed (minimum cooking loss). Sodium tripolyphosphate will form phosphate bridges and strengthen the three-dimensional structure of starch from cassava flour and cassava starch. The presence of STPP in noodles causes the noodle strands to not break easily. Furthermore, a solution of soda ash and salt has a function similar to STPP in stabilizing and strengthening the structure and texture of noodles which are sturdy, plastic, elastic. Egg yolk functions as an emulsifier. In addition to the above ingredients, soy flour and skim milk are also added as protein sources. Soybean flour is made through the process of sorting, soaking, boiling, peeling the epidermis, drying, grinding and sifting. The protein content of soy flour ranges from 30-35%. Soy flour from local varieties of soybeans has a higher protein content than imported soybeans. The soybean flour used in this invention is derived from the soybean seed of the local Slamet variety. Skimmed milk in powder form, obtained from the separation of the milk fat (cream). The drying process of skim milk is usually done by spray drying. Skim milk has a protein content of about 35%. The use of soy flour and skim milk in the production of gluten-free noodles from cassava flour, besides being able to increase protein content, can also improve texture. Noodles are more compact, cohesive, softer, less sticky, and sensory-wise, noodles are preferred because they smell and taste better.

The data from 14 formula variations recommended by DES showed in Table 2. The results of measurements of the responses of each formula showed ini Table 3. The Mathematic Models for All Responses showed in Table 4.

Table 2. Formula variation

Run	A_Soybean flour (%)	B_Skim milk (%)	Cassava flour (%)
1	4,39	2,93	85,61
2	15	10	75
3	25,61	17,07	64,39
4	4,39	17,07	85,61
5	15	10	75
6	25,61	2.93	64,39
7	15	10	75
8	15	10	75
9	0	10	90
10	15	10	75
11	15	20	75
12	15	0	75
13	15	10	75
14	30	10	60

Table 3. The results of measurements of the responses of each formula

Run	Elongation±SD*)	Cooking Loss±SD*)	Rehidration time±SD*)	Springiness±SD*)	Brown color±SD*)
1	40.28 ± 6.81	18.21 ± 0.04	18 ± 0.00	4.87 ± 0.78	2.43 ± 0.94
2	31.23 ± 12.61	19.79 ± 0.04	20 ± 1.14	4.63 ± 0.56	3.77 ± 1.01
3	18.19 ± 0.08	28.42 ± 0.06	22 ± 0.00	4.23 ± 0.77	4.83 ± 0.91
4	40.36 ± 0.18	19.11 ± 0.07	19 ± 1.41	4.97 ± 0.76	3.23 ± 0.77
5	30.86 ± 4.91	20.11 ± 0.1	20 ± 1.41	4.67 ± 0.61	4.27 ± 0.83
6	42.86 ± 9.07	24.18 ± 0.03	21 ± 1.41	3.93 ± 1.28	4.60 ± 0.72
7	29.35 ± 5.26	19.78 ± 0.08	19 ± 0.00	4.73 ± 1.20	3.83 ± 0.59
8	34.42 ± 0.93	21.02 ± 0.08	21 ± 2.83	4.73 ± 1.11	3.73 ± 0.69
9	27.73 ± 3.50	18.39 ± 0.07	18 ± 1.41	4.63 ± 0.81	2.73 ± 1.11
10	25.57 ± 5.12	19.90 ± 0.06	21 ± 0.00	4.70 ± 0.75	4.17 ± 0.87
11	24.45 ± 0.52	21.39 ± 0.04	18 ± 2.83	4.83 ± 0.83	4.67 ± 0.66
12	48.59 ± 2.75	22.60 ± 0.06	22 ± 1.41	4.37 ± 0.76	2.97 ± 1.07
13	31.97 ± 0.37	19.79 ± 0.15	19 ± 2.83	4.77 ± 0.68	3.70 ± 0.65
14	40.66 ± 12.08	25.66 ± 0.06	22 ± 2.83	4.10 ± 0.96	4.77 ± 0.63

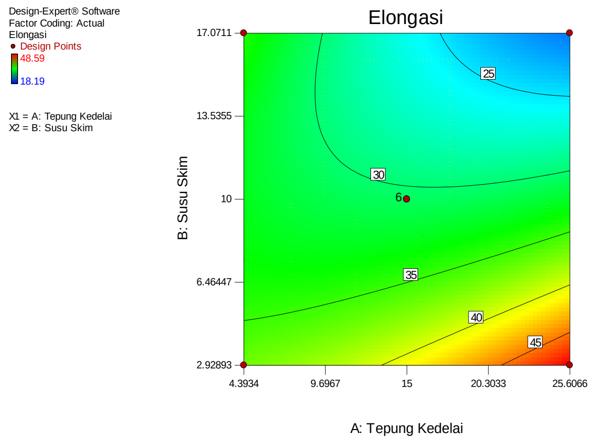
Run	Cassava flavor±SD*)	Beany Flavor±SD*)	Milky Flavor±SD*)	Elasticity±SD*)	Preferency±SD*)
1	3.70 ± 0.99	3.27 ± 1.11	2.87 ± 0.94	4.37 ± 1.10	4.83 ± 0.70
2	3.50 ± 1.11	3.53 ± 1.07	3.03 ± 0.96	4.30 ± 0.65	5.03 ± 0.85
3	3.23 ± 1.25	3.60 ± 0.97	3.13 ± 0.90	3.97 ± 0.93	4.77 ± 0.90
4	3.83 ± 1.09	3.13 ± 1.01	3.27 ± 0.78	4.70 ± 0.65	4.87 ± 0.73
5	3.53 ± 1.01	3.53 ± 1.04	3.00 ± 0.91	4.40 ± 0.67	5.07 ± 0.64
6	3.37 ± 1.03	3.80 ± 1.19	2.83 ± 0.95	3.90 ± 0.80	4.97 ± 0.81
7	3.43 ± 0.97	3.43 ± 0.94	3.00 ± 1.17	4.37 ± 0.89	5.00 ± 0.69
8	3.50 ± 1.07	3.47 ± 0.73	2.90 ± 0.84	4.40 ± 1.19	5.07 ± 0.91
9	3.33 ± 0.99	3.03 ± 1.13	2.83 ± 0.70	4.60 ± 0.93	4.70 ± 1.12
10	3.47 ± 1.14	3.50 ± 1.11	2.93 ± 0.74	4.43 ± 1.01	5.10 ± 0.99
11	3.57 ± 1.04	3.37 ± 1.13	3.37 ± 1.00	4.50 ± 1.28	5.23 ± 0.77
12	3.63 ± 1.07	3.60 ± 0.97	2.53 ± 0.73	4.03 ± 1.16	4.83 ± 1.02
13	3.57 ± 0.86	3.57 ± 1.04	2.97 ± 1.07	4.33 ± 0.84	5.13 ± 0.73
14	3.17 ± 0.79	3.90 ± 0.71	2.77 ± 0.94	4.23 ± 0.77	4.63 ± 0.96

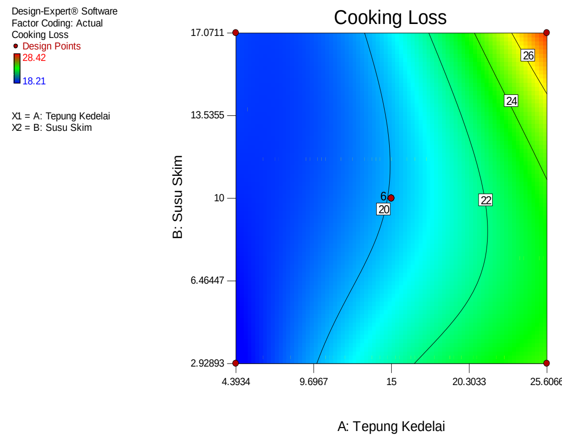
Table 4. Mathematic Models for All Responses

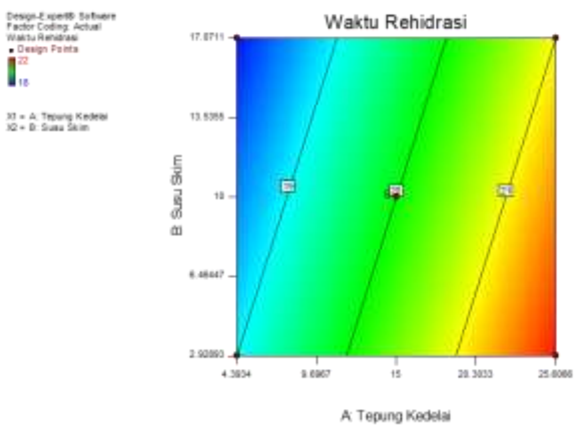
Responses	Mathematic Model	Mathematic Equation	Significant level (p<0.05)			(R2)
			Model	Lack of Fit	Faktor	
Elongation	*Quadratic*	30.57 - 0.16 (A) – 7.34 (B) – 6.19 (AB) + 1.83 (A2) + 2.99 (B2)	0.0492*	0.0610	A: 0.9387 B: 0.0089	0.55
Cooking Loss	*Cubic*	20.06 + 2.57 (A) – 0.43 (B) + 0.84 (AB) + 1.10 (A2) + 1.08 (B2) + 1.7 1 (A2B) + 1.25 (AB2)	0.0002*	0.2060	A: 0.0003* B: 0.1866	0.97
Rehidration time	*Linear*	20.00 + 1.46 (A) – 0.46 (B)	0.0071*	0.3509	A: 0.0029* B: 0.2470	0.55
Springiness	*Cubic*	4.71 – 0.19 (A) + 0.16 (B) + 0.050 (AB) – 0.17 (A2) – 0.048 (B2) – 0. 063 (A2B) – 0.23 (AB2)	0.0001*	0.1888	A: 0.0006* B: 0.0012*	0.98
Brown color	*Linear*	3.84 + 0.83 (A) + 0.43 (B)	0.0001*	0.4723	A: 0.0001* B: 0.0014*	0.88
Cassava flavor	*Cubic*	3.50 - 0.057 (A) - 0.021 (B) - 0.067 (AB) – 0.098 (A2) + 0.077 (B2) + 0.019 (A2B) - 0.18 (AB2)	0.0104*	0.0727	A: 0.1772 B: 0.5816	0.84
Beany Flavor	*Linear*	3.48 + 0.28 (A) - 0.083 (B)	0.0001*	0.6194	A: 0.0001*	0.95

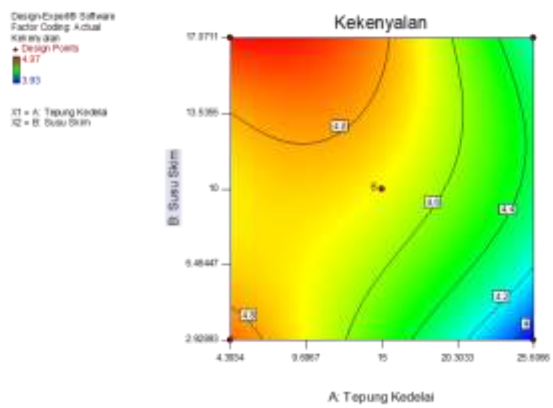
					B: 0.0010*	
Milky Flavor	*Cubic*	2.97- 0.021 (A) + 0.30 (B) - 0.025 (AB) – 0.048 (A2) + 0.027 (B2) - 0.12 (A2B) - 0.024 (AB2)	0.0003*	0.0703	A: 0.3283 B: 0.0001*	0.96
Elasticity	*Cubic*	4.37 - 0.13 (A) + 0.17 (B) - 0.065 (AB) – 0.00458 (A2) - 0.080 (B2) - 0.066 (A2B) - 0.17 (AB2)	0.0009*	0.2474	A: 0.0052* B: 0.0019*	0.94
Preferency	*Cubic*	5.07 - 0.025 (A) + 0.14 (B) - 0.060 (AB) – 0.20 (A2) - 0.015 (B2) - 0.18 (A2B) - 0.035 (AB2)	0.0009*	0.0882	A: 0.3108 B: 0.0013*	0.94

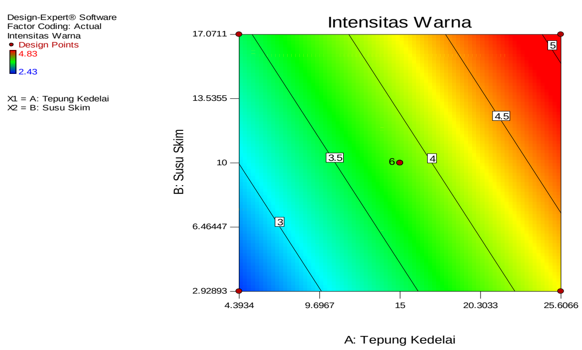
The mathematical model chosen for all optimized responses was able to explain well the effect of the dependent variable on the independent variable (all models are significant at 5% error level). All selected models have R2= 0.55-0.98. That is, the dependent variable of all measured responses can be explained by 55-98% of the independent variables. All selected models have an insignificant “lack of fit” value. This shows that the selection of a mathematical model was appropriate for the optimized response. The proportion of soybean flour has a significant effect on cooking loss, rehydration time, the intensity of springiness, brown color, beany flavor and elasticity. The increasing of the proportion of soybean flour caused an increase in cooking loss, rehydration time, the intensity of brown color and beany flavor , but decreasing in the intensity of springiness and elasticity. The proportion of skim milk has a significant effect on the intensity of springiness, brown color, milky flavor, elasticity, beany flavor and preferency. The increasing of the proportion of skim milk caused an increase in the intensity of springiness, brown color, milky flavor, elasticity, preferency, and decreasing in the intensity of beany flavor.

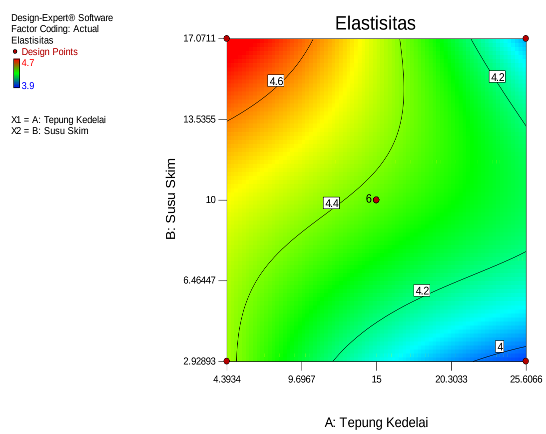

Design-Expert® Software
Factor Coding: Actual
Elongasi
Design Points
48.59
18.19
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Elongasi
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
25
30
6
35
40
45
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai


Design-Expert® Software
Factor Coding: Actual
Cooking Loss
Design Points
28.42
18.21
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Cooking Loss
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
26
24
6
20
22
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai


Design-Expert® Software
Factor Coding: Actual
Waktu Rehidrasi
Design Points
22
16
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Waktu Rehidrasi
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai


Design-Expert® Software
Factor Coding: Actual
Design Points
4.97
3.93
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Kekenyalan
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
6
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai


Design-Expert® Software
Factor Coding: Actual
Intensitas Warna
Design Points
4.83
2.43
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Intensitas Warna
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
5
4.5
3.5
6
4
3
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai


Design-Expert® Software
Factor Coding: Actual
Elastisitas
Design Points
4.7
3.9
X1 = A: Tepung Kedelai
X2 = B: Susu Skim
Elastisitas
17.0711
13.5355
10
6.46447
2.92893
B: Susu Skim
4.6
4.2
4.4
6
4.2
4
4.3934
9.6967
15
20.3033
25.6066
A: Tepung Kedelai

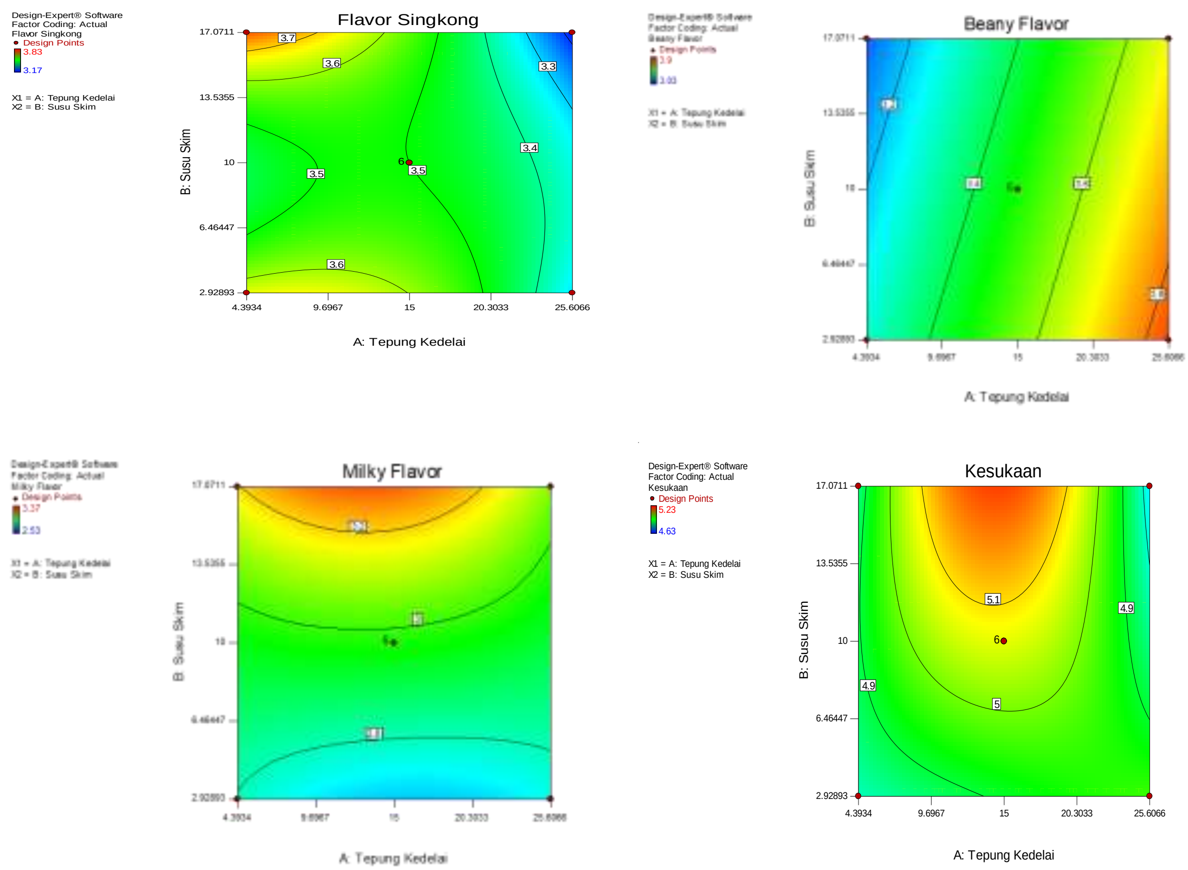


Figure 1. The two dimensional countur of all responses

Table 5. Criteria of responses

Responses	Criteria	Importance
Springiness	Maximum	5
Brown color	In range	3
Cassava flavor	In range	3
Beany Flavor	In range	3
Milky Flavor	In range	3
Elasticity	Maximum	5
Preferency	Maximum	5
Elongation	Maximum	4
Cooking loss	Minimum	4
Rehidration time	In Range	3

The optimum formula based on criteria of responses showed in Table 5. The optimum formula recommended by the Design Expert with Desirability value = 0.8, Soybean flour = 8%, Skim milk = 17% (Table 5). Mocaf noodle with the optimum formula had a higher intensity of springiness, milky flavour, beany flavour, cassava flavour, dan brown color. Mocaf noodle with optimum formula had a higher content of carbohydrate, ash, and fat content, and also cooking loss and rehydration time. Mocaf noodle with optimum formula had a higher content of carbohydrate, ash, and fat content, and also cooking loss and rehydration time. The actual scores of all responses were within the range predicted by DES was showed in Table 6. The spider web diagram of sensory attributes of optimum product compared to control was showed in Figure 2. The sensory and physicochemical properties of product with optimum formula and control showed in Table 7 dan Table 8.

Table 6. The actual scores of all responses

Responses	Actual value±SD*)	Prediction value	PI *Low*	PI *High*
Elongation	40.36±1.77	31.19	15.08	47.30
Cooking Loss	19.03±0.49	18.87	17.15	20.60
Rehidration time	20.75±0.35	18.58	15.96	21.20
Springiness	4.92±0.50	4.96	4.81	5.12
Brown color	3.46±0.44	3.72	3.02	4.41
Cassava flavor	3.68±0.85	3.72	3.50	3.94
Beany Flavor	3.21±0.46	3.21	3.09	3.34
Milky Flavor	3.18±0.42	3.27	3.15	3.39
Elasticity	4.61±0.38	4.67	4.50	4.84
Preferency	5.09±0.47	5.06	4.93	5.20

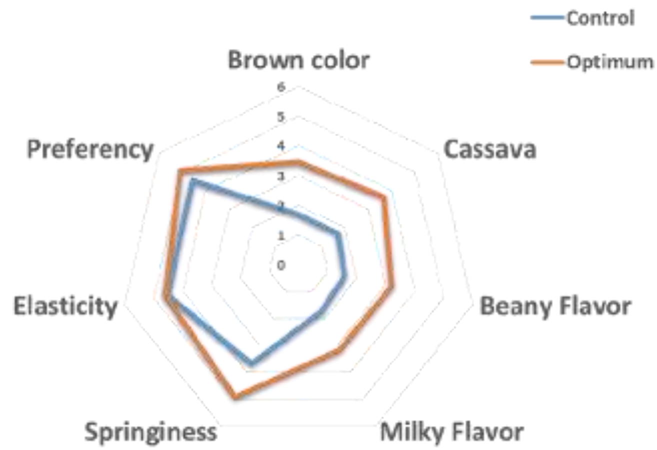


Figure 2. The spider web diagram of sensory attributes

Table 7. The sensory properties of carica fruit leather with optimum formula

Variables	Intensity score of product (1-7)	
	Control±SD*	Optimum±SD*
Brown color	1.70 ± 0.79b	3.46 ± 0.44a
Cassava	1.70 ± 0.47b	3.68 ± 0.85a
Beany Flavor	1.60 ± 0.50b	3.21 ± 0.46a
Milky Flavor	1.73 ± 0.52b	3.18 ± 0.42a
Springiness	3.67 ± 0.84b	4.92 ± 0.50a
Elasticity	4.53 ± 0.97	4.61 ± 0.38
Preferency	4.57 ± 1.07	5.09 ± 0.47

Table 8. The psycochemical properties of carica fruit leather with optimum formula

Variables	Product	
	Control±SD*	Optimum±SD*
Elongation (%)	39.56 ± 5.49	40.36 ± 0.18
Cooking Loss (%)	10.36 ± 0.39b	19.03 ± 0.49a
Rehidration time (minutes)	3.75 ± 0.35b	20.75 ± 0.35a
Water (%wb)	9.11 ± 0.30	8.85 ± 0.06
Protein (%db)	13.67 ± 0.15a	6.38 ± 0.26b
Fat (%db)	0.77 ± 0.07b	1.89 ± 0.25a
Ash (%db)	1.76 ± 0.35b	2.98 ± 0.01a
Carbohydrate (%db)	74.70 ± 0.13b	79.92 ± 0.45a

CONCLUSION

The formula consisting of 8% soy flour and 17% skim milk produced the optimum product with a desirability value of 0.8. Compared to the control, the product with the optimum formula had higher intensity for all sensory attributes and elongation values which were not significantly different, but higher rehydration time and cooking loss. The optimum product contains 5.8% wb protein, 1.8% wb fat, 2.7% wb ash, 80.85% wb carbohydrates, and produces 362.8Kcal/100g of energy. Reformulation still needs to be done to increase the protein content of noodles. One way is adding soy protein isolate or defatted soy flour

REFERENCES

Badan Standarisasi Nasional. 1996. SNI 01-2974-1996. Mi Kering. Jakarta.

Badan Pusat Statistik. 2019. Data Impor Gandum Indonesia 2018. [Online]. Available at: http://www.bps.go.id [Diakses 20 Oktober 2020].

Foreign Agricultural Service U.S. Department of Agriculture (USDA). 2020. Indonesia: Grain and Feed Update. [Online]. Available at: https://www.fas.usda.gov/data/indonesia-grain-and-feed-update-12 [Diakses 20 Januari 2021].

Li Y, Chen Y, Li S, Gao A, Dong S. 2017. Structural changes of proteins in fresh noodles during their processing. International Journal of Food Properties 20(S1) : 2-13. doi.org/10.1080/10942912.2017.1295253.

Lu ZH, Peng HH, Cao W, Tatsumi E, Li LT. 2008. Isolation, Characterization, and Identification of Lactic Acid Bacteria and Yeast from Sour Mifen, a Traditional Fermented Rice Noodle from China. *J Appl Microbiol*. 105:893-903.

Wan J, Huang W, Zhong J, Huang L, Patricia RD, Liu B. 2011. Effects of LAB Fermentation on Physical Properties of Oat Flour and Its Suitability for Noodle Making. *Cereal Chem.* 88 (2) : 153-158

Astuti, S.D., N. Andarwulan, D. Fardiaz, dan E.H. Purnomo. 2017 Karakteristik tepung talas varietas bentul dan satoimo hasil fermentasi terkendali dengan inokulum komersial. *J. Teknol. dan Industri Pangan*. 28(2): 180 – 193.

Umeh, S.O. and Odibo, F.J.C. 2014. Isolation of Starter Cultures to be Used for Cassava Tuber Retting to Produce Fufu. Journal of Global Biosciences Vol. 3 (2) : 520-528.

Misgiyarta, Mu’arif S, Arkenan Y. 2013. Strategi Teknologi dan Manajemen Inovasi Industri Tepung Kasava Fermentasi. *Jurnal Teknik Industri* : 64-77.

Javaid AB, Xiong H, Xiong Z, Soomro AH, Din Z, Ahmad I. 2018. Effect of xanthan gum on cooking qualities, texture and microstructures of fresh potato instant noodles. Journal of Food Measurement and Characterization; 12(4); 2453-2460. DOI:10.1007/s11694-018-9862-9

Wang X, Ma Z, Li X, Liu L, Yin X, Zhang K, Liu Y, Hu X. 2018. Food additives and technologies used in Chinese traditional staple foods. *Biol. Technol. Agric. 5:1:1-15.*

Gulia N, Dhaka V, Khatkar BS. 2014. Instant Noodles: Processing, Quality, and Nutritional Aspects (Review). *Critical Reviews in Food Science and Nutrition*; 54:1386–1399. DOI: 10.1080/10408398.2011.638227.

Formula Optimization and Characterization of Physicochemical and Sensory Properties of Gluten-Free Noodles Based on Modified Cassava Flour with Addition of Soybean Flour and Skim Milk

Santi Dwi Astuti[1)*], V. Prihananto[1)], Ali Maksum,[1)] Ervina Mela D.,[1)] Indah Fitri H.[1)]

1) **Department of Agricultural Technology, Jenderal Soedirman University**
***E-mail : santi.astuti@unsoed.ac.id**

The 3nd International Conference on Sustainable Agriculture for Rural Development (3nd ICSARD)
"Strengthening Sustainable Agriculture through Development of Local Products and Innovative Technologies and Practices "
Purwokerto, Central Java, Indonesia; 23 August 2022

BACKGROUND

Noodles were food source of carbohydrates that were widely consumed by Indonesians besides rice. Usually, noodles were made from wheat which was still imported.

Production of non-gluten noodles from modified cassava flour (Mocaf) can be an alternative to reduce wheat, while optimizing the use of cassava.

Gluten-free noodles from modified cassava flour had low protein content and a less favorable taste.

Besides being able to increase the protein content, the addition of soy flour and skim milk in the noodle formula was intended to reduce the unfavorable flavor.

Soy flour and skim milk have a protein content of about 35%

OBJECTIVES

This study were aimed to :

1. Optimizing the proportion of soy flour and skim milk which had maximum elongation, intensity of preference, springiness, and elasticity; rehydration time, color intensity, cassava flavor, beany flavor, milky flavor in the range value; and cooking loss at the minimum value
2. Examine the effect of addition of soy flour and skim milk on the physicochemical and sensory properties of product
3. Comparing the physicochemical and sensory properties of products with optimum formula and control (products without the addition of soy flour and skim milk).

MATERIAL AND METHODS

Materials

1. Cassava tuber and local variety of soybean were obtained from Banjarnegara dan Banyumas district
2. Other ingrediens (Skim milk, xanthan gum, sodium tripoliphosphate, salt, alkaine solution) were obtained from CV. Nuru Jaya Surabaya

The stages of research

1. Determination of basic formula and process
2. Recruitment of semi trained panelists
3. Formula optimization (skoring test)
4. Physicochemical analysis of product with optimum formula

BASIC FORMULA

Type of ingredient	Name of ingredient	Basic value (%)
Main ingredients	Mocaf	82
	Soybean flour	8
	Cassava starch	10
	Total	100
Supporting ingredients	Xanthan gum	1
	Salt	1
	STPP	0.3
	Alkaline solution	1
	Egg	3
	Skim milk	15
	Water	87

The basic formula consists of the main and supporting ingredients, The percentage of supporting ingredients was calculated based on the total of the main ingredients used

Stages in the product manufacturing :

1. Manufacture of modified cassava flour using controlled fermentation technology (submerged method, tuber slice size 1 cm, soaking in 0.2% citric acid solution for 1 hour, followed by immersion with 0.2% bimo for 48 hours, drying, milling, and sifting 80 mesh)
2. Making soybean flour (soaking the seeds followed by boiling for 20 minutes, separating the epidermis, drying, milling and sifting 80 mesh)
3. Making noodles (gelatinization of cassava starch, mixing with other ingredients, kneading, aging 30 for minutes, sheeting and cutting, steaming 15 minutes, drying at room temperature followed by 60oC using cabinet dryer for 4 hours

Formula Optimization

1. The optimization of the formula was carried out by the response surface methodology using a central composite design.
2. There were 2 optimized factors, i.e. the proportion of HFS and sorbitol.
3. The minimum and maximum proportions for Soybean flour were 0 and 30%; while skim milk were 0 and 20%.
4. The selection of 2 blocks using design expert software (V.XIII for trial) produced 14 factor combinations.

Stages :

1. Determination of the upper and lower limits
2. Making products with treatments result from RSM recommendations
3. Measurement of responses
4. Verification and validation

Result : Formula variation

The following were data from 14 formula variations recommended by DES

Run	A_Soybean flour (%)	B_Skim milk (%)	Cassava flour (%)
1	4,39	2,93	85,61
2	15	10	75
3	25,61	17,07	64,39
4	4,39	17,07	85,61
5	15	10	75
6	25,61	2.93	64,39
7	15	10	75
8	15	10	75
9	0	10	90
10	15	10	75
11	15	20	75
12	15	0	75
13	15	10	75
14	30	10	60

Result : Determination of Responses

The following are the results of measurements of the responses of each formula

Run	Elongation±SD*)	Cooking Loss±SD*)	Rehidration time±SD*)	Springiness ±SD*)	Brown color±SD*)
1	40.28 ± 6.81	18.21 ± 0.04	18 ± 0.00	4.87 ± 0.78	2.43 ± 0.94
2	31.23 ± 12.61	19.79 ± 0.04	20 ± 1.14	4.63 ± 0.56	3.77 ± 1.01
3	18.19 ± 0.08	28.42 ± 0.06	22 ± 0.00	4.23 ± 0.77	4.83 ± 0.91
4	40.36 ± 0.18	19.11 ± 0.07	19 ± 1.41	4.97 ± 0.76	3.23 ± 0.77
5	30.86 ± 4.91	20.11 ± 0.1	20 ± 1.41	4.67 ± 0.61	4.27 ± 0.83
6	42.86 ± 9.07	24.18 ± 0.03	21 ± 1.41	3.93 ± 1.28	4.60 ± 0.72
7	29.35 ± 5.26	19.78 ± 0.08	19 ± 0.00	4.73 ± 1.20	3.83 ± 0.59
8	34.42 ± 0.93	21.02 ± 0.08	21 ± 2.83	4.73 ± 1.11	3.73 ± 0.69
9	27.73 ± 3.50	18.39 ± 0.07	18 ± 1.41	4.63 ± 0.81	2.73 ± 1.11
10	25.57 ± 5.12	19.90 ± 0.06	21 ± 0.00	4.70 ± 0.75	4.17 ± 0.87
11	24.45 ± 0.52	21.39 ± 0.04	18 ± 2.83	4.83 ± 0.83	4.67 ± 0.66
12	48.59 ± 2.75	22.60 ± 0.06	22 ± 1.41	4.37 ± 0.76	2.97 ± 1.07
13	31.97 ± 0.37	19.79 ± 0.15	19 ± 2.83	4.77 ± 0.68	3.70 ± 0.65
14	40.66 ± 12.08	25.66 ± 0.06	22 ± 2.83	4.10 ± 0.96	4.77 ± 0.63

Run	Cassava flavor±SD*)	Beany Flavor ±SD*)	Milky Flavor±SD*)	Elasticity±SD*)	Preferency ±SD*)
1	3.70 ± 0.99	3.27 ± 1.11	2.87 ± 0.94	4.37 ± 1.10	4.83 ± 0.70
2	3.50 ± 1.11	3.53 ± 1.07	3.03 ± 0.96	4.30 ± 0.65	5.03 ± 0.85
3	3.23 ± 1.25	3.60 ± 0.97	3.13 ± 0.90	3.97 ± 0.93	4.77 ± 0.90
4	3.83 ± 1.09	3.13 ± 1.01	3.27 ± 0.78	4.70 ± 0.65	4.87 ± 0.73
5	3.53 ± 1.01	3.53 ± 1.04	3.00 ± 0.91	4.40 ± 0.67	5.07 ± 0.64
6	3.37 ± 1.03	3.80 ± 1.19	2.83 ± 0.95	3.90 ± 0.80	4.97 ± 0.81
7	3.43 ± 0.97	3.43 ± 0.94	3.00 ± 1.17	4.37 ± 0.89	5.00 ± 0.69
8	3.50 ± 1.07	3.47 ± 0.73	2.90 ± 0.84	4.40 ± 1.19	5.07 ± 0.91
9	3.33 ± 0.99	3.03 ± 1.13	2.83 ± 0.70	4.60 ± 0.93	4.70 ± 1.12
10	3.47 ± 1.14	3.50 ± 1.11	2.93 ± 0.74	4.43 ± 1.01	5.10 ± 0.99
11	3.57 ± 1.04	3.37 ± 1.13	3.37 ± 1.00	4.50 ± 1.28	5.23 ± 0.77
12	3.63 ± 1.07	3.60 ± 0.97	2.53 ± 0.73	4.03 ± 1.16	4.83 ± 1.02
13	3.57 ± 0.86	3.57 ± 1.04	2.97 ± 1.07	4.33 ± 0.84	5.13 ± 0.73
14	3.17 ± 0.79	3.90 ± 0.71	2.77 ± 0.94	4.23 ± 0.77	4.63 ± 0.96

Result : Mathematic Models for All Responses

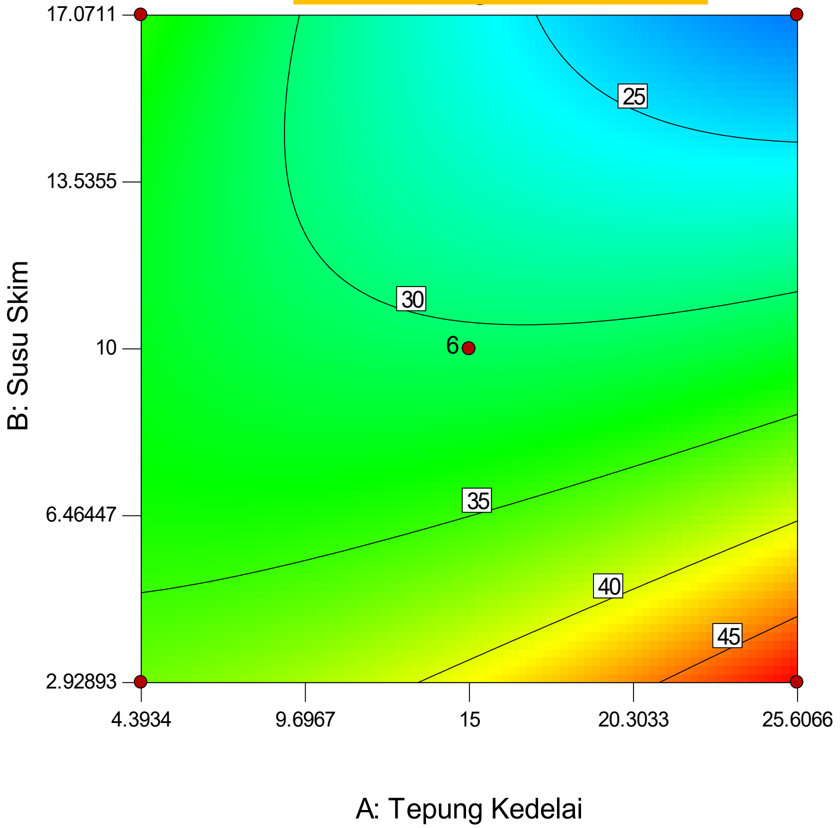
Responses	Mathematic Model	Mathematic Equation	Significant level ($p<0.05$)			(R^2)
			Model	Lack of Fit	Faktor	
Elongation	*Quadratic*	30.57 - 0.16 (A) – 7.34 (B) – 6.19 (AB) + 1.83 (A^2) + 2.99 (B^2)	0.0492*	0.0610	A: 0.9387 B: 0.0089	0.55
Cooking Loss	*Cubic*	20.06 + 2.57 (A) – 0.43 (B) + 0.84 (AB) + 1.10 (A^2) + 1.08 (B^2) + 1.71 (A^2B) + 1.25 (AB^2)	0.0002*	0.2060	A: 0.0003* B: 0.1866	0.97
Rehidration time	*Linear*	20.00 + 1.46 (A) – 0.46 (B)	0.0071*	0.3509	A: 0.0029* B: 0.2470	0.55
Springiness	*Cubic*	4.71 – 0.19 (A) + 0.16 (B) + 0.050 (AB) – 0.17 (A^2) – 0.048 (B^2) – 0.063 (A^2B) – 0.23 (AB^2)	0.0001*	0.1888	A: 0.0006* B: 0.0012*	0.98
Brown color	*Linear*	3.84 + 0.83 (A) + 0.43 (B)	0.0001*	0.4723	A: 0.0001* B: 0.0014*	0.88
Cassava flavor	*Cubic*	3.50 - 0.057 (A) - 0.021 (B) - 0.067 (AB) – 0.098 (A^2) + 0.077 (B^2) + 0.019 (A^2B) - 0.18 (AB^2)	0.0104*	0.0727	A: 0.1772 B: 0.5816	0.84
Beany Flavor	*Linear*	3.48 + 0.28 (A) - 0.083 (B)	0.0001*	0.6194	A: 0.0001* B: 0.0010*	0.95
Milky Flavor	*Cubic*	2.97- 0.021 (A) + 0.30 (B) - 0.025 (AB) – 0.048 (A^2) + 0.027 (B^2) - 0.12 (A^2B) - 0.024 (AB^2)	0.0003*	0.0703	A: 0.3283 B: 0.0001*	0.96
Elasticity	*Cubic*	4.37 - 0.13 (A) + 0.17 (B) - 0.065 (AB) – 0.00458 (A^2) - 0.080 (B^2) - 0.066 (A^2B) - 0.17 (AB^2)	0.0009*	0.2474	A: 0.0052* B: 0.0019*	0.94
Preferency	*Cubic*	5.07 - 0.025 (A) + 0.14 (B) - 0.060 (AB) – 0.20 (A^2) - 0.015 (B^2) - 0.18 (A^2B) - 0.035 (AB^2)	0.0009*	0.0882	A: 0.3108 B: 0.0013*	0.94

From the table above it can be seen that :

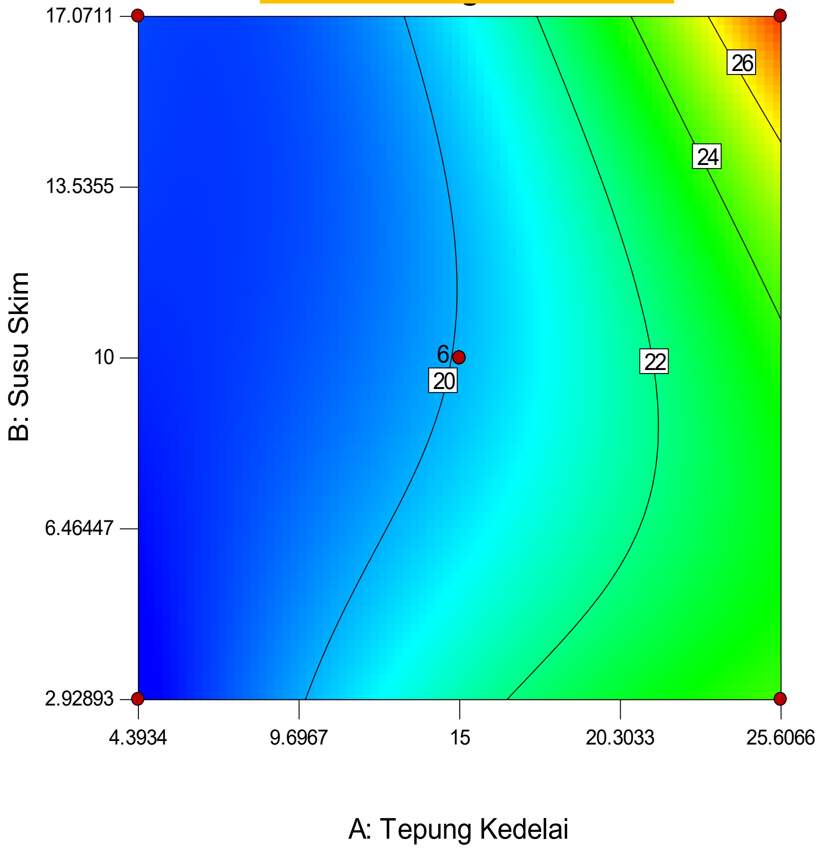
1. The mathematical model chosen for all optimized responses was able to explain well the effect of the dependent variable on the independent variable (all models are significant at 5% error level).
2. All selected models have R2= 0.55-0.98. That is, the dependent variable of all measured responses can be explained by 55-98% of the independent variables
3. All selected models have an insignificant “lack of fit” value. This shows that the selection of a mathematical model was appropriate for the optimized response
4. The proportion of soybean flour has a significant effect on cooking loss, rehydration time, the intensity of springiness, brown color, beany flavor and elasticity
5. The increasing of the proportion of soybean flour caused an increase in cooking loss, rehydration time, the intensity of brown color and beany flavor , but decreasing in the intensity of springiness and elasticity
6. The proportion of skim milk has a significant effect on the intensity of springiness, brown color, milky flavor, elasticity, beany flavor and preferency
7. The increasing of the proportion of skim milk caused an increase in the intensity of springiness, brown color, milky flavor, elasticity, preferency, and decreasing in the intensity of beany flavor

Two-dimensional contour of Responses

Elongation



Cooking loss

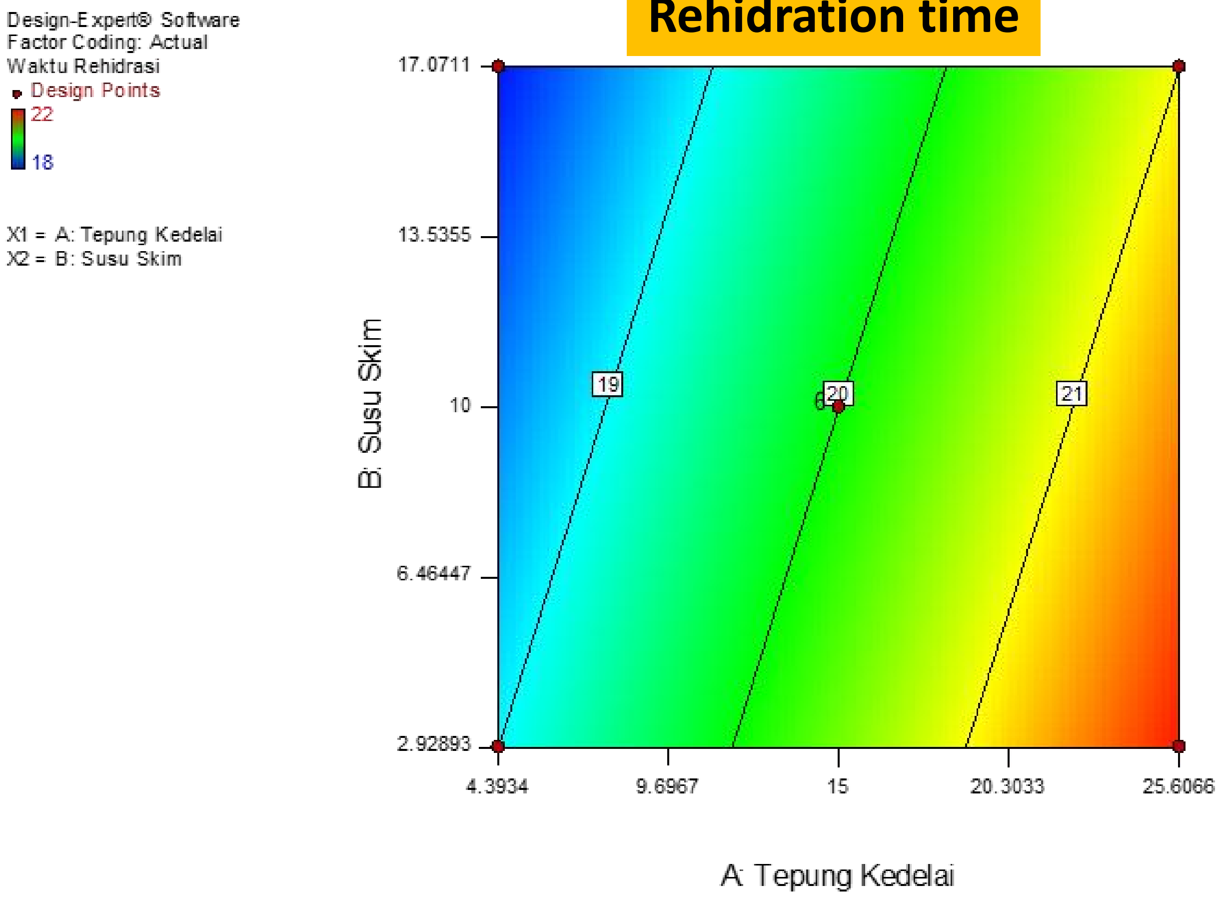


The lowest to highest values for elongation ranged from 18.9-48.59

The lowest to highest values for cooking loss ranged from 18.21-28.42

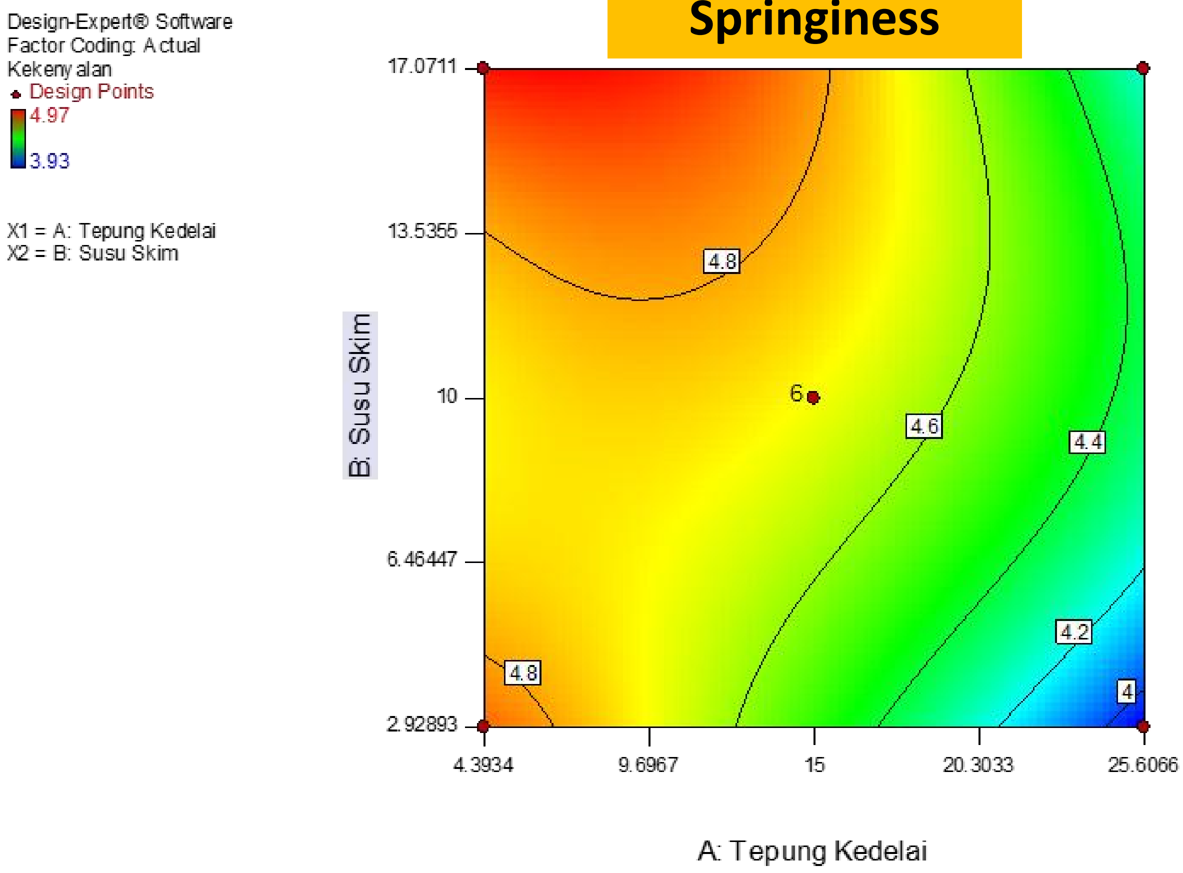
Two-dimensional contour of Responses

Rehidration time



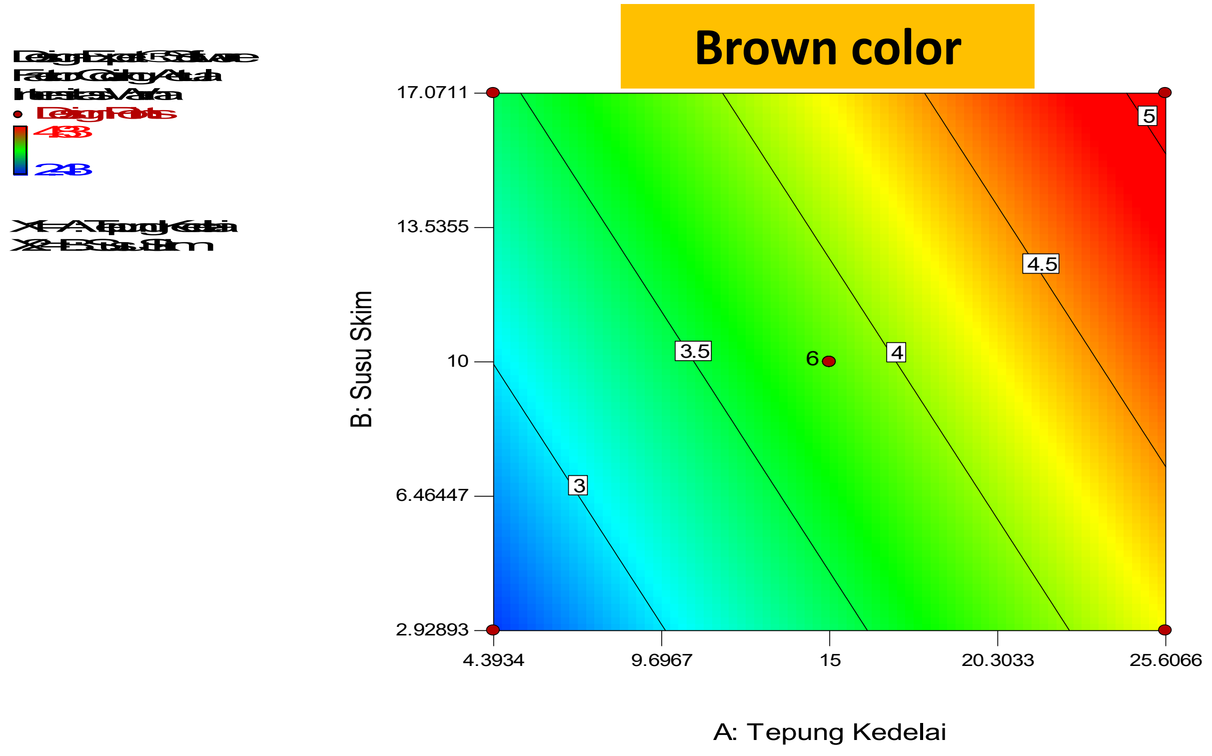
The lowest to highest values for preferency ranged from 3.86-4.64

Springiness

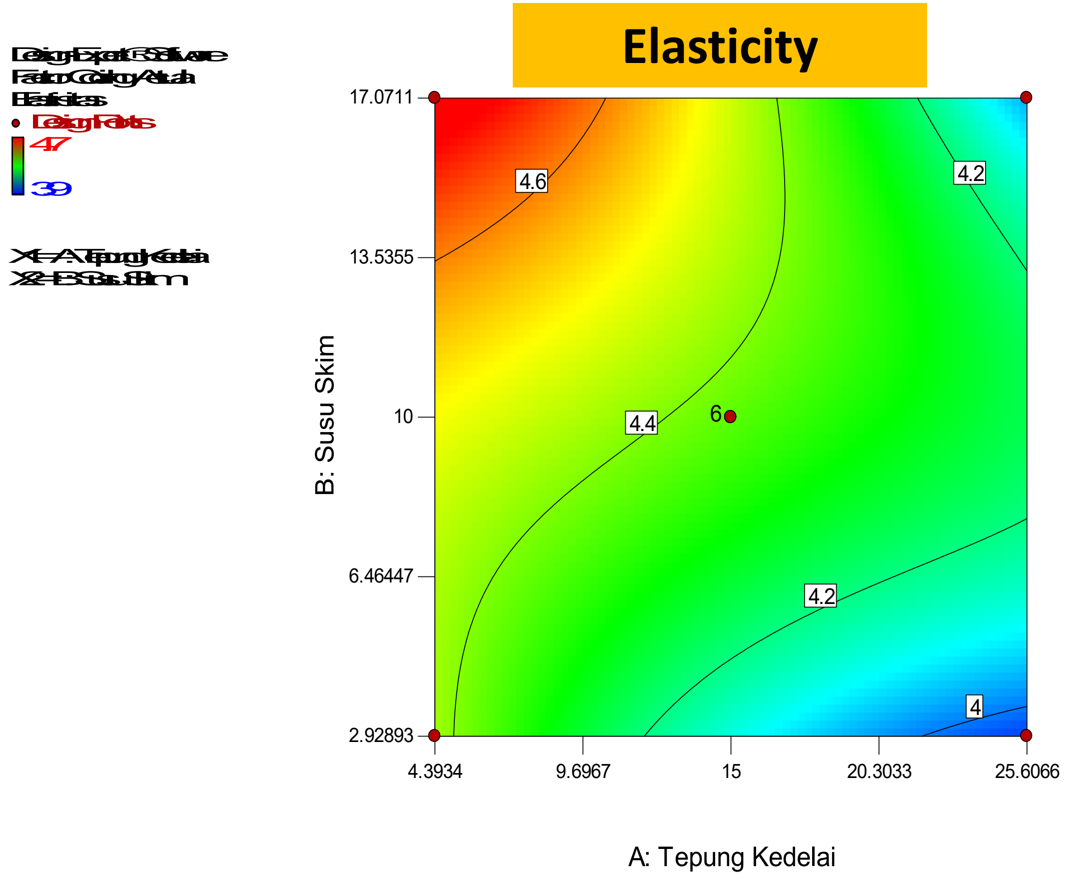


The lowest to highest values for preferency ranged from 3.86-4.64

Two-dimensional contour of Responses



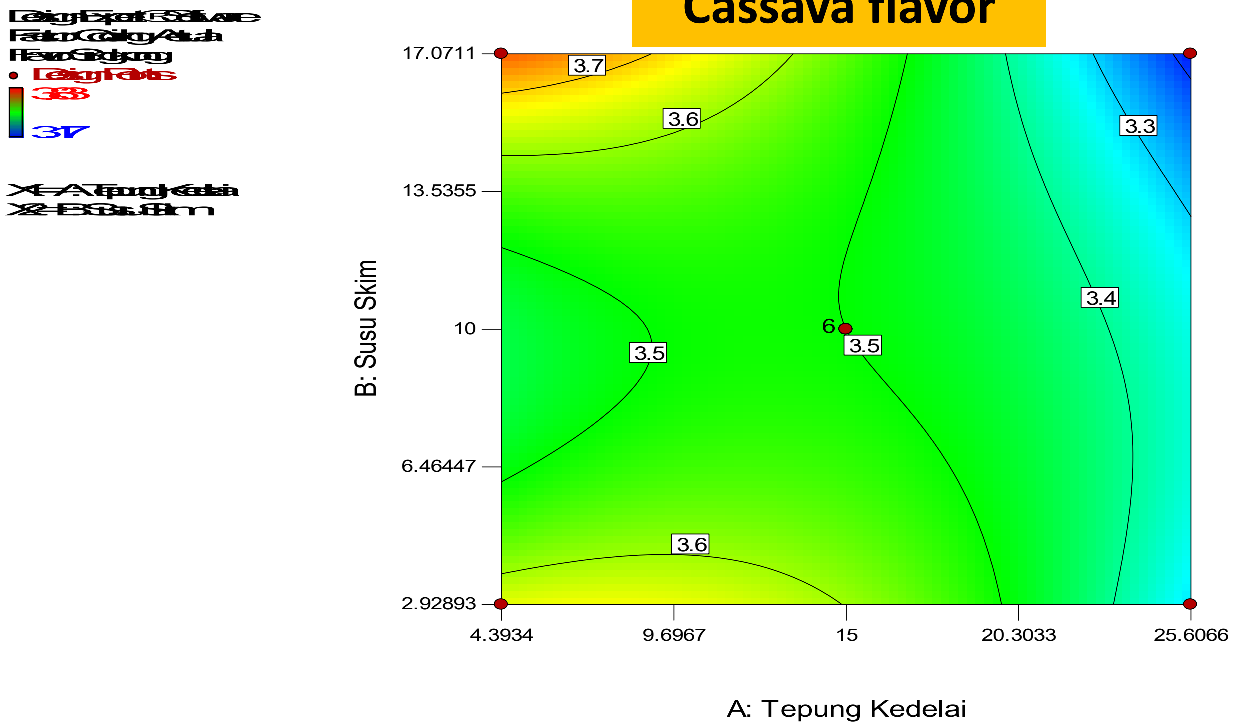
The lowest to highest values for brown color ranged from 2.43-4.83



The lowest to highest values for elasticity ranged from 3.9-4.7

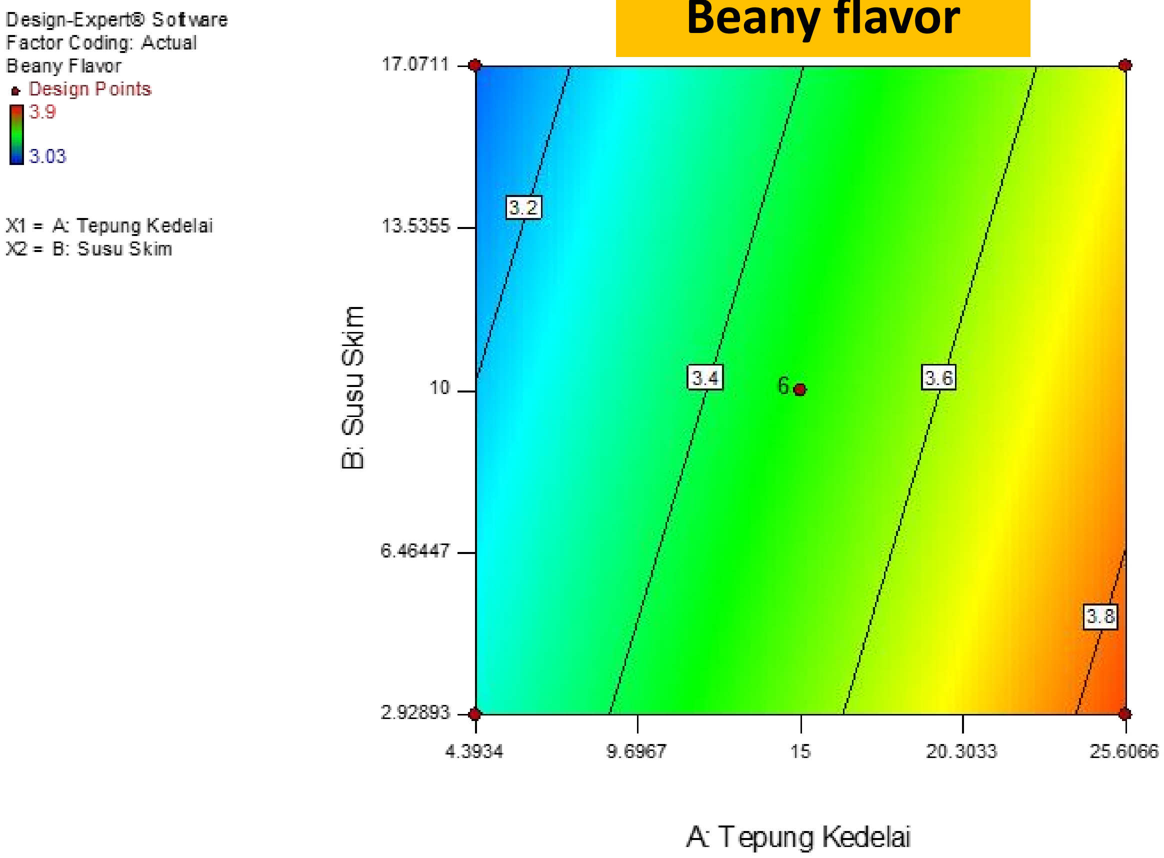
Two-dimensional contour of Responses

Cassava flavor



The lowest to highest values for cassava flavor ranged from 3.17-3.83

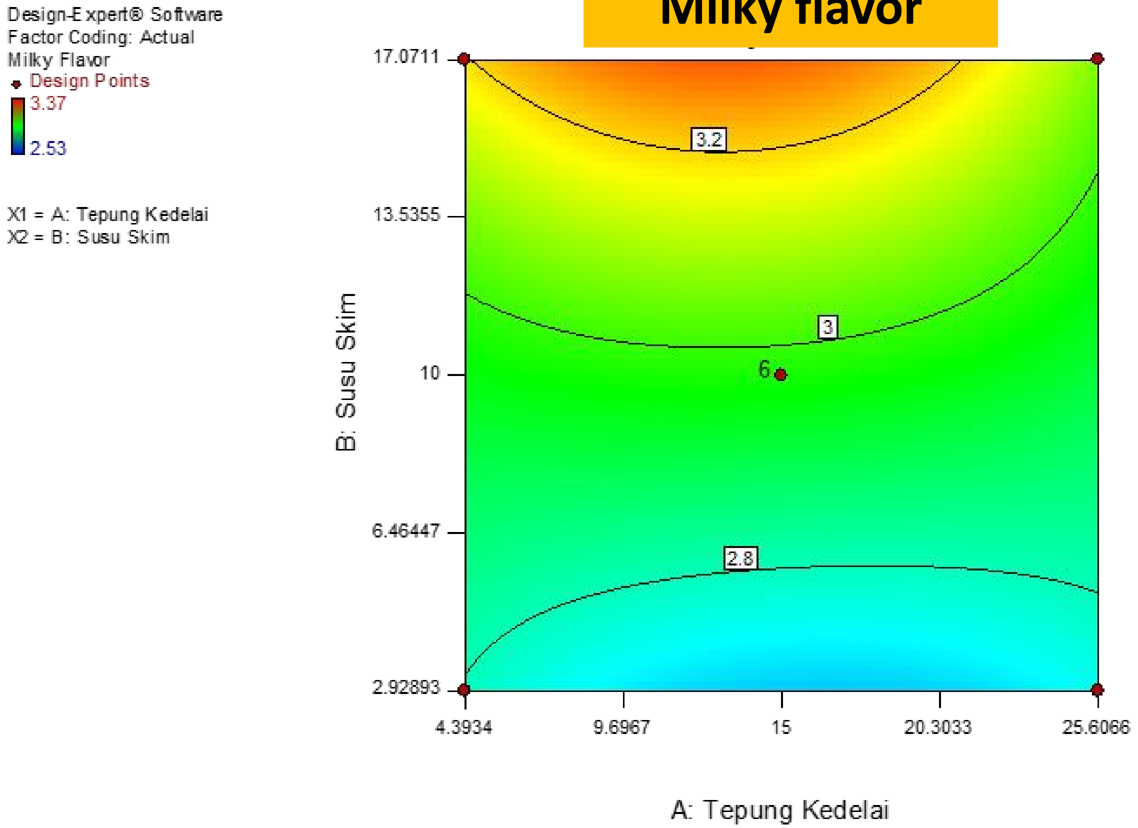
Beany flavor



The lowest to highest values for beany flavor ranged from 3.03-3.9

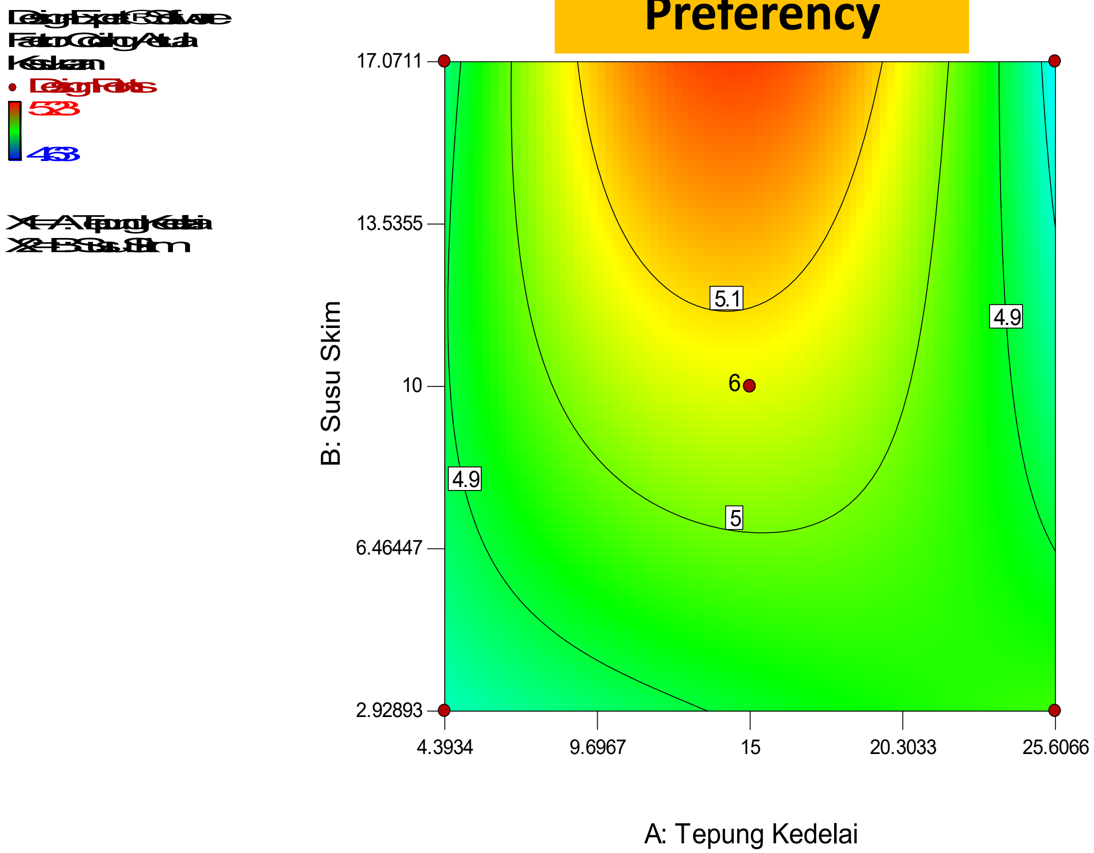
Two-dimensional contour of Responses

Milky flavor



The lowest to highest values for milky flavor ranged from 2.53-3.37

Preferency



The lowest to highest values for preferency ranged from 4.63-5.23

Optimum formula

The Criteria and Importance of Responses

Responses	Criteria	Importance
Springiness	Maximum	5
Brown color	In range	3
Cassava flavor	In range	3
Beany Flavor	In range	3
Milky Flavor	In range	3
Elasticity	Maximum	5
Preferency	Maximum	5
Elongation	Maximum	4
Cooking loss	Minimum	4
Rehidration time	In Range	3

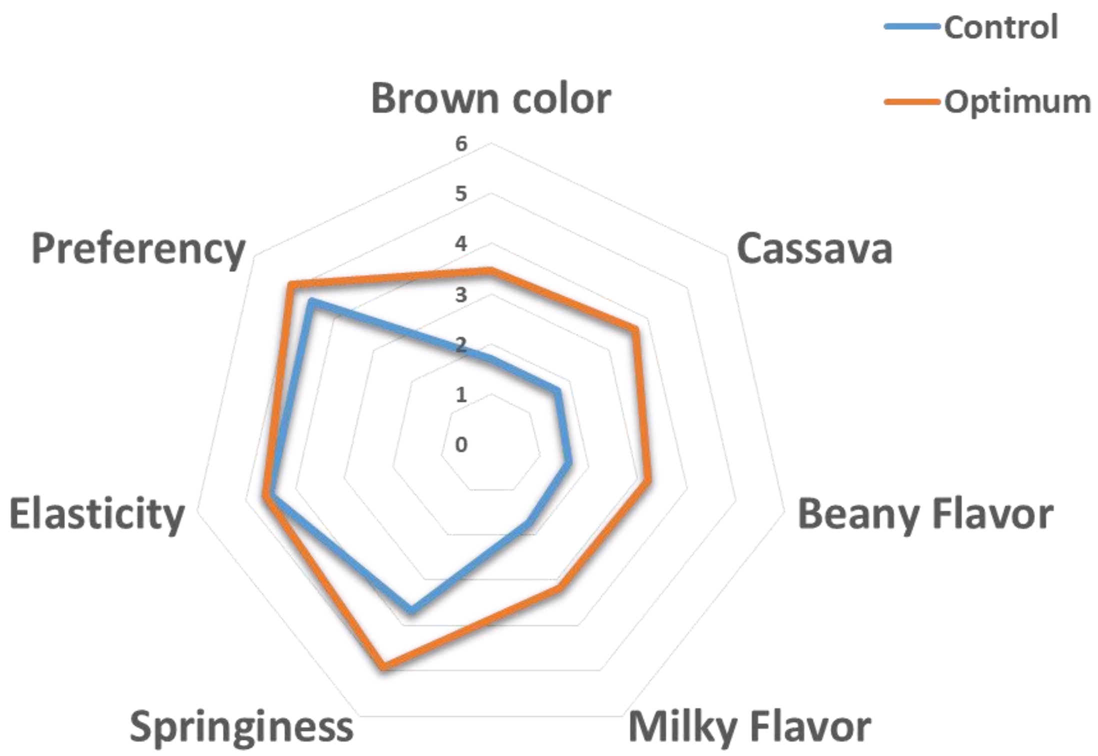
The optimum formula recommended by the Design Expert :
Desirability value = 0.8
Soybean flour = 8%
Skim milk = 17%

The actual sensory score of optimum formula

Responses	Actual value±SD*)	Prediction value	95% *Prediction Interval* (PI)	
			PI *Low*	PI *High*
Elongation	40.36±1.77	31.19	15.08	47.30
Cooking Loss	19.03±0.49	18.87	17.15	20.60
Rehidration time	20.75±0.35	18.58	15.96	21.20
Springiness	4.92±0.50	4.96	4.81	5.12
Brown color	3.46±0.44	3.72	3.02	4.41
Cassava flavor	3.68±0.85	3.72	3.50	3.94
Beany Flavor	3.21±0.46	3.21	3.09	3.34
Milky Flavor	3.18±0.42	3.27	3.15	3.39
Elasticity	4.61±0.38	4.67	4.50	4.84
Preferency	5.09±0.47	5.06	4.93	5.20

The actual scores of all responses were within the range predicted by DES

The spider web diagram of sensory attributes of optimum product compared to control



Variables	Intensity score of product (1-7)	
	Control±SD*	Optimum±SD*
Brown color	1.70 ± 0.79[b]	3.46 ± 0.44[a]
Cassava	1.70 ± 0.47[b]	3.68 ± 0.85[a]
Beany Flavor	1.60 ± 0.50[b]	3.21 ± 0.46[a]
Milky Flavor	1.73 ± 0.52[b]	3.18 ± 0.42[a]
Springiness	3.67 ± 0.84[b]	4.92 ± 0.50[a]
Elasticity	4.53 ± 0.97	4.61 ± 0.38
Preferency	4.57 ± 1.07	5.09 ± 0.47

Mocaf noodle with the optimum formula had a higher intensity of springiness, milky flavour, beany flavour, cassava flavour, dan brown color

The Physicochemical properties noodle with optimum formula compared to control

Variables	Product	
	Control±SD*	Optimum±SD*
Elongation (%)	39.56 ± 5.49	40.36 ± 0.18
Cooking Loss (%)	10.36 ± 0.39^{b}	19.03 ± 0.49^{a}
Rehidration time (minutes)	3.75 ± 0.35^{b}	20.75 ± 0.35^{a}

Variables	Product	
	Control±SD*	Optimum±SD*
Water (%wb)	9.11 ± 0.30	8.85 ± 0.06
Protein (%db)	13.67 ± 0.15^{a}	6.38 ± 0.26^{b}
Fat (%db)	0.77 ± 0.07^{b}	1.89 ± 0.25^{a}
Ash (%db)	1.76 ± 0.35^{b}	2.98 ± 0.01^{a}
Carbohydrate (%db)	74.70 ± 0.13^{b}	79.92 ± 0.45^{a}

Mocaf noodle with optimum formula had a higher content of carbohydrate, ash, and fat content, and also cooking loss and rehydration time

CONCLUSION

1. The formula consisting of 8% soy flour and 17% skim milk produced the optimum product with a desirability value of 0.8
2. Compared to the control, the product with the optimum formula had higher intensity for all sensory attributes and elongation values which were not significantly different, but higher rehydration time and cooking loss
3. The optimum product contains 5.8% wb protein, 1.8% wb fat, 2.7% wb ash, 80.85% wb carbohydrates, and produces 362.8Kcal/100g of energy
4. Reformulation still needs to be done to increase the protein content of noodles. One way is adding soy protein isolate or defatted soy flour

Thanks to...

Thank you to KEMENDIKBUDRISTEK for providing financial support for this research through Matching Fund Kedaireka program in 2022