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FORMULATION AND PROCESS OPTIMIZATION OF MUFFIN PRODUCED FROM COMPOSITE FLOUR OF CORN, WHEAT AND SWEET POTATO

[*Formulasi dan Optimasi Proses Produksi Mufin dari Tepung Komposit Jagung, Gandum dan Ubi Jalar*]

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ABSTRACT

Intensification of use of local carbohydrate sources such as corn and sweet potato is expected to minimize wheat import and support food diversification program. The objective of this research was to optimize the composite flour composition and baking process conditions in muffin production. This research was divided into 3 steps namely formula optimization using mixture design techniques, process optimization using response surface methodology and final product analysis. The formula and process optimization was based on sensory parameter using hedonic rating test involving 70 untrained panelists. The results showed that the optimum formula was a formula with 4% wheat flour, 86% corn flour, and 10% sweet potato flour. The optimum baking condition was 39 minutes at 157°C. Analysis of muffin made with the optimum formula and baking conditions showed that the muffin had hardness, moisture, ash, protein, fat, cabohydrate, and crude fibre of 107.3 gf, 23.22%, 1.83%, 5.89%, 22.46%, 69.82%, and 0.26%, respectively.

Keywords: composite flour, corn flour, muffin, sweet potato flour

ABSTRAK

Intensifikasi penggunaan sumber karbohidrat lokal, misalnya jagung dan ubi jalar, diharapkan mampu menurunkan impor gandum dalam rangka mendukung program diversifikasi pangan. Tujuan dari penelitian ini adalah untuk mengoptimasi komposisi tepung komposit dan kondisi pemanggangan dalam pembuatan mufin. Penelitian terdiri dari 3 tahap utama yaitu optimasi formula menggunakan teknik mixture design*, optimasi proses pemanggangan menggunakan* response surface methodology*, dan analisis produk akhir. Optimasi formula dan proses pemanggangan didasarkan pada parameter sensori yang diperoleh dari uji hedonik dengan menggunakan 70 panelis tidak terlatih. Hasil yang diperoleh menunjukkan bahwa formula tepung komposit yang optimum adalah 4% tepung terigu, 86% tepung jagung, and 10% tepung ubi jalar. Kondisi optimum pemanggangan adalah pada suhu 157°C selama 39 menit. Analisis produk akhir menunjukkan bahwa mufin dari tepung komposit secara berurutan memiliki kekerasan, kadar abu, protein, lemak, karbohidrat, dan serat kasar sebesar 107,3 gf, 23,22%, 1,83%, 5,89%, 22,46%, 69,82%, dan 0,26%.*

Kata kunci*: komposit tepung, tepung jagung, mufin, tepung ubi jalar*

INTRODUCTION

The dependency of Indonesia on import of wheat flour is historically originated from diversification of carbohydrate source during Green Revolution in 1970. Over the past four decades, there was a shift in culture which leads to the higher consumption of wheat, in the form of wheat flour-based products such as noodles and bread, than corn or tubers. Based on data from the Association of Indonesian Wheat Flour Producers in 2007, wheat flour consumption in Indonesia reached up to approximately 12% of the whole food consumption. In 2009, wheat became the largest imported commodity (4.66 million tons) (FAO, 2009). The quantity of imported wheat continued to increase in 2011 to 5.49 million tons (BPS, 2011).

One of bakery products traditionally made from wheat is muffin. Muffin is small cup-shaped quick bread that is generally dominated by sweet taste and can be served with meal or consumed as a snack. Muffin is characterized by a typical porous structure and high volume. To obtain such a structure, a stable batter lodging many tiny air bubbles is required (Baixauli *et al*., 2008). Wheat flour normally used for muffin is moderate to weak flour with 8%-10% protein content. This open the possibility to produce muffins from local flours such as corn and sweet potato which are lacking in gluten.

The introduction of corn and sweet potato flour in muffin production is aimed to support food diversification program and reduce our dependence on wheat flour. Productivity of sweet potato and corn is relatively high. The production of corn in

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Indonesia reaches 18.33 million tons while that of sweet potatoes as much as 2.05 million tons (BPS, 2011). The purpose of this study is to optimize the composite flour composition and baking process condition in muffin production.

MATERIALS AND METHODS

Materials

The materials used in muffin making process were 'Segitiga Biru' wheat flour, sweet potato flour (100 mesh), corn flour (100 mesh), margarine, water, salt, eggs, sugar, and baking powder.

Formula optimization

Formula optimization was initiated by determination of the maximum level of single flour substitution. The range of substitution level tested for corn flour was 50%-100%, while for sweet potato flour was 20%-70%. Substituted muffins were sensory tested using hedonic rating test to 30 panelists and the data was futher analyzed statistically (ANOVA). The next step after determining the maximum point of single flour substitution was optimization step using mixture design method in Design Expert 7.0® software. The range of flours composition (wheat flour, corn flour, and sweet potato flour) was feed to the software to obtain the formula combinations. Each formula obtained from the software was sensory tested using line scale hedonic rating test to 70 untrained panelists. The sensory atribute tested were color, aroma, taste, texture, and overall sensory response of muffin. Responses were then analyzed and optimized to obtain an optimum formula. Finally, optimum formula was verified to check the agreement between the actual and predicted response. Flow diagram of muffin production is shown in Figure 1. Formula optimization was based on basic recipe which is shown in Table 1. Level of corn and sweet potato flour was calculated relative to total flour used.

Table 1. Muffin basic formula

Ingredients	Amount (g)
Wheat flour	525
Eggs	300
Margarine	345
Salt	3
Water	165
Refined sugar	320
Baking powder	7.5

Process optimization

Process optimization was conducted using response surface method in Design Expert 7.0® software. The range of baking parameters (time and temperature) were feed into the software to obtain different combinations of baking time and temperature. Each process was sensory tested using line scale hedonic rating test to 70 untrained panelists. The sensory atribute tested were color, aroma, taste, texture, and overall response of muffin. Responses were then analyzed and optimized to obtain an optimum process. Finally, optimum process was verified to check the agreement between the actual and predicted responses.

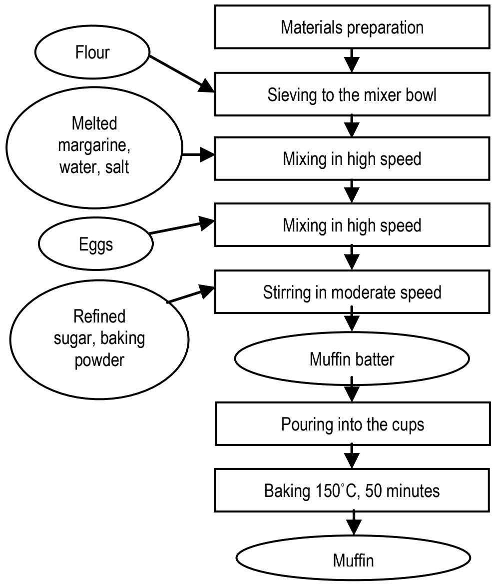

Figure 1. Flow diagram of muffin production

Hardness analysis of final product

Texture of muffin was measured using Texture Analyzer Stable Micro System TA-XT2. Probe specification and setting is shown in Table 2.

Table 2. Probe specification and texture analyzer setting for muffin

Specification	
Type	TA-XT2
Mode	Measure force in compression
Option	Return to Start
Pre-test speed	2.0 mm/s
Test speed	0.5 mm/s
Post-test speed	10.0 mm/s
Distance	10 mm
Trigger type	Auto – 5 g
Data acquistion rate	200 pps

Proximate analysis of final product

Proximate analysis consists of moisture content analysis using oven evaporation method (Indonesian National Standard (SNI) 01-2891-1992), ash content analysis using dry ashing method (SNI 01-2891-1992), protein content analysis using Kjeldahl method (AOAC, 1995), fat content analysis using Soxhlet method (SNI 01-2891-1992), carbohydrate content analysis using by difference method (Nielsen, 2010), and crude fiber content analysis using gravimetric method (Nielsen, 2010).

RESULTS AND DISCUSSION

Formula optimization

Sensory responses on the muffin produced from corn flour substitution is presented in Table 3.

Duncan test on the panelist acceptance of corn substituted muffin indicates that the maximum point of substitution was 100%. This was because the panelists' hedonic score for all sensory attributes at substitution level from 50% to 100% was

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not significantly different at 5% significance level. In addition, the average hedonic score for overall attribute at 100% substitution level was equal to 6.69, which means that the muffin was preferred by panelists.

Table 3. Panelist acceptance of corn substituted-muffin

Parameter	Hedonic Score of Muffin at Different Level of Corn Flour Substitution					
	50%	60%	70%	80%	90%	100%
Color	6.8[a]	6.6[a]	6.8[a]	7.2[a]	7.1[a]	7.3[a]
Aroma	5.8[a]	6.0[a]	5.8[a]	6.2[a]	6.5[a]	6.9[a]
Taste	6.2[a]	6.2[a]	6.0[a]	6.1[a]	6.4[a]	6.7[a]
Texture	5.3[a]	5.3[a]	5.6[a]	5.9[a]	5.9[a]	5.6[a]
Over all	6.5[a]	6.3[a]	6.2[a]	6.3[a]	6.6[a]	6.7[a]

Note: the same superscript indicates no significance difference at significance level of 5%

The characteristics of 100% corn flour-muffin were yellow in color, slightly less compact texture, strong corn aroma, uniform cells structure and moderate in size (similar to 100% wheat flour-muffin), and well developed. The 100% corn flour-muffins are shown in Figure 6a.

Sensory responses on muffin produced from sweet potato flour substition is shown in Table 4. Duncan test on hedonic score of sweet potato flour substituted muffin showed that the maximum point of substitution was 40%. This was because the hedonic score for the substitution level of 50% to 70% is less than 5 (dislike).

Table 4. Panelist acceptance of sweet potato flour substituted-muffin

Parameter	Hedonic Score of Muffin at Different Level of Sweet Potato Flour Substitution					
	20%	30%	40%	50%	60%	70%
Color	6.5[a]	6.0[ab]	5.8[ab]	5.5[ab]	5.1[b]	5.4[ab]
Aroma	6.1[a]	5.6[ab]	5.6[ab]	4.9[abc]	4.8[c]	4.4[c]
Taste	6.0[a]	6.1[a]	5.9[a]	4.9[b]	4.5[b]	4.4[b]
Texture	6.2[a]	5.4[a]	5.3[a]	4.3[b]	4.0[b]	3.7[b]
Over all	6.4[a]	6.0[a]	6.1[a]	4.9[b]	4.4[b]	4.3[b]

Note: the same superscript indicates no significance difference at significance level of 5%

The characteristics of 40% sweet potato flour substituted muffin were dark brown in color, compact and sticky texture, strong sweet potato aroma, and not well developed. The 40% sweet potato flour substituted muffins are shown in Figure 6b. The texture of sweet potato flour substituted muffin was less preferred by panelists due to its slightly sticky texture. The sticky texture of the product is due to high viscosity of sweet potato flour dough (480 BU) (Ijarotimi and Ashipa, 2005). Viscosity of wheat flour and corn flour dough are 430 BU (Oladunmoye *et al*., 2010) and 154.46 BU (Phattanakulkaewmorie, 2011) respectively. Dough with lower viscosity exhibited more compact texture of muffin than sweet potato flour substituted muffin, thus more preferred by the panelists. Based on the maximum level of single flour substitution, the percentage of wheat, corn, and sweet potato flour feed into the mixture design software were 0-20%, 60-90%, and 10-40%, respectively. The maximum point of corn flour used in the design was 90% to retain the use of sweet potato flour in formula.

All of the formula combinations were tested and the response values obtained are shown in Table 5. Hedonic score of 1 corresponded to extremely dislike response whereas hedonic score of 10 indicated extremely like response with score of 5 indicated neither like nor dislike response. The panelist response was further used to developed models to describe the response and shown in Table 6.

Table 5. Hedonic response of muffin produced from different flour compositions

Flour Composition (%)			Hedonic Score				
WF*	CF*	SPF*	Color	Aroma	Taste	Texture	Over all
0	75	25	6.2	5.5	5.2	4.7	5.4
0	90	10	6.7	5.8	5.8	5.1	6
0	75	25	6	5.6	5.5	5.1	5.8
11	60	29	4.3	5.2	5.2	5.1	5.3
20	60	20	6.7	6	5.4	4.6	5.7
4.4	67	28.5	5.7	5.8	5.4	4.5	5.4
20	66.7	13.3	6.2	5.4	5.2	4.6	5.5
0	90	10	6.7	5.7	5.5	5.4	6
5.5	79.6	14.9	6.4	6.2	5.9	5.7	6
10.3	69.3	20.4	5.1	5.6	5.6	5.3	5.6
15.6	74.4	10	6.9	6	5.6	5.3	6.1
20	60	20	6.3	6.1	6	5.4	6.3
0	60	40	3.9	5	5.1	4.2	5.1
15.6	74.4	10	7	5.6	6	4.9	6
5.2	60.6	34.2	4.8	5	5.1	4.1	5
0	60	40	3.7	4.9	5.1	4.3	4.7

Note: *WF: wheat flour; CF: corn flour ; SPF: sweet potato flour

Each sensory parameter was satisfactorily described using different polynomial models. Based on the p-value, all the parameters had significant model ($p<0.05$) and not significant lack of fit ($p>0.05$). This indicates that the model appropriately describe the hedonic response. Adjusted R^2 is a measure of the amount of variation about the mean explained by the model while Predicted R^2 represented the amount of variation in new data explained by the model. Value of 1.0 for Adjusted R^2 and Predicted R^2 showed the ideal condition in which 100% of the variation in the observed values could be represented by the chosen model. Adequate precision is a measure of the range in predicted response relative to its associated error, in other words a signal to noise ratio. Its desired value is 4 or more.

All parameters had adequate precision greater than 4. The positive constant in the equation showed that the hedonic score would increase with an increase in the number of components or interactions between components. Increased amount of sweet potato flour resulted in dark brown color muffin and lower hedonic score. Crust browning is associated with caramelization and Maillard reactions between protein and reducing sugars (Purlis and Salvadori, 2009). High sugar content in sweet potato flour, amounting to 12.7-12.9% (w.b) (Brinley *et al*., 2008, Nabubuya *et al*., 2012), induces Maillard reaction intensively. Increased amount of sweet potato flour also caused strong sweet potato aroma and lower hedonic scores for aroma attribute. Higher amount of sweet potato flour produced high viscosity batter and give sticky texture to the final product.

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Table 6. Mathematical model to describe hedonic response at formula optimization step

Parameter	Model Orde	p-Value		Adjusted R^2	Predicted R^2	Adequate Precision	Equations
		Model	Lack of Fit				
Color	Reduced cubic	<0.0001 (sig)	0.1155 (n sig)	0.9705	0.874	22.156 (>4.0)	Color = 12.31A + 0.16B – 4.25C – 0.21AB – 0.07AC + 0.07BC – $1.01x10^{-3}$AB(A-B) –($5.35x10^{-4}$)AC(A-C) – ($4.97x10^{-4}$) BC(B-C)
Aroma	Cubic	0.0048 (sig)	0.9461 (n sig)	0.8516	0.7628	10.152 (>4.0)	Aroma = 5.91A + 0.1B – 1.96C – 0.11AB – 0.04AC + 0.04BC + 2.3x10-4ABC – 5.48x10-4AB(A-B) –1.5x10-5AC(A-C) – 2.4x10-4BC(B-C)
Taste	Linear	0.0214 (sig)	0.6125 (n sig)	0.3612	0.1342	5.673 (>4.0)	Taste = 0.06A + 0.06B + 0.04C
Texture	Linear	0.0135 (sig)	0.3517 (n sig)	0.4035	0.2405	5.673 (>4.0)	Texture = 0.05A + 0.06B + 0.02C
Overall	Linear	0.0002 (sig)	0.6151 (n sig)	0.6848	0.5669	10.259 (>4.0)	Overall = 0.07A + 0.06B + 0.03C

Note: A = wheat flour (%), B = corn flour (%), C = sweet potato flour (%), sig = significant (α=0.05), n sig = not significant (α=0.05)

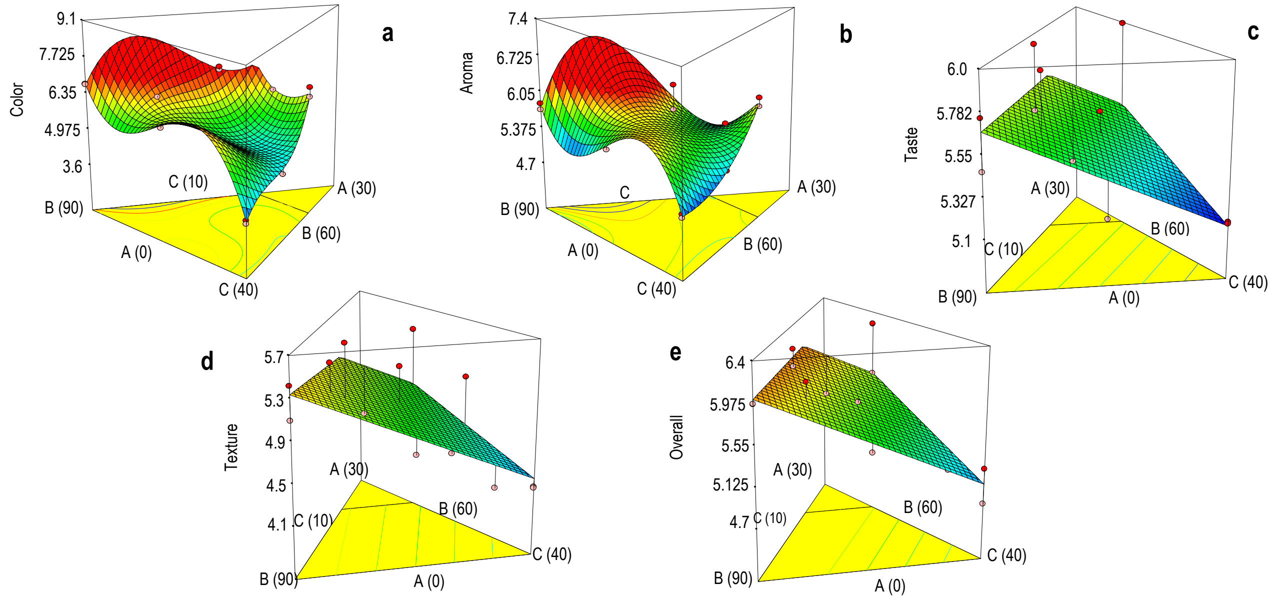

Figure 2. Three-dimensional graphs in formula optimization for (a) color (b) aroma (c) taste (d) texture and (e) overall responses

The high viscosity in sweet potato flour was due to a high swelling ability by its high starch content (65.5%) and low protein content (3.15%) so that the starch granules are easier to expand and absorb water (Aprianita *et al*., 2009). Three-dimensional graphs of sensory responses (color, aroma, taste, texture, and overall) in formula optimization step are shown in Figure 2. Sensory responses were then optimized by determining desired goal and importance level of the variable as indicated in Table 7. Optimum formula obtained from optimization of sensory responses was 4% wheat flour, 86% corn flour, and 10% sweet potato flour.

Table 7. Goal and importance criteria of each variable in formula optimization

Variable	Goal	Lower	Upper	Importance
WF*	In range	0	20	
CF*	In range	60	90	
SPF*	In range	10	40	
Color	Maximize	3.74	7.01	+++++
Aroma	Maximize	4.91	6.19	+++++
Taste	Maximize	5.11	6.00	+++++
Texture	Maximize	4.12	5.66	+++++
Overall	Maximize	4.74	6.27	+++++

Note: *WF: wheat flour; CF: corn flour; SPF: sweet potato flour

Desirability value of optimum formula was 0.844. The higher desirability value indicated the high suitability of formula to achieve the desired response. Characteristics of muffin obtained from formula optimization (Figure 6c) were dark yellow, slightly less compact texture, strong corn aroma, moderate size cells, and high volume development. Three-dimensional graph of the optimum formula is presented in Figure 3.

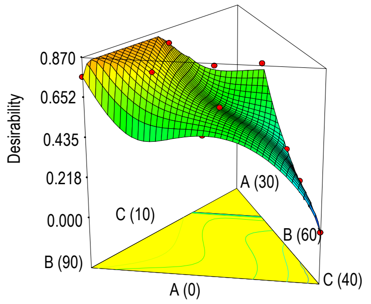

Figure 3. Three-dimensional graph of the optimum formula

The formula was then verified to prove the conformity between the actual response and the predicted response value. Conformity was indicated by the sensory response of verification process which is within the range Confident Interval (CI) or a

Prediction Interval (PI). Confident interval is a range that shows the expectation of the average results from subsequent measurements on a particular significance level, in this case 5%. Prediction interval is a range that shows the expectation of results from subsequent measurements. Table 8 shows the verification results of the optimum formula.

Table 8. Comparison of predicted and measured sensory response obtained from verification process

Parameter	Sensory Response		Sensory Interval			
	Prediction	Verification	95% CI Low	95% CI High	95% PI Low	95% PI High
Color	8.25	7.61	7.57	8.94	7.44	9.07
Aroma	6.91	6.39	6.30	7.51	6.19	7.62
Taste	5.69	6.21	5.44	5.94	5.10	6.29
Texture	5.32	5.62	4.95	5.69	4.45	6.19
Overall	6.04	6.23	5.79	6.29	5.44	6.63

Verification result showed that the value for the response of color, aroma, texture, and overall was in the 95% Confident Interval. The response of taste was within the 95% Prediction Interval. Verification of sensory response was close to the predicted value. Therefore, it could be concluded that the models are suitable to determine the optimum formula within the studied range.

Process optimization

Process optimization was carried out using response surface experimental design which was available in the Design Expert 7.0 ® software. The optimized variables were baking temperature and time. Minimum and maximum point of baking time and temperature feed into the software is shown in Table 9.

Table 9. The range of baking time and temperature

Variable	-1 Level	+1 Llevel	-Alpha	+Alpha
Temp. (°C)	150	170	145.86	174.14
Time (min)	25	50	19.82	55.18

The combinations of baking temperature and time suggested by the software are shown in Table 10. Muffin produced using optimum formula was then baked under different baking condition as suggested by the software. Table 10 also shows the sensory responses of the muffin obtained from 70 untrained panelists. The models developed based on the sensory responses are shown in Table 11. Based on the results obtained, only the overall response had a significant lack of fit. This could becaused by the large standard deviation of the data. More over, the value of Predicted R^2 for overall parameter was negative which indicated that the overall mean was a better predictor than the model. Nevertheless, it still has a significant model so that the overall parameter is still eligible to be included in the optimization stage. Three-dimensional graphs in formula optimization for each parameter is shown in Figure 4.

Table 10. Hedonic response of muffin produced from different baking temperature and time

Temp. (°C)	Time (min.)	Color	Aroma	Taste	Texture	Over all
160	38	6.6	6.2	5.9	5.3	6.1
170	25	3.5	4.5	5.0	5.2	4.5
160	38	6.4	6.1	6	5.5	6.1
150	50	6.1	6	6.0	5.2	5.8
170	50	3.1	3.9	4	3.6	3.6
160	38	6.2	6.3	5.9	5.5	6.0
150	25	4.7	5.3	5.0	4.1	4.7
146	38	4.9	5.2	5.5	4.9	5.3
174	38	4.8	5.1	5.8	5.2	5.6
160	55	4.6	5.1	5.2	4.7	5.1
160	38	6.4	5.9	6.1	5.7	6.2
160	20	4.6	4.9	4.8	4.0	4.6
160	38	6.2	6.0	6.2	5.6	6.2

Sensory response optimization resulted in an optimum baking process condition at 158°C for 39 minutes with desirability value of 0.979. Baking time was around 20% shorter than the baking time of muffins before optimization. Such a reduction in baking time is very important in increasing through put during full production in a factory. The hedonic scores for all parameter were more than 5 meaning that the product was desirable and acceptable by panelists.

Desirability value of 0.979 was considered as high for a new product. Compared to the characteristics of the 100% wheat flour-muffin, muffin obtained from the baking process optimization (Figure 6d) had brown color, crumbly and dry texture, and the volume development was not as high as the 100% wheat flour-muffin. The brown color of substituted muffin occurred was due to the natural colour of sweet potato flour. Crumbly texture and the development of lower volume was caused by the low content of gluten in the batter that needed to form structure and trap air bubbles. Three-dimensional graphs of the process optimization is presented in Figure 5.

The advantages of using composite flour in muffin is to diversify the use of local carbohydrate resources. The combination of sweet potato flour, corn flour and wheat flour could also increase certain nutritional content of the final product. Beta-carotene content of sweet potato (2300 mkg/100g, Teow *et al.,* 2006) is much higher than corn (29 mkg/100g, Perry *et al*., 2009) so that it is expected to increase the presence of beta-carotene on the final product. However, beta-carotene is unstable to heat. Nevertheless, high retention of beta-carotene was ever observed in oven drying that reached 89%-96% (Vimala *et al*., 2011), whereas retention by baking was up to 43.17% (Inocent *et al*., 2011). High intake of beta-carotene may help protect against oxidative damage, thus lowering cancer and cardiovascular disease risk (Genkinger *et al*., 2004). These four types of muffins are shown in Figure 6.

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Table 11. Mathematical model to describe hedonic response at baking optimization step

Parameter	Model Orde	p-value		Adjusted R^2	Predicted R^2	Adequate Precision	Equations
		Model	Lack of Fit				
Color	Reduced cubic	0.0004 (sig)	0.0661 (n sig)	0.9313	0.4295	14.323 (>4.0)	$Color = 6.39 - 0.053A + 0.12B - 0.45AB - 0.86A^2 - 0.98B^2 - 0.98AB^2$
Aroma	Reduced cubic	<0.0001 (sig)	0.3773 (n sig)	0.9518	0.7594	19.747 (>4.0)	$Aroma = 6.07 - 1.41A - 0.34AB - 0.49A^2 - 0.58B^2 + 0.69A^3$
Taste	Reduced cubic	0.0028 (sig)	0.0543 (n sig)	0.8646	0.2926	11.570 (>4.0)	$Taste = 6.03 + 0.11A + 0.073B - 0.52AB - 0.27A^2 - 0.59B^2 - 0.63AB^2$
Texture	Reduced quadratic	<0.0001 (sig)	0.0771 (n sig)	0.8651	0.7554	11.541 (>4.0)	$Texture = 5.52 - 0.66AB - 0.28A^2 - 0.64B^2$
Overall	Quadratic	0.0168 (sig)	<0.0001 (sig)	0.6825	-0.2972	5.840 (>4.0)	$Overall = 6.11 - 0.23A + 0.13B - 0.52AB - 0.45A^2 - 0.76B^2$

Note: A = wheat flour (%) B = corn flour (%) C = sweet potato flour (%), sig = significant (α=0.05), n sig = not significant (α=0.05)

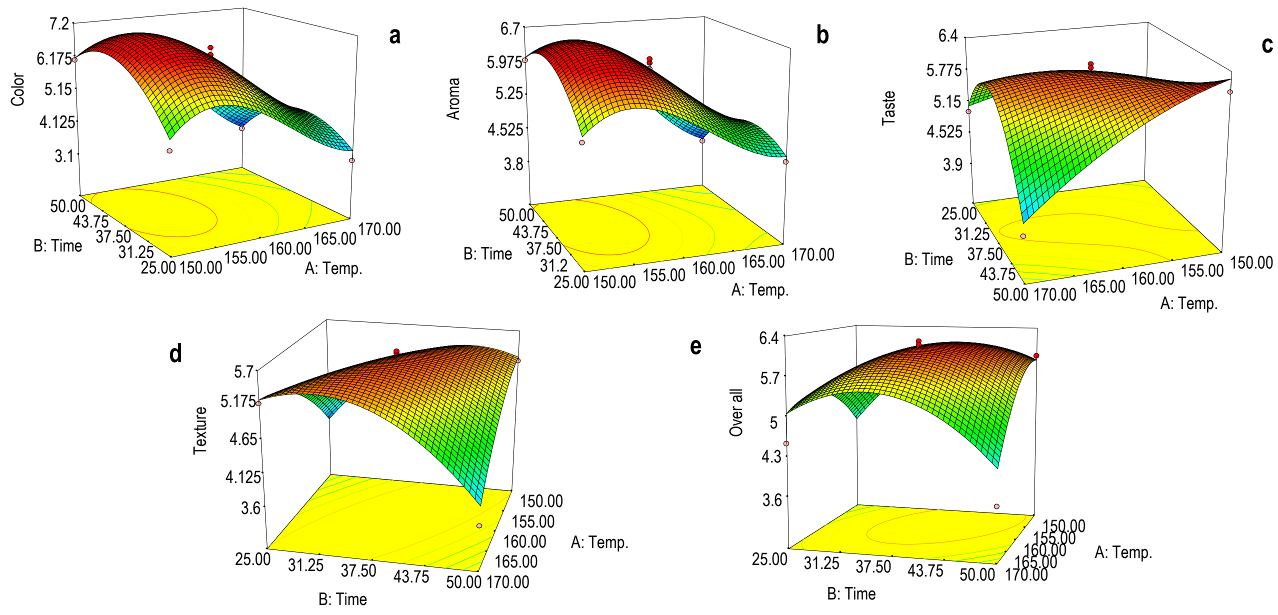

Figure 4. Three-dimensional graphs in process optimization for (a) color (b) aroma (c) taste (d) texture and (e) overall responses

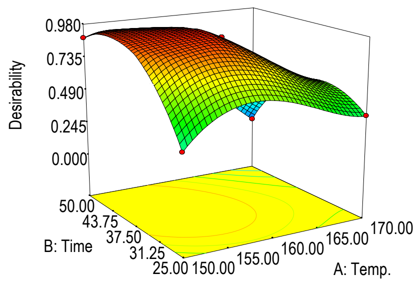

Figure 5. Three-dimensional graphs of the process optimization

Figure 6. (a) 100% corn flour-muffin (b) 40% sweet potato substituted-muffin(c) Muffin made from optimum formula (d) Muffin made from optimum formula and process

Table 13 shows the comparison between the predicted and measured sensory responeses of muffin obtained from process optimization. Based on the verification result (actual response), the value for the response of color, aroma, texture, and overall were still within 95% Confident interval (in the range of 95% CI low and 95% CI high). For the taste response, even though the value was not in the range, the result of verification provided a better value as compared to the predicted value (above the maximum range). Verification result value was in agreement with the predicted value. Therefore, it was concluded that the model obtained was suitable to determine the optimum process condition.

Table 13. Comparison of predicted and measured sensory response obtained from verification of baking process

Parameter	Sensory Response		Sensory Interval			
	Pre-diction	Veri-fication	95% CI Low	95% CI High	95% PI Low	95% PI High
Color	6.88	6.62	6.49	7.27	6.03	7.72
Aroma	6.41	6.58	6.22	6.61	5.99	6.84
Taste	6.34	7.27	6.02	6.65	5.66	7.02
Texture	5.51	5.67	5.27	5.75	4.91	6.11
Overall	6.16	6.51	5.68	6.64	4.97	7.35

Texture of final product

Average force measured to deform the sample up to 1.8 mm is 107.3 gf. The greater force required to deform the sample indicates that the sample is harder. Chung *et al*. (2010) reported that 100% wheat flour-muffin has hardness value of 290 gf. The hardness of composite flour muffin was smaller than the 100% wheat flour-muffin. It means that the composite flour substituted-muffin has softer texture than 100% wheat flour-muffin. Texture analysis results is shown in Table 14.

Table 14. Texture analysis result of composite flour substituted-muffin

Sample	Force (gf)	Time (s)	Distance (mm)
1	111.8	3.605	1.800
2	113.1	3.605	1.803
3	92.8	3.605	1.800
4	111.5	3.605	1.803

Proximate composition of final product

The proximate composition of the composite flour substituteed-muffin is presented in Table 15. Muffin had 18.84% moisture content. The moisture content of substituted baking product was lower than 100% wheat flour baking product which ranging from 35.3-36.5% (Barcenas and Rosell, 2006).

Table 15. Proximate analysis result of composite flour substituted-muffin

Analysis	Wet Based (%)
Moisture	18.84
Ash	1.48
Protein	4.78
Fat	18.23
Carbohydrate	56.67
Crude fiber	0.26

The low level of moisture in substituted muffin was due to lower baking temperature and longer baking time as compared to traditional process (200°C for 20 minutes). A fairly high fat content (18.23%) came from the use of margarine in muffins making process that reached up to 20.71% of the total ingredients. Carbohydrate content of 56.67% came from the use of flour which reaches up to 31.52% of the total ingredients. Substitution of sweet potato also was found to increase ash content in the baking product (Hathorn *et al*., 2008).

CONCLUSION

Corn and sweet potato flour could substitute wheat flour in muffins up to 96% with acceptable sensory properties. Optimum formula of muffin from composite flours was 4% wheat flour, 86% corn flour and 10% sweet potato flour. The results of the process optimization showed that the optimum baking process conditions was at 158°C for 39 minutes. The baking time was shorter than the baking time of wheat flour muffin which was 50 minutes. The final product (muffin made from 4% wheat flour, 86% corn flour and 10% sweet potato flour baked at 158°C for 39 minutes) had a hardness value of 107.3 gf and contains 18.84% moisture, 1.48% ash, 4.78% protein, 18.23% fat, 56.67% carbohydrate, and 0.26% crude fiber.

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