EFFECT OF EXTRACTION VARIABLES ON THE MINERAL COMPOSITION OF COCONUT MILK

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Abstract
The composition of coconut milk depends, to a large extent, on the extraction procedure. However, effect of extraction process conditions on the mineral composition of coconut milk has not been documented. In this study, response surface methodology (RSM) with a central composite design (CCD), consisting three factors (extraction time, extraction temperature and coconut meat particle size) was used to study the effect of process conditions on the mineral content of coconut milk. Results revealed that process variables significantly ($p<0.05$) affected the mineral contents of coconut milk. The R^2 for Ca, Na, and Mg were 0.9612, 0.8725 and 0.9885 respectively, indicating that over 87% proportion of variation in Ca, Na, and Mg were explained by the fitted models while, R^2 for K and P were 0.7916 and 0.6544 respectively indicating that only 79.16% variation in K and 65.44% variation in P were explained by the fitted models. Ca, Na, Mg, K and P content of the coconut milk ranged from 0.26 to 0.48%, 0.11 to 0.18%, 0.04 to 0.09%, 0.28 to 0.50% and 0.0026 to 0.0040% respectively. The optimum conditions obtained for extraction of coconut milk with a desirability index of 86.4% were extraction time of 10.96 min, extraction temperature of 60°C and ≤ 1617µm particle size of coconut meat respectively. The optimum Ca, Na, Mg, K and P were estimated at 0.461, 0.171, 0.083, 0.459 and 0.004% respectively.

Keywords: Coconut Milk; Central Composite Design; Modelling; Response Surface Methodology; Desirability Index; Optimization

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1. INTRODUCTION

Coconut milk is a nutritious food product consumed all over the world. Narataruka *et al.* (2010) defined coconut milk as a sweet, milky white cooking base obtained, by mechanical extraction, from the endosperm of mature coconut, with addition of water. In recent times, coconut milk has gained importance due to its wide utilization by confectionaries, bakeries, biscuits and ice cream industries worldwide to enhance flavour and taste of various products (Edem, 2016). Coconut milk can also be used as an alternative for milk in desserts such as chocolate while other confectionaries can be flavoured with coconut milk (Muda, 2002). Besides, it also serves as a raw material for the development of dairy-like products such as yoghurt (Belewu *et al*., 2010; Edem and Elijah, 2016 a).

According to Yaakob *et al*. (2012), the nutritional content of coconut milk is superior to cow milk. Coconut milk has about 35% fat, 54% moisture and 11% solid non-fat (Simuang *et al*., 2004; Tansakul and Chaisawang, 2006), and is equally rich in minerals and vitamins (Sanful, 2009). Moreover, coconut milk is a good source of proteins particularly prolamin, globulin, albumin and glutenin, thus can be considered as animal milk substitute which could play important role in reducing protein malnutrition in the developing world (Edem and Elijah, 2016 b).

In Nigeria, the extraction of coconut milk is usually done manually and thus time and energy consuming. Extraction is carried out under diverse process conditions resulting in inconsistent quality products. The composition of coconut milk, and by extension its quality, depends to a large extent, on the extraction process conditions (Edem and Elijah, 2016 c).

According to PCA (2014), the amount of water used for extraction significantly affects the moisture and fat content of the milk. Furthermore, temperature of extraction (Minh, 2014), extraction time (Olarewaju *et al*., 2015) and coconut meat particle size (Edem and Elijah, 2016 c) have been identified as factors affecting coconut milk extraction. Agarwal and Bosco (2014) reported that enzymes enhanced the extraction efficiency of coconut milk by aiding disintegration of the coconut meat cell walls and subsequent release of the milk and its components.

Process optimization, using response surface methodology (RSM), is one of the recent procedures adopted for development of optimum food products to enhance their quality (Edem and Elijah, 2016 c). RSM is a collection of mathematical and statistical tools used for modelling and analysis of problems, in which a response of interest is influenced by several variables, with a view to optimizing the response (Montgomery, 2005). RSM has been used as an effective tool for the optimization of a wide range of food products including extraction of soybean oil (Campbell and Glatz, 2009), olive oil (Meziane, 2013), coconut oil (Agarwal and Bosco, 2014), and more recently coconut milk (Edem and Elijah, 2016 c), among others.

A recent study showed that extraction time, extraction temperature and coconut meat particle size significantly affected consumer acceptability of coconut milk (Edem and Elijah, 2016 b). However, there is no documented literature on the effect of extraction process conditions on the mineral content of coconut milk. Considering the importance of mineral elements in human nutrition, this study was conducted to determine the effect of extraction time, extraction temperature and coconut meat particle size on the mineral composition of coconut milk. Findings from this study would provide baseline data for maximum derivation of mineral element during coconut milk extraction.

2. MATERIALS AND METHODS

2.1 Sample Collection

Matured coconuts (7-8 months old) of the dwarf variety were collected directly from the coconut trees in EmVic farm in Ibesikpo Asutan Local Government Area, Akwa Ibom State, Nigeria and transported to the Processing Laboratory of the Department of Food Science and Technology, University of Uyo, Uyo, Akwa Ibom State, Nigeria, for analysis.

2. 2 Extraction of Coconut Milk

Coconut milk was extracted following the method reported by Edem and Elijah (2016 c) with slight modification. The coconut was dehusked and cracked to separate the meat from the shell. The coconut water obtained was transferred into a container and stored for further use. The brown skin of the coconut meat was carefully removed and the meat thoroughly washed and then grated using a manual grater fabricated by the Department of Food Engineering, University of Uyo, Nigeria, with different particle size numbers. The grated coconut meat was mixed in a ratio of 1:1 with a solution containing 75% distilled water and 25% coconut water, and allowed to stand in a water bath at temperatures and time specified by the experimental design. The resulting slurry was pressed and filtered through cheese cloth to recover the milk. Coconut milk obtained was pasteurized at 90°C for 30 min and allowed to assume room temperature (37°C) before analyzing for mineral composition.

2.3 Experimental Design and Statistical Analysis

The experimental variables (range and levels) for the effects of extraction conditions on mineral compositions of coconut milk are presented in Table 1.

Effect of extraction variable on mineral composition of coconut milk was determined using Design Expert software version 10.0 (Stat-Ease Inc., Minneapolis, MN, USA).

Table 1: Experimental range and levels of independent variables

Independent Variable	Factor	Unit	Coded Levels				
			+α	-1	0	+1	+α
Time	X_1	min	6.591	10	15	20	23.409
Temperature	X_2	^oC	33.182	40	50	60	66.8179
Particle Size	X_3	µm	1114.86	1617	2353.5	3090	3592.14

Response Surface Methodology (RSM) with a Central Composite Design (CCD) was used to study linear, interaction and quadratic effects of extraction variables on mineral content of coconut milk. Three (3) independent variables; extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3), each having 5 different coded levels from low (-1), to medium (0) and high (+1) as well as star points (+ α), were used for efficient determination of curvature and quadratic term.

The dependent variables; Ca, Na, Mg, K and P contents of the milk extracted were evaluated as responses. The design matrix of the CCD and experimental runs are presented in Table 2. Effect of independent variables on the dependent variables was assessed using multiple regression analysis. The full quadratic equation of the response variables for coconut milk extraction was derived using RSM as follows:

$$Y = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_{12}X_1X_2 + \beta_{13}X_1X_3 + \beta_{23}X_2X_3 + \beta_{11}X_{12} + \beta_{22}X_{22} + \beta_{33}X_{32} \quad (1)$$

where Y is the response; βo is the constant; β_1, β_2, β_3 are the coefficients of linear regression; β_{12}, β_{13}, β_{23} are the coefficients of interaction regression; β_{11}, β_{22} and β_{33} are the coefficients of quadratic regression and X_1, X_2, X_3 are the independent variables.

2.4 Analytical Methods

The mineral elements were analyzed from the digested coconut milk sample. Each analysis was performed in duplicate. Flame emission spectrophotometer (Sherwood 410) was used for the determination of Na and K; calcium and magnesium was determined using versenate titration method (EDTA), while phosphorous was determined using vanado-molybdate (yellow) method following AOAC (2007) procedures. All chemicals were analytical reagent grade and used without further purification.

3. RESULTS AND DISCUSSION

3.1 Model Fitting

Results of the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the mineral composition of coconut milk are presented in Table 2.

Table 2: Descriptive statistics of the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the mineral composition of coconut milk

Exp Run	Independent variable			Response (%)				
	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4	Y_5
1	15	33.1821	2353.5	0.42	0.15	0.07	0.35	0.0028
2	23.409	50	2353.5	0.46	0.14	0.07	0.35	0.0034
3	10	40	1617	0.46	0.17	0.08	0.46	0.0037
4	15	50	2353.5	0.44	0.15	0.07	0.33	0.0028
5	20	60	1617	0.46	0.16	0.08	0.49	0.0038
6	15	50	2353.5	0.44	0.15	0.07	0.35	0.0028
7	15	50	3592.14	0.26	0.11	0.02	0.28	0.0019
8	15	66.8179	2353.5	0.46	0.14	0.07	0.39	0.0032
9	15	50	1114.86	0.48	0.18	0.09	0.50	0.0040
10	20	60	3090	0.38	0.15	0.04	0.38	0.0036
11	10	40	3090	0.32	0.13	0.04	0.38	0.0030

Exp Run	Independent variable			Response (%)				
	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4	Y_5
12	20	40	1617	0.45	0.16	0.08	0.44	0.0038
13	15	50	2353.5	0.44	0.15	0.07	0.33	0.0028
14	6.59104	50	2353.5	0.42	0.15	0.07	0.33	0.0030
15	10	60	3090	0.38	0.13	0.04	0.38	0.0028
16	15	50	2353.5	0.44	0.15	0.07	0.33	0.0032
17	20	40	3090	0.36	0.15	0.04	0.38	0.0026
18	15	50	2353.5	0.44	0.15	0.07	0.33	0.0028
19	10	60	1617	0.45	0.17	0.08	0.48	0.0037
20	15	50	2353.5	0.44	0.15	0.07	0.33	0.0028

X_1 = Extraction time, X_2= Extraction temperature, X_3 = Particle size, Y_1 = Calcium content, Y_2 = Sodium, Y_3 = Magnesium, Y_4 = Potassium, Y_5 = Phosphorous

Results show that calcium, sodium, magnesium, potassium and phosphorous contents of coconut milk ranged from 0.26 to 0.48%, 0.11 to 0.18%, 0.02 to 0.09%, 0.28 to 0.50% and 0.0019 to 0.0040% respectively. The highest Ca, Na Mg, K and P contents of coconut milk were obtained when extracted at 50°C for 15 min using a particle size of 1114.86 μm. These experimental data were used to generate the best predicted model and its statistical analysis using RSM software. Fitness of the final predicted polynomial model was estimated using the results of analysis of variance (ANOVA) presented in Table 3. The regression model which had the highest R^2, adjusted and predicted R^2 as well as the lowest standard deviation, values were shown to be significant ($p<0.05$) and effective in describing the effect of independent variables on the dependent (Ca, Na, Mg, K and P) variables. For this reason, calcium and magnesium were fitted to quadratic model, potassium was fitted to reduced quadratic model because there were a number of insignificant terms in the regression model. In order to develop a statistically significant regression model, the insignificant terms were removed from the model thus resulting in a model's efficiency in describing response (Sudamalla *et al.*, 2012, Edem and Elijah, 2016 c). On the other hand, phosphorus and sodium were fitted to a linear model and a two factor interaction (2FI) model respectively. Results (Table 3) show that the probability value of the response models was < 0.01, suggesting that the models were statistically correct and effective.

Furthermore, the model's goodness-of-fit was also ascertained by the coefficient of determination (R^2) presented in Table 4. Jusoh *et al*. (2013) noted that the best R^2 value for a good model fitting is between 0.8 and 1.0. The R^2 values of Ca, Na and Mg were 0.9612, 0.8725 and 0.9885 respectively. This indicated that over 80% variations in the observed values of Ca, Na and Mg were explained by respective regression models. $R^2 < 0.8$ had been reported previously (Gupta *et al*., 2014; Edem and Elijah, 2016 c), signifying a fair fit of the model, yet reliable in making predictions. Thus R^2 of 0.7916 and 0.6544 for K and P respectively, indicated that the models were fairly fitted. This showed that only 79.16% variations in K and 65.44% variations in P were explained by reduced quadratic and linear models respectively. The reliability of the experiment was tested using coefficient of variation (CV). Table 4 shows a CV values < 10% for Ca, Na, Mg and K while a CV > 10% was obtained for phosphorus. Shishir *et al*. (2016) reported that CV < 10% indicates good precision and reliability while Gupta *et al*. (2014) reported that CV > 10% indicates that the experiment was reliable but less precise.

Table 3. Analysis of variance (ANOVA) for the fitted polynomial model of the dependent variables

Response	Source	df	Sum of Square	Mean Square	F-value	P-*value*
Calcium	Model	5	0.054	0.011	69.44	0.0001*
	Residual	14	2.194E-003	1.567E-004		
	Lack -of -fit	9	2.194E-003	2.438E-004		
	Pure error	5	0.000	0.000		
	Total	19	0.057			
Sodium	Model	3	3.922E-003	1.307E-003	36.49	0.0001*
	Residual	16	5.732E-004	3.582E-005		
	Lack -of -fit	11	5.732E-004	5.210E-005		
	Pure error	5	0.000	0.000		
	Total	19	4.495E-003			
Magnesium	Model	9	6.222E-003	6.914E-004	95.19	0.0001*
	Residual	10	7.263E-005	7.263E-006		
	Lack -of -fit	5	7.263E-005	1.1453E-005		
	Pure error	5	0.000	0.000		
	Total	19	6.295E-003			
Potassium	Model	4	0.059	0.015	14.12	0.0001*
	Residual	15	0.015	1.032E-003		
	Lack -of -fit	10	0.015	1.515E-003	22.72	0.0015
	Pure error	5	3.333E-004	6.667E-005		
	Total	19	0.074			
Phosphorus	Model	3	3.401E-006	1.134E-006	10.10	0.0006*
	Residual	16	1.796E-006	1.123E-007		
	Lack -of -fit	11	1.663E-006	1.512E-007	5.67	0.0341
	Pure error	5	1.333E-007	2.667E-008		
	Total	19	5.198E-006			

*Values are significant at p =0.05

Table 4: Estimated regression coefficients, coefficients of determination of the fitted polynomial model for Ca, Na, Mg, K and P content of coconut milk at the design response surface

Source	Ca		Na		Mg		K		P	
Model constant	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Bo	0.44		0.15		0.070		0.34		3.125E-003	
Linear										
β_1	7.855E-003	0.0360	NS	0.8874	NS	1.0000	NS	0.432	NS	
β_2	0.011	0.0066	NS	0.7222	NS	1.0000	NS	0.2657	NS	
β_3	-0.055	0.0001	-0.016	0.0001	-0.020	0.0001	-0.053	0.0001	-4.78E-004	0.0001
Interaction										
β_{12}	NS		NS	1.0000	NS	1.0000	-		-	
β_{13}	NS		7.500E-003	0.0027	NS	1.0000	-		-	
β_{23}	0.010	0.0403	NS	1.0000	NS	1.0000	-		-	
Quadratic										
β_{11}^2	NS				NS	1.0000	NS		-	
β_{22}^2	NS				NS	1.0000	0.023	0.0147	-	
β_{33}^2	-0.026	0.0001			-6.29E-003	0.0001	0.030	0.0027	-	
C.V. %	2.98		4.00		4.18		8.47		10.72	
R^2	0.9612		0.8725		0.9885		0.7916		0.6544	
Adjusted R^2	0.9474		0.8486		0.9781		0.7361		0.5896	

Source	Ca		Na		Mg		K		P	
Model constant	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Predicted R^2	0.8620		0.7667		0.9129		0.6745		0.4336	
Adequate precision	29.677		20.403		35.894		11.429		10.737	

R^2 = coefficient of determination, CV=coefficient of variation; NS= values not significant

3.2 Effect of Extraction Time, Extraction Temperature and Coconut Meat Particle Size on Calcium Content of Coconut Milk

The calcium content (Y_1) of coconut milk as affected by extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) is presented in Table 4. The regression model showing the effect of process variables on calcium content of coconut milk is given in equation 2.

$$Y_1 = 0.44 + 0.007855X_1 + 0.011X_2 - 0.055X_3 + 0.010X_2X_3 - 0.026X_3^2 \quad (2)$$

Result shows that extraction time, extraction temperature, coconut meat particle size, interaction of extraction temperature and coconut meat particle size and quadratic effect of coconut meat particle size had significant (P<0.05) effect on the calcium content of coconut milk (Table 4). In addition, the coefficients of estimate (Table 4) represent the relative impact of process variables on the calcium content of coconut milk. Positive and negative coefficients in the model indicate synergistic and antagonistic effects respectively. The main effect of coconut meat particle size (Fig. 1a) showed that increase in coconut meat particle size resulted in decrease in calcium content of the coconut milk. However, interaction effect of extraction temperature and coconut meat particle size led to a gradual increase in the calcium content of the coconut milk. This may be as a result of increase in temperature which could increases the diffusion rate of soluble components of coconut and consequently increase calcium content of the coconut milk.

Effect of extraction time and coconut meat particle size at 50°C extraction resulted in decreased calcium content of coconut milk from 0.4588 to 0.3494% (Fig.1b).

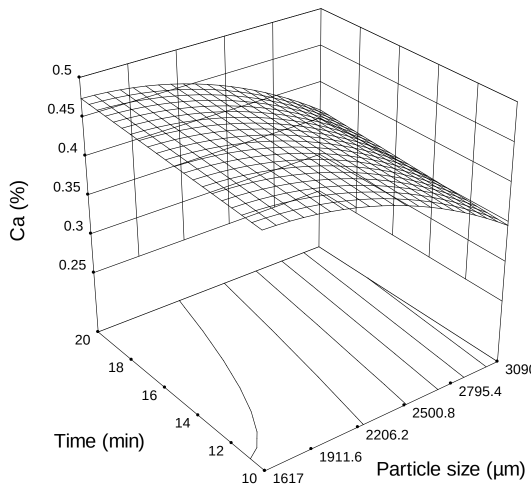

Figure 1a: Effect of extraction temperature and coconut meat particle size on calcium content of coconut milk

This may be due to non diffusion of water soluble components of coconut meat with increased particle size. The calcium content (0.26 – 0.48 %) obtained in this work is similar to the value of 2130.6 mg/l (0.21306 %) reported by Omotosho and Odeyemi (2012) but however, higher than the value (0.0078 %) reported by Pichitvittayakarn *et al*. (2006). Calcium is an important component of a healthy diet and one of the essential minerals necessary for life. Omotosho and Odeyemi (2012) reported that calcium is vital in building stronger, denser bones early in life and maintaining strong and healthy bones later in life.

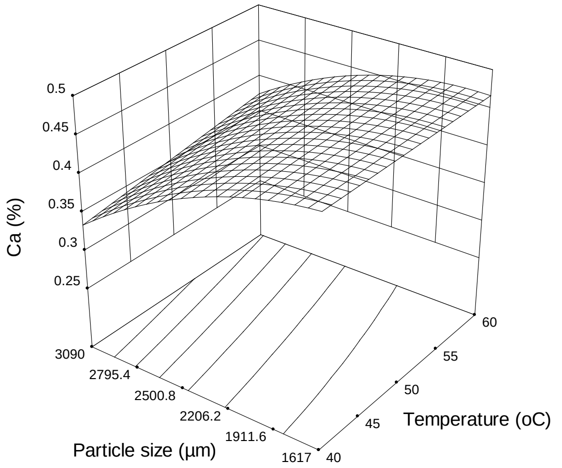

Figure 1b: Effect of extraction time and coconut meat particle size on calcium content of coconut milk

3.3 Effect of Extraction Time, Extraction Temperature and Coconut Meat Particle Size on Sodium Content of Coconut Milk

The estimated regression showing the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the sodium content (Y_2) of coconut milk is expressed in equation (3).

$$Y_2 = +0.15 - 0.016X_3 + 0.00760X_1X_3 \qquad (3)$$

Result shows that coconut meat particle size and interaction of extraction time and coconut meat particle size had significant ($P<0.05$) effect on the sodium content of coconut milk. However, extraction temperature, extraction time and interaction of time and temperature were not significant. The negative main effect of coconut meat particle size indicate that increase in coconut meat particle size (Fig. 2) resulted in decreased sodium content of coconut milk.

However, the positive coefficient of the interaction effect of extraction time and coconut meat particle size resulted in synergism, thus increase in extraction time and coconut meat particle size resulted in increased sodium content of coconut milk.

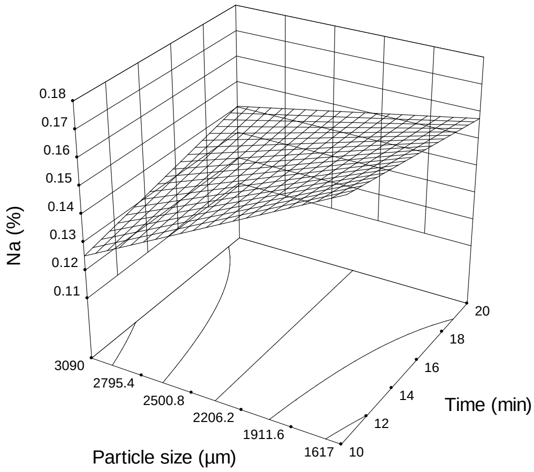

Figure 2: Effect of extraction time and coconut meat particle size on sodium content of coconut milk

The percentage sodium content of coconut milk obtained in this study is higher than the value (0.0415 %) reported by Pichitvittayakarn *et al*. (2006). This increase may be due to the extraction method employed in this study. Furthermore, Omotosho and Odeyemi (2012) reported that sodium plays significant role in ionic exchange and balance in the kidneys, maintenance of balance of positive and negative ions in the body fluid and tissues, and it also helps in signal transmission and muscle contraction.

3.4 Effect of Extraction Time, Extraction Temperature and Coconut Meat Particle Size on Magnesium Content of Coconut Milk

Result shows that the main effects of coconut meat particle size as well as the quadratic term of coconut meat particle size were the only significant terms influencing the magnesium content of coconut milk. However, extraction time, temperature, interaction effect of process variables and quadratic terms of extraction time and extraction temperature showed no significant effect on magnesium content of coconut milk. The relationship showing the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the magnesium content (Y_3) of coconut milk is expressed in equation 4.

$$Y_3 = +0.070 - 0.020X_3 - 0.006294X_3^2 \qquad (4)$$

The 3-D surface model graphs (Fig. 3a and 5b) showed that irrespective of time, coconut meat particle size is a major factor influencing the magnesium content of coconut milk. Increase in coconut meat particle size led to decreased magnesium content of coconut milk. Temperature of extraction did not influence the magnesium content whereas decrease in magnesium content of coconut milk was observed with increased coconut meat particle size. The magnesium contents (0.04 - 0.09 %) of coconut milk in this study were higher than the value (0.0121 %) reported by Pichitvittayakarn *et al*. (2006). In addition, magnesium is a component of bones, teeth, enzyme cofactor, etc. Soetan *et al*. (2010) reported that magnesium is an essential activator for the enzymes myokinase, diphosphopyridinenucleotide kinase and creatine kinase in the body.

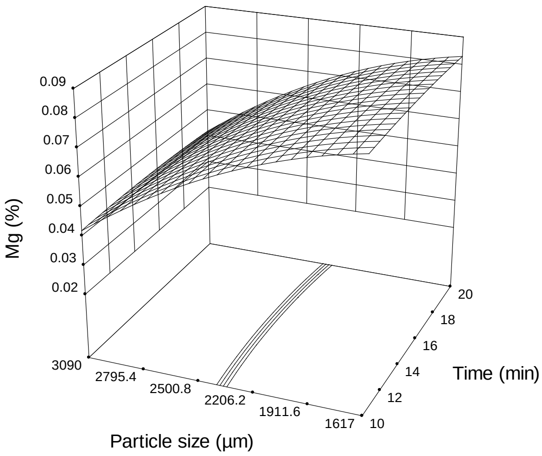

Figure 3a: Effect of extraction time and coconut meat particle size on magnesium content of coconut milk

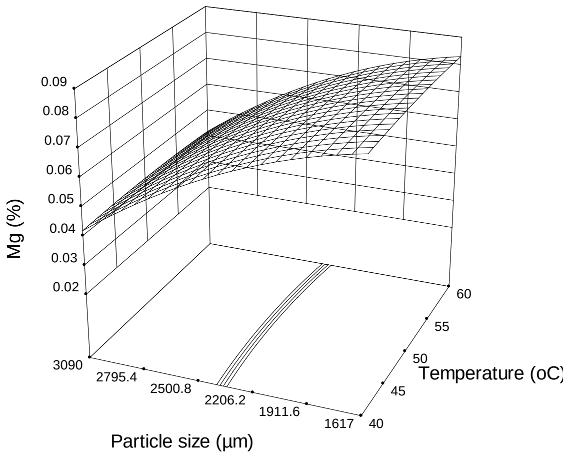

Figure 3b: Effect of extraction temperature and coconut meat particle size on magnesium content of coconut milk

$$Y_4 = +0.34-0.053X_3+0.023X_2^2+0.030X_3^2 \quad (5)$$

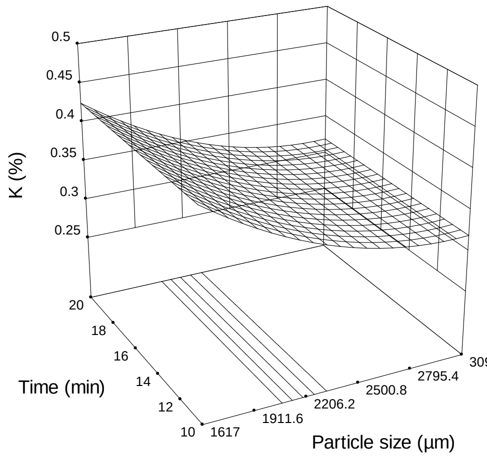

Figure 4a: Effect of extraction time and coconut meat particle size on potassium content of coconut milk

3.5 Effect of Extraction Time, Extraction Temperature and Coconut Meat Particle Size on Potassium Content of Coconut Milk

The significant ($p<0.05$) terms in the reduced quadratic model (Table 4) are the main effect of coconut meat particle size, quadratic term of extraction temperature and quadratic term of coconut meat particle size.

The relationship showing the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the potassium content (Y_4) of coconut milk is expressed in equation 5.

Positive and negative coefficients in the model signify positive and negative effect on the potassium contents of coconut milk respectively. Figure 4a shows that effect of extraction time and coconut meat particle size resulted in decreased potassium content of coconut milk. However, effect of extraction time and extraction temperature resulted in a slight increase in potassium content of coconut milk (Fig. 4b). This may be due to the fact that the quadratic term of extraction temperature exerted an upward effect on the response, thus resulting in increased potassium content of coconut milk. Omotosho and Odeyemi (2012) reported that potassium is one of the abundant minerals in coconut. The results of this study revealed that the highest mineral content of

0.50% was from potassium which is higher than the value of 0.0920 % reported by Pichitvittayakarn *et al*. (2006). Potassium helps in the regulation of the heartbeat and the functions of the muscles in the body.

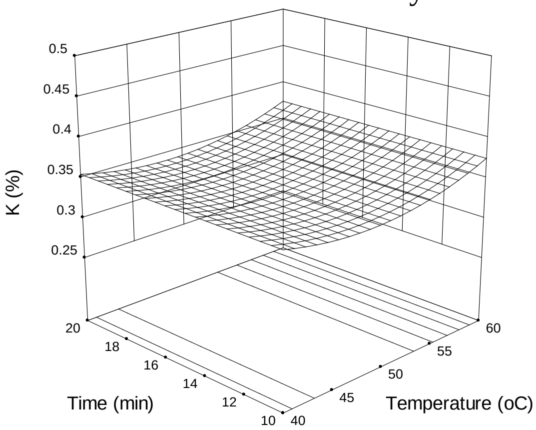

Figure 4b: Effect of extraction time and extraction temperature on potassium content of coconut milk

3.6 Effect of Extraction Time, Extraction Temperature and Coconut Meat Particle Size on Phosphorus Content of Coconut Milk

The significant ($p<0.05$) term in the regression model as shown in Table 4 influencing the phosphorus content of coconut milk is the coconut meat particle size, and the relationship showing the effect of extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3) on the phosphorus content (Y_5) of coconut milk is expressed in equation 6.

$$Y_5 = +0.003125 - 0.0004783X_3 \qquad (6)$$

A negative coefficient in the model represents an antagonistic effect on the response. The 3-D plot of response surface methodology revealed that effect of extraction time and coconut meat particle size resulted in decreased phosphorus content of coconut milk (Fig. 5). Phosphorus functions as a constituent of bones, teeth, adenosine tryphosphate (ATP), phosphorylated metabolic intermediate and nucleic acids (Soetan *et al*., 2010).

3.7 Process Optimization

The optimum extraction time (X_1), extraction temperature (X_2) and coconut meat particle size (X_3), for extraction of coconut milk with maximum amount of Ca, Na, Mg, K and P were determined using maximum desirability index of RSM.

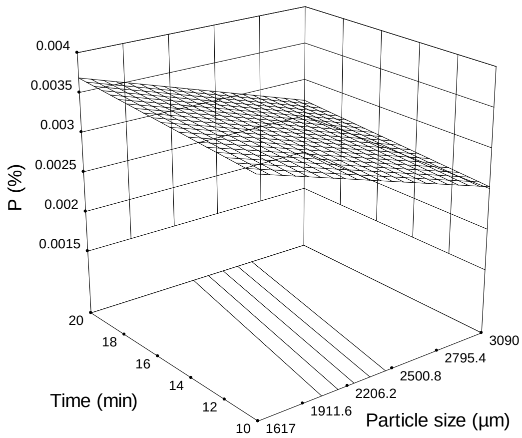

Figure 5: Effect of extraction time and coconut meat particle size on phosphorus content of coconut milk

The result of optimal conditions at the highest desirability index of 0.864 (86.4%) to obtain the highest quantity of Ca, Na, Mg, K and P were 10.96 min extraction time, 60°C extraction temperature and < 1617 µm particle size of coconut meat. The estimated amount of Ca, Na, Mg, K and P were 0.461, 0.171, 0.083, 0.459 and 0.004% respectively.

4. CONCLUSION

The application of central composite design of response surface methodology in studying effect of extraction time, extraction temperature and coconut meat particle size on the Ca, Na, Mg, K and P content of coconut milk revealed that extraction time, extraction temperature and coconut meat particle size significantly affected the contents of mineral elements studied. Results showed that Ca, Na, Mg, K and P contents of coconut milk obtained ranged from 0.26 to 0.48%, 0.11 to 0.18%, 0.02 to 0.09%, 0.28 to 0.50% and 0.0019 to 0.0040% respectively. Therefore, for maximum mineral composition, coconut milk should be extracted at the particle size of coconut meat < 1617 µm, and at extraction temperature of 60°C for 10.96 min to facilitate efficient leaching of the mineral element into the coconut milk during extraction. The estimated amount of Ca, Na, Mg, K and P at the optimum extraction conditions were 0.461, 0.171, 0.083, 0.459 and 0.004% respectively. Thus, the respective regression models can be used to make predictions on the effect of independent variables on mineral content of coconut milk within the experimental range and conditions used in this study.

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