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Characterization of *Irvingia gabonensis* (Ogbono) Soup and Optimization of Process Variables

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Abstract: This work evaluated some quality characteristics and optimization of process varibles of *ogbono* (dikanut) soup using three level factorial design of response surface methodology. The seeds of *Irvingia gabonensis* (dikanut) were cleaned, sorted and milled together with crayfish. Other ingredients: dry fish, palm oil, ground pepper, magi cubes, salt, okra fruits and bitter leaves were added and allowed to cook at medium heat of specified temperature for 13 min., cooled and analyzed using standard procedures. The results of the proximate composition showed that the *ogbono* soup contanined 9% protein, 70.42% fat, 4.61% fibre, 1.92% ash and 11.91% carbohydrate. There was correlation between process variables (temperature and dikanut concentration) and dependent variables (overall acceptability, drawability and consistency index). The processing temperature showed high significance ($p<0.05$) effect and is inversely related to the consistency index, drawability and overall acceptability. The consistency index was not significantly ($p>0.05$) influenced by dikanut concentration. At higher concentration of dikanut, the drawability and dikanut concentration exhibited inverse relationship. The interaction of temperature and concentration of dikanut showed statisical significance ($p<0.05$). Comsumer acceptability was inversely influenced by dikanut concentration. Optimal condition of temperature (50°C) and dikanut concentration (10.96%) with corresponding consistency index (57.25), drawability (7.39) and overall acceptability (7.40) were established. The results may provide useful information during canning operation of *ogbono* soup.

Keywords: *Ogbono* Soup, Proximate Composition, Drawability, Consistency Index, Dikanut Concentration

1. Introduction

Dikanut, commonly known as African mango, bush mango or wild mango is an essential products that serve as valuable source of income to the rural and urban in Africa [1]. Dikanut seed is obtained from the fleshy fruit of *Irvingia gabonensis.* It is locally known in Yoruba land (South West of Nigeria) as “Apon”and “Ogbono” in Igbo land (South East of Nigeria). In Nigeria, dikanut is poplularly used as soup ingredient. The tree of dikanut grows well in tropical rainforests of Africa. The fleshly harvested seeds are dried, comminuted and used in the formulation of recipe for “ogbono” soup [2]. There are two known species of dikanut that grow freely in the southern rain forest of Nigeria. These are: *lrvingia gabonensis var. gabonesis* and *Irvingia gabonensis var. excelsa*. The pulp of the *I. gabonesis var. excelsa* is usually eaten, although bitter and acrid with the flavour of turpentine and slightly slimy. Its seed contains 54 – 67% of fatty matter; hence it is classified as an oil seed [3, 4]. The kernels of *I. Gabonensis* contain oil, which are sometimes extracted. The oil/fat is used in the production of margarine, and pharmaceuticals. After the extraction of oil from the kernels, the by-product (residue) is also used as thickening agent in soup [1]. The kernel serves as condiment used in thickening and flavouring soups. The more the ground kernel ‘draws’ in soup, the more acceptable it is; thus *I. gabonensis var*. *excelsa*, which draws more than the *Irvingia gabonensis var. gabonensis* and is more used in soup making in Nigeria. On the other hand, the pulp of the *I. gabonensis* var. *gabonensis* is sweet, smooth in the mouth and has brittle pulp but its kernel draws less than that of *I. gabonensis* var. *excelsa* [4, 5].

The qualities and types of ingredients used in the formulation of *ogbono* soup differ from tribe to tribe, from low social class to high social strata and depend on the inherited cultural habits. However, there are various formulations [6, 7] with different ingredients ratio. Oladimeji [8] reported soup formulation ingredients as presented in Table 1. However, there is no generalized formulation, but recipes adopted and adapted are developed to suit organoleptic cultural flavours and possibly to reflect aristocratic influence. The aristocratic background is manifested in the type of supplements/condiments added. Each formula is proposed in such a manner that a balance is achieved among taste, flavour, mouth-feel or rheological characteristic and palatability. Traditionally, tomatoes and onions are not added to *ogbono* soup because tomato reduces drawability and onion gives the soup a darker colour. Thus, there is a need to produce *ogbono* soup with a better characteristic [9].

The pseudoplastic behaviour of the *ogbono* soup confers on it the preservative and stabilizing properties [8]. While the soup is rich in flavour and nutrients, the rheological properties, however, affect the drawability of the soup as well as overall consumer acceptability. It is also desirous to relate the consistency index, drawability and overall acceptability of the soup in order to establish the optimal conditions or parameters required for canning processing of the ogbono soup. Therefore this study was designed to optimize the concentration of milled dikanut (*Irvingia gabonensis var.* e*xcelsa*) seed and the temperature of cooking with a view to identifying the significant process parameters and its effect on the consistency, drawability and overall acceptability.

2. Materials and Methods

2.1. Preparation of Materials

Irvingia gabonensis var. excelsa seeds (dikanut) were obtained from Abeokuta markets in Nigeria. The seeds were cleaned and sorted out to remove unwanted particles and other adhering materials. Palm oil, ground pepper, magi cubes, crayfish, dry fish, salt, okra fruits and bitter leaves were purchased from Abeokuta Central Market. The seeds were milled together with crayfish using Laboratory Mill (Corona Lander YCIA Model 1199, South Africa).

2.2. Formulation and Preparation of Ogbono Soup

The formulation described by Oladimeji [8] was adopted (Table 1). The bitter leaves were shredded, washed and squeezed to remove the bitter taste with the aid of salt. The dry fish was washed first with warm water and then with cold water. The dry fish was added to the milled mixture (dikanut seeds and crayfish) and then added to 30 ml of heated palm oil while stirring to avoid lumps. Hot water was gradually added with mixing. Ground pepper, 2 pieces of bouillon cube (maggi cube) and chopped okra were added. These were allowed to cook at medium heat of specified temperature for 10 mins. The bitter leaves were later added and allowed to cook for another 3 mins. Finally salt was added to taste.

2.3. Viscosity Measurement

Table 1. *Ogbono soup formular (%).*

Ingredients	A1	A2	A3
Ground Ogbono	9.64	12.22	14.80
Water	75.40	75.40	75.40
Palm oil	4.52	4.13	3.75
Dry fish	3.60	3.30	2.05
Bitter leaf	2.81	2.60	2.40
Dry ground pepper	1.21	1.10	1.00
Crayfish	0.60	0.55	0.50
Okra	2.12	0.60	0.00
Maggi cube	0.10	0.10	0.10
	100.00	100.00	100.00

*Salt was added to taste
Source: Oladimeji [8]
A1, A2, A3, legends are various formulation of *ogbono* soup with constant water mixture

The viscosity of fully prepared soup was determined at temperatures of 50, 70 and 90°C using viscometer RV (Brookfield Engineering Laboratories Inc., Stoughton MA) according to the method of Abubakar and Sopade [6]. The temperature was maintained by the use of water bath (Grant Instrument Ltd. Model S42, Cambridge, UK). The viscosity readings 5 per sample and 3 samples per temperature were taken at 5 mins intervals, 3 mins for rotation at each of the speed (20, 50 and 100 rpm) and 3 mins resting after each reading. Appropriate spindles were used for all readings between 20 and 100 of the dial. A 600 ml beaker was used for all measurements with the viscometer guard leg on and enough samples were added to cover the immersion grooves on the spindles. Shaft viscosity values were obtained by multiplying viscometer reading by appropriate factors (provided by the equipment manufacturer). The consistency index, K was calculated and used to develop mathematical model as a function of temperature T and dikanut concentration Y. The experimental model adopted is stated as follows:

$$K = a + bT + cY + dT + TY + eT^2 + FY^2 \quad (1)$$

2.4. Proximate Composition of Dikanut

Moisture content, crude protein, crude fat, crude fibre, ash content and carbohydrate were determined by AOAC [10] official methods.

2.5. Sensory Evaluation

A panel of 10 judges (all of whom were regular consumers of the test product) selected from pool of volunteers for sensory profiling [11]. Each of the selected judges evaluated the 9 treatments on a 9-point hedonic scale (from 1 extreme dislike to 9 extreme likeness) for drawability and overall acceptability. These treatments were replicated three times by each panelist for the sensory attributes considered. The design was balanced for order and carry over effects [12]. The sensory data for the attributes were subjected to multiple regression analysis. The significance of the effects was tested with F- test.

2.6. Statistical Data Analysis

The experimental design was carried out using three level factorial design of Response Surface Methodology. The data were optimized using Response Surface Methodology (RSM) by employing Design Expert software version 10.0.1.0 64-bit (Stat-ease Inc., USA, 2016). Multiple regression analysis was used to fit the coefficients of the polynomial models of the dependent variables. The following statistical indicators were employed: coefficient of determination (R^2), adjusted (Adj. R^2), probability value at 95% confidence interval, coefficient of variation, lack-of-fit, and analysis of variance (ANOVA).

3. Results and Discussion

3.1. Proximate Composition of Dikanut

The proximate composition of the market grade seeds is shown in Table 2. The results showed that the seed contained 9.0% ± 0.242 crude protein, 70.42% ± 1.93 crude fat, 4.61% ± 0.208 crude fibre, 1.92% ± 0.11 ash content, 11.91% carbohydrate content and 2.14% ± moisture content. Okolo [13] obtained higher percentage of crude protein (19.4± 0.40), lower fat content (58.0 ± 1.0), higher ash content (11.60 ± 0.60) and lower crude fibre (1.80 ± 0.60). Bamidele [3] reported higher crude protein (10.40 ± 0.20), lower fat (56.41 ± 0.41), higher ash (8.16 ± 0.10) and lower crude fibre (1.52 ± 0.20). Fashogbon [9] stated similar crude protein content (9.23 ± 0.01), lower fat (60.19 ± 0.69), higher ash (2.43 ± 0.37), and higher fibre (6.02 ± 0.05). The drawability of ogbono soup has correlation with the fat content [4].

Table 2. *Proximate composition of dikanut seeds.*

Component	% ± Standard error mean*	% ± Standard error mean**
Protein	9.00±0.24	19.4±0.40
Moisture content	2.14±0.00	2.10±0.80
Crude fat	70.42±1.93	58.0±1.00
Crude fibre	4.61±0.21	1.80±1.00
Ash content	1.92±0.11	11.60±0.60
Carbohydrate	11.91±0.29	12.30±0.20
Dry matter	97.86±1.20	97.90±1.10

*Results obtained from this study (Mean of 10 determinations)
**Results obtained by Okolo [13]

3.2. Factorial Experiment

The average values for sensory responses measured for all the treatments depicting various dikanut concentrations and different temperature of preparation are listed in Table 3. By employing multiple regression analysis on the data in Table 3, second order polynomial models which characterize the relationships between the process variables and depended variables were generated (Tables 4, 5 and 6). The empirical expression for the relationship between process variables and overall acceptability is given as:

$$\text{Overall acceptability} = 7.54 - 0.1A - 0.32B + 0.17AB - 1.24A^2 - 0.29B^2 \quad (2)$$

The relationship between drawability and the studied variables is given as

$$\text{Drawability} = 6.88 - 0.12A - 0.20B + 0.15AB + 0.34A^2 + 0.089B^2 \quad (3)$$

The relationship between consistency index, K and the studied variables is given as

$$\text{Consistency Index, K} = 32.11 - 19.10A + 4.19B + 1.74AB + 6.20A^2 - 3.90B^2 \quad (4)$$

Equations (2) – (4) indicated that the main effects of temperature and dikanut concentration correlated with overall acceptability, drawability and consistency index.

Table 3. *Drawability and overall acceptability of dikanut soup as influenced by concentration of dikanut and temperature of preparation.*

Experimental Run Order	Concentration of dikanut (%)	Temp. of Preparation (°C)	Drawability	Overall Acceptability
8	9.64	50	7.8	6.6
1	12.22	50	7.2	7.6
2	14.80	50	7.2	6.0
9	9.64	70	7.3	6.2
4	12.22	70	6.9	7.8
7	14.80	70	7.2	6.1
3	9.64	90	7.1	5.8
5	12.22	90	6.8	66
6	14.80	90	7.1	5.9

3.3. Consistency Index

Table 4a shows the consistency index, *k* of freshly prepared *ogbono* soup at various dikanut concentrations and different temperatures of soup preparation. The high negative value of the temperature showed high significance ($p< 0.05$) effect and it is inversely related to the consistency index K (Tables 4b and 4c). Although dikanut concentration did not have significant ($p > 0.05$) effect on consistency index. A large *F*-value indicates that most of the variation can be explained by a regression equation whereas a low *p*-value ($p<0.05$) indicates that the model is considered to be statistically significant [14]. The ANOVA result for the consistency index is given in Table 4b. The adequacy of a model is tested through *F*-value and *p*-value [15]. The *F*-value of 23.36 and *p*-value 0.0046 indicated statistical significance ($p < 0.05$) of the model. Thus, the relationship between the process variables (temperature and dikanut concentration) and the consistency index could be explained according to the regression model.

The goodness of fit of the model is confirmed by R^2 (0.9669) and adj. R^2(0.9255). This establishes a high correlation between the observed and the predicted values [16]. The statistical significance of each of coefficient is determined by *p*-value shown in Table 4b. Lower *p*-value ($p< 0.05$) indicates a higher significance of the parameter [15]. The results showed the statistical significance of temperature ($F = 105.84$; $p = 0.0005$). Other coefficient, dikanut concentration ($F = 5.09$; $p = 0.087$) indicates no statistical significance ($p>0.05$). From the regression coefficients, it is clear that an increase in the temperature of *ogbono* soup preparation decreases the consistency index of the soup.

3.4. Drawability

Table 5a shows panel means for drawability of freshly prepared *ogbono* soup at various dikanut concentrations and different temperatures of soup preparation. The drawability is related to the viscosity of the soup. The negative values of the coefficients of temperature and dikanut concentration (Table 5c) show that they are inversely related to the drawability of the soup. That is, the higher the temperature and the higher the concentration of dikanut, the decrease in the drawability of the soup and show statistical significance ($p< 0.05$) both for temperature ($p < 0.0009$) and dikanut concentration ($p < 0.0094$). However, the interaction of temperature and dikanut concentration was positively significantly correlated ($p= 0.0077$) to the drawability of the soup. The relationship between the process variables (temperature and dikanut concentration) and the drawability of the soup could be explained according to the regression model.

Table 4. *(a) Consistency index, k of freshly prepared ogbono soup at various dikanut concentrations and different temperatures of soup preparation (b) Analysis of variance of k (c) Coefficient estimate and standard error of k.*

a. Expt. Run Order	*Temperature (°C)*	*Conc. of Dikanut (%)*	*Consistency, k*
1	90(1)	9.64(-1)	6.49
2	50(-1)	9.64(-1)	52.36
3	70(0)	14.80(1)	28.64
4	70(0)	12.22(0)	32.9
5	90(1)	14.80(1)	21.03
6	50(-1)	12.22(0)	52.15
7	70(0)	9.64(-1)	25.64
8	90(1)	12.22(0)	22.33
9	50(-1)	14.80(1)	59.96

b. Model Term	*Sum of Squares*	*df*	*Mean Square*	*F-value*	*p-value*
Model	2416.473	5	483.2946	23.36	0.0046
A-Temperature	2189.624	1	2189.624	105.84	0.0005
B-Conc. of Dikanut	105.3366	1	105.3366	5.09	0.0870
AB	12.0409	1	12.0409	0.4880	0.58
A^2	89.81738	1	89.81738	4.34	0.1056
B^2	35.41204	1	35.41204	1.71	0.2609
Residual	82.75029	4	20.68757		
Lack of Fit	82.58209	3	27.52736	163.66	0.0574
Pure Error	0.1682	1	0.1682		
Cor Total	2499.2239				
Std. Dev	4.55				
Mean	33.50				
C.V. %	3.58				
R^2	0.9669				
Adj R^2	0.9255				

c. Factor	*Coefficient Estimate*	*df*	*Standard Error*
Intercept	32.113	1	2.72
A-Temperature	-19.103	1	1.86
B-Conc. of Dikanut	4.190	1	1.86
AB	1.735	1	2.27

c. Factor	Coefficient Estimate	df	Standard Error
A²	6.204	1	2.98
B²	-3.896	1	2.98

The goodness of fit of the model for drawability is confirmed by high values of R^2 (0.9701) and adj. R^2 (0.9403). The result shows the statistical significance of temperature ($F = 49.21$; $p = 0.0009$) and dikanut concentration ($F = 16.74$; $p = 0.0094$) in the drawability of the soup; and the interaction of temperature and concentration of dikanut has statistical significance ($F = 18.45$; $p = 0.0077$) on the drawability of the soup. While the effect of each of the parameter individually is inversely related to the drawability, their combined effect is directly related to the drawability.

3.5. Overall Acceptability

The panel means for overall acceptability of freshly prepared *ogbono* soup at various dikanut concentrations and different temperatures of soup preparations are presented in Table 6a. The overall acceptability of the soup is inversely related to the temperature of preparation a well as the concentration of the dikanut (Tables 6b and 6c). The lower the temperature, the better the overall acceptability, and the lower the dikanut concentration in the soup the more acceptable it is. However, the combined effect of dikanut concentration and the temperature produces a positive correlation in the overall acceptability of the soup. The results show the statistical significance of temperature ($F = 7.38$; $p = 0.042$). The relationship between process variables (temperature and dikanut concentration) and the overall acceptability could be explained by the regression model presented in Eq. (2). The goodness of fit of the model for overall acceptability was confirmed by high values of R^2 (0.9338) and adj R^2 (0.8676).

Table 5. *(a) Panel means for drawability of freshly prepared ogbono soup at various dikanut concentrations and different temperatures of soup preparation (b) Analysis of variance for drawability (c) Coefficient estimate for drawability.*

a. Expt. Run	Conc. of Dikanut (%)	Temperature (°C)	Drawability
Order			
8	9.64	50	7.8
1	12.22	50	7.2
2	14.80	50	7.2
9	9.64	70	7.3
4	12.22	70	6.9
7	14.8	70	7.2
3	9.64	90	7.1
5	12.22	90	6.8
6	14.8	90	7.1

b. Model Term	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.79	5	0.158396	32.48	0.0008
A-Conc. of Dikanut	0.08	1	0.081667	16.74	0.0094
B-Temperature	0.24	1	0.24	49.21	0.0009
AB	0.09	1	0.09	18.45	0.0077
A²	0.29	1	0.291947	59.86	0.0006
B²	0.02	1	0.020281	4.16	0.0970
Residual	0.02	5	0.004877		
Lack of Fit	0.02	3	0.005906	1.77	0.3806
Pure Error	0.01	2	0.003333		
Cor Total	0.82	10			
Std. Dev.	0.07				
Mean	7.12				
C.V. %	0.98				
R²	0.9701				
Adj R²	0.940				
Pred R²	0.7756				

c. Factor	Coefficient Estimate	df	Standard Error
Intercept	*6.884*	*1*	*0.04*
A-Conc. of Dikanut	-0.117	1	0.03
B-Temperature	-0.200	1	0.03
AB	0.150	1	0.03
A²	0.339	1	0.04
B²	0.089	1	0.04

3.6. Optimization of Process Parameters

The optimal condition for the process parameters and dependent variables are presented in Table 7. The results showed that the optimal temperature and dikanut concentration for preparation of quality *ogbono* soup were 50°C and 10.96%, respectively. The corresponding consistency index, drawability and overall acceptability were 57.25, 7.39 and 7.40, respectively. The graphical representations of the regression equations for the optimization of the process parameters are shown as 3-D surface plots in Figures 1 – 3. The graphical interpretation of interactions between variables using surface plots of the regression equation has been recommended [17]. Figure 1 shows the response surface plots representing the quadratic effect of dikanut concentration and linear effect of temperature on the overall acceptability of the soup. The results show that low temperature of preparation and low dikanut concentration favour overall acceptability of the soup. However, low temperature seems to exert high influence on these sensory attribute by the soup. Figure 2 shows the response surface plot for temperature for temperature and dikanut concentration on the drawability of the soup. The combination of low temperature of preparation and low dikanut concentration gave high draw-ability of the *ogbono* soup. Figure 3 shows the response surface plot for temperature and dikanut concentration on consistency index, *K* of the *ogbono* soup. Low temperature significantly influenced the consistency index, *K* of the soup.

Table 6. *(a) Panel means for overall acceptability of freshly prepared ogbono soup at various dikanut concentrations and different temperatures of soup preparations (b) Analysis of variance for overall acceptability (c) Coefficient estimate for overall acceptability.*

a. Expt. Run Order	*Conc. of Dikanut (%)*	*Temperature (°C)*	*Overall Acceptability*
8	9.64	50	6.6
1	12.22	50	7.6
2	14.80	50	6.0
9	9.64	70	6.2
4	12.22	70	7.8
7	14.8	70	6.1
3	9.64	90	5.8
5	12.22	90	6.6
6	14.8	90	5.9

b. Model Term	*Sum of Squares*	*df*	*Mean Square*	*F-value*	*p- value*
Model	5.75	5	1.150465	14.11	0.0057
A-Conc. of Dikanut	0.06	1	0.06	0.74	0.4302
B-Temperature	0.60	1	0.601667	7.38	0.0420
AB	0.12	1	0.1225	1.50	0.2749
A^2	3.91	1	3.908491	47.94	0.0010
B^2	0.22	1	0.216158	2.65	0.1644
Residual	0.41	5	0.081535		
Lack of Fit	0.24	3	0.080336	0.96	0.5455
Pure Error	0.17	2	0.083333		
Cor Total	6.16	10			
Std.Dev.	0.29				
Mean	6.70				
C.V. %	4.26				
R^2	0.9338				
Adj R^2	0.8676				

c. Factor	*Coefficient Estimate*	*df*	*Standard Error*
Intercept	7.537	1	0.15
A-Conc. of Dikanut	-0.100	1	0.12
B-Temperature	-0.317	1	0.12
AB	0.175	1	0.14
A^2	-1.242	1	0.18
B^2	-0.292	1	0.18

Table 7. *Optimal values of process parameters for Ogbono soup.*

Parameter (s)	**Optimal Value**
Temperature (°C)	50.00
Dikanut concentration (%)	10.96
Consistency index	57.25
Drawability	7.39
Overall acceptability	7.40

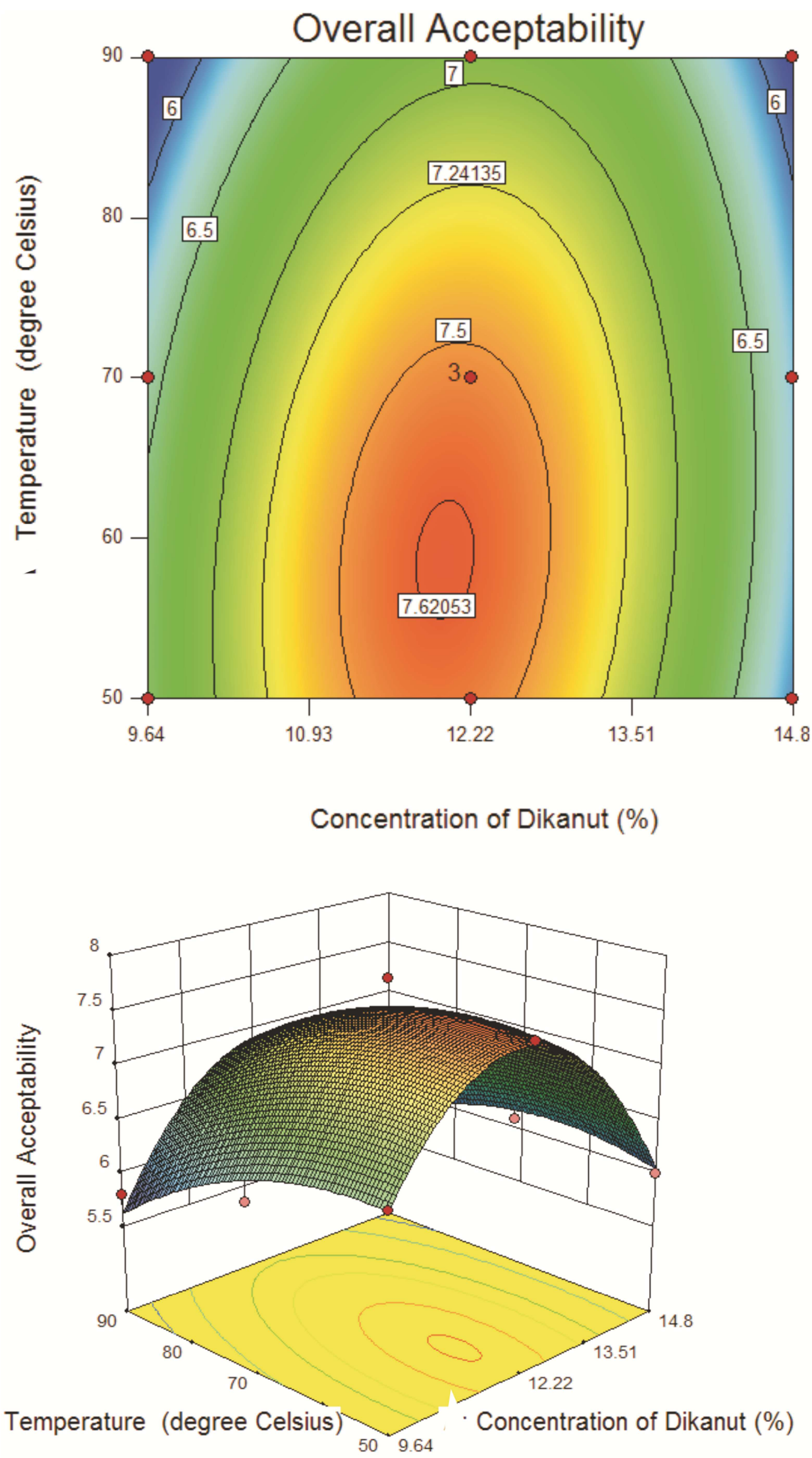

Figure 1. *Contour and response surface plots for the optimization of overall acceptability of ogbono soup.*

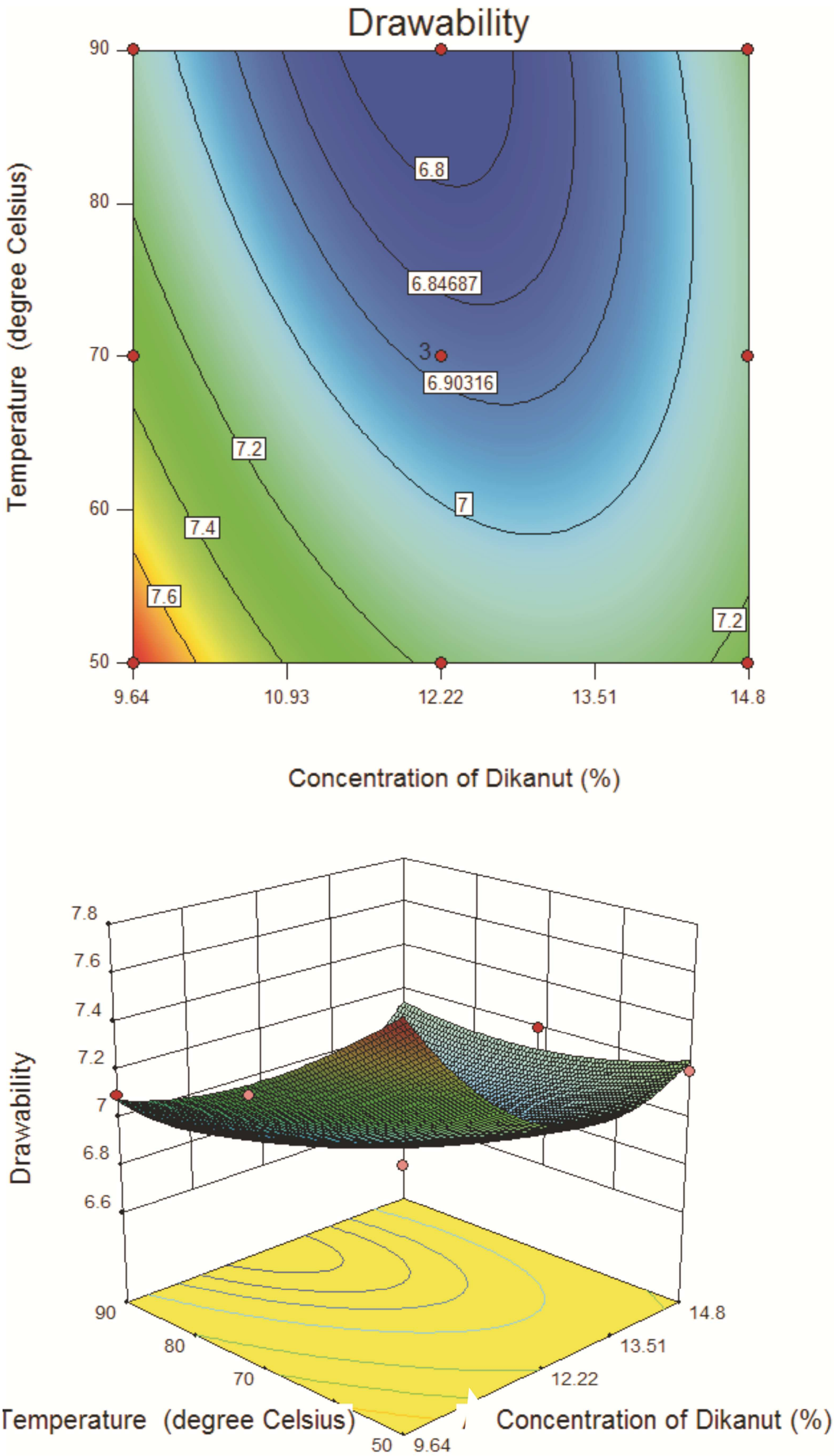

Figure 2. *Contour and response surface plots for the optimization of drawability of ogbono soup.*

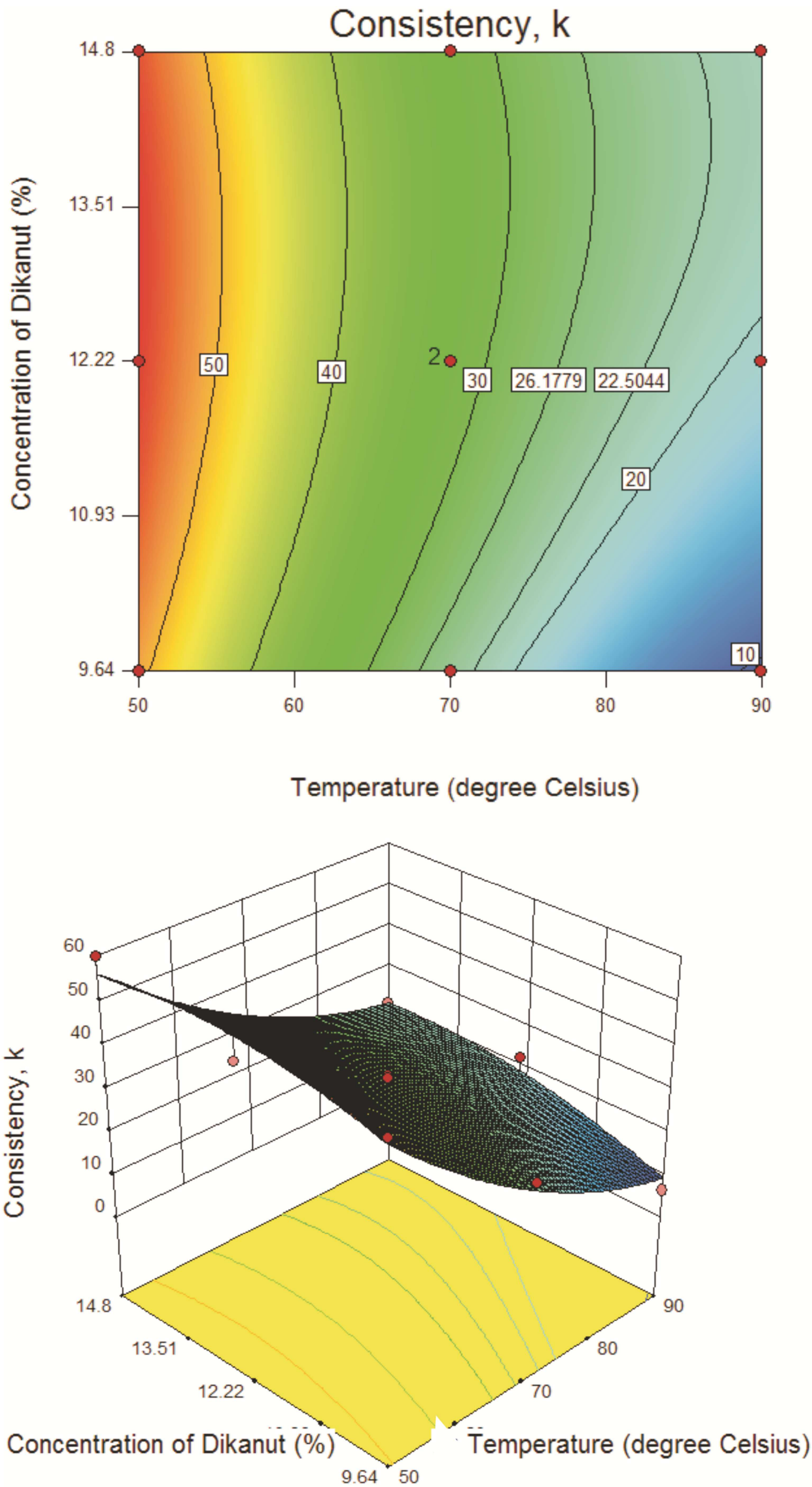

Figure 3. *Contour and response surface plots for the optimization of consistency (K) of ogbono soup.*

4. Conclusion

The study investigated some quality characteristics of *I. Gabonesis* (*ogbono*) soup and optimization of the process varables through application of three level factorial design of response surface methodology. The proximate composition showed that *I. Gabonesis* soup is rich in fat and fibre. The effect of the processing temperature on consistency index, drawability and overall acceptability was significant ($p<0.05$) and inversely correlated. At higher concentration of dikanut, the drawability and dikanut concentration exhibited inverse relationship The optimal temperature and dikanut concnetration for preparation of quality *ogbono* soup were 50°C and 10.96%, respectively. The corresponding consistency index, drawability and overall acceptability were 57.25, 7.39 and 7.40, respectively. Low temperature is required for optimal drawability, consistency index and overall acceptability of the *ogbono* soup. The results may provide useful information during canning operation of *ogbono* soup.

Conflicts of Interest

The authors state that there was no conflicts of interest.

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