Optimization of the Properties of Vegetable Tallow (*Allanblackia floribunda*) and Soybean Oil Blends for Bakery Fat Formulation Using Response Surface Methodology

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Abstract
Response surface methodology (RSM) is an essential mathematical and statistical tool useful for developing, improving, and optimizing response variables. This study was aimed at optimization of the physical properties of vegetable tallow (Allanblackia floribunda) and soybean oil blends for bakery fat formulation using response surface methodology. Hot water floatation method was used in extraction of A. floribunda oil while soybean oil was extracted in a Solid–liquid extraction method using ethyl alcohol as solvent. Simplex lattice response surface model was used to generate the experimental design, analyze the experimental data and regression models while adequacy was tested with lack of fit test and coefficient of determination (R^2). The design involved two mixture component, A. floribunda seed oil (ASO) and soybean oil (SBO) represented by X_1 and X_2 with a sum of 1 whereas slip melting point (SMP °C), solid fat content (SFC %) and density (pg/cm^3) were evaluated as responses. Optimum conditions selected after verification was; 34.90℃, 46.16% and 0.901g/g for melting point, Solid fat and density respectively. Best blend ratio was obtained by the model: ASO = 0.400 x SBO = 0.600 (%, w/w) where, ASO = A. floribunda oil and SBO = soybean oil achieved at a desirability of 0.966. The coefficient of determination (R^2) values of the entire responses exceeded 80% indicating a high proportion of variability as elucidated in the data. The obtained model is adequate providing useful information for bakery fat formulation from ASO and SBO blends.

Keywords: *Allanblackia floribunda, soybean Oil, Optimization, Density, Solid fat content, Melting point*

1. Introduction

Most commonly used shortenings and confectionary coatings in Nigeria currently are formulated from partial hydrogenated vegetable oils. This contributes 80 – 90 percent of the trans fatty acids in fried foods, snack products, cooking oils, margarine and spreads. Regrettably, *trans* fatty acids contained in partial hydrogenated vegetable oils have been known to have negative effects on health. They can alter production of biologically active metabolites that would have been derivative from essential fatty acids (Wijittra *et al.*, 2022). Partially hydrogenated vegetable oils were originally supposed to be a healthier oil substitute to saturated fats, but then it has turned out that trans fats are even worse than saturated fats. Saturated fatty acids (SFAs) on its own have shown significantly increased low-density lipoprotein cholesterol levels which is a risk factor for coronary heart disease (Patel *et al.*, 2020).

Basic ingredients for Bakery fats formulation which includes fats and oil differ widely from un-hydrogenated, partially hydrogenated, and fully hydrogenated oils of animal fat or vegetable oil origin. They are the essential components in baked products and influence their physical properties; besides contributing to flavour release and tenderness of baked foodstuffs (Tarancón; Salvador; & Sanz, 2013). Fats and oils play crucial role in acceptability of baked goods and contribute important nutrient in human diet (Jalili *et al*., 2018). Important properties of fats and oils required for producing spreadable and acceptable bakery fat are related to their physical characteristic (Saghafi *et al*., 2019). Several physical parameters of edible fat and oil depend on their fatty acid composition; high percentage of saturated fatty acids is related with high melting point while density indicates how weighty a substance is, the density of unsaturated glycerides is higher than the corresponding saturated ones due to their molecular weight (Devi & Khatkar, 2016), on the other hand, the solid fat content is the percentage of the total lipid that is solid at a particular temperature. Manufacturers resort to modification of fats and oil in form of interesterification, fractionation, and partial hydrogenation or blending among others to meet the desired physical properties, however, most of these approaches require cost, functionality and health considerations **(**Zbikowska *et al*., 2020). Partially hydrogenated oils are gradually being phased out to enable the production of *trans*-free products with desirable functionality.

With the rising demand for natural products and emphasis on nutritional enrichment, blending of vegetable oils and fats has emerged as an economical way to produce edible oils devoid of any chemical treatment and which possess natural flavour and characteristics as well as nutritional value. The advantages of using blending as a means of modifying oils is that it is easy and inexpensive. More importantly blending of oils serves to improve and enhance the nutritional and qualities of the oils by combining oils into one, thereby improving commercial viability (Norizzah *et al*., 2014). Two potential oils that can be blended in the formulation of bakery fat are vegetable tallow (*Allanblackia floribunda*) and soybean oil. Blending *A. floribunda* which is highly monounsaturated fat and soybean oil which is highly polyunsaturated oil at different ratios can modify their physical and chemical characteristics thus offering greater health benefits and functionality for food preparations.

Vegetable tallow trees (*Allanblackia floribunda*) mainly found in the rainforest belt of Western and Eastern Africa has long been utilized in food and cosmetics in several West African countries due to its commercial values (Crockett, 2015). An individual tree can produce up to 250-300 fruits that weigh up to 3 - 4 kg and holding 25-50 seeds rich in edible vegetable oil (48-60%) (Okwechime *et al.*, 2017). Unfortunately, the seed oil is unexploited in Nigeria. A. *floribunda* seed oil does not require any form of modification before it can be used (Atangana *et al.*, 2011). Research has shown that Allanblackia contains 52-58% Stearic acid, 38-45% oleic acid, and 2-3% palmitic acid with a unique triglyceride arrangement; stearic-oleic-Stearic (SOS) and stearic-oleic-oleic (SOO) which gives the oil a sharp melting range of 38-42 degrees Celsius (Norizzah *et al*., 2014). This means that the oil remains solid at room temperature, but melts in the mouth and imparts a cooling sensation to the tongue which is a good physical property for bakery fat formulation.

Soybean oil is gotten from soybeans (*Glycina maxima)*, which are grown in several countries of the world. Soybean oil is one of the most widely consumed cooking oils due to its nutritional properties, functionality, cost, and availability (Kleinman, 2013). Fatty acid composition of

Soybean oil is predominantly unsaturated; it is relatively high in linoleic acid and linolenic acid (Gunstone, 2011). These two fatty acids are of nutritional importance due to their status as 'essential fatty acids. However, soybean oil has low melting points and oxidizes easily (Shurtleff *et al.*, 2016). Blending of soybean with *A. floribunda* oils could improve overall properties.
Physical properties of fat and oils are critical qualities attributes considered in developing bakery fat, some consumers expect a spreadable bakery fat from the fridge, smooth, melt away quickly in the mouth, and having a rather long shelf life, the right combination cannot always be met from single oil or fat (Devi and Khatkar, 2016). Blending two or more oils with distinct properties is one technique in improving the fatty acids profile without altering intrinsic composition and maintaining similar structural properties (Ureta *et al*., 2016; Tafa and Sundramurthy, 2020). The reason for choosing *A. floribunda* fractions was to provide a reasonable and cheap alternative to hydrogenated fat, in which the crystalline, solid form exists naturally. Soybean oil will provide the needed structure that will complement Allanblackia oil to give good plasticity to the finished product and also provide the essential fatty acid required for human health. Response surface methodology (RSM) is an essential mathematical and statistical tool useful for developing, improving, and optimizing the response variables. Hence, this study was aimed at using response surface methodology in optimization of the physical properties of blends of *A. floribunda* and soybean seed oil for use in bakery fat formulation.

2. Materials and Methods

2.1 Materials

Mature fruits from vegetable tallow (*Allanblackia floribunda*) tree were sourced from the forest of seven communities (Okehi, Igbodo, Rumuewhor, Ubimini, Elibrada, Oyigbo and Ndoki) in Rivers state, Nigeria. Soybean was purchased from Mile 3 Market, Diobu, Port Harcourt. Chemical and apparatus were provided by DiVi Laboratories Elelewoh, Port Harcourt.

2.2 Oil extraction (Hot Water Flotation Method)

Fruits were stored in bags and covered for two weeks to allow fruit pulp to ferment and disintegrate after which the seeds were removed manually. Seeds were cleaned, washed and dried in an air oven (Memmert Hot Air Oven, Btl 27, India) at 60 ℃ for 12 h. The dried seeds were pulverized using a hammer mill before blending in a Panasonic mixer (MXAC2105, Panasonic, Japan) to obtain a much finer powder. Oil was extracted using the hot water floatation method as described by Okwechime *et al.*, (2017) while soybean oil was extracted using Solid–liquid extraction method (Azmir *et al.,* 2013). Soybean were cracked in a hammer mill and extracted in a 3:1 ratio (ethyl alcohol: soybean mill) after shaking in a motorized stirrer for 2 h. The resultant mixture of oil and ethanol were filtered through a clean handkerchief into a stainless vessel and dried in an air oven at 50 ℃ for 3 h to remove residual ethyl alcohol. Recovered oil was kept in an air tight bottle until required for use.

2.3. Experimental Designs

Simplex lattice (Stat-Ease, 2018) a type of response surface methodology (RSM) was used to determine the experimental design and the optimal blend ratio for formulation of bakery fat. The experimental design with coded values and actual percentages and ranges of levels for independent variables are mentioned in Table 1. There were two independent variables (factor); ASO represented by X_1 and SBO X_2 with the sum of $X_1 + X_2 = 1$. The design generated 8 experimental runs while dependent variables (responses) were three physical properties of bakery fat; Slip melting point (SMP °C), solid fat content (SFC %), and density (g/mL). These responses were selected because they represent the main parameter for bakery fat quality. The results of the responses were used for optimization. The experimental data for each response variable was fitted to the linear-quartic model before the regression parameters for the equations were generated.

2.4. Optimization of Blend Parameters

The optimization of the properties of vegetable tallow (*Allanblackia floribunda*) and soybean oil blends for bakery fat formulation was achieved using simplex lattice design. The design matrix blend ratios of *A. floribunda* and Soybean oil is shown in Table 2. The target was to optimize the blend parameters to obtain a suitable blend ratio comparable to blends found in commercial bakery fat formulation. The optimum designs were selected and used for calculating the predicted values of response variables using the prediction equations derived by RSM. Optimal solution was subjected to confirmatory test using the Design Expert software at 95 percent confidence interval. Verification of the optimum formulation for bakery fat formulation was performed. The oil blends were experimentally analyzed and the result was statistically compared to the predicted values of the mathematical model.

Table 1: The coded and actual levels used for independent variables (Mixture Components)

Component	Name	Units	Type	Minimum	Maximum	Coded Low	Coded High	Mean	Std. Dev.
A=x_1	ASO	%	Mixture	0.4	0.8	+0 ↔ 0.4	+1 ↔ 0.8	0.6	0.16
B=x_2	SBO	%	Mixture	0.2	0.6	+0 ↔ 0.2	+1 ↔ 0.6	0.4	0.16
				Total (X_1 + X_2 = 1)	1.0000	**L_Pseudo Coding**			

ASO **-** *A. floribunda* seed oil, SBO - Soybean oil

Table 2: Design matrix and Blend ratios of *A. floribunda* and Soybean oil

Run	Space Type	Component 1 A:ASO%	Component 2 B:SBO%	Total
1	Center	0.6	0.4	1
2	Axial	0.7	0.3	1
3	Vertex	0.4	0.6	1
4	Center	0.6	0.4	1
5	Vertex	0.8	0.2	1
6	Vertex	0.8	0.2	1
7	Vertex	0.4	0.6	1
8	Axial	0.5	0.5	1

ASO = *Allanblackia* seed oil, SBO = Soybean oil

2.5. Physicochemical Analysis

The physicochemical properties *A. floribunda* (ASO) and Soybean (SBO) oil blend: Slip melting point, Solid fat content (SFC) and density (DN) were determined using standard methods of AOAC, (2019).

2.5.1 Determination of Slip melting point (SMP)

The Slip melting point was determined according to AOAC, (2019) (capillary tubes Method). Tubes were filled each with 1 cm high column of fat before chilling in a refrigerator at 4°C for 1 h. The sample was finally removed from the refrigerator and tied to a thermometer using a rubber band then immersed in a beaker of cold distilled water with ice cubes and placed over a thermostatically controlled water bath with temperature regulated to 60 ℃. The water was heated with occasional stirring. Temperature at which the column of fat rose in the tube was recorded as slip melting point of the oil.

2.5.2 Determination of Solid Fat Content (SFC)

The SFC of the blends was measured using the density method, as reported by Onwuka, (2018) and Nazaruddin, (2013) with little adjustment. Density of the sample was measured over a range of temperatures: 10℃, 20℃, 30℃, and 40℃. The percentage SFC was calculated using the following equation below;

$$\text{SFC } (\%) = \frac{\rho - \rho l}{\rho s - \rho l} \times \frac{100}{1} \quad \text{---Eq (1)}$$

Where, ρ = Density of fat at the desired temperature

$\rho l =$ Density of fat when completely liquid

ρs = Density of fat when completely solid.

2.5.3. Determination of Density (ρ)

Standard Association of Official Analytical Chemist method (AOAC, 2019) was used. Empty pycnometer (50 mL) volume with stopper was weighed (m_0) and weight recorded, the pycnometer was then filled with the oil sample until the capillary hole in the stopper was filled, oil that leaked through the capillary hole was wiped dry before measurement and recorded (m_1). The laboratory temperature (T) was recorded. Density was calculated as:

$$\rho = \frac{\boldsymbol{m1 - m0}}{\text{V}} \quad \text{--------------------------------------Eq (2)}$$

Where:

m_1 - m_0 = measured weight of sample minus weight of empty pycnometer

V = volume of pycnometer

2.6. Statistical analysis

The statistical software Design Expert version 8.0.7 (Stat ease, Inc., Minneapolis, USA) was used to generate the experimental design matrix and analyze the experimental data. Analysis of variance (ANOVA) was used to inspect the selected model and to assess the significance of experimental results. It was used to test the model, linear terms, quadratic terms and different interaction terms. Model significance was at $p \leq 0.05$ and the terms that was insignificant ($p \geq 0.05$) was removed from the model. Response surface plots were generated. The contour plots for all responses were superimposed, and the regions that best satisfied the constraints were selected.

3. Results and Discussions

The estimated regression coefficient and analysis of variance (ANOVA) for all the models are presented in Tables 4 - 6 while final equations of the models are in equations 3 - 5. The contour plots (Figures 1- 3) for all responses are represented.

3.1 Effect of Allanblackia and soybean oil blends on Slip melting point (SMP)

Results of the physical properties of the blends are presented in Table 3. The SMP of *A. floribunda* and soybean oil blends decreased with an increase in the amount of SBO. The values ranged from 34.00 – 41.00°C for blends with 60% and 20% soybean oil respectively. This could be due to the decrease of saturated fat present in *A. floribunda* and increase in unsaturated (soybean) fatty acids, thus giving the opportunity to replace the saturated acyl with the unsaturated one. The melting profile produced is minimum, indicating that the percentage of solid fat is in range. The result was consistent with observations of Naeli *et al*., (2017) who reported that in margarine production using palm stearin, the SMP of the blends increased with the increase in palm stearin ratio because of the increase in saturated fat content. The melting point of a lipid describes the temperature point at which it changes its solid states to liquid states (Naeli *et al*., 2017).

Table 3. Experimental Design (Simplex Lattice) and Experimental values of the responses for optimization of the properties of *A. floribunda* and soybean oil blends for bakery fat formulation

Run	Component A: ASO(x_1) %	B:SBO(x_2) %	Response SMP (°C)	SFC (%)	DN (ρ g/cm^3)
1	0.8	0.2	41.00^a ±0.00	81.13^a ±0.11	0.8895^e±0.00
2	0.7	0.3	40.00^b ±0.00	80.40^b ±0.10	0.8957^c±0.01
3	0.6	0.4	38.00^d ±0.00	73.40^c ±0.17	0.8946^d ±0.01
4	0.5	0.5	39.00^c ±0.00	61.16^d ±0.15	0.8961^b±0.00
5	0.4	0.6	34.00^e ±0.00	46.17^e ±0.28	0.9007^a±0.00

ASO = *Allanblackia* seed oil, SBO = Soybean oil, SMP = Melting point, Dn =Density

Table 4. Analysis of Variance (ANOVA) of the fitted linear models for slip melting point of ASO/SBO oil Blend

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	46.72	1	46.72	34.39	0.0011	significant
[(1)]Linear Mixture	46.72	1	46.72	34.39	0.0011	
Residual	8.15	6	1.36			
Lack of Fit	8.15	3	2.72			
Pure Error	0.0000	3	0.0000			
Cor Total	54.88	7				

R^2 = 0.8514, Adjusted R^2 =0.8267, Predicted R^2 =0.7496, Adeq Precision = 11.0570

Final Equation of linear model for slip melting point of ASO/SBO oil Blends

SMP = +41.35* A+34.90* B--Eq (3)

Where A = A. *floribunda* oil and B = soybean oil

Regression analysis and analysis of variance (ANOVA) of linear models for slip melting point of ASO/SBO oil blend are reported in Table 4, while, the regression equation is depicted in Equation 3. The result revealed that the linear model and model terms (AB) were significant. In this case AB (A-B), AB $(A-B)^2$ is significant model terms. The values for R^2 and adjusted R^2 were 0.8514 and 0.8267, respectively. The Predicted R^2 of 0.7496 is in reasonable agreement with the Adjusted R^2 of 0.8267. This is indicative of the suitability of the model for predicting SMP. The R^2 values closer to 1.0 also affirms the model is the best fit. The results showed that the models for SMP response variables was highly adequate since it has satisfactory levels of R^2 of more than 80% and there was no significant lack of fit in the response variables (Stat-Ease, 2018). The Model F-value of 34.39 and P-values less than 0.05 implies that the model and the model terms is significant.

3.2. Effect of Allanblackia and soybean oil blends on Solid Fat Content (SFC)

Solid fat content (SFC) of *A. floribunda* and soybean oil blend (46.17 – 81.13%) decreased with increase in the amount of soybean oil (Table 3). SFC is the ratio between solid fat and liquid fat. In bakery fat, solid fat content is responsible for the characteristics of fat hardness and quick melting. It has a correlation with some functional characteristics such as physical appearance, consistency, spreadability, and sensorial acceptance (Augusto *et al*., 2012). SFC is essential for fat stability at room temperature, high storage temperatures at room conditions above 20^{o}C determines product stability and resistance to oil exudation, which requires SFC to survive above 10 % (Zbikowska; Kowalska & Rutkowska, 2012).

Table 4 Analysis of Variance (ANOVA) of the fitted Quartic models for Solid fat content of ASO/SBO oil Blend

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1557.45	3	519.15	50371.71	< 0.0001	significant
(1)Linear Mixture	1406.62	1	1406.62	1.365E+05	< 0.0001	
AB	149.46	1	149.46	14501.63	< 0.0001	
AB(A-B)	1.37	1	1.37	132.82	0.0003	
$AB(A-B)^2$	0.0412	4	0.0103			
Pure Error	0.0412	1	0.0412			
Cor Total	0.0000	3				

R^2 = 1.0000, Adjusted R^2 = 1.0000, Predicted R^2 =0.9998, Adeq Precision = 487.1444

Final Equation of Quartic models for Solid fat content (SFC)
SFC= +81.12*A+46.15*B+38.74*AB+9.36*AB(A-B) -----------------------Eq (4)
Where A = A. *floribunda* oil and B = soybean oil

Table 5 presents the estimated regression coefficient and analysis of variance (ANOVA) of quartic models for SFC of *A. floribunda* and soybean oil blend. The regression equation is depicted in Equation 4. The significance and adequacy of the quartic model is evident in F-value of 50371.71 and P-values less than 0.0500 indicating A, B, AB, AB(A-B) are significant while Adeq Precision ratio 487.1444 was more than 4 indicating an adequate signal thus, the model exhibited statistical adequacy (Stat-Ease, 2018). The values for the coefficient of determination, R^2 elucidated by the cubic models for solid fat content was more than 80 per cent (R^2 = 1.0), there is no significant lack of fit in the response variable. Therefore, for the optimization of independent variables, the response, solid fat was selected on the basis that the response had direct effect on the quality attributes and was dependent directly on specific composition of the formulation. Solid fat content is a principal feature which producers use to evaluate quality of bakery fat or margarine.

3.3. Effect of Allanblackia and soybean oil blends on Density

Density of *A. floribunda* and soybean oil blend (0.8895 – 0.9007 gcm^{-3}) increased with increase in the amount of soybean oil (Table 3). The density of vegetable oils is dependent on their fatty acid composition, minor components and temperature (Fakhri & Qadir, 2011). Density is an important factor which influences oil absorption; it is a useful aid in controlling hydrogenation and blending of fat. Okwunodulu, (2017) stated that density of oil is a guide of its total solid content. However, the density of unsaturated glycerides is higher than the corresponding saturated ones due to their molecular weight. This explains the observed increase in the blends having more soybean oil. Blend with 60% soybean had the highest density (0.9007 gcm^{-3}) as against 0.8895 gcm^{-3} in blend with 20% soybean oil.

The analysis of variance presented in Table 5 with F-value of 96.60 and P-values less than 0.050 indicate significance of the model; in this case A, B, AB (A-B), $AB(A-B)^2$ are significant model terms (Design Expert, 2018). Coefficient of determination (R^2) of 0.9864 suggested that fit model is good. The results showed that the models for the response variables (density) was highly adequate because it had satisfactory levels of R^2 of more than 80%. Density was selected on the basis that the response had direct effect on bakery fat quality and were dependent directly on specific composition of the product. Density is a crucial feature which manufacturers use to evaluate quality of bakery fat. It is generally affected by the particle size and the density of the material. Low density is an added advantage in preparing balancing foods as it increases nutrient and calorie.

Table 5 Analysis of Variance (ANOVA) of the fitted Quartic models for Density of ASO/SBO oil Blends

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	0.0001	3	0.0000	96.60	0.0003	significant
[1]Linear Mixture	0.0001	1	0.0001	262.05	< 0.0001	
AB	2.451E-09	1	2.451E-09	0.0057	0.9436	
AB(A-B)	0.0000	1	0.0000	27.75	0.0062	
$AB(A-B)^2$	1.733E-06	4	4.331E-07			
Pure Error	1.733E-06	1	1.733E-06			
Cor Total	0.0000	3	0.0000			

R^2 = 0.9864, Adjusted R^2 = 0.9762, Predicted R^2 = 0.9017, Adeq Precision = 24.0669

Final Equation of Cubi**c** models for Solid fat content (SFC)

DN= +0.8896*A+0.9008*B-0.0002*AB+0.0277*AB (A-B) ------------------- -----Eq (5)

Where A = A.*floribunda* oil and B = soybean oil

3.4 Contour plots of the physical parameters as affected by A. *floribunda* and soybean oil blends

Contour plots are two dimensional plots of the response across the selected factors. It gives an idea of region of interest, where the optimum conditions could be found without specifying the conditions. The contour plot of interaction of Allanblackia and soybean oil blends and Slip melting point is shown in Figure 1. Concentrations of the factors were varied. Slip melting point of the blends increases with increasing ASO and decreased with increasing SBO. It can be seen that in 80:20 (ASO: SBO) blend ratio which had more saturated fatty acid, melting point was 41℃ while incorporation of more unsaturated/polyunsaturated fatty acid such as in 60:40 (SBO: ASO) melting point was observed to be 34℃. Low melting point is required in bakery fat formulation for spreadability.

Figure 2 shows contour plot of interaction of ASO and SBO oil blends and Solid fat content; a dominant ASO increased solid fat content in the blends while an increase in SBO decreased solid fat. There was an increased solid fat in the blends with increase in ASO and vice versa. It is worthy to note that solid fat content has great influence in functional oil base that can provide acceptable aeration properties and plasticity during baking.

Interaction of ASO and SBO oil blends and density (Figure 3) revealed that increasing ASO over SBO decreases the density of the oil blends. On the other hand, increasing SBO percentage in the blends increases the density. Oils with unsaturated/polyunsaturated fatty acid have higher density than those with saturated fatty acids as a result of their molecular weight.

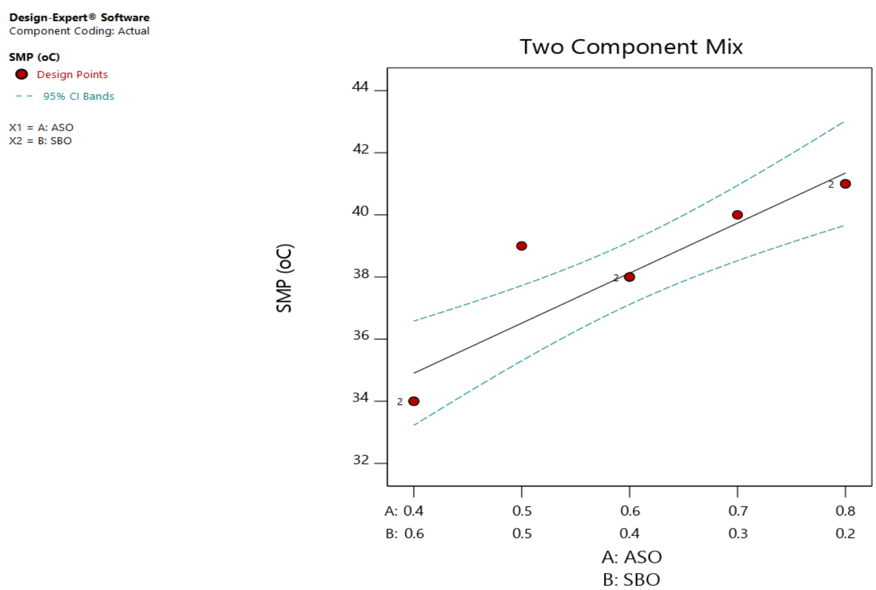

Figure1: Response surface plot showing the interaction between the variables and slip melting point.

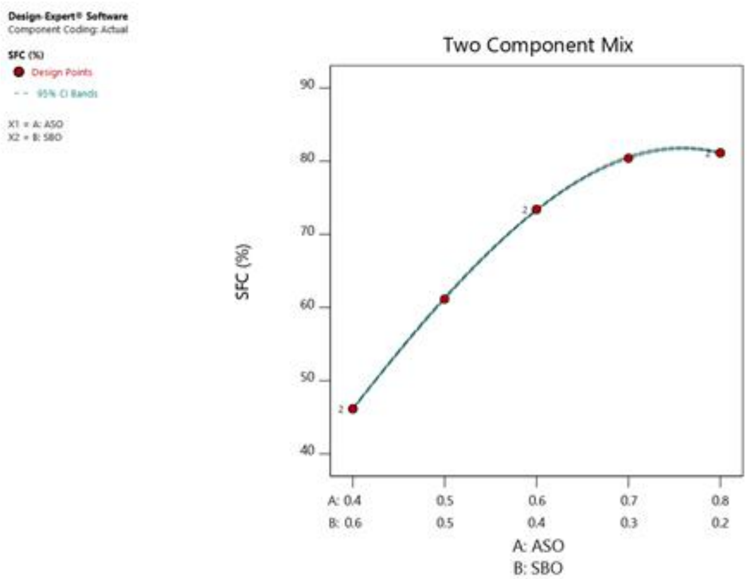

Figure 2: Response surface plot showing the interaction between the variables and Solid fat content

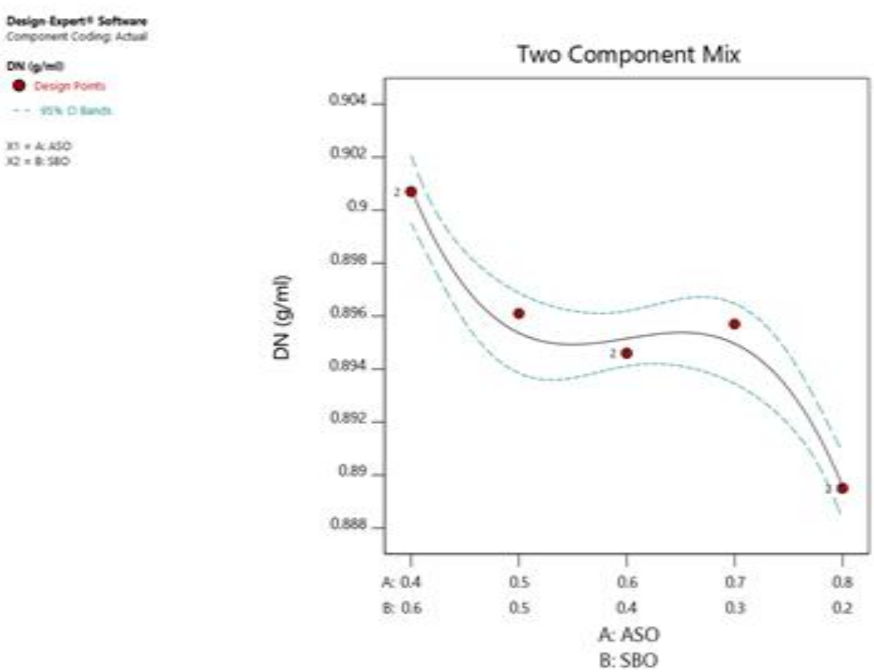

Figure 3: Response surface plots showing the interaction between the variables and Density

Validation for Optimization of physical properties of Allanblackia and soybean oil blends based on Response Surface Methodology

Predicted and experimental values are summarized in Table 6. Results obtained showed that there was no significant difference ($p < 0.05$) in slip melting point (SMP) and density (DN) on the corresponding experimental values between the predicted (replicated) and actual properties of the blended oils. Experimental data were consistent with the model and found to be not statistically different at 5% level (Ma *et al*., 2016). Significant difference ($p > 0.05$) was observed in solid fat content (SFC) in predicted and experimental values, 69.20 and 69.66% respectively. However; this result confirms the effectiveness of the design for optimum and effective blending of Allanblackia oil and soybean seed oils. Thus, the model can be used to optimize the basic formulation of bakery fat.

Table 6 Validation for Optimization of physical properties of Allanblackia and soybean oil blends based on Response Surface Methodology

Response	Predicted values	Experimental values
SMP	34.90	34.00±0.00
SFC	46.14	46.16±0.28
DN	0.9007	0.9007±0.00

*Significant ($p < 0.05$): using independent samples T-test

SMP = melting point, SFC = solid fat content, Dn = density

Conclusions

The physical properties of Allanblackia and soybean oil blends were successfully optimized using response surface methodology. The optimum conditions selected after verification were; melting point 34.90℃; SFC 46.14% and DN 0.901g/g. Optimum blend ratio was established by the model as: ASO = 0.408 x SBO = 0.592 (%, w/w) where ASO =*A. floribunda* oil and SBO = soybean oil achieved from a minimized ASO and maximized SBO, SMP was in range while SFC and DN were maximized to give a combination desirability value of 0.966. Formulating bakery fat from the optimized *A. floribunda* and soybean oil blend would bring about improvement in product nutrients. The use of these locally raw non-hydrogenated oils materials will go a long way in eliminating Tran's fatty acids in foods and reduce dependence on foreign exchange used in importing bakery fats. It will also add more value to local raw materials in Nigerian bakeries.

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