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Refining Raw Shea Butter to Industrial Grade using Biogenic-Based Heterogenous Catalyst developed from Waste African Giant Snail Shells

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***Abstract**: Shea butter is an agricultural raw material with wide industrial and domestic applications. It is produced generally in the local areas and the shea butter obtained is of low quality, thus limiting its market value, market price and industrial applications. The study aimed refining raw shea butter with biogenic-based heterogenous catalyst developed from African giant snail shells. Raw shea butter samples obtained from Tede town, were pre-treated by heating and filtering through a fine filter cloth. Then subjected to refining process involving mixing speed (700 - 1400 rpm), snail shell dosage (0.5 - 1.0 g) and time (30 - 60 min) which were optimised under the Factorial Methodology of Design Expert Software (12.0.1). The pH, ash content, specific gravity, saponification, acid, free fatty acid, peroxide, iodine and refractive index values of the refined samples were characterised and compared with the raw and industrial grade standard. Optimum condition for the best refinement of the local shea butter was 1400 rpm, snail shell dosage of 1.00g and agitation time of 60 min. . The pH, Specific gravity, Ash content value, Acid value, Saponification value, Free fatty acid (FFA), Refractive index, Peroxide value and Iodine value of refined local shea butter were in the range of 5.00- 6.72, 0.82- 1.01, 0.033-0.458 %, 4.64-14.79 mgKOH/g, 116.16- 187.40 mKOH/g, 2.32-7.39 mgKOH/g, 1.4600-1.4621, 10.79-16.05 meq/kg and 20.19-38.23 g/100 g, respectively. The Coefficient of Determination (R^2) values of the models for pH, specific gravity, ash content, acid, saponification, free fatty acid, refractive index, peroxide, and Iodine values were 0.9993, 0.9682, 1.0000, 0.9987, 0.9999, 0.9987, 0.8628, 0.9994 and 0.9996, respectively. The study suggested a novel approach to the refining of locally produced shea butter to industrial-grade shea butter for industrial applications with renewable catalysts.*

Keywords—Heterogenous Catalyst, Shea Nuts, Snail Shells, Oil

1. INTRODUCTION

Shea tree (Vitellaria paradoxa) also known as “tree of life” is of Sapotaceae family, it is indigenous to the savanna belt of sub-Sahara Africa (Nurah *et al.,* 2018*)*. The shea tree produces the fruit that encloses the nut and this houses the kernel from which the shea butter is obtained after processing. shea butter has been utilization in West African for almost 3,000 years as a cooking oil, oil for medicinal and cosmetic purposes (Gana *et al.,* 2022). There is a rising demand for shea butter in the European Union (EU) and the United States of America (USA) Shehu *et al.,* (2018). The shea butter is one of the most important vegetable fats being used by the rural women where it is being produced. Generally, the shea butter produced by the rural processors are of low quality and lack certification due to the methods used in producing them. Local shea butter has poor product quality which have adverse effects on nutritional properties of the shea butter and physicochemical properties of the shea butter (pH, specific gravity ash content, acid value, saponification value and free fatty value, refractive index, peroxide value and iodine value). Rural shea butter producers are unable to meet the International standard quality of shea butter (Akinsokeji *et.al.,* (2017)

Presently Nigeria is the leading exporter of shea nuts and butter in the world with a total trade value estimated at $400,000 (NIRSAL, 2018), Managing Director of Nigeria Incentive-Based Risk Sharing System for Agriculture- Aliyu Abdul Hammed (NIRSAL) (2018) reported that Nigeria presently produces 425,000 metric tonnes of shea kernels, which is only about 40 percent of its potential. Nigeria's Incentive-Based Risk Sharing System for Agriculture (NIRSAL) has estimated that Nigeria's current gross shea value is worth $320 million (N115 billion) (NIRSAL, 2018). The government’s quest to diversify the country’s revenue-earning sources from crude oil exports would be realized if the oil crops such as shea but processing were also refined by the processors using calcined snail shell. Olife *et al.,* (2013) reported that demand for shea products has grown in the European Union (EU) and United States of America (USA) necessitating Nigeria and other West African Countries to go into the export of shea products. There is also much demand by cosmetics and personal care companies for the use of shea butter in their products.

2. MATERIALS AND METHODS

2.1 Materials

The material and equipment used in the research work are local shea butter and African giant snail shell and equipment analytical weighing balances (accurate to ± 0.0001g) (Madein China), electronic weighing balance (M 200) range 0.001-200g, Stopwatch, Thermometer (0-120), moisture meter (Mexch MC 7821) (0-10%), Thermos scientific furnace (model F47910–33 U.S.A). Electric thermostat oven (model DHG 9023A), Magnetic stirrer (model 85-1/85-2, 5-100 ºC, time range 0-120 min, thermal rating 200W, work power source 220V 50HZ) and WAY-2W Abby Refractometer.

2.2 Methods

2.2.1 Material Preparation of Local Shea Butter and African Giant Snail Shell as a Catalyst through Calcination

Raw shea butter was bought at Tede Town in Oyo State, Nigeria. The shea butter (2 g) was pre-treated by weighing into a conical flask then placed on a hot plate magnetic stirrer maintained at 100 ºC and stirred until a homogenized mixture was obtained. The shea oil was filtered by pouring on muslin cloth (Figure 1) placed inside a glass funnel to remove impurities such as sand and dirt. (Parveen *et al.*, 2020).

Plate I: Pre-Treated Shea Butter

African giant snail shells were washed, rinsed with tap and distilled water to remove dirt and organic matter attached to them, dried in the open air under intense sunlight for 6 h (Udeozor *et al.*, 2014) and oven-dried at 110 ºC for 12 h (Maruf *et al.*, 2020). It was then crushed with a pestle and mortar to a smaller size and further oven-dried at 100 °C for 24 h to a constant moisture content (Udeozor *et al.*, 2014). The shells were ground and sieved using a 0.031mm size sieve to obtain uniform sizes (Ki *et al.*, 2017*:* Laskar *et al.*, 2018). The products were calcined in a furnace at selected temperatures of 500, 700, and 900 ºC for 4 h (Obadiah *et al.*, 2012: Buasri *et al.*, 2013; Laskar *et al.*, 2018 and Maruf *et al.*, 2020;).

2.2.2 Characterization of Snail Shell Catalyst (XRD)

The XRD of the calcined snail shell sample was done on a Mini Flex X– ray diffractometer using XRD machine (model Empyrean) with Ca-ka radiation fixated over a range from 20 to 80 ºC with a step size of 0.04 at a scanning speed of 3 rpm. The calcined snail shell samples (100 g) were analyzed by spreading them on carbon tape. Transmission electron microscopy images were viewed and the elemental composition of the samples observed and determined. The XRD analysis of the calcined investigated gave the crystalline structure of both the snail shell for the calcium oxide (CaO) catalyst content.

3. RESULTS AND DISCUSSION

3.1 Crystalline Structure of Calcined Snail Shell Sample

The XRD patterns of the calcined snail shell powder revealed diffraction peaks of 20 values of the calcium oxide (CaO) in the snail shell as the temperature increased. The peaks correspond to calcium oxide (CaO) according to the Joint Committee on Power Diffraction Standard (JCPDS) 00-037-1497 reference file (Kolawole *et al.,* 2020). The presence of aragonite (calcium carbonate) ($CaCO_3$) as the main phase of African giant snail shells when fired at higher temperatures decomposed through calcination (Kolawole *et al.,* 2020). This means aragonite (calcium carbonate) ($CaCO_3$) is presumed to be thermodynamically unstable when subjected to high temperature and it transforms into a thermodynamically stable hard phase (calcium, CaO) as the temperature increases from 500 ºC, 700ºC to 90ºC.

The graphical representation of the results of the XRD analysis of the calcined snail shell at different temperatures (500, 700 and 900 ºC) are shown in Figures 1-3. They indicated the intensity (X-axis) of the chemical structural composition of the calcined snail shell at different temperatures. The º2Theta (y-axis) (º2 theta is the angle between the transmitted x-ray beam and the reflected beam) indicates the location of the elemental chemical structural composition in the calcined snail shell.

3.2 Evolutionary Trend of Calcium Oxide in the Calcined Snail Shell

The evolutionary trend of calcium oxide in snail shell calcined is shown SDF in Table 1, the crystalline chemical composition score of the snail shell calcined at 500, 700 and 900 ºC are indicated. Naturally, snail shells consist of $CaCO_3$ without CaO peak (highest) with an increase in calcination temperature (500, 700 and 900ºC) the $CaCO_3$ completely transforms to CaO by evolving the CO_2. It was reported by

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Laskar *et al.* (2018) that $CaCO_3$ is the major component of uncalcined snail shells and it is in two crystalline phases of aragonite and calcite. This is confirmed as a reported data on $CaCO_3$ (JCPDS file no.41-1475 and 29-0306) (Wang *et al.*, 2011). Table 1: shows the Crystalline Composition of Oven-Dried Snail Shells at 500, 700, 900 ºC and Scores. The intensity vs Theta (°2Th) values of the snail shell calcined at 500 ºC is shown in Fig 1, it has Potassium Oxide with a reference code of 10-0235 with °2Th values of 29.4007 and 69.1955 at the intensity of 1800 and 210 respectively. There is no presence of Calcium Oxide in the calcined snail shell therefore; it cannot be used for refining shea butter.

The intensity vs Theta (°2Th) values snail shell calcined at 700 ºC in Fig. 2 shows the presence of Calcium Oxide with reference code of 21-0155 and °2Th value of 34.1832 at an intensity of 2500. Palladium has a reference code of 85-0713 with Theta (°2Th) values of 29.4625, 34.1058, 64.2430 and 71.8669 and intensity values of 120, 1000, 300 and 80. There is **no much** presence of Calcium Oxide in the calcined snail shell therefore; it cannot be used for refining shea butter.

The graphical representation of the intensity vs Theta (°2Th) values and compound composition of the snail shell calcined at 900 ºC is shown Figure 3. 900 ºC shows the presence of Calcium Oxide with a reference code of 21-0155 and with Theta (°2Th) values of 18.0930, 28.7228, 34.1058 and 64.2430 with intensity values of 210, 180, 1000 and 300 respectively. Periclase (Magnesium Oxide) has a reference code of 03-0998 with Theta (°2Th) values of 28.7228 and 62.5902 with intensity values of 180 and 200. The calcium oxide has highest score of 22 in snail shell calcined at 900 ºC. The high score of calcium oxide observed at these elevated temperatures could be ascribed to the fact that there is a destruction of organic molecules at elevated calcined temperatures. Thus, leaving behind the inorganic elements intact that can be oxygenated to produce a high score of the element present in the snail shell such as calcium oxide as observed in the XRD analytical report of snail shell calcined from 500, 700 to 900ºC..

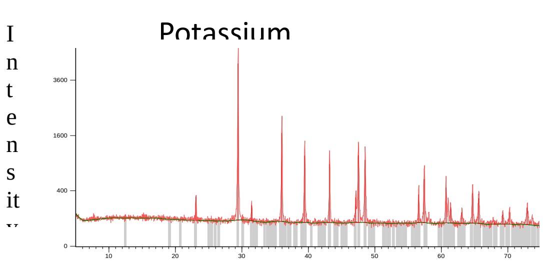

Fig. 1: XRD Graphical Representation of Calcined African Giant Snail Shell at 500 ºC

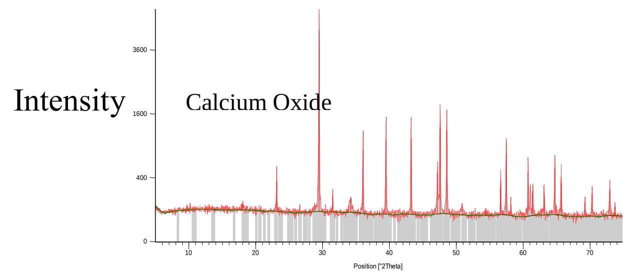

Fig. 2: XRD Graphical representation of calcined African giant snail shell at 700 ºC

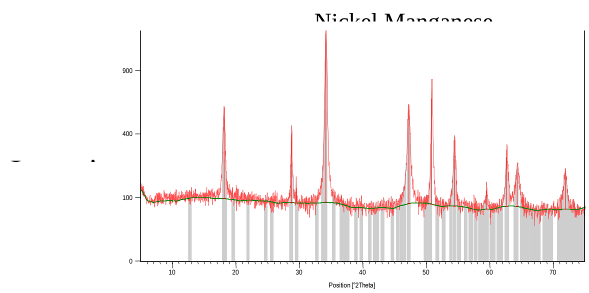

Fig. 3: XRD Graphical representation of calcined African giant snail shell at 900 ºC

3.3 Characteristics of the Refined Locally Produced Shea Butter

The results of the characteristics of unrefined and refined local shea butter are shown in Table 2 The pH value of 5.00–6.72 obtained from refined shea butter is within 6.09 as reported by Thioune *et al* (2019). And also, within 6.5–7.5 GRAS standard. The Africa Regional Standard and Code of Practice of Shea Butter Production (ARSCPSP) (2019) recommended pH value of 5.5-7.0, The maximum pH of the refined local shea butter is within the pH value of 6.78 recommended by The Africa Regional Standard and Code of Practice of shea butter Production (CFSAN, 2019

Table 1: Crystalline Composition of Oven-Dried Snail Shell at 500, 700, 900 ºC and Scores

500 ºC			700 ºC			900 ºC		
Score	**Compound Name**	**Chemical Formula**	**Score**	**Compound Name**	**Chemical Formula**	**Score**	**Compound Name**	**Chemical Formula**
27	Periclase	$Mg O$	16	Periclase	$Mg O$	22	Calcium Oxide	$Ca O_4$
15	Potassium Oxide	$K O_2$	4	Calcium Oxide	$Ca O_4$	9	Periclase	$Mg O$
8	Zinc Oxide	$Zn O$	9	Zinc Oxide	$Zn O$	31	Palladium Oxide	$Pd O$
5	Molybdenum Oxide	$Mo O_3$	11	Potassium Oxide	$K O_2$	13	Magnesium Manganese Oxide	$Mg6 Mn O_8$
13	Iron Oxide	$Fe O$	30	Cobalt Oxide	$Co O$	10	Manganese Oxide	$Mn O_2$
3	Copper Cobalt Oxide	$Cu Co_2 O_4$	6	Iron Oxide	$Fe2 O_3$	7	Nickel Manganese Oxide	$Ni Mn O_3$
13	Cobalt Magnesium Oxide	$Co_5 Mg_3 O_8$	5	Calcium Molybdenum Oxide	$Ca Mo O_4$	NA	NA	NA
NA	NA	NA	10	**500 ºC**	**700 ºC**	**900 ºC**	NA	NA
NA	NA	NA	4	Copper Manganese Oxide	$Cu Mn_2 O_4$	NA	NA	NA
NA	NA	NA	12	Palladium Oxide	$Pd O$	NA	NA	NA
NA	NA	NA	5	Calcium Manganese Oxide	$CaMn O_3$	NA	NA	NA
			4	Molybdenum Oxide	$Mo O_3$	NA	NA	NA
			3	Copper Oxide	$Cu_{64} O$	NA	NA	NA

NA – Not Applicable

The refined shea butter has ash content of 0.033-0.458 and lower than the 5.1-7.3 % reported by Menagerie (2014). And within the range of 0.084 as reported by Abidemi *et al.* (2021) and 0.451 by Abdul-Hammed *et al.,* (2020). ARSCPSP (2019) /FAO/WHO (2017) recommendation of 0.2-0.8% ash content for refined samples for the food industries. The acid value of the refined shea butter is 4.64 - 14.79 mgKOH/g. The values are within the range of 8.42, 9.77-13.765, 9.54, 9.54 and 10.6 mgKOH/g as reported by Munir *et al.,* (2012); Seweh *et al.,* (2016); Saba *et al*., (2018); Abdul-Hammed *et al.,* (2020) and Adeyemi *et al.,* (2020) respectively. But less than 18.39 mgKOH/g as reported by AjaIa *et al* (2019). The values fall within grade III of classification of shea butter for the soap-making industry.

The saponification values of the refined local shea butter are 116.761 - 187.395 mKOH/g. The value is within the range of 162.61, 184.0 to 2014, 1879.04, 187.5, 162.61, 180.20, 120.28 to 180.84 and 185.7 mgKOH/g reported by Munir *et al.,* (2012); Seweh *et al.,* (2016); Samuel *et al.,* (2017); Saba *et al.,* (2018); Thioune *et al.,* (2019); AjaIa *et al.,* (2019); Ibrahim *et al,* (2019) and Abdul- Hammed *et al.,* (2020) respectively for the refined local shea butter and within the range of 120.28 to 180.84 as reported by Ibrahim *et al,* (2019). The standard saponification value reported by FAO/WHO (2017) for refined shea butter is 160-190(195) mKOH/g while the Draft East African Standard (DEAS 967-1) (2019) and International Organization Standard recommended (ISO 3858) recommend 178.0 to 195.0 megKOH/g for refined shea butter for the cosmetic industry. Therefore, the saponification value obtained for the refined Shea butter (116.76 - 187.40) is within the acceptable value.

Free Fatty acid (FFA) from refined local shea butter 2.32 to 7.39. FFA obtained is within the range of 4.320 and 4.80 mgKOH/g reported by Saba *et al*., (2018) and Abdul-Hammed *et al.,* (2020) respectively. The Centre for Food Safety and Applied Nutrition (CFSAN) of the Food and Drug Administration USA (2019) gave I.00 mgKOH/g as recommended FFA value for refined shea butter, while Africa butter Regional Standard for Shea butter Production recommended FFA of 1.00 mgKOH/g for grade A, I.I - 3.0 mgKOH/g for grade B and 3.1-8 mgKOH/g for grade C for refined, Shea butter. Therefore, the refined shea butter falls into grades B and C.

The refractive index from the local refined shea butter refined is 1.4600-1.4621. These are between 1.461, 1.466 and 1.467 as reported by Samuel *et al.,* (2017); Abdul-Hammed *et al.,* (2020) and Thioune *et al.,* (2021) respectively and 1.4620–1.4650 recommended by FAO /WHO (2017), 1.455-1.465 reported by (CFSAN) for Food and Drug Administration USA (2019). Peroxide values from local refined shea butter 10.79 -16.05 are within the values of 15.00, 13.80 and 8.06 to 142 meq /kg reported by Munir, (2012); Ajala *et al.,* (2019) and Abdul-Mumeen *et al.,* (2019) respectively. The CFSAN (2019) and FDA (2019) recommended 10.00 meq/kg Draft East African Standard (DEAS 967-1) (2019) recommended 6 meg/kg and the International Organization Standard recommended (ISO 660) recommended 5 meq/kg for refined shea butter for the cosmetics.

The iodine values gave 20.19 to 38.23 g/100 g values. This is within the values of 31.19 g/100 reported by Okoye *et al.* (2020). Though lesser than 58.50 and 54.93, 45.6 I2, 54.93 g/100g by obtained by AjaIa *et al.,* (2019); Abdul-Mumeen *et al.,* (2019); Garti *et al.*, (2019) and Abdul-Hammed *et al* (2020) respectively. It has a higher value than 13.19 meq/kg reported by Thioune *et al* (2021). The CFSAN under the FDA 2019) and ISO recommended 50 to 75 g/100 g for iodine value while DEAS 967-1 (2019) and ISO 3961 recommends 60 to 70 g/100 g iodine for refined shea butter for the cosmetic industry. The colour of the shea butter samples is pale–yellow. The international standard rated colour value as white green, grey and yellow, pale yellow, red colour, and ivory colour. Africa Regional Standard and Code of Practice of shea butter Production and DEAS 2019, FDA, ISO 2019 recommendation of colour pale – yellow to Ivory for refined shea butter. Therefore, the colour of the shea butter is within the recommended standard by ARSCP (2019)/ FAO/WHO 2017).

3.4 Statistical Analysis of Refined Local Shea Butter

The analysis of the physiochemical properties of the locally produced shea butter was done to analysis the properties. Analysis of Variance (ANOVA) was carried out using design expert 12 software to determine the level of significance.

3.4.1 Analysis of Variance (ANOVA) of Refined Local Shea Butter

Analysis of Variance (ANOVA) was done and the F-value" obtained for pH value, Ash content, Saponification value, Peroxide value and iodine value were 249.70, 16637.72, 1553.70, 290.06 and 401.11 respectively (Table 3). It implies the model is significant and there is only a 4.84 %, 0.59%, 1.94%, 4.49%, and 3.82% chance of occurrences due to noise.

Model terms A, B, C, AC, BC and ABC were the significant model terms at a 95% confidence interval of $p<0.05$ while other variables (specific gravity, acid value, free fatty acid, and refractive index) have F-value" of 5.08, 128.86, 128.86 and 1.05 for the refined local shea butter with only 32.72%, 6.73%, 6.73%, and 63.37% chance of occurrences due to noise respectively.

The adequacy of the model was determined by evaluating the Coefficient of Determination (R^2) values of the models for pH value, specific value, ash content, acid value, saponification value, free fatty acid value, refractive index, peroxide value, and Iodine value gave 0.9993, 0.9682, 1.0000, 0.9987, 0.9999, 0.9987, 0.8628, 0.9994 and 0.9996 respectively. R^2 obtained for the eight variables of refined local shea butter is invested and closer to one except for ash content with a value of (1.0000). Adequate Precision of ratio values are 45.3557, 6.1289, 386.7505, 28.8312, 122.3506, 28.8312, 3.5254, 44.9358, and 63.5199 respectively. Adjusted (Adj R^2) of 0.9953, 0.7776, 0.9999, 0.9910, 0.9992, 0.9910, 0.0394, 0.9960 and 0.9971 for the eight variables. The Predicated R^2 for the variables were in reasonable agreement with the Adjusted (Adj R^2) This shows the capability of the model to predict the response adequately (Betiku *et al.,* 2020).

3.4.1 Model Equations

Model equations (1.0-9.0) show positive intercept values for model equations developed for pH value, specific value, ash content, acid value, saponification value, free fatty acid value, refractive index, peroxide value and Iodine value. The model equations showed the relationship among the selected factors (dosage, agitation, and time) are 0.2706, 0.0394, 0.0394. 0.2719 and 0.1656 for pH value for models terms B, C, AB, and ABC; ash content of 0.0249, 0.0375, and 0.553 for model terms, B, AC and ABC; specific gravity of 0.0113, 0.0421, 0.01170 and 0.0444 for a model terms A, B, AC and ABC; saponification of 0.0004, 0.0004 and 0.0004 for model terms of B, C, and BC; free fatty acid 0,01968, 0.0138, 0.0145C for model terms of B, C and BC; refractive index of 0.0001, 0,0002 for the model term of A and C; peroxide values are f 0.07175, 0.01700, 0.06375, 1.35 for a model term of A, B, BC and ABC; iodine value are 0.0055, 0.0077C, 0.0071 for a model term of B, C, and BC snail shell for the refined local shea butter were positive.

$$pH\ value = +6.11 - 0.0656A + 0.2706B + 0.0394C + 0.2719AB + 0.3494AC + 0.1656ABC \quad 1.0$$

$$(Specific\ gravity)^3 = +0.7305 + 0.01.0310C - 0.0585AB + 0.1170\text{A} + 0.0444\text{ABC} \quad 2.0$$

$$Ash\ content = +0.1603 - 0.0730A + 0.0249B + 0.0375C - 0.0294AC + 0.0553BC - 0.0769ABC \quad 3.0$$

$$(\text{Acid Value })^{-3} = +0.0032 - 0.0003\text{A} + 0.0025\text{B} + 0.0017\text{C} - 0.0001\text{AB} - 0.0003\text{AC} + 0.0003\text{ABC} \quad 4.0$$

$$(\text{Saponification Value}) = +0.0063 - 0{,}0003\text{A} + 0.0004\text{B} + 0.0004\text{C} - 0.0005\text{AC} + 0.0004\text{BC} - 0.0003\text{ABC} \quad 5.0$$

$$(Free\ fatty\ acid)^{-3} = +0.0254 - 0.0023A + 0.0196B + 0.0138C - 0.0010AB - 0023AC + 0.0145BC \quad 6.0$$

$$(Refractive\ index)^{-2.5} = +0.3874 - 0.0002A + 0.0001B + 0.0002C - 0.0001AB\ 0.0001AC - 0.0002C \quad 7.0$$

$$Peroxide\ Value = +12.35 + 0.7175A + 0.1700B - 0.6850C - 0.5250A\,B + 0.6375BC + 1.35ABC \quad 8.0$$

$$\frac{1}{Sqrt(Iodine\ Vaue)} = +0.1802 - 0.0087A + 0.0055B + 0.0077C - 0.0052AC + 0.0071BC - 0.0085ABC \quad 9.$$

Where A= Agitation, B = Dosage, C = Time of agitation.

3.5 Interaction of Selected Variable of Snail Shell on Refined Local Shea Butter

Design Expert 12 Software was used to obtain (2-D) and response surface (3-D) plots. The surface plot based on the model equation indicated the model equations are quadratic for pH, ash content, saponification value, peroxide value and Iodine value and surface plot on the model equation for specific gravity, acid value, free fatty acid and refractive index values indicated the model equations are linear. The contour plots are as shown in Figure 5-12.

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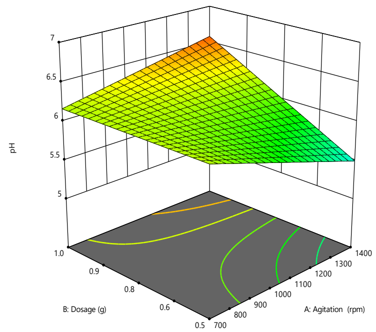
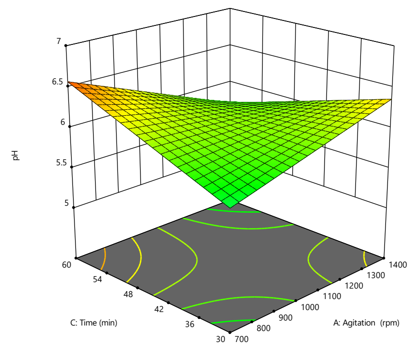
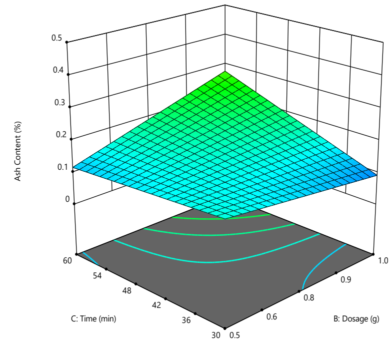


3-D Catalyst dosage vs agitation time on pH

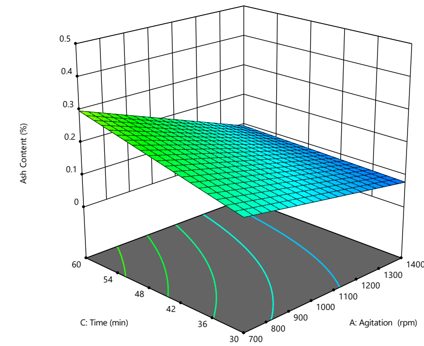


3-D Time vs agitation on pH

Fig. 5: Effect of Interaction of dosage, agitation and time on pH of refined local shea oil

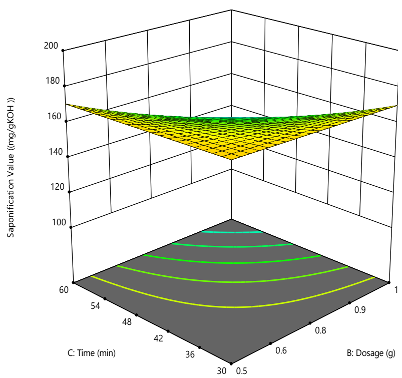


3-D Agitation vs catalyst dosage on Ash content

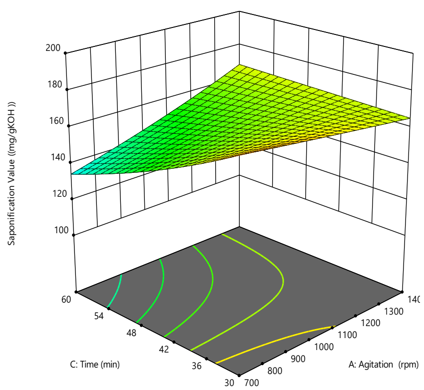


3-D Time vs agitation on Ash content

Fig.6: Effect of Interaction of dosage, agitation and time of agitation on Ash content of Refined Local Shea oil

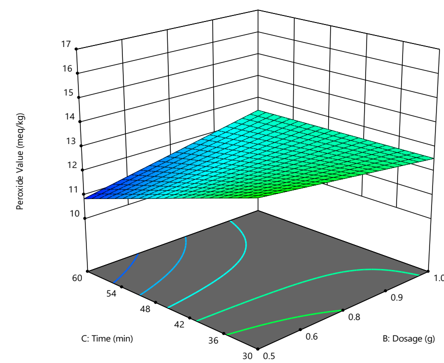


3-D Time of agitation vs catalyst on Saponification value

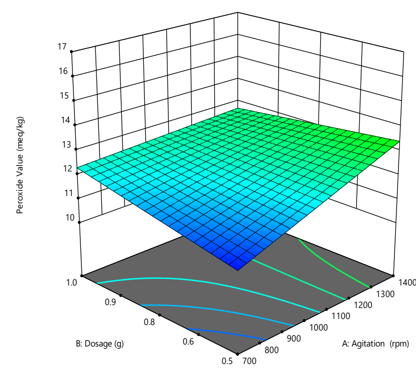


3-D Time vs agitation on Saponification value

Fig.7: Effect of Interaction of dosage, agitation and time of agitation on Saponification



3-D Time of agitation vs catalyst dosage on Peroxide value



3-D Time vs agitation on Peroxide value

Fig.8: Effect of Interaction of dosage, agitation and time of agitation on Peroxide of Refined Local Shea oil

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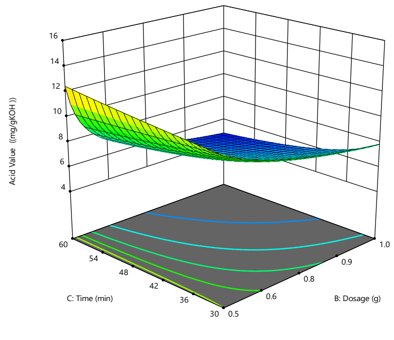
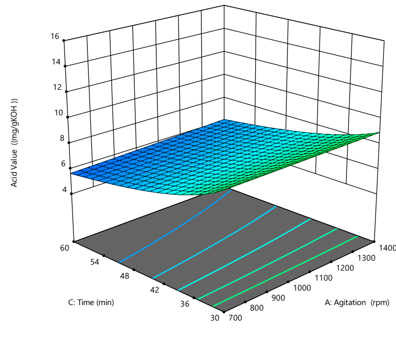
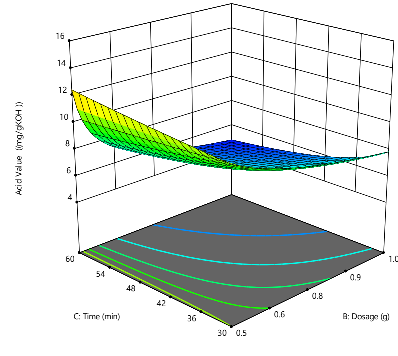


3-D plot of time agitation vs catalysts dosage on acid value

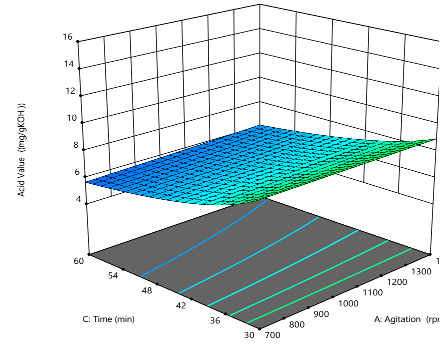


3-D plot of time of agitation vs agitation on acid value

Fig.9: Effect of Interaction of dosage, agitation and time of agitation on Acid value of Refined Local Shea oil

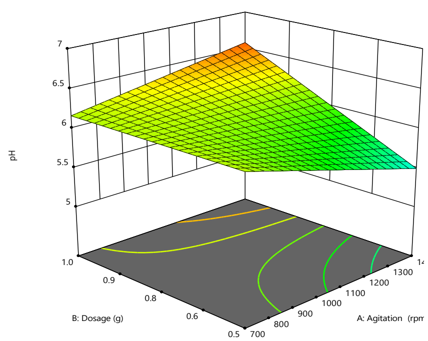


3-D plot of time of agitation vs dosage on Free fatty acid

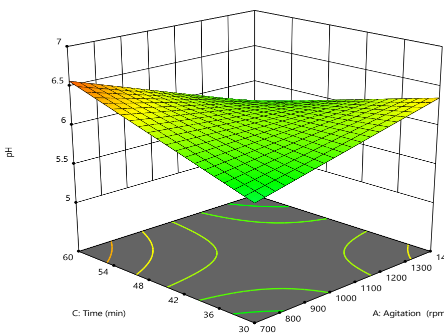


3-D plot of time of agitation against agitation on Free fatty acid

Fig..10: Effect of Interaction of dosage, agitation and time of agitation on Free Fatty Acid value of Refined Local Shea oil

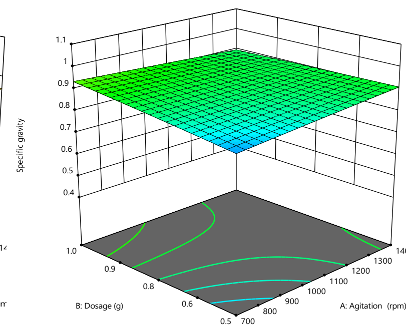


3-D plot of time of agitation vs catalyst dosage on Iodine

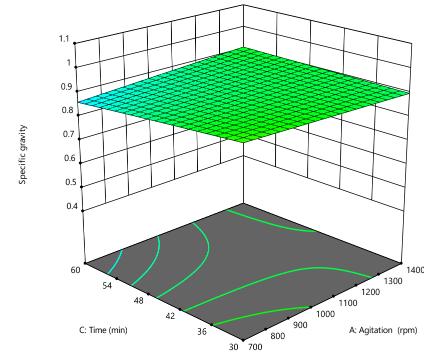


3-D plot of time vs agitation on Iodine

Fig. 11: Effect of Interaction of dosage, agitation and time of agitation on Iodine of Refined Local Shea oil

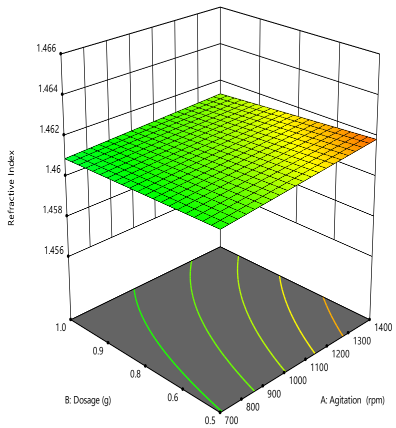


3-D plot of catalyst dosage vs agitation on specific gravity

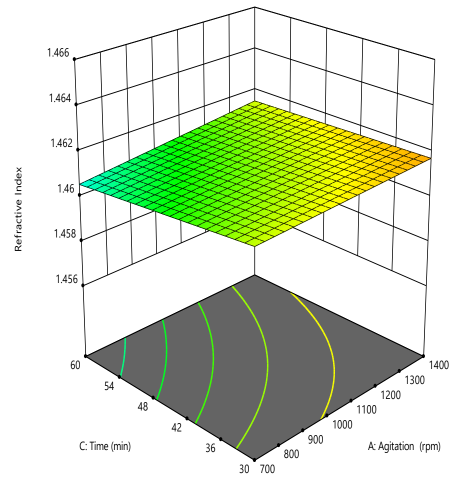


3-D time vs agitation on specific gravity

Fig. 12: Effect of Interaction of catalyst dosage, agitation and time of agitation on the Specific gravity of Refined Local Shea oil



3-D plot of time of agitation vs dosage on Refractive index



3-D plot of time vs agitation of the catalyst dosage on Refractive index

Fig. 13: Effect of Interaction of catalyst dosage, agitation and time of agitation on the refractive index of Refined Local Shea oil

4.0 Conclusion

The following conclusions were drawn from the study on refining shea butter using calcined African giant snail shells.

i. At a temperature of 900 ºC the calcined snail shell gave the highest CaO yield of 22 scores. Thus, indicating the material can be used as a catalyst and refining shea butter.

ii. The conditions that gave the best result in terms of refinement were agitation speed of 1400.00 rpm, snail shell dosage of 1.00g and agitation time of 60 min) for refining the local Shea butter.

iii. Results of values of the pH, Ash content, Saponification, Peroxide and Iodine values show that refining the shea butter with snail shell justified its relevance for soap making, cosmetics and pharmaceutical uses.

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