CHARACTERIZATION AND COMPARISON OF SOLVENT EXTRACTED AND TRADITIONAL MECHANICALLY EXTRACTED SHEA BUTTER

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ABSTRACT

Shea butter represents a very viable product for earning foreign exchange yet the potential of this abundant resource has not been adequately harnessed. This research compares the traditional mechanical extraction and solvent extraction methods of Shea butter using four different solvents namely ethanol, ethyl lactate, petroleum ether, and hexane. Fresh Shea nut was purchased from Kure market in Niger state and Shea butter was extracted from the nut using both traditional mechanical extraction and solvent extraction. Characterization of the extracted oil was done and the result showed the following chemical properties for solvent extraction method for the four solvents and traditional mechanical extraction respectively: acid value (6.72, 4.2, 8.96, 4.48, trace) mg KOH/g, free fatty acid (3.36, 2.1, 4.48, 2.24, trace) mg KOH/g, iodine number (6.36, 3.11, 5.43, 4.92, 5.36), peroxide value (9.30, 13.82, 10.99, 12.3, 14.13) meq O_2/kg, saponification value (401.39,351.32, 348.18, 416.32, 419.13) mg KOH/g. Other physio-chemical properties quantified were moisture content (0.1062, 0.1215, 0.1086, 0.1064, 0.1380) %, density (0.880, 0.867, 0.879, 0.881,0.850), specific gravity (0.879, 0.894, 0.891, 0.894, 0.862), viscosity (88, 70, 69, 78, 80), melting point (32, 33, 34, 33, 34) ^{O}C, cloud point (34, 34 38, 34, 35)C, pour point (32, 31, 32, 31, 32) ^{O}C, flash point (249, 256, 250, 253, 255) ^{O}C, smoke point (219, 224, 217, 223, 223) ^{O}C for both solvent extraction and traditional mechanical method. The result obtained indicated that the most suitable method in terms of yield and moisture content was the solvent extraction method whereas the traditional mechanical extraction method had the advantage of low acid value and free fatty acid. It also showed that there was no significant difference in property using the four different solvents for extraction. Also both methods of extraction yielded shea butter with equally good physical and chemical properties that can compete favorably in the international market.

***Keywords**: Shea butter, Characterization, Solvent extraction, Mechanical extraction.*

1.0 INTRODUCTION

Africa and Nigeria in particular is blessed with a wide variety of agricultural resources. Prominent among them is the shea tree fruit. Shea butter is a fat produced from the nut of the African Shea tree fruit (Vitellaria paradoxa), a tree belonging to the family of sapotaceae and it is typically yellow in color when raw, unprocessed, but extremely refined. Shea butter is often ivory or white in hue (Sangoremi, 2021). Shea butter is a poly saturated fatty acid bonded together in groups of three to create a molecule called triglycerides (Byakagaba, 2021). Shea butter in most rural areas is used as skin moisturizer, lantern oil, for medicinal purposes and soap making (Munir et al., 2012). It can equally serve as a cocoa butter equivalent in the manufacture of chocolate as well as an active ingredient in cosmetics (Alander, 2004). Additionally, the relatively low free fatty acid content of Shea butter and its use for biodiesel production have been reported (Ejeh and Aderemi, 2014).

About 80% of the world Shea nut production comes from Nigeria, Ghana, Burkina and Mali. In Nigeria, Shea nuts grow abundantly in Kwara, Niger, Kebbi, Kaduna and Oyo states (Munir, 2012). Shea butter represents a very viable product to earn foreign exchange, but improving the yield and quality of oil extraction from the Shea butter is necessary in order for the product to compete favorably in the international market. Shea butter is majorly produced by solvent extraction but traditionally and within the local community, mechanical methods are employed. Other extraction methods include supercritical solvent extraction, press extraction, and the use of ultrasound. (Addequay, 2004).

However, much uncertainty still exists about the standard method of extraction of Shea butter which will meet the standards declared by the various certification and standard organizations for Shea butter quality. Thus, there still remains huge information regarding the reasons for differing approach to the extraction of Shea butter and their efficiencies that are yet to be collected. This sort of information would extremely benefit communities and industries within the producing countries in the West African sub–region and the world at large (Abdul-Muneen et al., 2019).

1.1 Traditional Mechanical Extraction

In the traditional mechanical Shea butter extraction, the kernels are first broken into small pieces and then roasted. The roasted kernel pieces are then pounded to obtain a brownish paste. The paste is subjected to mild heating after which it is grinded thoroughly. The grinded paste is then kneaded and beat several times while adding hot water intermittently. During the beating process the butter appears as a creamy mass floating on top of the mixture. This mass is then washed once or twice before boiling. Washing will remove unwanted Shea nut and contaminant compounds from the butter, however it also removes vitamins and taste so too much washing is undesirable. To obtain the butter, the creaming mass is boiled in a cooking pot for water to evaporate leaving behind clear yellow oil which turns into a solid butter when it cools.

1.2 Chemical (Solvent) Extraction

With this method, the dried kernels are first crushed into paste and fed into the Soxhlet extractor. Afterward an organic solvent such as n–hexane or ether is added. The mixture is allowed to stand for some number of h for the oil to be separated which is decanted and allowed to solidify. The types of the solvents used in the extraction have some influence on the quality characteristics of shea butter especially the peroxide value of the butter. In a study conducted by Kar et al. (1981), on the best solvent for shea butter extraction, petroleum ether, n–hexane, chloroform, benzene, and water were employed. Hexane extraction gave the highest amount of fat from the kernel.

The principle with hexane extraction is that, the pulverized kernel is mixed with hexane which then unlocks the polymeric mass allowing all the oily and fatty constituents of the kernel to dissolve in it. The resulting oil–hexane mixture is later separated from the seed residue by filtration. The oil–hexane mixture is then heated to 68ºC to vaporise and recover the hexane to obtain the crude Shea Butter (Abdul–Mumeen, 2013; ASBI, 2004). The choice of hexane over other solvents for shea butter extraction is also informed by several factors: the physical properties of the solvent, the commercial economics of the butter and the edibility of shea oil from the extraction (Abdul–Mumeen, 2013).

Table 1 shows some typical characteristics of shea nut oil.

Table 1: Some typical Characteristics of Shea nut Oil

Relative density	0.859-0.869
Refractive index	1.463-1.467
Saponification value (mg KOH/g)	178-190
Iodine value (g I_2/100g)	53-65
Unsaponification matter (%)	2-11

Source: (Codex, 1970)

2.0 EXPERIMENTAL PROCEDURE

Reagents and chemicals used for the study include n-hexane, petroleum ether, ethyl lactate, ethanol, phenolphthalein indicator and potassium hydroxide while the major equipment used include oven, soxhlet extraction apparatus, refractometer and viscometer. All chemicals used were of analytical grade and were all manufactured by Guangdang Guanghua Chemical Factory Co. Ltd and purchased from Guangzhou JHD Chemical Reagent Co. Ltd.

2.1 Mechanical extraction of Shea butter

Shea fruit were purchased from Kure market in Niger state and the fleshy part removed. The seeds were then deshelled to bring out the kernels from which the oil was extracted. The nuts were sun-dried for10 days**.** They were further dried in an oven at 70˚C until a constant weight of sample was achieved after which they were roasted. They were then taken to a milling machine to grind the nuts into a fine paste. The milled paste was allowed to settle for a day to further remove any water molecule still within it. At this stage,the oil is ready for extraction. The milled paste wasthen kneaded gradually as water was added to it to enable the oil to riseto the top. At this stage the oil has been extracted along with some impurities. It was then heated to enable the separation of the oil from the tiny impurities; as the oil liquefied, the impurities settled below the pot. The oil was then decanted and filtered.

2.2 Solvent Extraction of Shea Butter

The method proposed by Mital et al (1974) was used. 300ml each of the respective solvents; normal hexane, petroleum ether, ethanol and ethyl lactate were measured separately into four clean round bottom flasks. 15.356g, 19.337g, 12.26g and 13.36g of sample were placed in four different thimbles, labelled A, B, C and D respectively and were inserted in the centre of each extractor according to their label. Each of the soxhlet was heated at 50 ºC. When the solvent boils, the vapour rises through the vertical tube into the condenser at the top. The liquid condensate drips into the filter paper thimble in the centre, which contain the solid sample to be extracted. The extract seeps through the pores of the thimble and fills the siphon tube, where it flows back down into the round bottom flask. This was

allowed to continue for 2hours. The samples were then removed from the tube, dried in the oven, cooled in a desiccator and weighed to determine the amount of oil extracted. Further extraction was carried out at intervals of 2 hours until the sample weight at further extraction and previous weight became equal. At the end of the extraction, the resulting mixture containing the oil was heated to recover the solvent from the oil. The percentage yield of the Shea oil extracted was then calculated for all four solvents.

2.3 Determination of Physical Properties

All reagents used were of analytical grade. The chemicals were all manufactured by Guangdang Guanghua Chemical Factory Co. Ltd and purchased from Guangzhou JHD Chemical Reagent Co. Ltd.

2.3.1 Refractive Index

The refractometer was used to determine the refractive index of the oil. The surface of the prism was cleaned with spirit and 2 drops of the oil sample were placed on the lower prism. The upper prism was then brought in contact with the lower prism so that the unbroken layer of the oil was formed between the two prisms. The refractometer control was adjusted to bring the light and dark field into focus with its cross hairs. The reading was then taken directly from the scale.

2.3.2 Specific Gravity

This was determined by the method proposed by Mital et al (1974). A 25cm^3 specific gravity bottle was rinsed with distilled water, allowed to dry and cleaned. The weight (W_0) of the empty flask was taken after which the bottle was filled with the sample and the new weight (W_1) was noted. The flask was subsequently filled with distilled water and the weight (W_2) was recorded.

$$\text{Specific gravity} = \frac{W1-W0}{W2-W0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

2.3.3 Viscosity

Viscosity was determined by introducing the oil sample into a viscometer tube and the rate of flow at room temperature was observed. The experiment was conducted four times.

2.4 Determination of Chemical Properties

2.4.1 Moisture Content

The moisture content was determined by drying a sample of the oil until constant weight was achieved then calculating the percentage loss in moisture.

2.4.2 Saponification Value

As 10g of KOH (molecular weight 56.1) was weighed and transferred into a 500ml volumetric flask containing 250ml ethanol. The mixture was shaken for about 10min until the KOH was completely dissolved. 1ml of the oil sample was measured in a conical flask and 25ml of the prepared mixture of KOH and ethanol was measured into the flask and a blank was set at the same time. The sample flask and the blank were transferred into the oven and heated for 30min. The flask was then removed and allowed to cool. 3 drops of phenolphthalein were added to the sample flask and the blank flask then each was titrated against 0.5M HCl.

$$\text{Saponification Value} = \frac{(S-B)\ X\ M\ X\ 56.1}{W} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where: S = Amount (cm^3) standard required for sample, B = Blank titre value (cm^3), M = Molarity of the HCL, W = Sample weight (Oil)

2.4.3 Acid Value

1.0g of the oil was weighed and dissolved using 20ml of the neutral solvent(methanol) in a 250ml conical flask. 3-4 drops of the indicator was added then titrated with 0.1M KOH. The mixture was shaken continuously until the pink colour that perseveres for about 20sec was observed.

$$\text{Acid value (mg)/KOH/g} = \frac{\textit{Titre value X 0.1 M KOH}}{\textit{Weight of sample (g)}} \quad \ldots\ldots\ldots\ldots(3)$$

2.4.4 Peroxide value

This was determined by the method proposed by Mital et al (1974). 1g of the oil sample was weighed and transferred into a clean dry boiling tube, then 1g of potassium iodide powder KI and 200ml of solvent mix of acetic acid and toluene was added. The tube was relocated into a boiling water and the liquid allowed to boil for roughly 30sec. The mixture in the tube was then hurriedly relocated into a conical flask containing 20ml of 5% KOH solution. The tube was washed twice with 25ml of water each time and collected into the conical flask and then titrated with 0.002M $Na_2S_2O_3$ until the yellow colour almost disappears. A blank was set at the same time. The equation below was used to calculate the peroxide value.

$$\text{Peroxide value (mol Peroxide/Kg Sample)} = \frac{\textit{T X M X 1000}}{\textit{Weight of sample (g)}} \quad \ldots\ldots\ldots(4)$$

Where:T = titre value of $Na_2S_2O_3$ = sample titre – blank M = Molarity of $Na_2S_2O_3$

2.4.5 Iodine Value

1.5g of oil sample was weighed and transferred into a clean dry volumetric flask (250cm^3). 15cm^3 of chloroform was added to dissolve it followed by 25cm^3 of iodine solution. The flask was kept in the dark and allowed to stay for 30 minutes. 20cm^3 of 15% solution was added. The volumetric flask was stoppered and shaken vigorously. The solution was then titrated with a standard 0.1M $Na_2S_2O_3$ while continuously swirling until the yellow colour of iodine almost disappears. 2cm^3 of 1% starch indicator was added and the titration was continued until the blue colour disappeared. Blank determination was carried out for 5cm^3 of chloroform and an equal proportion solution and equation (5) below was used to calculate the iodine value.

$$\text{Iodine value} = \frac{\textit{(B−S) X N X 0.1269 X 100}}{\textit{W}} \quad \ldots\ldots\ldots\ldots (5)$$

Where: B = Volume of standard $Na_2S_2O_3$ for blank, S = volume of standard $Na_2S_2O_3$, N = normality of $Na_2S_2O_3$, and W = Weight of sample.

2.4.6 Free Fatty Acid

1 g of the oil sample was measured into conical a flask, 20cm^3 of methanol was added to the flasks then four drops of indicator (phenolphthalein). The mixture was then titrated with 0.1M potassium hydroxides until a color change was observed.

$$\text{Free fatty acid} = \frac{\textit{T X N X 56.1}}{\textit{Weight of Sample}} \quad \ldots\ldots\ldots\ldots(6)$$

Where: T = Titre value and N = Normality of the acid

3.0 RESULTS AND DISCUSSION

The physicochemical properties of oil obtained from shea nut is shown in Table 3 and 4.

Table 2 shows the percentage yield of oil obtained from solvent extraction for each of the four solvents used after every two hours until all oil present have been extracted while Table 3 shows the effect of extraction method on the physical properties of shea oil.

Table 2: % Oil Yield from Solvent Extraction.

Hours	Ethanol (%)	Ethyl Lactate (%)	Petroleum Ether (%)	N-Hexane (%)
2	4.8	23.84	8.68	9
4	16	27.54	27.9	22.7
6	26.4	30.5	35.45	37.83
8	35.9	40.89	44.9	47.18

Table 3: Effect of Extraction method on the Physical Properties of Shea Oil

Parameters	Ethanol	Ethyl Lactate	Petroleum Ether	N-Hexane	Traditional
Melting Point (^{O}C)	32	33	34	33	34
Moisture Content (%)	0.1062	0.1215	0.1086	0.1064	0.1380
Specific Gravity	0.879	0.894	0.891	0.894	0.862
Density (g/ml)	0.880	0.867	0.879	0.881	0.850
Viscosity (mPa.s)	88	70	69	78	80

Table 4 below gives the chemical properties of Shea butter for the four different solvents used for the extraction.

Table 4: Chemical Properties of Shea Butter for Different Solvents of Extraction

Parameter	Ethanol	Ethyl Lactate	Petroleum Ether	N-Hexane	Mechanical Method
Acid Value (mgKOH/kg)	6.72	4.2	8.96	4.48	Trace
Peroxide Value (mEq/kg)	9.30	13.82	10.99	12.3	14.13
Saponification (mgKOH/kg)	401.39	351.32	348.18	416.32	419.13
Iodine Value	6.36	3.11	5.43	4.92	5.36
Free Fatty Acid	3.36	2.1	4.48	2.24	Trace

Table 5 below shows the maximum allowable limit for some constituents of shea butter as specified by CODEX. Other requirements states that it should be free from off-flavours and off-odours and should have a uniform colour and consistency ranging from white to yellowish. Limits for heavy metals and pesticide residues are also specified.

Table 5: Extract from Codex Alimentarius Standard for Edible Oils (CODEX STAN 325-2017)

CONSTITUENT	MAXIMUM LIMIT
FREE FATTY ACID	1.5 %
PEROXIDE VALUE	10 meq/kg
UNSAPONIFIABLE MATTER	19 %
MOISTURE CONTENT	0.2 %
IODINE VALUE	30 – 70 g I_2/100 g
SAPONIFICATION VALUE	170 – 190 mg KOH/g
REFRACTIVE INDEX (AT 40 ^{O}C)	1.455 - 1.464

3.1 Yield

From table 2, the oil yield values for the solvent extraction method (ethanol, ethyl lactate, petroleum ether and n-hexane) was recorded as 36%, 41%, 45%, and 47% while the yield for the traditional mechanical method was 32%. The experimental results obtained agrees with reports on efficiency of 40 – 66% for chemical method as reported by Akingbala et al. (2006); Francis (2009); Tano-Debrah and Ohta (1994); Okullo et al., (2010); mechanical method falls within the range of 30 – 45% efficiency as reported by Olaniyan and Oje (2007b); Gezahegn et al. (2016) and Francis (2009). Higher percent oil extract was observed from solvent extraction method with greater amount in hexane. This is because solvent extraction typically results in higher oil yield compared to mechanical methods due to

its ability to efficiently extract oil from the cellular structure of plant materials. Solvents such as hexane can penetrate the cell walls and dissolve the oil, releasing it from the plant matrix. This is evident in the percent oil yield from hexane as compare with other solvents used. Lower yield of 32% was observed in mechanical method because some oil may be left trapped in the cellular structure, resulting in lower overall yield as can be seen by the graphical relationship shown in Figure 1 below

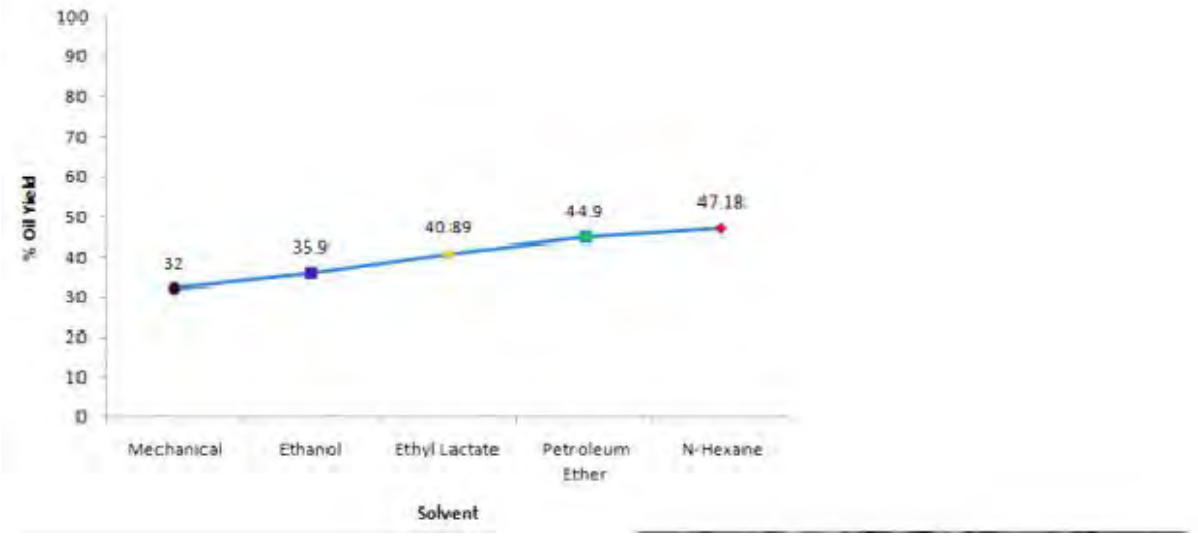

Figure 1: **Graphical relationship between % Oil yield and various extractio**

According to Matchet (1963), oil bearing seeds that can yield up to 30% oil can be considered as suitable for industrial application. Thus all solvents used for the extraction are suitable for domestic, commercial and industrial applications however, From the graph shown above, it can be visible seen that the solvent extraction is more efficient in terms of yield compared to the traditional method, also is can deduced that both n-hexane and petroleum ether yields more oil as compared to the other green solvents.

3.2 Moisture Content

Moisture is a chemical contaminant which is usually well mixed with oil. Presence of moisture in oil affects the quality of the oil, it has been reported that significant amount of moisture in oil support microbial growth (Alirezali et al., 2011). The value recorded for the moisture content with solvent extraction method for ethanol, ethyl lactate, petroleum ether, n-hexane and traditional method were 0.1062, 0.1215, 0.1086, 0.1064 and 0.1380 respectively as tabulated in table 3. The result also shows slightly high moisture content for ethyl lactate which is recorded at 0.1215. The values obtained were similar to reports of 0.l% by Asuquo et al. (2010) though the values were higher than 0.037% obtained by Enweremadu and Alamu, (2010). The solvent extraction method resulted in lower moisture content compared to traditional methods due to the nature of the process. Solvent extraction involves using a chemical solvent to dissolve the oil from the plant material. This method is typically carried out at elevated temperatures, and the solvent properties which effectively removes both oil and moisture from the material. The lower value in mechanical extraction method can be said to be due to its inefficiency operating at a more controlled conditions as the solvent extraction method. Solvent extraction method has a significantly lower moisture content than traditional extraction method meaning that former method optimizes the keeping quality of Shea oil since oils with high moisture content are known to undergo rancidity (Fellows, 1997). Low moisture content is desirable in oil to preserve the shelf-life because oxidative rancidity, microbial growth and infestation are prevented or reduce by moisture removal.

3.3 Specific Gravity

Specific gravity is an important physical property that can give information on the identity of the sample as well as aid in detection of adulteration of shea butter oil (Hee, 2011). The observed value recorded for the solvent method was gotten as 0.894, 0.879, 0.891, 0.894 g/cm^3 for ethanol, ethyl lactate, petroleum ether and n-hexane respectively, also the value for traditional method was gotten as 0.862 g/cm^3. The Density for the respective samples for both solvent method and traditional method was deduced to be 0.880, 0.867, 0.879, 0.881 and 0.850 g/cm^3 respectively. These values show close proximity to results reported as 0.860 g/cm^3 (Munir et al., 2012), 0.8788 g/cm^3 (Azuaga et al., 2021) and observed to be lower than 0.911 (Ofoegbu-Chukwu et al., 2022), 0.927 (Chibor et al., 2017) and 0.907

in traditional method and 0.927 in solvent method by Audu and Awulu, 2017. The value obtained from this research shows close proximity to 0.8 – 1.0 as the required standard.

3.4 Acid Value

A low Acid value means that an oil sample contains less fatty acid thus reducing its exposure to rancidification (Roger et al., 2010; Asuquo et al., 2012). Acid value is also an indicator for edibility of oil as well as their suitability for industrial use. As observed from table 4, the acid value for Shea butter oil extracted by solvent method was 6.72%, 4.20%, 8.96%, 4.48% respectively. These values are higher than those obtained by Ejeh and Aderemi, 2014 (2.279%) and Saba et al., 2018. Also, the values were observed to have close range to Ofoegbu-Chukwu et al., 2022 (4.77%), (4.21%) Munir et al., 2012 and (5.32 – 6.60%) from Animasaun et al., 2019. From the experimental result it can be deduced that petroleum ether has a high acid value recorded at 8.96% while trace amount was observed for the traditional method. Solvent such as hexane showed lower acid value which means it produces the best quality oil extract. The lower acid values in solvent extraction can be due to the gentle (milder) nature of the process which helps to minimize the hydrolysis of triglycerides into free fatty acid reducing the reducing the overall acid content. A higher acid value was observed for the solvent method which was above the 1% threshold. However, the recommended codex value is 0.6 and 10% for virgin and non- virgin edible fats and oil, respectively (Codex Alimentairus commission, 1993). Therefore, using the codex standard, the oil extracted by both methods are suitable for edible purposes as well as use in the manufacture of paints and vanishes even though oils from traditional method seem most suitable for cooking purposes.

3.5 Free Fatty Acid (FFA)

Free Fatty Acid (FFA) by definition are the fatty acids present in oil or fat which has not been neutralized (Guy, 2009) or just unattached fatty acids present in a fat (Sapna and Nirmali, 2009). FFAs are related to their acid values and are less stable than neutral oil and thus more prone to oxidation and turning rancid (Mahesar et al., 2014). From table 4, the free fatty acid value deduce were recorded as 3.36%, 2.1%, 4.48% and 2.24% for the solvent method respectively and a minute percentage was observed for the traditional method. Similar results 2.39% of crude shea butter extract were reported by Ofoegbu-chibuzo et al., 2022. As explained in the discussion of lower values of acid values in solvent extraction method, free fatty acid is a directly proportional to the acid value (Roger et al., 2010). Apart from the milder process which can affect the acid value in solvent extraction, the controlled temperatures and minimized exposure to air reduces the likelihood of oxidation reactions that can contribute to the formation of free fatty acids.

3.6 Peroxide Value (PV)

Perioxide is the initial product of unsaturated fat oxidation and that fresh oil has peroxide values (PV) below 10 mEq/kg while rancid oil gives peroxide values between 20 and 40 mEq/kg (Kirk and Sawyer, 1991). The peroxide value (PV) was obtained as 9.30, 13.82, 10.99, 12.30, and 14.13 for both solvent extraction method and traditional method respectively as shown in table 4.The P.V obtained relates positively to 8.80 mEq/kg and 9.8 mEq/kg obtained by previous authors (Saba et al., 2018), (Garti et al., 2019) respectively. However, it is lower than reported values of 15 mEq/kg (Munir et al., 2012); 14.2 mEq/kg (Adetuyi et al., 2015) and 29.5 mEq/kg (Dandjouma et al., 2009). The PV obtained for Shea oil extracted by traditional method is higher than those of the solvent extracted from Shea even though both methods possess acceptable PV. Lower refinement in mechanical methods may lead to higher levels of impurities and natural substances which can contribute to increased oxidation and consequently a higher PV.High Peroxide Value (PV) is associated with the development of rancidity in fats and oils, which eventually limits their use in the food industry (Shahidi, 2005). PV is the most common determinant of lipid oxidation (Shahidi, 2005) and can be deduced that solvent extraction method produced lower PV making it a better extraction method.

BIodine value helps to determine the amount of unsaturation in fatty acids. It can be defined as the number of grams of iodine that can be added to 100 g of oil. Reports by Chibor et al., 2017 indicate that shea nut oil with low iodine value is an indication of its richness in saturated fatty acids and this ensures stability against oxidation, thus making it a good source of oil. The observed value deduced from the result as tabulated in table 4 was recorded at 6.36, 3.11, 5.43,4.92 and 5.36 for both solvent method and traditional method respectively. The low iodine value of shea butter shows that the oil is rich in saturated fatty acids, which maintains the stability of meals cooked with the oil against oxidation and rancidity (Fernande et al., 2011). The higher the iodine value the more the bonds chains are present in the fat. The lower the iodine numbers the lower the degree of unsaponification and the longer the shelf-life of the oil (Azuaga et al., 2021). The methods of shea nut extraction had a significant effect on the iodine content of the oil as reported by Audu and Awulu, 2016. Mechanical extraction method produces higher iodine values as compared to solvent extraction which makes it less efficiency in achieving higher purity of oil extract.

3.8 Saponification Value

The saponification value of 401.39, 351.32, 348.18, 416.32 (solvent extraction method respectively) and 419.13 (traditional method) was recorded as shown in table 4. The saponification value of an oil increases with its lauric acid content. The lauric acid content and the saponificaton value of oil serve as important parameters in determining the suitability of oil in soap making. Saponification value is also used in checking adulteration. A low value could suggest non-suitability of oil sample for industrial use. Even though there was significant difference in the saponification value of the five samples, the oils from the two methods may not enjoy a comparative advantage with oil from other seeds in terms of their ability to saponify. The result showed that low saponification value found in the solvent method was due to the high fat content of the oil. Oil that is used for fuel are recommended to be extracted using the mechanical method. Similar results were discussed by Audu and Awulu, 2016 and Okafor et al., 2015.

Extraction method had varying effect on sensory parameters of texture, appearance, odour and general acceptability. While the texture and general acceptability for solvent extraction method which was significantly different for traditional extraction method seem more acceptable, appearance and odour for the same method was not acceptable to the test panelists.

4.0 CONCLUSION

1. There is a contrast in physical and chemical properties of Shea oil extracted by solvent, and traditional mechanical methods.
2. There is no much different in the physical and chemical properties of Shea butter extracted using the four different solvent.
3. Solvent extraction method is the more suitable method in terms of yield and moisture content.
4. Traditional mechanical extraction method had the advantage of low acid value and free fatty acid.
5. Traditional mechanical extraction had a higher moisture content of 0.138 % compared with solvent extraction which had a maximum moisture content of 0.1086 % for petroleum ether.
6. The specific gravity of the two methods were close to each other; 0.894 for solvent extraction and 0.869 for traditional mechanical extraction.
7. The acid value for solvent extraction was a maximum of 8.96% with petroleum ether while it was trace for traditional mechanical method.
8. A free fatty acid of 4.48 was the maximum obtained with petroleum ether while it was trace for traditional mechanical extraction.
9. The peroxide value for solvent extraction was 13.82 with ethyl lactate while it was 14.13 for traditional mechanical extraction.

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