Evaluation of Proximate Composition and Characterization of Oil in Kernel Seeds of Selected Nigerian Mangoes

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Abstract: Analysis of the percentage proximate composition and oil quality indices of selected Nigerian mango kernel were investigated. Four mango varieties (german, fazli, cherry and safeda) were sourced from Owerri, Imo State, Nigeria, processed, and their oil extracted using Soxhlet extractor, with n-hexane as solvent. AOAC standard procedures were adopted for the analyses, and the analyses were carried out in triplicates. The means were compared using The Origin Software at P>0.05. The proximate composition of kernel seeds showed that the percent ash, moisture, fat, fibre, protein and carbohydrate content varied from 1.501±0.036-4.786±0.302%, 2.495±0.559-3.98±0.537%, 6.947±1.339-10.484±0.685%, 2.096±0.419-3.861±0.652%, 1.344±0.345-1.736±0.33% and 78.24±0.622-81.644±0.487% respectively. Protein showed no significant difference in all the varieties investigated while there was significant difference in ash, moisture, fat, fibre, and carbohydrate. The physicochemical indices of the oil were as follow: smoke point (60±2.828-80±7.071 oC), refractive index (1.402±0.143-1.441±0.199), fire point (68±4.243-110±7.071 oC), flash point (55±7.071-82±2.823 oC), pH (6.42±0.044-7.51±0.014), viscosity (452.2±11.597-723.9±14.284Pas-1), density (0.856±0.079-0.938±0.0536 g/ml), specific gravity (0.36±0.057-0.442±0.059g/ml), free fatty acids (2.244±0.204-5.049±0.211), peroxide value (16.6±0.849-20.4±0.566g/ml)), acid value (4.488±0.266- 10.098±0.421mg/KOH/g), iodine value(29.269±0.769-40.978±1.478mg/g/g), saponification value (153.967±5.610-270.731±8.105mg/KOH). Similarly, refractive index showed no significant difference at P>0.05 in all the varieties investigated. Generally, the results indicated variations in proximate composition of mango kernels seeds, while the kernel seeds oil is a good source of fatty acids, with potentials as nutrient rich oil of economic value.

Keywords: Mango kernel oil, Proximate, Nigerian mango seed, Oil characterization, Physicochemical, varietal composition

1. Introduction

Mango also called Mangifera indica L. is cultivated worldwide and generally accepted by consumers because of its sweet taste, appealing to eyes and exotic flavor. After mango processing and consumption, a significant quantity of by-products in the form of peels, coats and seeds are generated and afterward discarded as waste product. Mango kernel remains the chief by-products of mango fruits that is gotten after the pulp consumption and is reported to be a good source of carbohydrates, protein and fat (Choudhary et al., 2023). According to FAO (2015), Nigeria, is the 8th largest mango producer in the world with a production of approximately 850,000 metric tons of mango fruit per year. It is approximated that 35–60% of mango seed is discarded as waste after fruit consumption (O'Shea et al., 2012); above one million tons of the seeds are produced as wastes annually, and are not currently utilized for any commercial and economic purposes (Leanpolchareanchai, 2014).

The involvement of agro product processes result in the formation of by-products (leaves, pulp, seed and peel) in high concentration creating environmental nuisance. Successful studies for their re-utilization as medicinal value (Aloket al., 2013), promising antimicrobial agent (Chandra et al., 2013), and nutritional compound (Bandyopadhyay et al., 2014) could have a vital element to fill the costly and unavailability of feed both for livestock and industry purposes; and reduce waste of these seeds in regions of production. It is believed that information on the biochemical and physicochemical properties of mango seed would aid to identify the potential benefit of the seed and reduce waste. Energy and protein availability are specifically major constraint in production of poultry feed and the best solution to cope with the current cost of production is to improvise non-conventional feed resources which could be by-products from industries, agriculture and fruit wastes. The work of Jafari et al., (2014) shows that mango kernel is a prospective source of wide range of bioactive compounds and antioxidants. Mango kernel is proposed as a suitable replacement for grains especially maize and soya beans in poultry diets, due to its nutritional profile but there exists a significant broad range of varietal differences in composition which is worthy of note. Torres-Leon et al., (2016) documented that direct incorporation of mango kernel in food represents a good strategy to increase consumers' intake of antioxidants, fat and protein. They suggested that research should continue to find the profiles of the phytochemicals inherent in different seed varieties, their bioavailability and health effect. In some cases, the byproducts of mango represent greater mass (Ayala et al., 2011) and have more bioactive compounds than pulp and peel or the end products after processing. To fully utilize their biological potential, wastes with high nutritional content and functional value such as the mango seed can be incorporated in the human meals (Da Silva & Jorge, 2014).

Mango seed is estimated to provide equivalent energy as maize and can be substituted as alternative source of energy in bird's diet and has been incorporated up to 50% in biscuit production (Ashoush and Gadallah, 2011).Mango kernel oil (MKO) is the oil fraction extracted from kernel of mango fruit. It contains 12–15 % edible oil (Nadeem et al., 2016). It is approximated 32–36 °C melting point, solid at room temperature and may not require partial hydrogenation for relevance in foods (Nadeem et al., 2016). MKO may be used as an alternative of cocoa butter, which is used in chocolates and confectionaries and many more. From hidden hunger and food insecurity perspective, it is vital to efficiently utilize agro waste, for safer environment and feeding of increasing animal population. Principally, the issue of food insecurity in Africa and Asia may lead to hunger and malnourishment in the coming 35–50 years (FAO, 2006).Due to progressive increase in world population which demands corresponding food supply, feed cost is known as a chief factor of poultry production cost accounting for up to 60-70% of absolute cost and is the biggest limitation to poultry production. Beside mango kernel uses for animal feed formulation, it has the potentials to serve edible purposes (Torres-León et al, 2016). Evaluation of individual varietal properties of mango kernel will greatly help in understanding and selection for incorporation into food products and confectionary at large.

No detailed study has been reported previously on the proximate and oil extraction of mango kernel from the selected mango varieties of Nigeria. Information available in most literature are on the fruits, leaves, and peels. However, it's vital to conduct investigations on the kernel that is seen as a waste material in Nigeria to determine if waste could be converted to wealth. In this research, a complete analysis to evaluate the proximate from kernels of selected Nigerian mango varieties and characterization of their oil was carried out.

2.0. Materials and Methods

2.1. Source of mango kernel

Varieties of ripped mango fruits were harvested from mango trees in Nekede and Obinze communities in Owerri-West Local Government Area, Imo State, Nigeria and studied during the 2023 and 2024 mango fruiting seasons. These varieties were identified as Cherry, Garman, Falzi and Safeda cultivars by a botanist (Prof. C.M. Duru), in the Department of Biology, Federal University of Technology, Owerri. They were separated, decorticated and washed thoroughly in a running tap water, shade and sun dried. The seeds were carefully removed from their endocarp and tenacious seed coat. These seeds were decocted into fine pieces and dried in hot air oven for eight to twelve hours at60 °C and thereafter, finely ground into kernel flour (mango kernel flour)in a mill till the particles were able to pass through a number 20 sieve

2.2. Proximate Analysis

The defatting of kernels was done using Soxhlet method, using petroleum ether at boiling point 40-60°C and the defatted cakes were then investigated or their proximate compositions as follows:

2.2.1. Determination of moisture content. Petri-dish was washed and dried in the oven and 2g of the sample were weighed intoit. The petri dish with sample was weighed and the weight noted, the petridish with sample was put in the oven (Fisher Scientific Isotemp) for 30minutes, at the temperature of 102°C and the weight was also noted. The drying procedure was repeated until a constant weight was obtained. Percentage moisture content was determined as follows:

$$\% \text{ Moisture Content} = \frac{W_1 - W_2}{\text{Weight of Sample}} X\ 100$$

Where w_1 = weight of petridish with sample before drying, W_2 weight of petridish with sample after drying.

2.2.2. Determination of crude fibre content. The crude fiber content of the powder was analyzed by the method described by(AOAC, 1984). 2 to 3g of the defatted kernel was weighed and put into 200 ml of 1.25% H_2SO_4 and heated for 30 minutes. It was then poured into bucheur funnel equipped with muslin material and protected with elastic band. The solution was allowed to filter and residue washed with boiled water to eradicate acid. The residue was poured into 200 ml boiling 1.25% NaOH and heated for 30 min, and then filtered. It was then washed twice with alcohol; petroleum ester was used to wash material obtained thrice. The resulted residue was put in a dirt free dry crucible and dried in oven to a constant weight. The dried crucible was removed, allowed to cool and weighed. The difference of weight was recorded as crucible fibre and expressed in percentage of the original weight.

$$\% \text{ Crude Fibre} = \frac{\text{Weight of Fibre}}{\text{Weight of Sample}} X\ 100$$

2.2.3. Determination of Crude fat: The total fat content was analyzed by method described **by** (AOAC, 1984). 2 grams of the processed kernel was loosely wrapped with filter paper and put into the thimble fixed to a neat round bottom flask containing 120 ml of petroleum ether, which has been washed, dried and weighed. The sample was heated and allowed to reflux for 5 hours. The heating was then suspended and the thimbles with the samples kept and weighed. The difference resulted in weight was received as mass of fat and is expressed in percentage of the sample. The percentage fat content was calculated thus

$$\% \text{Crude fat} = \frac{W_E - W_e}{W_z} \text{ x } 100$$

Where:
WE = Weight of the flask and oil extracted
We = Weight of the empty extraction flask
WZ = Weight of the sample

2.2.4. Determination of Crude Proteins: Protein content in seed was determined by the method as described by(AOAC, 1984). 2 grams of the kernel flour was mixed with 10 ml of concentrated H_2SO_4 in a heating tube. 1 tablet of catalyst (selenium) was added to the tube and the mixture was heated inside a fume cupboard. The solution was transferred into a volumetric flask (100ml) and made up with distilled water. 10ml portion of the solution was mixed with equal volume of 45 % NaOH solution and transferred into a kjeldahl distillation apparatus. The mixture was distilled and the concentrates collected into 4 % boric acid solution containing 3 drops of indicator zuazaga. A total of 50 ml concentrates were collected and titrate. The nitrogen content was calculated and multiplied with 6.25 to get the crude protein.

$$\% \text{ Crude nitrogen} = \frac{100 \text{ x } N \text{ x } (14\text{-}V_f)}{100 \text{ x } V_a} \text{ x } T$$

Where:
N = Normality of the titrate (0.1 N)
V_f = Total volume of the digest = 100 ml
T = Titre value
V_a = Aliquot volume distilled.

2.2.5. Determination of Carbohydrate. Carbohydrate content was analyzed by differential method as described by(AOAC, 1984). Carbohydrate was calculated as weight by difference between 100 and the summation of other proximate parameters as Nitrogen Free Extract (NFE).
100 – (%Protein + %Moisture + %Ash + %Fat + %Fibre).

2.2.6. Determination of Ash content: Ash content was estimated by the method as described by (AOAC, 1984). Two grams of each of the processed mango kernel flour were weighed into crucible, heated for 3 hrs at 100˚C in a moisture extraction oven before being transferred into a muffle furnace till it was free of carbon and turned white. The sample was thendetached from the muffle furnace, allowed to cool in desiccators to a room temperature and reweighed. The weight of the residue obtained was calculated as ash content given in percentage.

$$\%\,\text{Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \text{ x } 100$$

2.3. Extraction of Oil from Mango Seed

Oil extraction was carried out using Soxhlet extraction method: A 500-ml round bottom boiling flask was dried in an oven at 105-110°C for about 15 minutes, transferred into a desiccator and allowed to cool. The flask was filled with n-hexane solvent. Forty (40g) grams of the sample were inserted into the thimble of the Soxhlet apparatus, with cotton wool underneath to serve as filter. The apparatus was assembled on the boiling flask of the Soxhlet apparatus and allowed to stand on electric hot plate at temperature of 60-75°C, and then allowed to reflux about 4 times for five repeated extractions. Extract from the flask was collected and emptied into a rotatory evaporator at temperature of 40-60°C to separate the n-hexane solvent from the extracted oil. The extracted oil was collected and stored in a container for characterization.

2.4. Procedures for oil characterization/ Determination of quality indices

The acid values, iodine value, peroxide value, saponification value, refractive index, specific gravity and viscosity were determined in triplicates, according to AOAC (2012) as summarized below**:**

2.4.1. Determination of Acid Value. Twenty-five (25ml) milliliters of diethyl ether was mixed with 25ml ethanol and 1ml phenolphthalein solution (1%) and carefully neutralized with 0.1M NaOH. Ten (10g) grams of the sample oil was dissolved in the mixed neutral solvent and titrated with aqueous 0.1M NaoH, shaking constantly until a pink colour which persists for 15 seconds was ascertained.

$$\text{Acid Value} = \frac{\text{Titre volume (ml) x } 5.61}{\text{Weight of sample used (g)}}$$

2.4.2. Determination of Iodine Value. A 0.5g portion of mango kernel oil was dispensed into a 250cm^3 glass stoppered flat. Ten (10ml) milliliters of carbon tetrachloride was added to the sample oil and dissolved, followed by 20ml of Wiji's solution; thereafter, the stopper (previously moistened with potassium iodine solution) was inserted and allowed to stand in the dark for 30 minutes. Fifteen (15ml)milliliter of potassium iodide solution (10%) and 100ml of water were added, mixed and titrated with 0.1M thiosulphate solution, using starch as indicator just before the end-point (titration = aml). A blank titration was also carried out at the same time commencing with 10ml of carbon tetrachloride (titration = bml).

$$\text{Iodine Value} = \frac{(\text{b-a}) \text{ x } 1.269}{\text{Weight of sample (g)}}$$

Where b= mL thiosulphate for blank, a= mL thiosulphate for sample.

2.4.3. Determination Peroxide Value. One (1g) gram portion of the sample oil was weighed into a clean dry boiling tube. While still liquid, 1g powdered potassium iodide and 20ml of solvent mixture (2 vol glacial acetic acid + 1 vol chloroform) was added. The tube was placed in boiling water so that the liquid boils vigorously for not more than 30 seconds. The contents were quickly poured into a flask containing 20ml of potassium iodide solution (5%), and the tube was washed out twice with 25ml water and titrated with 0.002M Sodium thiosulphate solution using starch as an indicator. Blank was performed at the same time and the result was calculated as follows:

$$\text{Peroxide value} = \frac{(V_2 - V_1)\text{cm}^3 \text{ x molarity of titrant}}{\text{Weight of oil}} \text{ x } 100 \text{ (meqKOH/g)}$$

Where: V_2= blank titre value, V_1= sample titre value

2.4.4. Determination of Saponification Value. Two (2g) grams of the oil was weighed into a conical flask and 25ml of the alcoholic potassium hydroxide solution was added. A reflux condenser was attached and the flask in boiling water was heated for 1hr, with frequently shaking. One (1ml) milliliter of phenolphthalein (1%) solution was added which serves as indicator, and titrated while hot, the excess alkali was neutralized with 0.5M hydrochloric acid (titration = aml). Blank titration was carried out at the same time (titration = bml).

$$\text{Saponification Value} = \frac{(\text{b-a}) \text{ x } 28.05}{\text{Weight of sample (g)}}$$

Where b=ml of HCl used in blank titration, a =ml of 0.5M HCl solution used for sample titration.

2.4.5. Determination of Viscosity. The test for the viscosity of the oil samples were carried out with the use of viscometer (model 35). The spindle of the viscometer was set with spindle 3 and rpm speed of 65. The spindle of the viscometer was inserted into the oil sample and the viscosity of the sample measured and read from the monitor of viscometer.

2.4.6. Specific Gravity. A 50-ml pyrometer bottle was washed with detergent water, and petroleum ether, dried and weighed. The bottle was filled with water and weighed. After drying, the bottle was then filled with the oil sample, weighed and specific gravity calculated as follow:

$$\text{Specific gravity} = \frac{\text{Weight of sample}}{\text{Weight of Xml of water}}$$

2.4.7. Determination of Refractive index. Abbes Refractometerwas reset with a light compensator (water at 20^{o}C) and the oil sample was smeared on the lower prism of the instrument and close. Light was allowed to pass by means of the angled mirror, making the reflected light to appear in form of a dark background. The telescope tube was adjusted until the black shadow appeared central in the crosswire indicator. Then the refractive index of the sample was the read out and recorded

2.4.8. Determination of **Smoke, flash and Fire points.** Two (2ml) milliliter volume of the oil was dispensed into an evaporating dish. A thermometer was suspended at the center of the dish ensuring that the bulb just dips inside the oil without touching the bottom of the dish. The temperature of the oil was gradually raised using an electric hot plate at temperature of 80^{o}C. The temperature at which the oil sample gave off a thin bluish smoke continuously was noted as the smoke point. Similarly, the temperature at which the oil started flashing (when flame was applied) without supporting combustion was equally noted as the flash point. The temperature at which the oil started supporting combustion was recorded as the fire point.

2.4. Statistical analysis:

The values represented in this work are the means and standard deviations for triplicates. The means were compared using the Origin Software at P>0.05.

3.0. Results and Discussion

Table 1: Proximate composition of different varieties of mango kernel seeds

% Proximate composition	Safeda	Cherry	German	Fazli
Moisture	2.495±0.559^{b}	3.98±0.537^{a}	3.378±0.535^{a}	2.648±0.916^{b}
Fat	8.466±0.659^{b}	10.484±0.685^{a}	9.199±0.281^{b}	6.947±1.339^{c}
Ash	2.19±0.055^{c}	3.688±0.973^{b}	1.501±0.0355^{c}	4.786±0.302^{a}
Fibre	3.861±0.652^{a}	2.096±0.419^{c}	3.691±0.553^{ab}	2.884±0.837^{bc}
Protein	1.344±0.345^{a}	1.512±0.3^{a}	1.736±0.33^{a}	1.624±0.526^{a}
Carbohydrate	81.644±0.487^{a}	78.24±0.622^{c}	80.495±0.559^{b}	81.111±0.864^{ab}

Data are presented as mean ± SD. Variables with the same letter indicates that the difference between the mean values is not statistically significant, but variables with different letters are significantly different (P> 0.05).

Table 2: Oil characterization of different varieties of mango kernel seeds

Indices	Safeda	Cherry	German	Fazli
Refractive index	1.405±0.144^{a}	1.402±0.143^{a}	1.403±0.137^{a}	1.441±0.199^{a}
Smoke point (^{o}C)	65±4.243^{bc}	70±5.657^{b}	60±2.828^{c}	80±7.071^{a}
Fire point (^{o}C)	110±7.071^{a}	90±7.071^{b}	80±4.243^{c}	68±4.243^{d}
Flashpoint (^{o}C)	82±2.823^{a}	55±7.071^{c}	60±4.243^{c}	68±5.657^{b}
Ph	6.57±0.042^{c}	7.51±0.014^{a}	6.78±0.028^{b}	6.42±0.044^{d}
Viscosity (Pas^{-1})	495.5±7.778c	603.8±28.143^{b}	723.9±14.284^{a}	452.2±11.597^{d}
Density (g/ml)	0.938±0.0536^{a}	0.856±0.079^{b}	0.912±0.045^{a}	0.918±0.026^{a}
Specific Gravity (g/ml)	0.442±0.059^{a}	0.36±0.057^{b}	0.419±0.044^{a}	0.422±0.045^{a}
Acid Value (mg/KOH/g)	7.8515±0.497^{b}	10.098±0.421^{a}	6.732±0.328^{c}	4.488±0.266^{d}
FFA	3.927±0.321^{b}	5.049±0.211^{a}	3.366±0.235^{c}	2.244±0.204^{d}
Iodin Value (mg/g/g)	40.978±1.478^{a}	29.269±0.769^{d}	31.201±0.701^{c}	38.158±0.658^{b}

Saponification value(mg/KOH)	153.967±5.610[d]	270.731±8.105[a]	179.34±6.138[b]	166.551±6.436[c]
Peroxide Value (g/ml)	16.8±1.131[b]	20.4±0.566[a]	16.6±0.849[b]	19.6±0.849[a]

Data are presented as mean ± SD. Variables with the same letter indicates that the difference between the mean values is not statistically significant, but variables with different letters are significantly different at P> 0.05

The percentage proximate composition of the four varieties of Nigerian mango kernel is shown in Table 1. The percent moisture content varied from 2.495±0.559-3.98±0.537%. The decreasing order of moisture content in the selected varieties was Safeda<Fazli<German<Cherry. This result showed close agreement with the work of Ashoush and Gadallah (2011). They reported 6.57% moisture content in zebda variety obtained during the summer season of 2010 from Al-Qahera Company for Agriculture Industry, Al- Obor, Egypt. The relatively low moisture content of the mango kernel seeds as observed in this study could be of advantage given that increased biodegradation is associated with high moisture content during storages (Akintayo et al., 2002).

Total fat percentage value ranged from 6.947±1.339-10.484±0.685%, in the mango kernels investigated. The lowest fat percentage was reported in Fazli while Cherry had the highest value. Percentage composition of fat ranging from 7.84-14.84% and 6.98-13.0% have been reported in previous studies by Sagaret al. (2022) and Nzikouet al. (2010) respectively, in mango kernels. However, Fowomola (2010) in his study reported a lower percentage fat content of 2.62%. This sharp variation in percentage fat contents could be attributed to the environmental and storage conditions, as well as the extraction methods used. Percent crude fibre and total ash contents ranged between 2.096±0.419-3.861±0.652%and 1.501±0.036-4.786±0.302%, respectively (Table 1). Highest percentage fibre content was seen in Safeda kernel (3.861±0.652%), followed by German (3.691±0.553%), while Cherry kernel had the least (2.096±0.419%).The highest ash value was found in Falzi while the least was seen in German kernel. These results were in agreement with those reported previously by various researchers on mango kernel seeds (Nzikouet al. 2010; Fowomola, 2010; Ashoush and Gadallah2011; Sagaret al., 2022). They reported (2.02% fibre and 3.2% ash), (2.62±0.02% fibre, 2.40 ± 0.01% ash), (0.26% fibre and 1.46% ash), and (1.50- 1.78% fibre and 1-3% ash) crude fibre and ash respectively. Mangifera indica kernels may not be a rich source of crude fibre and thus fell short of the Recommended Daily Allowance for fibre need in adults, children, pregnant and lactating mothers(21 -38%, 19 – 25%, 28% and 29% respectively) (Ishida,2000).

The percent carbohydrate content varied from 78.24±0.622-81.644±0.487% and was highest in the kernel of Safeda variety (81.644±0.487%), followed by Fazli (81.111±0.864), while Cherry variety recorded the least value (78.24±0.622%). Similar results have been

reported. According to Sagar et al. (2022), Safeda kernel had the highest carbohydrate content among the three Indian varieties investigated while Ashoush & Gadallah (2011) observed 75.8% carbohydrate composition in Egypt mango variety studied. Crude protein was between 1.344±0.345-1.736±0.33%, which is extremely low compared to the percentage proteins reported in finger millet (7.16- 10.96 %) and other nuts (Aniket, 2020). The % protein increased in the order of Safeda< Cherry<Falzi<German. Carbohydrate contents of Mangifera indica kernel analysis show that mango seed is a good source of carbohydrate, and with percentage protein of about ten times that of cassava (Fowomola, 2010). All the studied varieties of mango kernel showed significant variations in proximate compositions at P>0.05, except for protein contents.

The physicochemical properties of the extracted oil from mango kernels are in Table 2.The mango kernel oils were flamboyantly light yellow in color. Refractive index of mango kernel oil ranges from 1.402±0.143-1.441±0.199 at 20º C. The result is in accordance with 1.443 and 1.45 °C at 40 ºC and 30°C respectively reported by Fahimdanesha and Bahrami (2013) and Olajumoke (2013), in their respective studies of mango kernel seeds. Refractive index is a clear indication of quality assurance analyzing the stability of oil during thermal action and the level of saturation of the oil. Since Refractive index is also a determining factor of rancidity in oil, low value of Refractive index indicates less possibility of mango kernel oil undergoing such chemical process. Cherry has the least Refractive index value (1.402), while Fazli showed the highest Refractive index value (1.441±0.199) but there was no significance difference at P > 0.05.

The temperature at which the mango kernel oil samples gave off a thin bluish smoke continuously was noted as the smoke point. The smoke point varied from 60±2.828 (° C) to 80±7.071 (° C) and there were significant differences between the kernel varieties investigated. The values obtained were however lesser compared to the report of Gurjar and Raj, (2022).

The temperature at which the kernel oil started supporting combustion was recorded as the fire point. The fire point of mango kernel oil varies widely between 68±4.243°C to 110±7.071°C as shown in Table 2. These values were in agreement with the work of Reddy (2020). The study reported that fire point of mango seed oil after trans-esterification (65°C and 53°C for mango kernel oil and diesel respectively) was comparably higher than the diesel and its physical properties closer to diesel. In this study, oil from Safeda showed the highest fire point value while Fazli showed the least value.

Characterization of the oil on the basis of flash point was carried out and the temperature at which the oil started flashing (when flame was applied) without supporting combustion was noted as the flash point. The flash point of the mango kernel oil from the varieties investigated ranges from 55±7.071°C to 82±2.823°C. Oil from Safeda variety has the highest flash point while oil from Cherry variety showed the least flash

point. This result contradicts the reported flash point of 261.66-351.66^{o}C by Gurjar and Raj, (2022). This discrepancy may be as a result of the extraction method used and or varietal differences. The pH of mango kernel oil as observed in this study ranged from 6.42±0.044-7.51±0.014. Most bacterial growth is best at this pH. The result shows that pH values of the kernel oil were near neutral and varied significantly among the kernel varieties.

The viscosities of mango kernel oil at rotation per minute speed of 65 showed high variation as well as high values ranging from 452.2±11.597 (Pas^{-1})- 723.9±14.284 (Pas^{-1}). Highly viscous oil will not pour or widen out easily as fluid with less viscosity would. Information on viscosity of oil is required in the design of food products since the resistance of food products to flow is critical to processing, pumping, filling and molding of the food products. German variety had the highest viscosity value (723.9±14.284) while Fazli was the least viscous (452.2±11.597).

The density of the kernel oils investigated was between 0.856±0.079 (g/ml) to 0.938±0.0536 (g/ml) at 25 °C. These values were similar to those reported by Diomande et al. (2021). The density of the oils depends on its chemical constituents. There was no significant difference in the densities of the extracted oil among the studied varieties at P>0.05.The low density values recorded for the oils was a characteristic confirmation of the usefulness of Mangifera indica oil for different functional, nutritional and industrial purposes.

Specific gravity of mango kernel oil from the studied varieties ranges from 0.36±0.057-0.442±0.059g/ml). Similarly results were obtained in the studies conducted by Gurjar and Raj, (2022). The acid value was highest in Cherry kernel oil (10.098±0.421mg/KOH/g), followed by Safeda kernel oil (7.8515±0.497 mg/KOH/g) and Fazli kernel oil recorded the least acid value (4.488±0.266mg/KOH/g). This result is similar with 5.35 mg/KOH/g documented by Nzikou et al. (2010). In contrast, a lower value of 8.17 mg/100g (0.0817 mg/g) was reported by Olajumoke (2013). The acidity value is a measure of total acid of the lipid, the totality of all the constituent fatty acids that make up the glyceride molecule (Ekpa and Ekpe, 1995). The acid value range of 4.488±0.266- 10.098±0.421mg/KOH/g as obtained in this study indicates that the oil is edible since it falls within the recommended codex of 0.6 and 10 for virgin and non-virgin edible fats and oil respectively. The moderate acid value means that the oil contains lower fatty acids (Amadi et al., 2027). It also provides an indication of the condition and edibility of the oil (Ajayi and Oderinde, 2002). Similarly, comparing of the fatty acids composition of mango seed kernel oil with that of vegetable oils indicates that the oil is rich in free fatty acid (C18:0) and oleic (C18:1) (Nzikou et al., (2010).).

The value of iodine is used to establish the unsaturated nature of oils and to assess their stability in industrial applications (Xuet al., 2007). The range of iodine value which

is also useful in predicting the drying property of oils was seen to be 29.269±0.769-40.978±1.478mg/g/g. The high iodine values recorded in this research maybe as a result of extraction method used which is in agreement with the work of Kittiphoom and Sutasinee (2013). Their work revealed that oil extracted with ethanol solvent has high iodine value (27.55 mg/KOH/g) while oil extracted with hexane and petroleum ether have iodine values 0.10 mg/KOH/g and 0.15 mg/KOH/g respectively. The difference in iodine values between oil samples from different mango kernel varieties maybe due to the different fatty acid compositions as reported by Kittiphoom and Sutasinee (2013).

The saponification values of Mangifera indica kernel seed oil ranged from 153.967±5.610-270.731±8.105mg/KOH. The order of the saponification values is as follows cherry>german>fazli<safeda. These values are in agreement with 190.2-207.5(mg/KOH/g) recorded by Kittiphoom and Sutasinee (2013) and 207.5(mg/KOH/g) recorded by Nzikou et al. (2010). The observed variations could be attributed to differences in varieties studied by the different authors. Saponification value is a functional tool for the evaluation of the chain length i.e. molecular weight of fatty acids in the triacylglycerols in oil. A lower saponification number indicates a high content of low molecular weight triacylglycerols. The saponification values of kernel oil are sufficient and could be useful for soap production and other industrially purposes if processed.

Peroxide value is one of the most widely used tests for oxidative rancidity and deterioration in oils. It determines the concentration of hydroperoxides and peroxides formed in the primary stages of lipid oxidation. From this study, the peroxide values varied widely with the varieties studied, ranging from 16.6±0.849-20.4±0.566g/ml. German kernel variety had the least peroxide value as against the Cherry variety had the highest value in comparison. The high peroxide value in this study has a relationship with the report of Kittiphoom and Sutasinee (2013). They recorded peroxide values of 26.35 mg/g, 8.72 mg/g oil and 8.82 mg/g oil, for ethanol, hexane and petroleum ether respectively. The peroxide values seem to vary with the solvent of extraction, as could be observed in the results of both studies. Usually, the peroxide value should be less than 10 mg/g oil in the fresh oils. The results suggested that the mango kernel oils could not be stored for a very long period to prevent deterioration.

5.0 Conclusion

The present study on the proximate composition and physicochemical properties of the kernel seeds oil from four Nigerian mango varieties (Safida, Cherry, German and Safeda) conclusively deduce that mango kernels could be used as a potential source for useful food ingredients and could be further processed into therapeutic functional food products. The result of this research also showed significant variations in the proximate compositions of mango kernels except in proteins whose contents in the different

varieties investigated were quite low. Furthermore, mango kernel oil is rich low free fatty acids (FFA) and peroxide value, and may be used without any prior processing, and could be suitable as commercial vegetable oils. Generally, the values of most of the parameters evaluated in the oil complied with the standard specifications, thus suggesting that the oil is of good quality and could also be suitable for industrial usage.

6. References

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Supplementary Tables

Table 3: Multiple Comparisons of the %proximate composition of selected varieties of mango kernels.

LSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ash content	1.00	2.00	-1.49800*	.34982	.003	-2.3047	-.6913
		3.00	.68900	.34982	.084	-.1177	1.4957
		4.00	-2.59600*	.34982	<.001	-3.4027	-1.7893
	2.00	1.00	1.49800*	.34982	.003	.6913	2.3047
		3.00	2.18700*	.34982	<.001	1.3803	2.9937
		4.00	-1.09800*	.34982	.014	-1.9047	-.2913
	3.00	1.00	-.68900	.34982	.084	-1.4957	.1177
		2.00	-2.18700*	.34982	<.001	-2.9937	-1.3803
		4.00	-3.28500*	.34982	<.001	-4.0917	-2.4783
	4.00	1.00	2.59600*	.34982	<.001	1.7893	3.4027
		2.00	1.09800*	.34982	.014	.2913	1.9047
		3.00	3.28500*	.34982	<.001	2.4783	4.0917
Moisture content	1.00	2.00	-1.48500*	.37930	.004	-2.3597	-.6103
		3.00	-.88300*	.37930	.048	-1.7577	-.0083
		4.00	-.15300	.37930	.697	-1.0277	.7217
	2.00	1.00	1.48500*	.37930	.004	.6103	2.3597
		3.00	.60200	.37930	.151	-.2727	1.4767
		4.00	1.33200*	.37930	.008	.4573	2.2067
	3.00	1.00	.88300*	.37930	.048	.0083	1.7577
		2.00	-.60200	.37930	.151	-1.4767	.2727
		4.00	.73000	.37930	.090	-.1447	1.6047
	4.00	1.00	.15300	.37930	.697	-.7217	1.0277
		2.00	-1.33200*	.37930	.008	-2.2067	-.4573
		3.00	-.73000	.37930	.090	-1.6047	.1447
Fat content	1.00	2.00	-2.01800*	.48094	.003	-3.1271	-.9089
		3.00	-.73300	.48094	.166	-1.8421	.3761
		4.00	1.51900*	.48094	.013	.4099	2.6281
	2.00	1.00	2.01800*	.48094	.003	.9089	3.1271
		3.00	1.28500*	.48094	.028	.1759	2.3941
		4.00	3.53700*	.48094	<.001	2.4279	4.6461

	3.00	1.00	.73300	.48094	.166	-.3761	1.8421
		2.00	-1.28500*	.48094	.028	-2.3941	-.1759
		4.00	2.25200*	.48094	.002	1.1429	3.3611
	4.00	1.00	-1.51900*	.48094	.013	-2.6281	-.4099
		2.00	-3.53700*	.48094	<.001	-4.6461	-2.4279
		3.00	-2.25200*	.48094	.002	-3.3611	-1.1429
Fibre content	1.00	2.00	1.76500*	.36594	.001	.9211	2.6089
		3.00	.17000	.36594	.655	-.6739	1.0139
		4.00	.97700*	.36594	.028	.1331	1.8209
	2.00	1.00	-1.76500*	.36594	.001	-2.6089	-.9211
		3.00	-1.59500*	.36594	.002	-2.4389	-.7511
		4.00	-.78800	.36594	.063	-1.6319	.0559
	3.00	1.00	-.17000	.36594	.655	-1.0139	.6739
		2.00	1.59500*	.36594	.002	.7511	2.4389
		4.00	.80700	.36594	.059	-.0369	1.6509
	4.00	1.00	-.97700*	.36594	.028	-1.8209	-.1331
		2.00	.78800	.36594	.063	-.0559	1.6319
		3.00	-.80700	.36594	.059	-1.6509	.0369
Protein content	1.00	2.00	-.16800	.22307	.473	-.6824	.3464
		3.00	-.39200	.22307	.117	-.9064	.1224
		4.00	-.28000	.22307	.245	-.7944	.2344
	2.00	1.00	.16800	.22307	.473	-.3464	.6824
		3.00	-.22400	.22307	.345	-.7384	.2904
		4.00	-.11200	.22307	.629	-.6264	.4024
	3.00	1.00	.39200	.22307	.117	-.1224	.9064
		2.00	.22400	.22307	.345	-.2904	.7384
		4.00	.11200	.22307	.629	-.4024	.6264
	4.00	1.00	.28000	.22307	.245	-.2344	.7944
		2.00	.11200	.22307	.629	-.4024	.6264
		3.00	-.11200	.22307	.629	-.6264	.4024
Carbohydrate content	1.00	2.00	3.40400*	.37445	<.001	2.5405	4.2675
		3.00	1.14900*	.37445	.015	.2855	2.0125
		4.00	.53300	.37445	.192	-.3305	1.3965
	2.00	1.00	-3.40400*	.37445	<.001	-4.2675	-2.5405
		3.00	-2.25500*	.37445	<.001	-3.1185	-1.3915
		4.00	-2.87100*	.37445	<.001	-3.7345	-2.0075

3.00	1.00	-1.14900*	.37445	.015	-2.0125	-.2855
	2.00	2.25500*	.37445	<.001	1.3915	3.1185
	4.00	-.61600	.37445	.139	-1.4795	.2475
4.00	1.00	-.53300	.37445	.192	-1.3965	.3305
	2.00	2.87100*	.37445	<.001	2.0075	3.7345
	3.00	.61600	.37445	.139	-.2475	1.4795

*. The mean difference is significant at the 0.05 level.

Table 4: Mean and Standard deviation of %proximate compositionof the selected mango varieties

	Fazli	Cherry	German	Safeda
Ash content	4.572	3	1.25	1.8
	5	4.376	1.752	2.58
Mean	**4.786**	**3.688**	**1.501**	**2.19**
SD	**0.302642**	**0.972979**	**0.354968**	**0.551543**
Moisture content	2	3.6	3	2.1
	3.296	4.36	3.756	2.89
Mean	**2.648**	**3.98**	**3.378**	**2.495**
SD	**0.91641**	**0.537401**	**0.534573**	**0.558614**
Fat content	6	10	9	8
	7.894	10.968	9.398	8.932
Mean	**6.947**	**10.484**	**9.199**	**8.466**
SD	**1.33926**	**0.684479**	**0.281428**	**0.659024**
Fibre content	2.292	1.8	3.3	3.4
	3.476	2.392	4.082	4.322
Mean	**2.884**	**2.096**	**3.691**	**3.861**
SD	**0.837214**	**0.418607**	**0.552958**	**0.651952**

Protein content	1.252	1.3	1.5	1.1
	1.996	1.724	1.972	1.588
Mean	**1.624**	**1.512**	**1.736**	**1.344**
SD	**0.526087**	**0.299813**	**0.333754**	**0.345068**
Carbohydrate content	80.5	77.8	80.1	81.3
	81.722	78.68	80.89	81.988
Mean	**81.111**	**78.24**	**80.495**	**81.644**
SD	**0.864084**	**0.622254**	**0.558614**	**0.486489**

Table 5: Multiple Comparisons of oil quality indices of selected Nigerian mango (Mangiferaindica) kernels

LSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Refractive index	1.00	2.00	.00200	.09119	.983	-.2083	.2123
		3.00	.00300	.09119	.975	-.2073	.2133
		4.00	-.03600	.09119	.703	-.2463	.1743
	2.00	1.00	-.00200	.09119	.983	-.2123	.2083
		3.00	.00100	.09119	.992	-.2093	.2113
		4.00	-.03800	.09119	.688	-.2483	.1723
	3.00	1.00	-.00300	.09119	.975	-.2133	.2073
		2.00	-.00100	.09119	.992	-.2113	.2093
		4.00	-.03900	.09119	.680	-.2493	.1713
	4.00	1.00	.03600	.09119	.703	-.1743	.2463
		2.00	.03800	.09119	.688	-.1723	.2483
		3.00	.03900	.09119	.680	-.1713	.2493
Smoke point (°C)	1.00	2.00	5.00000	3.00000	.134	-1.9180	11.9180
		3.00	-5.00000	3.00000	.134	-11.9180	1.9180
		4.00	-15.00000*	3.00000	.001	-21.9180	-8.0820
	2.00	1.00	-5.00000	3.00000	.134	-11.9180	1.9180
		3.00	-10.00000*	3.00000	.010	-16.9180	-3.0820
		4.00	-20.00000*	3.00000	<.001	-26.9180	-13.0820
	3.00	1.00	5.00000	3.00000	.134	-1.9180	11.9180
		2.00	10.00000*	3.00000	.010	3.0820	16.9180
		4.00	-10.00000*	3.00000	.010	-16.9180	-3.0820
	4.00	1.00	15.00000*	3.00000	.001	8.0820	21.9180
		2.00	20.00000*	3.00000	<.001	13.0820	26.9180
		3.00	10.00000*	3.00000	.010	3.0820	16.9180
Fire point (°C)	1.00	2.00	30.00000*	3.36650	<.001	22.2368	37.7632
		3.00	20.00000*	3.36650	<.001	12.2368	27.7632
		4.00	42.00000*	3.36650	<.001	34.2368	49.7632
	2.00	1.00	-30.00000*	3.36650	<.001	-37.7632	-22.2368
		3.00	-10.00000*	3.36650	.018	-17.7632	-2.2368
		4.00	12.00000*	3.36650	.007	4.2368	19.7632
	3.00	1.00	-20.00000*	3.36650	<.001	-27.7632	-12.2368

		2.00	10.00000*	3.36650	.018	2.2368	17.7632
		4.00	22.00000*	3.36650	<.001	14.2368	29.7632
	4.00	1.00	-42.00000*	3.36650	<.001	-49.7632	-34.2368
		2.00	-12.00000*	3.36650	.007	-19.7632	-4.2368
		3.00	-22.00000*	3.36650	<.001	-29.7632	-14.2368
Flash point (°C)	1.00	2.00	22.00000*	3.00000	<.001	15.0820	28.9180
		3.00	27.00000*	3.00000	<.001	20.0820	33.9180
		4.00	14.00000*	3.00000	.002	7.0820	20.9180
	2.00	1.00	-22.00000*	3.00000	<.001	-28.9180	-15.0820
		3.00	5.00000	3.00000	.134	-1.9180	11.9180
		4.00	-8.00000*	3.00000	.029	-14.9180	-1.0820
	3.00	1.00	-27.00000*	3.00000	<.001	-33.9180	-20.0820
		2.00	-5.00000	3.00000	.134	-11.9180	1.9180
		4.00	-13.00000*	3.00000	.003	-19.9180	-6.0820
	4.00	1.00	-14.00000*	3.00000	.002	-20.9180	-7.0820
		2.00	8.00000*	3.00000	.029	1.0820	14.9180
		3.00	13.00000*	3.00000	.003	6.0820	19.9180
Ph	1.00	2.00	-.21000*	.01958	<.001	-.2551	-.1649
		3.00	-.94000*	.01958	<.001	-.9851	-.8949
		4.00	.15000*	.01958	<.001	.1049	.1951
	2.00	1.00	.21000*	.01958	<.001	.1649	.2551
		3.00	-.73000*	.01958	<.001	-.7751	-.6849
		4.00	.36000*	.01958	<.001	.3149	.4051
	3.00	1.00	.94000*	.01958	<.001	.8949	.9851
		2.00	.73000*	.01958	<.001	.6849	.7751
		4.00	1.09000*	.01958	<.001	1.0449	1.1351
	4.00	1.00	-.15000*	.01958	<.001	-.1951	-.1049
		2.00	-.36000*	.01958	<.001	-.4051	-.3149
		3.00	-1.09000*	.01958	<.001	-1.1351	-1.0449
Viscosity (Pas-1)	1.00	2.00	-228.40000*	9.96251	<.001	-251.3736	-205.4264
		3.00	-108.30000*	9.96251	<.001	-131.2736	-85.3264
		4.00	43.30000*	9.96251	.002	20.3264	66.2736
	2.00	1.00	228.40000*	9.96251	<.001	205.4264	251.3736
		3.00	120.10000*	9.96251	<.001	97.1264	143.0736
		4.00	271.70000*	9.96251	<.001	248.7264	294.6736
	3.00	1.00	108.30000*	9.96251	<.001	85.3264	131.2736

		2.00	-120.10000*	9.96251	<.001	-143.0736	-97.1264
		4.00	151.60000*	9.96251	<.001	128.6264	174.5736
	4.00	1.00	-43.30000*	9.96251	.002	-66.2736	-20.3264
		2.00	-271.70000*	9.96251	<.001	-294.6736	-248.7264
		3.00	-151.60000*	9.96251	<.001	-174.5736	-128.6264
Density	1.00	2.00	.08200*	.03143	.031	.0095	.1545
		3.00	.02600	.03143	.432	-.0465	.0985
		4.00	.02000	.03143	.542	-.0525	.0925
	2.00	1.00	-.08200*	.03143	.031	-.1545	-.0095
		3.00	-.05600	.03143	.113	-.1285	.0165
		4.00	-.06200	.03143	.084	-.1345	.0105
	3.00	1.00	-.02600	.03143	.432	-.0985	.0465
		2.00	.05600	.03143	.113	-.0165	.1285
		4.00	-.00600	.03143	.853	-.0785	.0665
	4.00	1.00	-.02000	.03143	.542	-.0925	.0525
		2.00	.06200	.03143	.084	-.0105	.1345
		3.00	.00600	.03143	.853	-.0665	.0785
Specific Gravity	1.00	2.00	.08200*	.02986	.025	.0131	.1509
		3.00	.02300	.02986	.463	-.0459	.0919
		4.00	.02000	.02986	.522	-.0489	.0889
	2.00	1.00	-.08200*	.02986	.025	-.1509	-.0131
		3.00	-.05900	.02986	.084	-.1279	.0099
		4.00	-.06200	.02986	.072	-.1309	.0069
	3.00	1.00	-.02300	.02986	.463	-.0919	.0459
		2.00	.05900	.02986	.084	-.0099	.1279
		4.00	-.00300	.02986	.922	-.0719	.0659
	4.00	1.00	-.02000	.02986	.522	-.0889	.0489
		2.00	.06200	.02986	.072	-.0069	.1309
		3.00	.00300	.02986	.922	-.0659	.0719
Acid Value	1.00	2.00	-2.24650*	.22417	<.001	-2.7634	-1.7296
		3.00	1.11950*	.22417	.001	.6026	1.6364
		4.00	3.36350*	.22417	<.001	2.8466	3.8804
	2.00	1.00	2.24650*	.22417	<.001	1.7296	2.7634
		3.00	3.36600*	.22417	<.001	2.8491	3.8829
		4.00	5.61000*	.22417	<.001	5.0931	6.1269
	3.00	1.00	-1.11950*	.22417	.001	-1.6364	-.6026

		2.00	-3.36600*	.22417	<.001	-3.8829	-2.8491
		4.00	2.24400*	.22417	<.001	1.7271	2.7609
	4.00	1.00	-3.36350*	.22417	<.001	-3.8804	-2.8466
		2.00	-5.61000*	.22417	<.001	-6.1269	-5.0931
		3.00	-2.24400*	.22417	<.001	-2.7609	-1.7271
Iodin Value	1.00	2.00	-1.12200*	.14261	<.001	-1.4509	-.7931
		3.00	.56100*	.14261	.004	.2321	.8899
		4.00	1.68300*	.14261	<.001	1.3541	2.0119
	2.00	1.00	1.12200*	.14261	<.001	.7931	1.4509
		3.00	1.68300*	.14261	<.001	1.3541	2.0119
		4.00	2.80500*	.14261	<.001	2.4761	3.1339
	3.00	1.00	-.56100*	.14261	.004	-.8899	-.2321
		2.00	-1.68300*	.14261	<.001	-2.0119	-1.3541
		4.00	1.12200*	.14261	<.001	.7931	1.4509
	4.00	1.00	-1.68300*	.14261	<.001	-2.0119	-1.3541
		2.00	-2.80500*	.14261	<.001	-3.1339	-2.4761
		3.00	-1.12200*	.14261	<.001	-1.4509	-.7931
FFA	1.00	2.00	11.70900*	.78530	<.001	9.8981	13.5199
		3.00	9.77700*	.78530	<.001	7.9661	11.5879
		4.00	2.82000*	.78530	.007	1.0091	4.6309
	2.00	1.00	-11.70900*	.78530	<.001	-13.5199	-9.8981
		3.00	-1.93200*	.78530	.039	-3.7429	-.1211
		4.00	-8.88900*	.78530	<.001	-10.6999	-7.0781
	3.00	1.00	-9.77700*	.78530	<.001	-11.5879	-7.9661
		2.00	1.93200*	.78530	.039	.1211	3.7429
		4.00	-6.95700*	.78530	<.001	-8.7679	-5.1461
	4.00	1.00	-2.82000*	.78530	.007	-4.6309	-1.0091
		2.00	8.88900*	.78530	<.001	7.0781	10.6999
		3.00	6.95700*	.78530	<.001	5.1461	8.7679
Saponification value	1.00	2.00	-116.76400*	3.83251	<.001	-125.6018	-107.9262
		3.00	-25.37300*	3.83251	<.001	-34.2108	-16.5352
		4.00	-12.58400*	3.83251	.011	-21.4218	-3.7462
	2.00	1.00	116.76400*	3.83251	<.001	107.9262	125.6018
		3.00	91.39100*	3.83251	<.001	82.5532	100.2288
		4.00	104.18000*	3.83251	<.001	95.3422	113.0178
	3.00	1.00	25.37300*	3.83251	<.001	16.5352	34.2108

		2.00	-91.39100*	3.83251	<.001	-100.2288	-82.5532
		4.00	12.78900*	3.83251	.010	3.9512	21.6268
	4.00	1.00	12.58400*	3.83251	.011	3.7462	21.4218
		2.00	-104.18000*	3.83251	<.001	-113.0178	-95.3422
		3.00	-12.78900*	3.83251	.010	-21.6268	-3.9512
Peroxide Value	1.00	2.00	-3.60000*	.50332	<.001	-4.7607	-2.4393
		3.00	.20000	.50332	.701	-.9607	1.3607
		4.00	-2.80000*	.50332	<.001	-3.9607	-1.6393
	2.00	1.00	3.60000*	.50332	<.001	2.4393	4.7607
		3.00	3.80000*	.50332	<.001	2.6393	4.9607
		4.00	.80000	.50332	.151	-.3607	1.9607
	3.00	1.00	-.20000	.50332	.701	-1.3607	.9607
		2.00	-3.80000*	.50332	<.001	-4.9607	-2.6393
		4.00	-3.00000*	.50332	<.001	-4.1607	-1.8393
	4.00	1.00	2.80000*	.50332	<.001	1.6393	3.9607
		2.00	-.80000	.50332	.151	-1.9607	.3607
		3.00	3.00000*	.50332	<.001	1.8393	4.1607

*. The mean difference is significant at the 0.05 level.

Table 6: Mean and Standard deviation of oil quality indices of selected Nigerian mango (Mangiferaindica) kernels

Sample	**Safeda**	**German**	**Cherry**	**Fazli**
Refractive index	1.303	1.306	1.301	1.3
	1.507	1.5	1.503	1.582
Mean	**1.405**	**1.403**	**1.402**	**1.441**
SD	**0.14425**	**0.137179**	**0.142836**	**0.199404**
Smoke point (°C)	68	58	74	75
	62	62	66	85
Mean	**65**	**60**	**70**	**80**
SD	**4.242641**	**2.828427**	**5.656854**	**7.071068**
Fire point (°C)	115	83	95	65
	105	77	85	71
	110	**80**	**90**	**68**

Mean	**7.071068**	**4.242641**	**7.071068**	**4.242641**
SD				
Flash point (°C)	84	57	50	64
	80	63	60	72
Mean	**82**	**60**	**55**	**68**
SD	**2.828427**	**4.242641**	**7.071068**	**5.656854**
Ph	6.54	6.76	7.52	6.39
	6.6	6.8	7.5	6.45
Mean	**6.57**	**6.78**	**7.51**	**6.42**
SD	**0.042426**	**0.028284**	**0.014142**	**0.042426**
Viscosity (Pas-1)	490	734	583.9	444
	501	713.8	623.7	460.4
Mean	**495.5**	**723.9**	**603.8**	**452.2**
SD	**7.778175**	**14.28356**	**28.14285**	**11.59655**

0.938g/ml	0.856g/ml	0.912g/ml	0.918g/ml
0.9	0.8	0.88	0.9
0.976	0.912	0.944	0.936
0.938	**0.856**	**0.912**	**0.918**
0.05374	**0.079196**	**0.045255**	**0.025456**
0.442g/ml	0.360g/ml	0.419g/ml	0.422g/ml
0.4	0.32	0.388	0.39
0.484	0.4	0.45	0.454
0.442	**0.36**	**0.419**	**0.422**
0.059397	**0.056569**	**0.043841**	**0.045255**
7.854mg/KoH/g	10.098mg/KoH/g	6.732mg/KoH/g	4.488mg/KoH/g
7.5	9.8	6.5	4.3
8.203	10.396	6.964	4.676
7.8515	**10.098**	**6.732**	**4.488**
0.497096	**0.421436**	**0.328098**	**0.265872**
3.7	4.9	3.2	2.1
4.154	5.198	3.532	2.388
3.927	**5.049**	**3.366**	**2.244**

0.227	**0.149**	**0.166**	**0.144**
40.978mg/g	29.269mg/g	31.201mg/g	38.158mg/g
39.5	28.5	30.5	37.5
42.456	30.038	31.902	38.816
40.978	29.269	31.201	38.158
40.978	**29.269**	**31.201**	**38.158**
1.478	**0.769**	**0.701**	**0.658**
153.967 Mg/KOH	270.731 Mg/KOH	179.340Mg/KOH	166.551 Mg/KOH
150	265	175	162
157.934	276.462	183.68	171.102
153.967	**270.731**	**179.34**	**166.551**
5.610185	**8.104858**	**6.137687**	**6.436086**
16.80 mleq/kg	20.40mleq/kg	16.60mleq/kg	19.60mleq/kg
16	20	16	19
17.6	20.8	17.2	20.2
16.8	**20.4**	**16.6**	**19.6**
1.131371	**0.565685**	**0.848528**	**0.848528**