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Article

Influence of Processing on Some Quality Identities of Crude Sesame (*Sesamum indicum*) Seed Oil

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Abstract: Sesame seeds were dried and ground, and its oil was solvent extracted using n-hexane. The crude oil obtained was subjected to degumming, neutralization and bleaching to obtained degummed, neutralized and bleached oils. These oil samples were analyzed for physicochemical properties and fatty acid composition using gas chromatography to establish the effect of each processing stage on the oil. The oil content of sesame seed was 47.80±0.10%. Processing of the oil did not show any significant difference in specific gravity, refractive index and moisture content but reflected slight increase in iodine value (111.90± 0.17 - 117.50±0.21 g/100g), smoke point (206.00±2.10 - 210.00±1.10^{0}C), flash point (312.00±1.50 - 326.00±1.30^{0}C) and fire point (335.00±0.88 - 342.00±1.10^{0}C). The processing improved the quality of the oil by showing gradual decrease in turbidity point (8.00±0.25 - 5.00±0.45JTU), peroxide value (3.45±0.81 -0.86± 0.01 meq peroxide/Kg), saponification value (191.20±0.43 - 187.90± 0.23 mg KOH/g oil), colour (12.0 – 4.0 units), free fatty acid (1.92±0.01 - 0.82±0.12 % Linoleic acid) and acid value (3.84±0.24 - 1.64± 0.23 mg KOH/g oil). The oil was found to contain palmitate, stearate, arachidate, oleate, linoleate and very minute linolenate in bleached oil. The percentage of these fatty acid increased during processing. There was gradual increase in saturated, monounsaturated, polyunsaturated and total fatty acid as the crude oil was processed to bleached oil. The oil was very rich in linoleic acid (44.79- 47.65%) and oleic acid (31.68-36.90%) while its palmitic and stearic acid content were 8.81-9.17% and 3.47- 4.86% respectively. Processing

of the oil enhances its identity and quality characteristics thereby making the oil consumable rather than for industrial applications.

Keywords: sesame oil, degumming, neutralization, bleaching, physicochemical properties, fatty acid composition

1. Introduction

Seeds have nutritive and calorific values, which make them necessary in diets. They are also good source of edible oils and fat (Odoemelan, 2005). Various vegetable oils are usually obtained from various sources; which include soybean oil, cotton seed oil, peanuts oil, sunflower oil, palm oil, palm kernel oil, coconut oil, castor oil, rice bran oil-, tiger nut oil etc. (Aluyor and Eri-Jesu, 2008).The utilization of oil in various applications is largely determined by the yield, composition, physical and chemical properties of the oil (Aluyor and Eri-Jesu, 2008).

Lipids (fats and oils) are important constituents of foods that not only provide a concentrated source of energy but also affect the texture and flavor of food and therefore its palatability. The principal lipids found in the diet and in the body include the free fatty acids (FFAs); the esters of glycerol and fatty acids (triacylglycerol, diacylglycerol, and monoacylglycerol); the esters of glycerol that, in addition to fatty acids, also contain a phosphate group (glycerophospholipids); the esters that contain a long chain hydroxylic base esterified to a long chain fatty acid and a phosphate group (sphingolipids); the lipids that contain a sugar group (glycolipids); and cholesterol and its esters (Chow, 2008). Nutritionally, lipids (fats and oils) are concentrated sources of energy (9 Cal/gram) and certain lipids such as the fat soluble vitamins, A, D, E, and K, and the essential fatty acids (EFAs) are not synthesized in the body and have to be supplied in the diet. The fat-soluble vitamins are necessary for vision (vitamin A), regulation of calcium metabolism (vitamin D), prevention of autoxidation of unsaturated lipids (vitamin E), and normal clotting of blood (vitamin K). (Chow, 2008; O'Brian, 2004; Gurr, 1984).

Oils and fat occur in oil seeds (18-70%), fruit pulp (30-58%), animal tissues (60-90%) and fish (10-20%) (Gunstone and Norris, 1983). The quality of vegetable oils which is a measure of their identity and edibility is also related to the method of obtaining the oils from the vegetable source (i.e. whether it is virgin oil or cold pressed oil) both obtained without altering the nature of the oil. This may be purified by washing with water, settling, filtering and centrifuging only (Chabiri *et al*., 2009).

Some naturally occurring compounds present in crude fats and oils include gums, phospholipids, pigments, colour bodies, tocopherols and free fatty acids (Chow, 2008; Brekke, 1980; Pryde,1980).Crude oils also contain compounds and contaminants formed or introduced during processing such as soaps, hydroperoxides and their breakdown products, hydrogenation catalysts,

bleaching clay, moisture and trace metals (Lists and Erickson, 1980). Many of these compounds are responsible for the development of undesirable odours, flavours and colours in the oil; therefore most steps of processing are carried out to remove these unwanted contaminants (Chow, 2008).

The most frequently occurring cause of oil quality deterioration during processing and storage is autoxidation (Patterson, 1989). The breakdown product of the autoxidation of unsaturated fatty acid are the major source of off-flavours and odours in the oil (Patterson, 1989). The second most frequently cause of deterioration of fats and oil is hydrolysis, which occurs when a triglyceride reacts with water and the fatty acids are split off from the glyceride backbone (Patterson, 1989). Hydrolysis reduces the final yield of finished product as well as increasing the susceptibility to oxidation (Chow, 2008).

Sesame (*Sesamum indicum*) is one of the Worlds important oil crops Worldwide. It is a member of Pedialaceae family and also an annual shrub with white bell-shaped flowers with a hint of blue, red, or yellow with or without branches (Kandangath, *et al*., 2010; Martin and Leonard, 1967). The plant has an unpleasant odour. The leaves vary from ovate to lanceolate and are hairy on both sides. The flowers are purple to whitish, resembling fox glove, followed by 3cm capsule/fruits containing numerous seeds (Kandangath, *et al*., 2010; McCormick, 2001). Each plant may bear 15-20 fruits, which contain 70-100 seeds. It matures in 80-180 days. The stems are cut and hung upside down for the ripe seeds to fall out to be collected on mats. The plant is propagated by seeds and grow best in tropical climates, sandy, well-drained soil with hot climate and moderate rainfall (Kandangath, *et al*., 2010; McCormick, 2001).There are numerous varieties and ecotypes of sesame adapted to various ecological conditions. However, the cultivation of modern varieties is limited due to insufficient genetic information. Many farmers continue to grow local sesame (Souza and Sorrels, 1991), bean (*Phaseolus vulgaris* L. (Singh *et al*., 1991), cotton (*Gossypium hirsutum* L.) (Brown, 1990), triticale (Nzikou *et al*., 2009; Royo *et al*., 1995). Sesame is commonly known as till (Hindi), huma (Chinese), sesame (French), goma (Japanese), gergelim (Portuguese), and ajonjoli (Spanish) (Shah, 2013).

The seeds were taught to have first originated in India and from India introduced to the Middle East, Africa and Asia. Its primary marketable products are the whole seeds, seed oil and meal. The seeds were one of the first crops processed for oil as well as one of the earliest condiments (de Carvalho *et al*., 2001).The seeds are typically crushed intact for the oil and the meal or flour yielded which is of high protein content can be added to recipes to give a better nutritional balance to health food products (Quasem *et al*., 2009; Prakash, 1985). The whole seeds and toasted seeds are crushed and blend by the Middle East muslims for seasoning flavor and texture (Facciola, 1990). Sesame seeds contain two unique substances, Sesamin and Sesamoli. Both of these substances belong to Lignans and have been shown to possess cholesterol-lowering effect in humans (Ogawa *et al*., 1996; Hirata *et al*., 1995). Sesame oil has been found to inhibit the growth of malignant melanoma in vitro and proliferation of human colon cancer cells (Smith and Salerno, 1992).

Crude edible oils are sometimes being processed to refined oil by subjecting it to degumming, neutralization, bleaching and deodourization in order to enhance its edibility qualities. During degumming, phosphatides which are referred to as gum are being removed. Neutralization process involves the removal of free fatty acids from degummed oil by mixing a calculated volume of a specific concentration of caustic soda (sodium hydroxide) with the oil at a definite temperature ($60 – 80^0$C) and atmospheric pressure (1.01325×10^4 N/M^2), for a definite time and with prescribed agitation conditions. The alkali treatment is designed to remove the undesirable crude oil impurities without saponifying any degummed oil which would increase refining loss (Erickson *et al*., 1980). Edible oils generally contain colour pigments which are predominantly yellow, red and green. The yellow, orange and red pigments are known as "carotenoids". Other colours include chlorophyll, steroid, tocopherols and gozypoll (Bernadini, 1973). Colour pigment must be removed so as to produce oil of brighter colour acceptable to consumers and these pigments are removed from the oil with bleaching earth or fullers' earth (Lucas, 2000; John, 1990) through a process known as bleaching.

This work is aimed at assessing the physicochemical properties and fatty acid composition of crude, degummed, neutralized and bleached *Sesamum indicum* seed oil with a view of establishing the effects of these processes on the parameters.

2. Materials and Methods

2.1. Sample Collection and Preparation

Sesame seeds were bought from a local market in Owo, Ondo State of Nigeria. The seeds were screened and cleaned to remove unwanted materials and bad seeds. The cleaned seeds were milled smoothly into flour. The flour was then stored into tight container prior to oil extraction.

2.2. Chemicals

The chemicals and reagents used are n-hexane, food grade phosphoric acid, caustic soda, bleaching earth, sodium chloride, sodium thiosulphate, potassium hydroxide, phenolphthalein indicator and various standards of fatty acid methyl esters. They all are analytic grade.

2.3. Instruments

The instruments used in this research are:

- Abbey refractometer
- Lovibond tintometer, moisture analyzer,
- GallenKamp Authomatic Pensky-Martens flash point and fire point tester with thermometer, Cleveland open cup apparatus, Palm test turbidity tube,

- HP 6890 gas chromatography fitted with flame ionization detector and powered with HP Chemistation Rev.09.01 [206] software and HP capillary column (HP-INNowax; cross-linked PEG).

2.4. Oil Extraction

The oil content of Sesame seeds were obtained by complete extraction using soxhlet extractor. The 60g of milled seeds sample was put into a porous thimble and placed in a soxhlet extractor using n-hexane as the solvent at 6ºC for 8 hours (Das *et al*., 2002).The oil was obtained after the solvent was removed under reduced temperature and pressure and refluxing at 70ºC to remove the excess solvent from the extracted oil. The oil was termed crude sesame seed oil. The samples were extracted in sets until enough oil required for the analysis was obtained and stored in an air-tight bottle for further analysis.

2.5. Oil Yield Determination (%)

The oil obtained after the extraction was transferred into a measuring cylinder which was placed over water bath for 30 minutes at 70ºC to ensure complete evaporation of solvent and volume of the oil was recorded and expressed as oil content (%).
The oil content was calculated as follows:

$$\%\ Oil\ yield = \frac{Weight\ of\ oil}{Weight\ of\ sample} \times 100$$

2.6. Refining Process

The crude *Sesamum indicum* seeds oil extracted were then subjected to degumming, neutralization and bleaching processes.

2.6.1. Degumming process

400 cm^3 of the crude oil was heated to temperature of 70 ^{0}C followed by addition of 0.80 cm^3 of 50% phosphoric acid and the mixture was then vigorously stirred for 10 minutes. Thereafter 10 cm^3 of water heated to 80ºC was added and whole mixture agitated for another 10 minutes. The agitation was stopped and the mixture was allowed to stand undisturbed for 1 h. The mixture then separated into two layers i.e. oil and gum. The gum was drained off while the oil obtained was termed as **degummed oil** (Salunkhe *et al*., 1992, Carlson, 1991; Erickson *et al*., 1980). The degummed oil was further subjected to alkali neutralization.

2.6.2. Neutralization process

200 cm^3 of the degummed oil sample was heated to temperature of 70^0C with constant stirring in a beaker. 3.3 cm^3 of 3.59 M (20 Baume) sodium hydroxide solution was added to the oil with vigorous stirring and the temperature rose to 90ºC. Thereafter, 10 cm^3 of saturated solution of sodium chloride (an electrolyte) was added and the resulting mixture stirred vigorously at 90ºC for 30 minutes. The mixture was left undisturbed in a separating funnel for 6 h and it later separated into two layers, the lower layers which is known as 'soap stock' was then heated to 90ºC and washed with water heated to 95^0C. The washing was done six consecutive times to remove any excess caustic soda and water soluble gum remaining in the oil (Salunkhe *et al*., 1992; Erickson *et al*., 1980). The resulting neutral oil was then dried in a hot air oven, and later cooled in the desiccators. The dried oil was further bleached.

2.6.3. Bleaching processes

100 cm^3 neutralized oil was heated to 75ºC constant agitation. Then 1.00 g of the bleaching earth was added and the mixture heated to 110ºC with constant stirring for 45 minutes (Salunkhe *et al*., 1992; Erickson *et al*., 1980). The mixture was then filtered and the resulting oil termed **bleached oil**.

2.7. Physicochemical Characterization of the Oil Samples

The crude, degummed, neutralized and bleached oils were analyzed for physicochemical properties. The moisture content and specific gravity were determined according to AOAC, 1999 while the refractive index was measured using Abbey Refractometer coupled with thermometer (ASTM, 1985). The colour was determined using Lovibond Tintometer (Model 520).The colour of crude oil was determined in half ½" inch cell while that of degummed, neutralized and bleached oils were determined in 1" inch cell. The colour was calculated based on the expression (5R+Y) – B, where R stands for red pigment, Y for yellow pigment and B for blue pigment (Abitogun and Oshodi, 2010; Bernadini, 1973). The flash and fire points were measured using GallenKamp Authomatic Pensky-Martens flash point and fire point tester with thermometer while the smoke point was determined using Cleveland Open Cup apparatus (Lawson, 1995; ASTM, 1985). The temperature at which turbidity is first detectable was also measured using Palm Test turbidity tube (ASTM, 1985). The free fatty acid, acid value, saponification value, peroxide value were determined using methods described by AOAC, 1999 while iodine value was determined by method described by Jacobs 1999 and Pearson 1976.

2.8. Fatty Acids Identification

The oil samples were converted to Fatty acid methyl esters (FAMEs) using the method described by Oshodi, 1996 and Hall, 1982. The fatty acid methyl esters were analyzed using an HP 6890 gas chromatography fitted with flame ionization detector and powered with HP chemistation Rev.09.01 [206] software. The career gas was helium at pressure of 19 psi. The FAMEs sample (1.5 µL) was

injected and the separation was carried out on an HP capillary column (HP-INNowax; cross-linked PEG); 30.0 m length, 0.32 mm i.d., and 0.50 µm film thickness. The oven temperature was held initially at 60ºC for 2 minutes, increased from 180ºC at 12ºC/min to 320ºC at 14ºC/min and then maintained at 320ºC for 5.0 minutes. The temperature of the injection port and the detector were set at 250ºC and 300ºC respectively. The peaks were identified by comparison with standard fatty acid methyl esters (ASTM, 1985).

3. Results and Discussion

3.1. Physicochemical Properties of Crude, Degummed, Neutralized and Bleached Oils Obtained from Sesamum indicum Seeds

Table 1 shows physicochemical properties of crude, degummed, neutralized and bleached oils obtained from *Sesamum indicum* seeds. Sesame seeds contained 47.80±0.10% oil and the crude oil was light yellow, characterized with pleasant smell and its colour was found to be 12.0 units in half inch cell using Model 520 Lovibond tintometer. The oil yield is comparable to the value (48.5%) reported for *Sesamum indicum* by Nzikou *et al*., 2009 and 50% reported by Mohammed and Hamza, 2008. The high content of the oil in the seeds (i.e. 47.80±0.10%) classified the seed among oilseeds and the processing of the oil for industrial or edible purpose would be economical. The slight variation in the oil yield may be due to the differences in variety of the plants, cultivation, climate, ripening stage, the harvest time of the seeds and extraction methods used (Nzikou *et al*., 2009; Egbekun and Ehieze, 1997). The oil yield is lesser than 54% reported for *T. occidentalis* seeds (Akwaowa *et al*., 2000). The oil samples may have prolonged shelf-life as no moisture was detected in them. Colour of oil is an important quality which influences consumers' decision on acceptability of oil. The brighter the colour the higher the chance of acceptability by consumers. The colour of crude, degummed, neutralized and bleached oil are 12, 7.0, 6.5 and 4.0 Lovibond unit respectively in one inch cell. This was calculated based on the expression (5R+Y-B) where R is the red pigment, Y is yellow pigment and B is blue pigment. The progressive decreased in colour from crude oil to bleached oil was as a result of phosphoric acid used for degumming and bleaching earth specifically used to remove colour pigments during bleaching (Abitogun and Oshodi, 2010). There was no remarkable difference in the values of both specific gravity (0.92±0.01 - 0.93±0.03) and refractive indices (1.474±0.01 - 1.475±0.02) of crude, degummed, neutralized and bleached oil samples. The specific gravity of the oil samples is very close to 0.915 and 0.939 reported for Beni seed oil and neem seed oil, respectively by Mohammed and Hamza 2008; Akpan, 1999. The refractive indices of sesame oil samples were higher than 1.449 and 1.412 reported for coconut oil and palm kernel oil accordingly (Amira *et al*., 2014).

The smoke point (ºC) for crude, degummed, neutralized and bleached oils were 206.00±2.10, 207.00±1.86, 208.00±1.75 and 210.00±1.10 respectively, while flash point (ºC) for crude, degummed, neutralized and bleached oils were 312.00±1.50, 320.00±2.22, 321.00±2.20 and 326.00±1.30. And the fire points (ºC) for crude, degummed, neutralized and bleached oils were 335.00±0.88, 339.00±1.20, 340.00±1.70 and 342.00±1.10 respectively. It was conspicuously observed that there was slight gradual increase in the smoke, flash and fire points as degumming, neutralization and bleaching treatments were carried out on the crude oil sample. The progressive increase in values of smoke, flash and fire points from crude oil to bleached oil might be as a result of removal of impurities such as volatile organic material and the residual extraction solvent during the oil processing (Nielsen, 2002; Erickson *et al*., 1980). It is noted that oil samples containing low FFA give high smoke, flash and fire points and this quality will enhance the suitability of the oil for deep fry cooking (Akintayo and Bayer, 2002). Thus the high values of smoke, flash and fire points of the oil showed that the oil has a combustion characteristics (Giwa, 2010) and can be used for stir-fry cooking (Bello *et al*., 2011; Sama, 2001).Turbidity is used to described the amount of substances (impurities) present in the oil that make it look cloudy. Turbidity of the oil samples reduces from 8.00 JTU to 5.00 JTU, showing that some of the impurities present in the oil samples which make clarity difficult had been removed during the oil processing.

Table 1. Physicochemical properties of crude, degummed, neutralized and bleached oils obtained from Sesame (*Sesamum indicum*) seeds

Parameters	Crude oil	Degummed oil	Neutralized oil	Bleached oil
Specific gravity (at 25ºC)	0.93±0.02	0.92±0.01	0.92±0.03	0.92±0.01
Refractive index (at 25ºC)	1.474±0.01	1.474±0.01	1.475±0.02	1.474±0.01
Moisture content (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Turbidity point (JTU)	8.00±0.25	5.00±0.35	5.00±0.30	5.00±0.45
Smoke point (ºC)	206.00±2.10	207.00±1.86	208.00±1.75	210.00±1.10
Flash point (ºC)	312.00±1.50	320.00±1.30	321.00±2.20	326.00±1.30
Fire point (ºC)	335.00±0.88	339.00± 1.20	340.00± 1.70	342.00±1.10
Colour (Unit)	12.0	7.0	6.5	4.0
Free Fatty Acid (% Linoleic)	1.92±0.01	1.10±0.13	0.61±0.03	0.82±0.12
Acid value (mg KOH/g)	3.84±0.24	2.20±0.16	1.22±0.14	1.64± 0.23
Iodine value (g/100g)	111.90± 0.17	113.20±0.12	113.80±0.13	117.50±0.21
Peroxide value (meq peroxide/Kg)	3.45±0.81	2.35±0.65	1.06±0.02	0.86± 0.01
Saponification value (mg KOH/g oil)	191.20±0.43	190.55±0.25	189.00±0.34	187.90± 0.23
Yield (%)	47.80±0.10			

Mean ± standard deviation of triplicate determination.

Free fatty acid (FFA) is often used as general indication of the condition and edibility of oils (Jacob, 1999; Pearson, 1981). The values of free fatty acid (FFA) (% Linoleic) and acid value (mg KOH/g oil) of crude oil, degummed oil, neutralized oil and bleached oil are presented thus: (1.92±0.0 and 3.84±0.24); (1.10±0.13 and 2.20±0.16); (0.61±0.03 and 1.22±0.14) and (0.82±0.12 and 1.64±0.23) accordingly. The FFA and acid value decreased from crude oil to neutralized oil but slightly increased as the neutralized oil was converted to bleached oil during bleaching. The decrease in FFA and acid value is owing to the effective use of caustic alkali in neutralization of the oil sample which led to reduction in the free fatty acids, acid values and other impurities while the increase in FFA and acid values of bleached oil is as a result of acidic nature of bleaching earth used for colour removal (Salunkhe *et al*., 1992; Bernadini, 1973) and the acidity is to be reduced in the next processing stage known as deodourization as a result of high temperature and low pressure (vacuum) applied during this stage. The free fatty acid of the oil samples was lower than 2.75% reported for coconut oil (Amira *et al*., 2014). Acid value is an index of FFA content of oils due to enzymatic activity. Acid values of the oil samples were lower than 3.98% reported for crude Sesame oil (Dawodu, 2009) and 4.0% which is the minimum accepted value for vegetable oils as recommended by the CODEX Alimentarius Commission for oil seeds (Abayeh *et al*., 1998).

Iodine value of vegetable oil is the weight of iodine absorbed by 100g of the oil sample. This is related to its saturation, the higher the iodine value, the greater the degree of unsaturation and the greater the liquidity of the oil (Jacobs, 1999). The iodine values (g/100g) of the crude, degummed, neutralized and bleached oils are 111.90±0.17, 113.70±0.12, 113.80±0.13 and 117.50±0.21 respectively. The iodine value of the oil samples classified the oil among the semi drying oil (Fernando and Akujobi, 1987) and the oil may not congeal at room temperature. In addition, the high iodine value of the oils indicates that the oil contains more unsaturated fatty acid than saturated fatty acid (Nielsen, 2002). The iodine values of the samples compare favourably with 111.00 mg iodine/g (Dawodu, 2009); 116mg iodine/g (Mohammed and Hamza 2008); 112 – 117 mg iodine/g (Nzikou *et al*., 20090 reported for sesame oil but lower than 139.78 and 145.87 mg iodine/g reported for degummed and bleached sunflower oil samples by Abitogun and Oshodi (2010). Moreover, the iodine value of the oil increases progressively at each stage of the processing owing to gradual removal of some impurities present. Saponification value is a rough index of the molecular weight of fat and oil. The smaller the saponification value the higher the molecular weight (Amira *et al*., 2014). Saponification value can also be used to check adulteration of fats and oils (Amira *et al*., 2014; Theodore, 1983). The saponification values (mg KOH/g oil) of the crude, degummed, neutralized and bleached oil samples are 191.20±0.43, 190.55±0.25, 189.00±0.34 and 187.90±0.23 respectively. The saponification values are very close to 192 mg KOH/g (Nzikou *et al*., 2009) and 189- 191 mg KOH/g (Mohammed and Hamza, 2008) reported for sesame oil but relatively lower compare to palm kernel oil (280.50mgKOH/g) and Coconut oil (257.50mgKOH/g)

(Amira *et al*., 2014) and this is an indication that the oil will not be good for soap making but more suitable for consumption.

The peroxide values (meq peroxide/Kg) of the crude, degummed, neutralized and bleached oils are 3.45±0.81, 2.35±0.65, 1.06±0.02 and 0.86±0.01 respectively. These values are lower than 8.0 meq peroxide/Kg reported for sesame oil (Mohammed and Hamza, 2008) and 14.3 meq peroxide/Kg for palm oil (Amira *et al*., 2014). High peroxide value is associated with high rancidity rate (Epka and Epka, 1996). Thus the low peroxide values obtained for these oil samples simply imply that the oil samples are less liable to oxidative rancidity and spoilage at room temperature. It has been earlier reported that sesame oil has an excellent shelf-life because sesamolin is converted into sesamol and sesaminol (Shah 2013; Bedigion 2011 and Anonymous 2009), this fact has been recently found to contribute to the oil strong resistance to rancidity. However, the peroxide values are lower than the maximum acceptable value of 10.0 meq KOH/g set by the CODEX Alimentarius Commission for vegetable oils (Abayeh *et al*., 1998; Pearson, 1981).

3.2. Fatty Acid Composition of Crude, Degummed, Neutralized and Bleached Oils Obtained from Sesame (Sesamum indicum) Seeds.

Table 2 depicts fatty acid composition of crude, degummed, neutralized and bleached oils obtained from sesame (*Sesamum indicum*) seeds. The fatty acid detected in sesame oil samples were palmitic, stearic, arachidic, oleic, linoleic and linolenic. The amounts (%) of fatty acids in crude oil are palmitic (8.81), stearic (3.47), oleic (31.68) and linoleic (44.79). The values (%) of these fatty acids in degummed oil sample are palmitic (8.90), stearic (4.10), arachidic (0.03), oleic (32.93) and linoleic (45.40). Furthermore, the amounts (%) of fatty acids found in neutralized oil are palmitic (8.94), stearic (4.35), arachidic (0.04), oleic (33.36) and linoleic (45.82) while the percentage (%) of fatty acid detected in bleached oil are palmitic (9.17), stearic (4.86), arachidic (0.04), oleic (36.90), linoleic (47.64) and linolenic (0.03). Arachidic acid was not detected in crude oil but was found in trace quantity in degummed, neutralized and bleached oil samples. Also, linolenic acid was detected in minute quantity in bleached oil alone while it was absent in crude, degummed and neutralized oil sample. In all the oil samples, linoleic acid has the highest percentage followed by oleic acid while linolenic acid was the least. Therefore, sesame seed oil can be classified in the Oleic-linoleic acid group (Bello *et al*., 2011). Linoleic acid is one of the most important polyunsaturated fatty acids in human because of its prevention of distinct heart vascular diseases (Bello *et al*., 2011; Nzikou *et al.*, 2009). Apart from preventing cardiovascular disorders such as coronary heart diseases and arteriosclerosis; linoleic acid prevents high blood pressure. In addition, linoleic derivatives serve as structural components of the plasma membrane and as precursors of some metabolic regulatory compounds (Bello *et al*., 2011; Matos *et al*., 2009). The results showed that the amount (%) of fatty acid in the oil samples increases progressively as the oil is

processed from one stage to another. This invariably revealed that when impurities are removed from the oil samples, more of the fatty acids are detected. The predominant fatty acid was linoleic acid (44.79 – 47.65%) followed by oleic acid (31.68 – 46.34). The value of linoleic acid (46.34%) reported for sesame seed oil by Nzikou *et al*., 2009 fell within the values obtained in this research. The high proportion of linoleic acid makes the oil possess high nutritional value since linoleic acid is an essential acid with cholesterol-lowering activity (Messink and Katan, 1992).

Table 2.Fatty acid composition of crude, degummed, neutralized and bleached oils obtained from sesame (*Sesamum indicum*) seeds.

Fatty acid methyl ester	Fatty acids (%)	Number of carbon	Crude oil (%)	Degummed oil (%)	Neutralized oil (%)	Bleached oil (%)
Palmitate	Palmitic	16:0	8.81	8.90	8.94	9.17
Stearate	Stearic	18:0	3.47	4.10	4.35	4.86
Arachidate	Arachidic	20:0	ND	0.03	0.04	0.04
Oleate	Oleic	18:1	31.68	32.93	33.36	36.90
Linoleate	Linoleic	18:2	44.79	45.40	45.82	47.65
Linolenate	Linolenic	18:3	ND	ND	ND	0.03

ND: Not Detected

3.3. Total fatty acid composition of crude, degummed, neutralized and bleached oils obtained from sesame (Sesamum indicum) seeds

The summary of the total fatty acid composition of crude, degummed, neutralized and bleached oils obtained from sesame (*Sesamum indicum*) seeds is presented in Table 3.

Table 3. Summary of fatty acid composition of crude, degummed, neutralized and bleached oils obtained from sesame (*Sesamum indicum*) seeds

Oil sample	Saturated fatty acid (%)	Monosaturated fatty acid (%)	Polysaturated fatty acid (%)	Total (%)
Crude	12.28	31.64	44.83	88.75
Degummed	13.08	32.50	45.78	91.36
Neutralized	13.39	32.90	46.22	92.51
Bleached	14.13	36.84	47.68	98.65

The saturated fatty acid (%) in crude, degummed, neutralized and bleached oils are 12.28, 13.08, 13.39 and 14.13 respectively, and the mono-unsaturated fatty acids in crude, degummed, neutralized and bleached oils are 31.64, 32.50, 32.90 and 36.84 respectively; and that of polyunsaturated fatty acids are 44.83, 45.78, 46.22 and 47.68 accordingly. The total fatty acid in crude, degummed, neutralized and bleached oils are 88.75, 91.36, 92.51 and 98.65% respectively. The results show that the amount (%) of

unsaturated fatty acid was much higher (i.e. 76.47 – 84.52%) than that of saturated fatty acids (less than 15%). The high proportion of unsaturated fatty acid in the oil confirm the reasons why sesame seed oil is liquid and may not congeal at room temperature. The level of oil liquidity increases with processing (refining).

4. Conclusions

The results of the assessment of the processed sesame seed oil revealed that, processing of the crude sesame oil to bleached oil improves the qualities of the oil. The values of combustion characteristics (i.e. smoke, flash and fire points), iodine value, saturated, unsaturated and total fatty acid composition of the oil increases while free fatty acid(%), acid value(%), peroxide value, saponification value and turbidity decreased in values. If the oil is completely refined, it will be of high quality in terms of physicochemical properties and edibility; and the oil will supply essential fatty acid needed in the body when consumed. In addition, consumption of this oil will reduce the risk of cardiovascular diseases in human being because of high content of unsaturated fatty acids. The oil can be refined and be more suitable for consumption rather than industrial application e.g. soap making. The processing of the oil is recommended to be extended to deodorization stage and the deodorized oil should be assessed for physicochemical properties and fatty acid composition.

Potential Conflicts of Interest

The authors declare no conflict of interest.

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