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EFFECTS OF METHODS OF PRODUCTION ON SOME QUALITY PARAMETERS OF PALM KERNEL OIL

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ABSTRACT

The effects of methods of production on some quality parameters of palm kernel oil were determined. Two methods of production used are the traditional method and the modern (mechanical) method. The oil obtained from both methods were compared for yields and quality attributes such as moisture content, ash content, lipid content, crude protein, fat, saponification value, free fatty acids (FFA), iodine value, acid value, peroxide value, intrinsic viscosity, melting point and density. The mechanically extracted oil gave a higher yield of 56.4% as against 34.6% yield for the oil extracted by the traditional method. The traditionally extracted oil had higher values of crude protein, acid value, free fatty acids and saponification value which are 12.0%, 32.77mgKOH/g, 5.75% and 285.16mgKOH/g respectively while the values for the mechanically extracted oil are respectively 1.75%, 9.98 mgKOH/g, 3.18% and 219.53 mgKOH/g. The mechanically extracted oil had higher values of moisture content, iodine value, intrinsic viscosity and melting point which are respectively 1.54%, 1.34gI_2/100g, 2.91dm^3/g and 25.67°C respectively while the values for traditionally extracted oil are 0.57%, 1.00gI_2/100g, 2.55dm^3/g and 17.73°C respectively. The higher saponification value recorded for the traditionally-extracted oil suggests that it may be industrially useful in manufacture of soaps, while the mechanically extracted oil will be more useful in the production of margarine due to its higher degree of unsaturation. Free fatty acid value of mechanically-extracted oil sample was 4.07% while 6.04% was obtained for the traditionally-extracted oil sample. The traditionally extracted oil has the tendency to go rancid faster than its mechanically-extracted counterpart due to its higher free fatty acid content. Free Fatty Acid value is an important variable in considering the quality of oil because the lower the free fatty acid, the better the quality of the oil. By inference it therefore implies that the mechanically-extracted oil is of better quality than the traditionally-extracted oil because of its low free fatty acid (4.07%).The traditionally extracted oil will be useful for medicinal purposes (hair and skin treatment) due to its higher acid value (9.98mg/KOHg^{-1}). Acid value is used as an indicator for edibility of oil and suitability for use in the paint industry. There was no significant difference (P>0.05) in the ash and lipid contents of the two oil samples.

Key words: Extraction, Mechanical method, Palm kernel oil, Quality parameter, Traditional method

INTRODUCTION

Oils from plants are classified as vegetable oil. The largest sources of vegetable oils are annual plants which include soyabean, cotton seeds, groundnut, sunflower, rapeseed, melon and sesame seed. Other sources are oil bearing perennial plants such as olive, coconut, cashew and palm fruit (Fellow and Hampton, 2003). Vegetable oil provides much quantity of carbohydrate and it is therefore considered to be a valuable part of a balanced diet. Oil also contains a range of fat soluble vitamins (A, D, E and K) and essential fatty acids, all of which are necessary for healthy functioning of the body. One of the greatest cash crops a nation can have is the palm fruit (*Elaeis guinensis*), provided its importance is realized and potentials fully harnessed. Palm oil is acclaimed to be the richest vegetable oil and is gotten from the palm fruit. *Elaeis guineensis* is a drupe with an outer pulp or mesocarp (rich in palm oil) and embedded hard shell nut containing palm kernel (rich in palm kernel oil). Palm kernel possesses high quantity of edible oil. Three basic types of palm fruits are common and are characterized by the thickness of the mesocarp and the endocarp shell. The *Dura* type possesses thin mesocarp and a thick shell with a large kernel. The *Tenera* type possesses thick mesocarp and a thin shell, with a reasonably sized kernel and the *Pisifera* type is characterized by a thick mesocarp and a thin or no endocarp (shellless). The best type of palm fruit for palm kernel oil is the *Dura* type, due to its nature of thick shell and large kernel (O'Brien, 1998).

Palm kernel oil is yellowish-white in colour. It contains 82% saturated fatty acid and 18% unsaturated fatty acid (O'Brien, 1998). Following the processing of palm fruit for palm oil, the residual palm nuts are dried to considerably low moisture content and cracked before the kernels are removed from the shells. The drying enables the kernels shrink away from the shells to reduce kernel breakage during nut cracking. Oil extraction is the process of recovering oil from oil-bearing agricultural seeds. The traditional method of oil extraction is usually a manual process which is labour intensive. The various stages involved in traditional methods of processing differ somewhat from place to place, thus it will not be feasible to record all minor variations. The different methods of extraction of palm kernel oil using the traditional method are heating, pounding and boiling. The heating method involves roasting the palm kernel nuts till all the oil drips out from the nuts, rendering the nuts almost without oil, the burnt nuts are then removed and the palm kernel oil left in the pot (Ajibola, 1989). The Mechanical extraction processes are suitable for both small and large capacity operations. The three basic steps in these processes are kernel pre-treatment, screw pressing and oil clarification. This method involves the application of pressure to already treated palm kernel seeds. It employs the use of devices like screw and hydraulic presses as means of applying pressure. Whichever method is employed, the yield and quality of the oil depend on the heating time, pressure applied and operating temperature (Fellow and Hampton, 2003). The objectives of this study are to determine the effects of two methods of oil extraction from palm kernel on the physicochemical properties of the oil and to establish the suitability of the oil for margarine and soap making.

MATERIALS AND METHODS

Dura variety of palm kernel nuts was obtained from Nigerian Institute for Oil Palm Research (NIFOR), Iyanomor, Benin. The nuts which were cleaned to remove dirt and other foreign materials were cracked and separated from the shell. After sorting, 1 kg of the nuts was subjected to two methods of oil extraction. The initial moisture content of the oil seeds was determined according to ASAE (1998) method for oil seeds. Oil viscosity was determined by pouring the sample into a viscosity apparatus. Time in seconds required for the flow was recorded and multiplied by the constant 1.073. The specific gravity was taken at 20°C using a relative density bottle.

METHODS OF OIL EXTRACTION

Traditional and mechanical methods were used.

Traditional Method of Oil Extraction

Cracked nuts were sorted, washed and sun-dried and a sample of 100 g was poured into a metallic pot and heated at 250°C. . The sample was continuously stirred until oil began to drip from the nuts. The heating process continued for 90 min until all the oil had been extracted from the nuts. The contents of the pot were poured into a woven basket and the oil separated from the nuts was collected in a basin beneath the basket. In order to separate fine particles from the oil, it was poured through a sieve and allowed to settle.

Mechanical Method of Oil Extraction

A sample of 100g of sorted nuts was milled into a paste using manual blender. The paste was heated for 15 min at 127°C to reduce the viscosity of the oil in order to allow for maximum oil extraction. The heated paste was turned into a sieve and transferred to the hydraulic press where pressure was applied to extract the liquid content (water and oil). The extract was heated continuously for 45 min at 100°C until all the water was evaporated, leaving the oil and sludge in the pot. They were allowed to cool and the oil decanted. After extraction, the oil was quantified gravimetrically. All extractions were performed in triplicates and results expressed as mean ± SD. Specific gravity was determined using specific gravity bottle according to the method described by Pearson (1980). Saponification, iodine and peroxide values were obtained as recommended by AOAC (1984).

Results and Discussion

The Proximate compositions of the mechanically and traditionally-extracted oil are shown in Table 1. Moisture contents are 1.54% and 0.57% for the mechanically and traditionally extracted oils respectively. There is a significant difference between the moisture contents of the two samples. It follows that the moisture content of the mechanically extracted oil is significantly greater than that of the traditionally extracted oil. The lower moisture content of the traditionally extracted oil could be as a result of a higher application of heat to the nuts during extraction. This heat may have helped to eliminate any excess moisture that may be found in the product. The moisture content of any food is an index of its water activity (a_w), as reported by Frazier and Westoff (1978). This implies that the mechanically extracted oil may have a shorter shelf life due to its higher moisture content compared to the traditionally extracted oil.

Table 1: Proximate Composition of the two oil samples.

Parameters	*Mechanically-extracted oil*	*Traditionally-extracted oil*
Moisture content (%)	1.54±0.04	0.57±0.02
Crude protein (%)	1.75±0.03	12.0±0.03
Ash content (%)	1.47±0.06	1.45±0.02
Lipid content (%)	97.6±0.69	97.68±0.06
Fat (%)	22.25±0.64	22.3±0.90

Mean ± standard deviation of three replicates

Table 2: Physical Properties of the two oil samples.

Parameters	*Mechanically-extracted oil*	*Traditionally-extracted oil*
Oil Yield (%)	56.4% ±0.26	34.6% ±0.18
Specific Gravity (g/ml)	0.94±0.23	0.95±0.14
Refractive Index	1.40± 0.16	1.41± 0.06
Colour	Yellowish-white	Black- brown
Viscosity(mm2/sec)	2.91±0.01	2.55±0.01
Density (g/ml)	0.92±0.01	0.91±0.01
Melting Point (0C)	25.67±0.58	17.73±0.46

Mean ± standard deviation of three replicates

The mechanically and traditionally extracted oils have protein contents of 7.5% and 12.0% respectively. Although the crude protein content of the traditionally extracted oil is greater than that of the mechanically extracted, the crude protein value of 7.5% of the mechanically extracted oil agrees with earlier reports of Akpanabiatu *et al.* (2001), 8.1-7.5% range. The low protein in both samples is indicative that the nut is not very suitable for animal feeds or to improve nutritional values.. There was no significant difference in the lipid, ash and fat contents of the two oil samples. The mechanically extracted palm kernel oil has a lipid content of 97.60%, ash content of 1.47% and fat content of 22.25% while the traditionally extracted oil has a lipid content of 97.68%, ash content of 1.45% and fat content of 22.30%. This implies that irrespective of the method employed for extraction, the percent lipid, ash and fat contents of the oil are not affected. The physical properties of both oils are shown on Table 2.The mechanically-extracted oil was yellowish-white in colour while the traditionally-extracted oil was black-brown; this could be due to the fact that the latter was heated until it was burnt. The percentage oil yield was 56.4±0.26% for the mechanically-extracted oil and 34.6±0.18% for the traditionally-extracted oil. This shows a significant difference between the two oils. The two oils did not differ significantly in specific gravity (0.94±0.23 and 0.95±0.14) and refractive index (1.40±

0.16 and 1.41± 0.06) for mechanically-extracted oil and traditionally-extracted oil respectively. The mechanically and traditionally produced oils have intrinsic viscosity of 2.91 dm^3/g and 2.55 dm^3/g; density of 0.92 g/ml and 0.91 g/ml; and melting points of 25.67°C and 17.73°C respectively. In each of these three parameters, there is a significant difference in the values obtained for the two oil samples ($P<0.05$), with the values for the mechanically extracted palm kernel oil being significantly greater than those of the traditionally extracted palm kernel oil. The intrinsic viscosity of the oil is dependent upon the level of saturation or unsaturation as well as the carbon-to-carbon chain length. The higher the level of saturation, the more solid, i.e. viscous, the oil becomes (David, 1984). More so, an increase in chain length leads to an increase in the viscosity value of the oil. Based on the level of saturation, the traditionally-extracted oil should have a viscosity value greater than that of mechanically-extracted oil because it has fewer double bonds, i.e. more saturated. However, the higher application of heat to the traditionally-extracted oil leads to a breakage of the carbon-to-carbon chain resulting to shorter chains. These shorter chains have the ability to flow more easily compared to the longer chains of the mechanically-produced oil. Thus, the mechanically-extracted oil has a viscosity value significantly greater than that of the traditionally-extracted oil. The melting point of the two oils can also be related to the carbon-to-carbon chain length. David (1984) reported that the longer the chain length, the higher the melting point of the oil. Thus, the mechanically extracted oil, because of its longer chain length, has melting point values significantly greater than those of the traditionally extracted oil. The chemical properties of both oil samples are shown in Table 3. The mechanically and traditionally extracted oils have saponification values of 219.53 mgKOH/g and 285.16 mgKOH/g respectively. There is a significant difference ($P<0.05$) in the saponification values of the two samples with the saponification value of the traditionally extracted palm kernel oil being significantly greater than that of the mechanically extracted oil.

Table 3: Chemical Properties of the two oil samples.

Parameters	*Mechanically-extracted oil*	*Traditionally-extracted oil*
Saponification Value (mg/KOH/g)	219.53±3.03	285.16±5.70
Iodine Value (g/100g)	1.34±0.02	1±0.02
Peroxide Value (%)	3.13±0.36	5.01±0.06
Free Fatty Acid (%)	4.07±0.46	6.04±0.69
Acid Value (%)	9.98±0.02	32.77±0.02

Mean ± standard deviation of three replicates

Ihekoronye and Ngoddy (1985) reported that saponification value is a measure of the average molecular weight or chain length of all the fatty acids present in oil. The longer the chain length, the less free fatty acid is liberated and the lower the saponification value. As a result, the traditionally extracted oil has shorter chain lengths resulting in the liberation of more free fatty acid, and hence a higher saponification value. These short chain lengths may be attributed to higher application of heat which breaks down the longer carbon-to-carbon chains resulting in the formation of shorter chain lengths. Since saponification value is the amount of potassium hydroxide required to neutralize the free fatty acids, it implies that more of potassium hydroxide is required to neutralize the free fatty acid present in the traditionally extracted oil. Thus, the traditionally extracted oil is more useful for soap making. The excess alkali present reacts with the liberated fatty acids to form sodium or potassium salt which gives the solution a characteristic soapy appearance (Ihekoronye and Ngoddy, 1985). Saponification value is used in checking adulteration. The higher value recorded for the traditionally-extracted oil suggests that it may be industrially useful. There is no significant difference ($P<0.05$) between the iodine values of the two oil samples, with the mechanically extracted oil having a value of 1.34 $gI_2/100g$ and the traditionally extracted oil having a value of 1.00 $gI_2/100g$. Low iodine value indicated low level of unsaturation in the oil. Iodine value is a measure of the degree of unsaturation, i.e. the number of double bonds in a fatty acid (Ihekoronye and Ngoddy, 1985). This implies that the mechanically extracted palm kernel oil has a higher proportion of unsaturated fatty acids due to its higher number of iodine value (double bonds). The lower proportion of unsaturated fatty acids in the traditionally extracted oil may be due to the higher application of heat which breaks the double bonds found in the free fatty acid resulting to less double bonds. The iodine value is an index for assessing the ability of oil to go rancid. The double bonds are reactive sites, which readily add hydrogen (a process known as hydrogenation) to unsaturated oil resulting in the saturation of some double bonds and the formation of a solid fat. This process is used to produce fats of a desired consistency (Ihekoronye and Ngoddy, 1985). It thus follows that the mechanical palm kernel oil will be more suitable for the hydrogenation process in the production of margarine, used in making various confectionery items like candies, biscuits, meat pie and dough-nut. The mechanically and traditionally extracted oil samples have acid values of 9.98 mgKOH/g and 32.77 mgKOH/g respectively. There is a significant difference ($P<0.05$) in the acid values of the two oil samples. Thus the acid value of the traditionally extracted oil is significantly greater than that of the mechanically extracted oil. The higher acid value of the traditionally extracted oil is as a result of more free fatty acids present in the oil. This is due to a higher application of heat during the extraction process resulting to a more degradation of lipids to yield glycerol and more free fatty acids. The traditionally extracted oil will be more useful for medicinal purposes (hair and skin treatment) due to its higher acid value. Acid value is used as an indicator for edibility of oil and suitability for use in the paint industry. Free fatty acid value of mechanically-extracted oil sample was 4.07% and 6.04% for the traditionally-extracted oil sample. O'Brien (1998) implicated free fatty acid as a catalyst in vegetable oil oxidation which leads to rancidity. Thus, the traditionally extracted oil, due to its higher free fatty acid content, will become rancid faster than the mechanically extracted oil. Also, free fatty acid value is an important variable in considering the quality of oil because the lower the free fatty acid, the better the quality of the oil. By inference it therefore implies that the mechanically-extracted oil is of better quality than the traditionally-extracted oil because of its lower free fatty acid (4.07%) and acid value (9.98 $mg/KOHg^{-1}$). Peroxide values obtained for both oil samples were 3.13 mEq/kg (mechanically-extracted oil) and 5.01 mEq/kg (traditionally-extracted oil). This showed a significant difference between the values of the two oil samples. The peroxide value is used as an indicator of deterioration of oils. Fresh oils have values less than 10 mEq/kg

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