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Extraction and characterization of vegetable oils from legume and palmae; using african oil bean (*Pentaclethra macrophylla)* and akwu ojukwu (*Elais guineensis*) respectively

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Abstract

The extraction and characterization of vegetable oils from the seed of *Pentaclethra macrophylla (oil bean)* and *Elaeis guineensis* (akwu Ojukwu) was done. Extraction was carried out by solvent extraction method using petroleum spirit as the solvent for "akwu Ojukwu" fibre and petroleum ether for oil bean kernel. There was a significant increase ($P \leq 0.05$) in the oil yield of "akwu Ojukwu" fibre (48%) when compared to oil bean seed (32%). Some Physico-chemical, vitamin and mineral parameters of both oils were analyzed. Results of the physico-chemical analysis showed no significant difference ($P \leq 0.05$) in the relative density, peroxide value and thiobarbituric acid value of both oils. The melting point and acid value (25^0C and 7.35mg respectively) of "akwu Ojukwu" oil increased significantly ($P \leq 0.05$) when compared with that of oil bean seed oil (22^0C and 3.62mg respectively). On the other hand, the moisture content (0.40%), iodine value (53.25mg) and saponification value (196.38mg) of "akwu Ojukwu" oil decreased significantly to that of oil bean oil (8.80%, 121.80mg and 213.10mg respectively). "Akwu Ojukwu" oil was red while oil bean oil had a light-yellow colour. The vitamin and mineral determination showed that P, Fe and vitamin C content increased significantly ($P \leq 0.05$) in oil bean seed oil. The general result shows that "akwu Ojukwu" oil is a non-drying oil, while oil bean oil is a semi-drying oil. Both oils could be used for edible (when processed), medicinal and industrial purposes.

Keywords

Vegetable oils, Legume, Palmae, Extraction and Characterization

1. Introduction

Man has always used fats: prehistoric populations already burned them to make light (Bronstone, 1976). These natural fats have been and continued to be used all over the world for multiple purposes which includes medicinal, edible or industrial.

Fats and oils obtained from various sources differ from one another in their physical and chemical properties because they contain varying amounts of different mixed esters. Some of these esters are solid, some liquid, some volatile, some saturated and some unsaturated compounds. Each ester influences the physical and chemical properties of an oil or fat in some measure according to the amount of that ester in that fat or oil. These differences are the basis of tests for their identification (Barley and Jacobs, 1944).

Fats and oils have a much higher catabolic value than any other type of food, producing about 4,100 calories of energy per pound doubling that produced by carbohydrates and proteins (Keong, 1981).

Vegetable oils are obtained from seeds, kernels and sometimes fruit (palm, olive and avocado) of plants, which grow in different parts of the world (Udo-Affia, 1979). According to the method of extraction, either crude or refined oil are obtained (Bronstone, 1976).

*Pentaclethra macrophylla (*African oil bean) belongs to the family "*Leguminosae*", one of the largest families of flowering plants. The trees are found growing wild throughout the forest belt of West and Central Africa (Robert et al, 1964) and provide economic products such as food fodder and fuel (Duke, 1981). The seeds of *Pentaclethra macrophylla* are the source of "Owala" butter or oil used in the East Africa for soap, candle, lubricants and medical lotion (Allen and Allen, 1981). Achinewhu (1982) showed that the oil apart from linoleic and oleic acid contains lignoceric and behemic acid which is characteristic of fats from legumes. Hilditch *et al,* 1980 reported that an attempt to use the oil from oil bean in making soap gave insoluble soap probably due to the presence of lignoceric and behemic acids.

Elaeis guineensis (oil palm) is one of the worlds most important sources of edible and soap-making oils. The palm originated in western tropical Africa, where it grows wild in large number (Hodge, 1975). The oil is rich in carotene and can be used in place of cod liver oil for correcting vitamin A deficiency (Jacobsberg, 1983). The chemical content of the oil has been reported by Duke (1981). According to Hartwell (1971), the oil is used as a liniment for indolent tumors and also reported to be anodyne, antidotal, aphrodisiac and diuretic. Palm oil and its products are naturally occurring sources of the antioxidant, vitamin E constituents, tocopherols and tocotrienols.

Much of the information that are available in the literature on the characterization of vegetable oils do not embrace all vegetable oils such as that from *Pentaclethra macrophylla* and where available (as in oil from *Elaeis guineensis*), needs updating. It therefore became necessary to extract the oil from these plants and comparatively characterize the oils in terms of their physical, chemical and some nutritional parameters.

2. Materials and Methods

2.1. Sample Collection and Preparation

The oil bean seeds and palm fruits (akwu Ojukwu) used for this work were obtained from Afor Nnobi and Nkwo Nnewi in Nnewi South and North Local Government Areas respectively, both in Anambra State of Nigeria.

The seed coat of the oil bean seeds were removed by breaking with iron rods and the endoderm of the oil bean seeds ground into fine particles using a manual grinder.

The raw palm fruits (akwu Ojukwu) were thoroughly pounded in a mortar-using pestle to separate the fibers from the kernels. The fibers, which contained the palm oil, were collected for extraction of the oil.

2.2. Extraction of Oil

The oils were extracted by solvent extraction method using petroleum spirit for *Elais guineensis* (akwu Ojukwu) and petroleum ether for *Pentaclethra macrophylla* (oil bean). The oils were separated from the solvent by distillation after which they were collected as the residues.

2.3. Characterization/Analysis of Oil

Physiochemical characteristics of the oils: Moisture, relative density, melting point, refractive index, saponfication value, iodine value, thiobarbituric acid value and peroxide value were determined by AOAC (1990) methods.

Mineral analyses were performed using atomic absorption spectrophotometry (AOAC, 1990)

2.4. Vitamin C Determination

10g of the oil sample was measured into a flask and dissolved with 5ml of HCl. The mixture was titrated with 1, 6 dichloroindophenol solution from a micro burette until the last drop discharges a pink colouration persistent within 30 seconds. Vitamin C was estimated as:

$$\text{Vit. C (mg/100g)} = \frac{\text{Xg x 5ml}}{\text{TV}}$$

Where Xg = weight of oil used

TV = Titre value

2.5. Vitamin A Determination

Some portion of oil sample was diluted directly with isopropanol. The estimation of the diluted oil was measured using UV spectrophotometer at 325nm and the absorbance recorded.

2.6. Vitamin E Determination

Some portion of oil was weighed into a 100ml flask with a reflux condenser. 10ml absolute alcohol and 20ml alcoholic sulphuric acid was added. The condenser and flask was wrapped in aluminum foil and was refluxed for 45mins and then cooled. 50ml water was added and transferred to a separatory funnel with the aid of a further 50ml of water. The unsaponifiable matter was extracted with 5x30ml diethyl ether. The combined ether extract was washed free from acid and was dried over anhydrous sodium sulphate. The extract was evaporated at a low temperature while protecting it from light. The residue was then dissolved immediately in 10ml absolute alcohol. The aliquots of solutions of the sample and standards (0.3-3.0mg Vit. E), was transferred to a 20ml volumetric flask. 5ml absolute alcohol was added, followed by 1 ml conc. nitric acid. The flask was placed in a water bath at 90^0C for exactly 3 minutes from the time the alcohol begins to boil. The content of the flask was cooled rapidly under running water and was adjusted to volume with absolute alcohol. The absorbance was then measured with U.V-visible spectrophotometer at 470nm against a blank containing 5ml

absolute alcohol and 1ml conc. nitric acid treated in a similar manner.

2.7. Data Analysis

Data presented were analyzed by the use of student's t-distribution test of significance as described by Pearson and Hartley (1966) and Steel and Torrie (1980).

3. Result and Discussions

Table 1. *Physiochemical characteristics of oil from raw Elaeis guineensis (Akwu Ojukwu) fiber and raw Pentaclethra macrophylla (oil bean) seed*

Parameter	"Akwu Ojukwu" oil	Oil bean oil
Oil yield(%)	48.00 ± 0.17	32.08 ± 0.88
Moisture content (%)	0.40 ±0.09	8.80 ± 0.29
Relative density	0.89 ± 0.03	0.91 ± 0.04
Melting point (^{0}C)	25.00 ± 1.00	22.00 ±1.02
Colour (Lovibond '1' inch)	27.6R ± 24.0Y (reddish)	3.0R ± 24Y +0.2B (Light yellow)
Peroxide value (Millieq/kg)	2.06 ± 0.04	2.09 ± 0.09
Thiobarbituric acid (mg/kg)	0.02 ± 0.01	0.03 ± 0.01
Acid value (mg)	7.35 ± 0.12	3.62 ± 0.05
Iodine value (mg)	53.25 ± 0.05	121.80 ± 0.03
Saponification value (mg)	196.38 ± 0.14	213.10 ± 0.25

Values are means of 3 determinations ± S.D.

The results are shown in table 1-2. Table 1 showed the physiochemical characteristics of the oils from raw *Elaeis guineensis* (Akwu Ojukwu) fibre and raw *Pentaclethra macrophylla* (oil bean) seed. From the result of the analyses, both the peroxide and thiobarbituric acid values of the extracted oils show that they are fresh oils. This is because, both factors appear to measure deterioration in oil as a result of oxidative rancidity, hence the higher the thiobarbituric acid values of oil, the more rancid the oil. The thiobarbituric acid values of both "akwu Ojukwu" oil (0.02mg/kg) and oil bean seed oil (0.03mg/kg) are very low. On the other hand, peroxide values of fresh oils are known to be well below 10millieq/kg (Onwuka, 2005) and so the peroxide values of 2.06 millieq/kg for "akwu Ojukwu" oil and 2.08 millieq/kg for oil bean oil indicates freshness of the analytical samples.

The moisture content of "akwu Ojukwu" oil was 0.04% which agrees with the work of Umoh (1998) on palm oil, but decreased significantly ($P \leq 0.05$) when compared to that of oil bean oil (8.80%). This significant increase in the moisture content of oil bean oil probably suggest that all the substances expelled at the drying temperature was not water but might include other volatiles such as essential oils and low boiling carboxylic acids.

The relative density of both oil are also in agreement with the result of Umoh (1998) on palm oil, but its significant decrease in oil bean oil (22^0C) compared to "akwu Ojukwu" oil probably indicates its high fluidity. The higher fluidity in oil bean oil suggests the presence of much unsaturation since the level of unsaturation determines the difference in the melting points of fats and oil (Rossel and Hamitton, 1986). This suggestion is further strengthened by the relatively high iodine value of 121.80mg. Oils with iodine values above 140 are considered to be drying while those with iodine values below 125 and 90 are considered to be semi-drying and non-drying respectively (Onwuka, *et al* 1984). Thus, the African oil bean oil can be conveniently considered to be a semi-drying oil while "akwu Ojukwu" oil whose iodine value (53.25mg) agrees with Umoh (1998) on palm oil is a non-drying oil. The iodine value also helps in the estimation of the individual fatty acid content of the oil (Onwuka, 2005). Considering the fact that the presence of one double bond contributes 90 units to the iodine value, it is possible to predict that the main fatty acids present in oil bean oil are oleic and linoleic acids, while the "akwu Ojukwu" oil as a palm oil contains both acids in addition to other fatty acids like palmitic, myristic and stearic acids (Pearson, 1976).

The acid value of "akwu Ojukwu" oil (7.35mg) which is in agreement with that of Umoh (1998) on palm oil could still be seen as high value if freshness of the oil is to be considered. This is probably why the "akwu Ojukwu" oil is used in Igbo (Eastern Nigeria) tradition as a high medicinal oil for curing of convulsion in children, used as worm expeller and for neutralization of poisons. On the other hand, the low acid values of both oils can be used to determine the chain length of the fatty acids in the oils. It is thus the measure of the amount of free fatty acids present in the oil, and since the values are relatively low, it means the oils contain few fatty acids.

The saponification values of "akwu Ojukwu" oil and oil bean oil (196.35mg and 213.10mg respectively) suggests that both oils contain high glyceride values. This value is a measure of the molecular weight of its fatty acids, as oils or fats composed of glycerides containing long chain, high molecular weight fatty acids have low saponification values and vice-versa (Jacobsberg, 1983). The high saponification values and low acid values suggest that both oils are quite suitable for cosmetic production (Eaton, 1989).

Table 2. *Some mineral and vitamin determinations of oil from Elaeis guineensis (akwu Ojukwu) fibre and Pentaclethra macrophylla (oil bean) seed*

Parameter	"Akwu Ojukwu" oil	Oil bean oil
Phosphorus (mg/100g)	10.31 ± 0.03	5.89 ± 0.12
Iron (mg/100g)	4.81 ± 0.01	4.55 ± 0.14
Vitamin A (mg/100g)	23,804.00 ±12.00	24,113.00± 1.01
Vitamin E (µg/100g)	4,038.00 ± 0.99	4,231.00± 0.84
Vitamin C (µg/100g)	12.00 ± 0.08	10.33 ± 0.12

Values are means of 3 determinations ± S.D

Table 2 shows some mineral and vitamin determinations of oil from *Elaeis guineensis* (akwu Ojukwu) Fibre and *Pentaclethra macrophylla* (oil bean) seed. From the vitamin

and minerals determination of both oils, there is a significant increase ($P \leq 0.05$) in the phosphorus, iron and vitamin C content of the "akwu Ojukwu" oil compared to that of oil bean oil. This could be understandable, since "akwu Ojukwu" oil is equally seen as a palm oil which is normally used as edible oil. At the same time, the vitamin E content and β-carotene equivalent of "akwu Ojukwu" oil decreased significantly ($P \leq 0.05$) compared to their values in oil bean oil. Since "akwu Ojukwu" oil is seen as a palm oil, and is already known that the reddish colour of palm oil is as a result of its high content of carotenoid pigments making it a very good source of correction of vitamin A deficiency disease, one now wonders how a light yellow oil could contain more β-carotenes than the reddish oil. Another confusion is that, since palm oil has always been noted to be a good source of tocopherols and tocotrenoids (anti-oxidants), could it be that the African oil bean provides more of these than palm oil? Probably these differences could be attributed to the difference between the usual "palm oil" (*Elaeis guineensis)* and this specie of oil palm in Igbo ethnic nationality of Eastern Nigeria known as "Akwu Ojukwu".

4. Conclusion

The results of this analysis show that "Akwu Ojukwu" oil as a specie of palm oil is good for edible and medicinal purposes more than the African oil bean oil. "Akwu Ojukwu" oil is a non-drying oil while oil bean oil is a semi-drying oil. Both oils could be used for edible, medicinal and industrial purposes.

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