Physico-Chemical Analysis of Eight Samples of Elaeis Oleifera Oil Obtained from Different Nifor Oil Palm Fields

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ABSTRACT
Eight samples of Elaeis oleifera palm oil milled from fresh fruit bunches harvested from different NIFOR oil palm fields were analyzed to determine their physical and chemical properties in comparison to the properties of the normal palm oil Elaeis guineensis mainly milled by the institute. Analyses conducted included palatability test, determination of the free fatty acid values of the samples, determination of their peroxide values and their moisture contents. Results obtained showed evidences of disparity in chemical properties and slight physical differences between the two species of palm. The average free fatty acid value of the samples was 0.76% as against 0.85% of the normal Elaeis guineensis. Also, the average peroxide value of the samples was 3.83% meg/kg as against that of E. guineensis which was 4.26meg/kg while the average % moisture content of the samples was 0.47% and that of E. guineesis 0.51%. The iodine value (wijs) of the samples was 88.50 and that of E. guineensis 60.80. Beta-ketoacyl ACP synthase II enzyme activity were also determined in the sample and was 7.51 as against 2.15 in E. guineensis. The E. oleifera samples also contained higher quantities of unsaturated fatty acids than the E. guineensis oil sample analysed.

Key words: *E. oleifera, E. guineensis, free fatty acids, Peroxide value, Iodine value*

Literature Review

Palm oil (also known as **dendê oil**, from Portuguese) is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms, primarily the African oil palm Elaeis guineensis, and to a lesser extent from the American oil palm Elaeis oleifera and the maripa palm Attalea maripa (Hardon J. et al 1969). Palm oil is naturally reddish in color because of its high carotene content. Red palm oil is rich in carotenes, such as alpha-carotene, beta-carotene and lycopene, which gives it a characteristic dark red color. It is different from palm kernel oil that is derived from the kernel of the same fruit, or coconut oil derived from the kernel of the coconut palm (Cocos nucifera). The differences are in color (raw palm kernel oil lacks carotenoids and is not red), and in saturated fats content as palm mesocarp oil is 49% saturated, while palm kernel oil and coconut oil are 81% and 86% saturated fats, respectively. Along with coconut oil, palm oil is one of the few highly saturated vegetable fats and is semisolid at room temperature. Palm oil is a common cooking ingredient in the tropical belt of Africa, Southeast Asia and parts of Brazil. Its use in the commercial food industry in other parts of the world is widespread because of its lower cost and the high oxidative stability (saturation) of the refined product when used for frying.

Elaeis oleifera oil is oil extracted from palm fruits or fresh fruit bunches obtained from E. oleifera species of palm, an agriculturally developed Tenera hybrid seen mainly in Panamá, Peru,

and Suriname. This tenera hybrid is scattered throughout Central America and Northern South America, from Venezuela to Peru through to the north of Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Honduras and Nicaragua. In Ecuador it is less common in the east lowlands on poorly drained soil and along streams and rivers. Its present distribution may, at least in part, be anthropogenically determined. (Parimoo, Obisesan and Akpan 1985) **Description:** E. 0leifera is unknown as an under-storey palm. Its stem is usually subterranean or prostrate, measuring around 10-20 cm in diameter and erect only for a few meters. Its leaves are about 3-4 m long; with pinnae about 30-90 on each side, regularly inserted in one plane with the central ones extending up to 60 cm long and 4 cm wide. Its inflorescence measures about 50-80 cm long, with about 50 branches that are 10-15 cm long. The flowers are borne singly and partly sunken into pits; the male branching 5-10 mm in diameter, with densely positioned flowers of about 5 mm long at anthesis while the female flowers branches to 15 mm in diameter, with more loosely inserted flowers extending up to 1 cm long. E. Oleifera fruits are usually yellowish, orange to red in colour, are oblong and are about 3 cm long. (Borchsenius, F.1998)/Palmweb.

Compared to its African relative E. guineensis; which today is cultivated in enormous numbers everywhere in the tropics, the American oil palm E. oleifera is outright rare. It is naturally distributed in Central America, from Honduras to Colombia, and in the Amazon region, where its distribution is patchy however and generally connected with human settlements, suggesting that it may have been introduced there. While the African oil palm can be a fairly scruffy looking plant, its American cousin makes a much more elegant appearance, with long, flat, gracefully recurving leaves. Its oil yield is not as high though as that of E. guineensis but it flourishes under the same conditions that E. guineensis does and has a preference for rich, wet soils.(Borchsenius, F. 1998) /Palmweb.

Refining of E. oleifera:

The fruits are first harvested from the palm trees and milled. After milling, various palm oil products are made from the fruits using refining processes. First is fractionation, with crystallization and separation processes to obtain solid (stearin), and liquid (olein) fractions. Then melting and degumming removes impurities. The oil is then filtered and bleached. Physical refining removes smells and coloration to produce "refined, bleached and deodorized palm oil" (RBDPO) and free sheer fatty acids, which are used in manufacturing industries. RBDPO is the basic palm oil product sold on the world's commodity markets. Many companies fractionate it further to produce palm olein for cooking oil, or process it into other products.

Uses of E. Oleifera

Edible Uses: Oil - two types of oil are obtained from the plant. Palm oil is obtained from the fruit whilst palm kernel oil is obtained from the seed. Both have a wide range of uses, including making margarine, ice cream and both serves as cooking oil. These oils contain a high proportion of unsaturated fatty acids and are thus very good for human consumption.

Medicinal Uses: The oil obtained from the pulp is applied externally in the treatment of rheumatism, is used to invigorate hair growth, combat dandruff and also to repel insects. The oil can be applied to the body as an insect repellent. Hairs from the leaf axils are said to be hemostatic and are used to stem bleeding from cut wounds.

Other Uses: Both oils also have a wide range of other uses, including making bathing soaps, washing soaps, detergents, shampoos, cosmetics, hair creams, lubricating oil, additives and fluxes.

Osa Peninsula of Costa Rica. Photo by Dr. Reinaldo Aguilar.

Panamá. Photo-C. florpan, Tramil.net.

Ciudad Neily, Costa Rica. Photos of Elaeis oleifera, at a friend's house and paddocks. Photo by Jose Maria Cornelis

E. Oleifera Palm trees in the Rain forests of South America

Brief History of The Nigerian institute for Oil Palm research (NIFOR):

Prior to the establishment of the Nigerian Institute for Oil Palm Research, some research on the husbandry of the crop had been undertaken by the then Colonial Department of Agriculture in Nigeria. Palm oil was among the first commodities of international trade, after the slave trade, between Nigeria and Europe. The world trade in palm oil at the turn of the 20th century and up to the Second World War, was dominated by countries of British West Africa (largely Nigeria), the Belgian Congo (later Zaire and now the Democratic Republic of Congo), and the Far-East Asia notably the Netherland's East Indies, (Sumatra and Java) now Indonesia. At the beginning of this period, exports from the British West African Countries accounted for about two-third of the world palm oil trade. However, this dwindled to no more than one-third towards the end of this period, as a result of increased production and export from the Netherland's East Indies, which had at the outset adopted plantation development of oil palm on a large scale. This development awakened the colonial government of British West Africa to the need to put in place policies and strategies to improve oil palm production and palm oil output in British West Africa. The outcome of the West African Agricultural conferences held between 1927 and 1930 adduced the decline in palm oil export from Nigeria to poor quality of oil produced, the absence of plantation development on any substantial scale and the use of inefficient methods. Arising from this, it was thought that Nigeria's economy would be negatively affected unless her production methods were improved upon and put on a sound footing through research. At the first West African Agricultural Conference held in 1927, preliminary consideration was given to the measures, which should be taken to enable the West African oil palm meet competition from the Far East and the Belgian Congo. The question was pursued at the second conference of the series held in 1930, when it was recommended that investigations should be undertaken by local Departments of Agriculture with a view to improving the oil palm industry in the various territories. This recommendation was followed up, but only to a limited extent because the financial depression of the nineteen-thirties had intervened and made it difficult to provide sufficient funds for the

prosecution of research on an adequate scale. At the Third West African Agricultural Conference held in 1938 a resolution was tabled to the effect that research on certain crops should be regionalized and the major work on them carried out in the most appropriate territory in the group. In the case of the oil palm this was to be Nigeria. In the meantime, however, proposals had been put up for the establishment in Nigeria of a central research station for the breeding of improved oil palms. These proposals received the attention of the Nigerian and United Kingdom Governments and were on the point of being approved, with the promise of the necessary funds, when the Second World War broke out. While this meant that no major developments could then be contemplated, it was decided to proceed to such extent as might be possible in the circumstances. Thus in 1939, a large area of land was acquired for the central research station and was developed quietly, the emphasis being on the planting of useful palms for future use. After the war, an additional area of land was acquired in Abak in the heart of the main palm belt of the then Eastern Region of Nigeria, for a sub-station. By 1951 the work had expanded to a considerable extent, and about three-quarters of a million pounds had been spent on the development of the Oil Palm Research Station, as it was then called. Throughout this period the station was administered as part of the Agricultural Department of Nigeria, and it received most of its funds from government sources or from the United Kingdom under the Colonial Development and Welfare Act. During the last three years of its existence, the Oil Palm Research Station was financed entirely by the Nigeria Oil Palm Produce Marketing Board, a statutory body which had been set up to control the oil palm industry in Nigeria. The board at the material time had decided, as part of its policy, to support research for the improvement of the industry. By 1950, it was realized that the work of the research station should be placed on a West African basis. Consequently after many discussions with all concerned, it was decided that a semi-autonomous institute be created as other similar organizations which had been set up to conduct research for the benefit of all the British territories in West Africa under the West African Research Organization (WARO). Thus the OPRS was taken over by WARO, by Ordinance No. 20 of 1951. Its scope of activities then extended to the then Gold Coast (now Ghana) and Sierra Leone. Upon independence of the member countries in the late 1950's and early 1960's, and the consequent dissolution of WARO, the Nigerian component was renamed the Nigerian Institute for Oil Palm Research (NIFOR) by the Research Institute's Act No. 33 of 1964. By the same development, the Institute's mandate was expanded to include coconut, date palm, Raphia and other palms of economic importance.

NIFOR has however, since 1992 came under the aegis of the Federal Ministry of Agriculture. The thrust of work at NIFOR today, as in the past, derives from national goals as currently defined by the national policy on agriculture and the needs of farmers. (NIFOR History)

Objective of the Study

Much of the palm oil that is consumed as food is cooking oil and to some degree, are oxidized rather than in the fresh state. This oxidation appears to be responsible for the health risk associated with consuming palm oil. According to studies reported on by the Center of Science in the Public Interest (CSPI), excessive intake of palmitic acid, which makes up 44 percent of palm oil, increases blood cholesterol levels and may contribute to heart disease. The CSPI also reported that the World Health Organization and the US National Heart, Lung and Blood Institute have encouraged consumers to limit the consumption of palmitic acid and foods high in saturated fat. According to the World Health Organization, (WHO Technical report 2003) evidence is convincing that consumption of palmitic acid increases risk of developing cardiovascular diseases, placing it in the same evidence category as trans fatty acid and in response to negative reports on palm oil, many food manufacturers transitioned to using hydrogenated vegetable oils in their products, which have also come under scrutiny for the impact these oils have on health. A 2006 study supported by the National Institutes of Health and the USDA Agricultural Research

Services concluded that palm oil is not a safe substitute for partially hydrogenated fats (trans fat) in the food industry, because palm oil results in adverse changes in the blood concentrations of LDL cholesterol and Apolipoprotein B just as trans-fat does. However, according to two reports published in 2010 by the Journal of the American College of Nutrition, palm oil is again an accepted replacement for hydrogenated vegetable oils and a natural replacement for partially hydrogenated vegetable oils, which are a significant source of trans fats.

The processing of the bunches of E. oleifera; although more difficult than that of E. guineensis species and also of a lesser yield, gives oil of better physical, chemical and clinical properties than those of the conventional E. guineensis fresh fruit bunches. The disparity in their properties is alluded to the higher activity of the enzyme beta-ketoacyl ACP synthase II in E.olefera (Abrizah and Sambanthamurthi 1995) leading to its higher content of unsaturated fatty acids. The clinical importance of this is that consumers of the oil stand a better chance of not suffering from arteriosclerosis, a disease condition of the heart in comparison to steady consumers of the normal palm oil (Guyton and Hall 1999). Also, the oil has rich contents of beta-carotenes, alpha-tocopherols and tecotrienol pigments which are good sources of vitamins A and E (Porim 1999).

The aim of this work was to compare the qualities of oils obtained from E. oleifera palm fruits harvested from oil palm fields of the Nigerian institute for oil palm research Benin, while comparing the results with the biochemical characteristics of E. guineensis oil also harvested from NIFOR palm fields to ensure that the E. oleifera oil produced by institute contained unsaturated fatty acids which confers high cardio-protective qualities to the oil.

Materials and Methods

PHYSICAL ANALYSIS

Palatability tests were conducted to determine the physical properties of Elaeis Oleifera oil and parameters tested for included those for taste, aroma, frying properties and appearance.

Analytical procedure for Taste or Flavour

Carbon-filtered tap water heated to 38 ^{o}**c** was first used to rinse the mouth before tasting. 10ml of the oil was taken into the mouth and thoroughly swished throughout the mouth, then cupped on the tongue while air was drawn over and through it. After tasting, oil was expectorated into paper waste cups and the mouth rinsed again with carbon-filtered water. The oil was checked for the taste properties of sweetness, sourness, tolerability and badness.

Analytical procedure for Aroma or Odor

10ml of oil samples were placed in 50ml glass beakers, each beaker capped with a tight-fitting ground-glass cover. The beakers were heated in a circulating air oven at 50 ^{o}**C** for 10 minutes. Covered beaker was then swirled and lifted ton nose and the covers removed to sniff the volatiles. The beakers were swirled again and again to determine precise odor. Smell characteristics checked for included those for pleasant smells and Rancidity.

Analytical Procedure for Frying Properties

The oil samples were bleached, used to fry food and then kept. The questions answered by those exercises included;

a. Does the oil bleach or change colour fast when heated?
b. After using to fry, say ‘Dodo’, does it congeal?
c. What is the appearance of food fried with the oil, (i) Attractive? (ii) Tolerance? (iii) Dull?

The appearances of the oil samples were also noted.

CHEMICAL ANALYSIS

Chemical analysis on three parameters was carried out on the oil samples and included tests for Free fatty acid values of the oils, Peroxide values and Moisture contents of the samples.

FREE FATTY ACID VALUE:

The acid value of an oil sample is a measure of the quantity of free fatty acids and minerals acids present in the sample. It is defined as the mg of KOH required to neutralize 1g of sample. F.F.A. is defined relative to the fatty acid used for its calculation e.g. for oleic acid, its acid value is Reagents: Ethyl alcohol 95% (v/v), NaoH 0.1N, NaoH 0.5N, Phenolphthalein 1% soln in 95% v/v ethanol, Oil samples.
Procedures: 5g of oil samples were weighed into flasks and 50ml hot neutralized alcohol added to the flasks. The mixtures were then titrated with 0.1N NaoH.

PEROXIDE VALUE:

This titration analysis is a measure of all substances (peroxides & similar oil or fat oxidation products) contained in all oils or fats and that oxidize potassium iodide under certain test conditions. This value helps to determine the degree of rancidity in an oil sample due to oxidation. Reagents: Glacial acetic acid, Chloroform, Sodium thiosulphate 0.002N, KoH 5%, Starch indicator, oil samples.
Procedures: 5g of the oil samples were weighed into flasks and 1g powdered potassium iodide and 20ml solvent added. The mixtures were heated then 20ml of 5% KI solution added. The solutions were then titrated with sodium thiosulphate solution using starch indicator. The experiment was conducted in duplicates and tires volumes were taken and the peroxide values calculated using the formula;
(TS-Tb)N*1000/wt. where Ts=titre of sample= average of 2 titers per sample
Tb=titre of blank=0.5ml
N=Normality of sodium thiosulphate=0.002N
Wt.=weight of sample=5g

MOISTURE CONTENTS:

This analysis determines the moisture of any volatile material or the water content of non –drying oils like palm oils with not more than 1% water and the procedure employed was the Air oven method.
The approximate known concentration of fatty acids in palm oil is (USDA National Nutrition Database):

Fatty acid content of palm oil

Type of fatty acid		pct.
Myristic saturated C14		1.0%
Palmitic saturated C16		43.5%
Stearic saturated C18		4.3%
Oleic monounsaturated C18		36.6%
Linoleic polyunsaturated C18		9.1%
Other/Unknown		5.5%

black: Saturated; *grey*: Monounsaturated; *blue*: Polyunsaturated

RESULTS

Tables 1: Results of Parameters analyzed for the eight E.oleifera samples

Oil samples No	Nifor Field / Date obtained	Free Fatty Acids (% Palmitic)	Average Peroxide titre	Peroxide Value (meg/kg)	Moisture content (%)
Sample 1	Field 2/ 30-09-2000	0.87	8.15	3.26	0.67
" 2	Field 25/ 16-10-2000	0.41	8.45	3.38	1.32
" 3	Field 2/ 18-10-2000	0.61	10.75	4.30	0.83
" 4	Field 21/ 6-10-2000	0.82	8.95	3.58	0.07
" 5	Field 46/ 13-10-2000	1.48	10.35	4.14	0.32
" 6	Field 46/ 26-9-2000	0.46	8.50	3.40	0.35
" 7	Field 21/ 16-10-2000	0.61	10.65	4.26	0.10
" 8	Field 25/ 11-10-2000	0.82	10.85	4.34	0.10

Table 2: Comparison of E.oleifera's chemical properties with those of E.guineenisis. (iheme unpub.& Porim 1999)

Property	E.oleifera	E.guineensis
Moisture content (%)	0.47	0.51
Free fatty acid (%)	0.76	0.85
Peroxide value (meg/kg)	3.83	4.26
Iodine value (wijs)	88.50	60.80
Beta-ketoacyl ACP II activity	7.51	2.15

Fatty acid composition (%)	E. oleifera	E. guineensis
C16:0	17.70	30.80
C18.0	0.82	6.60
C18.1	56.80	49.00
C18.2	22.70	11.70
C18:3	1.10	0.50

DISCUSSIONS

The physical properties of the samples of E.oleifera were found to exhibit better characteristics than those of E.guineensis. The samples had better taste, more pleasant aroma and better frying properties such as short bleaching times, deep-reddish colour and non- congealing of bleached oil after keeping for two months. Also, food fried with both bleached and unbleached samples had attractive colouration and taste. Bleached samples made very beautiful vegetable oil after deodorizing with activated charcoal and flavoured with vanilla; they also exhibited low cholesterol levels as against bleached E.guineensis oil (Journal of Oil Palm Research Porim 1999).

The chemical comparison between both species showed that the test samples had a lower peroxide value than the E. guineensis oil (3.83 to 4.26 meg/kg table 2).This means that the amount of oxidizing substances and fat oxidation products contained in the samples were lesser in E.oleifera than in E.guineesis samples there by confirming the easier rate at which rancidity occurs in E.guineensis oil than in E. oleifera oils. Also, more moisture was seen to be contained in E.guineesis than in E.oleifera (0.51 to 0.47 % table 2). The percentage fatty acid composition of both oils (Abrizah and Sambanthamurthi 1995) shows that there is a higher ratio of unsaturated fatty acids in E. oleifera oils than in E.guineesis oils and this is attributed to the action of beta–ketoacyl synthase II an enzyme which has exclusive responsibility for the conversion of palmitic acid to stearic acid which becomes further desaturated to oleic and linoleic acids in oil palms. The enzyme kas II has higher activities in E. oleifera than in E.guineesis thus conferring on E. oleifera oils a higher degree of unsaturation and fluidity.

The medical implication of these qualities of E. oleifera is that palm oil gotten from these species can serve as a replacement for hydrogenated vegetable oils and also as natural replacement for partially hydrogenated vegetable oils which serve as significant sources of Trans fat (Brown et al 2005). They also have known anti-cholesterolemic properties and tend to reduce blood cholesterol levels in man when compared to palm oil from E. guineensis species (Edem D.O. 2002).

CONCLUSION

From the statistical analysis of the above results (at $P< 0.05$), it could be deduced that the medical and clinical importance of E. oleifera oil is higher than that of E. guineensis and as such more emphasis should be placed on massive cultivation of the E. oleifera palm tree species at the Institute to enhance more production of E. oleifera oil for domestic and industrial uses in Nigeria.

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