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THE YIELD, SENSORY CHARACTERISTICS AND FATTY ACID CONTENT OF OILS EXTRACTED FROM AFRICAN OIL BEAN (*Pentaclethra macrophylla Benth*) SEEDS AT DIFFERENT MATURATION STAGES

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ABSTRACT: The yield, sensory characteristics and fatty acid content of oils extracted from African oil bean seeds at different maturation periods were investigated in this study. The seeds harvested from one-month development, two months' development and exploded seeds were extracted, ground, dried and analyzed for the titratable acidity; and crude oil was extracted from the dried ground seed flour. The oil yield from raw seeds increased with periods of seed development, being 8.86% at one month, 27.8% at two months and 39.2% at full maturity (exploded seed). The one month and two month developed seed yield a brown-coloured oil while the exploded seed oil was yellow in colour; both oils were bland in flavour and the physical state ranged from semi – liquid to liquid at room temperature. The titratable acidity values was higher (0.185% lactic acid) in exploded seed. The fatty acid, 11 – Octadecenoic acid were found at levels ≥ 14% in all the seed oils; 9,12 – Octadecadienoic acid were also ≥ 14% in one month and two months seed oil, while, 9,12 – Octadecadienoic acid were up to 13% in exploded seed oil.
Keywords: African oil bean seed oil, Sensory characteristics, Fatty acid.

INTRODUCTION

African oil bean tree (*Pentaclethra macrophylla Benth*) is planted or retained along the edges of home gardens and farms mainly for its seed from which an edible oil can be extracted (Oboh, 2007). The brownish flattened pod contains about 6 – 10 flat, glossy, brown, edible seeds which explodes at maturity and disperses the seeds. The mature dispersed seeds are harvested by gathering them manually from around the tree. The kernel (a dicotyledon), which is gray in colour, is embedded in a glossy brownish seed coat (Enujiugha, 2003). These seeds are edible when appropriately processed and contain some reasonable amount of oil, hence its inclusion as "oil bean" (Ladipo and Boland, 1995). The seed is a source of edible oil and is used for candle making, cooking and soap (TICO, 2005).

The seeds also contain essential fatty acids within the seed oil, as well as many minerals, particularly magnesium, iron, manganese etc. (Bonnie, 2010). Seed oils in different species vary widely in the proportion of different fatty acids, although 18 – carbon unsaturated fatty acids generally predominate (Srivastara, 2002).

Fatty acids are the building blocks of the fat in our bodies and in the food we eat. During digestion, the body breaks down fats into fatty acids, which can then be absorbed into the blood (Adamu, 2019). They rarely occur as free molecules in nature but are usually found as components of many complex lipid molecules such as fats (energy-storage compounds) and phospholipids (the primary lipid components of cellular membranes). Fatty acids from the diet can influence people's health condition, and they can deteriorate or ameliorate the evolution of some diseases. It is well known that omega-3 fatty acids have a high impact on health and play an important role in cardiovascular disease preservation. Many animals cannot synthesize linoleic acid (an omega-6 fatty acid) and alpha-linoleic acid (an omega – 3 fatty acid), though they are required for cellular processes and the production of other necessary fatty acids, they must be taken in through the diet, and are called essential fatty acids (Bender, 2006).

Fatty acids have a wide range of commercial applications; for example, they are used not only in the production of numerous food products but also in soaps, detergents, and cosmetics. Soaps are the sodium and potassium salts of fatty acids. Some skin care products contain fatty acids which can help maintain healthy skin appearance and function (Encyclopedia Britannica, 2020).
This study tends to investigate the actual yield of oil from African oil bean seeds at different maturity periods and their fatty acid constituents bearing in mind that these oil bean seeds are sometimes harvested prior to seed maturation time and then processed to their various end products.

METHODOLOGY

Raw Material Procurement and Preparations

African oil bean trees at the bank of Njaba River, Njaba Local Government Area, Imo State, were monitored from flowering, through the period of fruiting until fruit maturity. Within these periods, one-month old and two-month old pods were harvested and the seeds obtained by splitting with machetes. Three-month

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old, fully mature (exploded) seeds were manually picked from the surrounding bushes. The raw seeds at different intervals (one month, two months and exploded (three months)) were manually dehulled with knives, and ground separately using Corona™ hand grinder to small particle size, dried and used for analysis and oil extraction. The fatty acids were determined by Gas Chromatography at the National Research Institute of Chemical Technology (NARICT), Zaria, Kaduna State, Nigeria.

Determination of Titratable Acidity

The titratable acidity of the raw oil bean seed at different maturity stages was determined using the method of Nzelu *et al.* (2012). Ten grammes (10 g) of finely ground sample was added to 200 ml of carbon dioxide free water and boiled for 2 min. The solution was filtered, cooled and 100ml of the filtrate titrated with 0.1 N NaOH solution to end point using phenolphthalein as indicator.

Titratable acidity (as lactic acid) was calculated as follows:

$$\%\,Acidity = \frac{(ml\,base)\times(N\,of\,base)\times MeqWtof\,acid}{Weightof\,sample}\times\frac{100}{1} \quad \text{.....(1)}$$

Extraction of Oil

The oil (crude oil) of the African oil bean seed from different maturity stages and exploded seeds were extracted using petroleum ether as described by AOCS (2000). The ground samples were mixed/soaked in petroleum ether in a bowl, covered airtight and stored overnight. Muslin cloth was used in pressing out the oil solution. The oil was separated from the petroleum ether by evaporation. The nature (colour, flavour/aroma, and physical state – liquid or solid) of the extracted oil samples was examined for physical characteristics.

Determination of the Fatty Acid Composition of the Seed Oil

The extracted oil samples above were used in fatty acid determination. The fatty acid composition was determined using – GCMS – QP 2010 PLUS SHIMADU, JAPAN. The procedures were as follows:

i. Esterification with Boron trifluoride

The oil extracted from each sample was homogenized by heating gently in a water bath until clear sediment-free oil was obtained. Oil (about 3 drops) was put in a screw-capped test tube and 1.2 ml of 0.4 N sodium hydroxide in methanol was added to saponify the oil. The test tube with the contents was heated in a water bath at 60°C for 10 min to dissolve all the fat globules. The mixture was then neutralized with 1.2 ml, 0.7 NHCL to release the fatty acids. About 2 - 3 ml of Boron trifluoride (14%) in methanol was added to methylate the fatty acids. Test tube with content was again heated for another 10 min at 60°C. Approximately 3 ml of petroleum ether (B.P 40 - 60°C) was added and the test tube was joggled for about 5 min to effect distinct phase separation. The upper petroleum ether layer was decanted, dried over Sodium sulphate (anhydrous) and concentrated. As a control, 0.2 g of fatty acid standards was methylated instead of the oil sample.

ii. Chromatographic Analysis

Exactly 1µl of methylated samples was injected into the gas-liquid chromatograph using a micro syringe. The fatty acid methyl esters were analyzed by GLC using Q94 gas chromatograph with JCL 6000 for Windows 2.0 Chromatography data system.

Retention times of separated fatty acid methyl esters were compared with standards and a plot of the semi-log of the value of the relative retention against equivalent chain length was done. The identified fatty acids were quantized by obtaining the product of the response factor and the peak areas. The fatty acids were expressed as the percentage of weight of the total fatty acid.

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RESULT AND DISCUSSION

Table 1: The Yield, Physical and Sensory characteristics of the Oils Extracted from African Oil Bean Seeds at different Maturation Stages.

Degree of seed maturation Parameters	1 month	2 months	3* months
Oil Yield (%)	8.86	27.8	39.2
Colour	Brown	Light Brown	Light yellow
Flavour	Bland	Bland	Bland
State (Room temperature)	Semi-liquid	Liquid	Liquid
Titratable acidity (% lactic acid)	0.033	0.144	0.185

Note: 3* Exploded seed pod

Table 2: Fatty Acid Contents of Oils Extracted from African Oil Bean Seeds at different Maturation Periods

Fatty acids (months)/Fatty acids content (%)	Degree of seed maturation 1	2	3*
Methyl tetradecanoate	0.98	NIL	NIL
Hexadecanoic acid	10.80	NIL	NIL
Pentadecanoic acid	NIL	9.69	8.12
n-Hexadecanoic acid	2.94	2.64	3.74
9, 12- Octadecadienoic acid	15.38	14.69	13.41
11 – Octadecenoic acid	15.71	15.59	14.24
Octadecanoic acid	9.95	11.10	9.19
9-Octadecenoic acid	14.50	9.40	12.56
10 – Octadecanoic acid	NIL	3.23	NIL
11 – Octadecanoic acid	NIL	NIL	2.78
11 – Eicosenoic acid	3.14	NIL	NIL
Eicosenoic acid	6.48	8.52	6.94
10 – Undecenal	3.60	NIL	NIL
9 – Tetradecanal	NIL	2.88	NIL
9 – Octadecenal	NIL	NIL	2.62
Docosanoic acid	5.23	7.64	6.14
Heptacosanoic acid	11.06	NIL	NIL
Heneicosanoic acid	1.83	11.16	9.62

Note: * Exploded seed pod

DISCUSSIONS

The Yield, Sensory Characteristics and Titratable Acidity of the Oils Extracted from African Oil Bean Seeds at different Maturation Stages

At one-month developmental stage, the very tender African oil bean seed yielded 8.86 % of its weight as vegetable oil (Table 1). At two months of seed development, its oil yield increased to 27.8 %, while the exploded (mature) seed had 39.2 % oil yield. This result implied that the oil in the African oil seeds increased with increase in maturity period, indicating that the oil was synthesized as the seed matured and the amount of extractable oil depended on the stage of seed maturity when other factors such as the extraction method was controlled.

At one month of seed development, the seed was laden with water (moisture) which decreased as the seed matured to give way for the formation of more nutrients in the seed. The quantity of oil extracted at full maturity (Exploded) was higher (27.6 %) than the oil obtained in raw seed by Akindahunsi (2004), but lower (53.98 %, 43.3 %) than the oil obtained in raw seed (Enujiugha and Akanbi, 2005; Achinewu, 1982). The fat content of oil crop varied widely, it ranged from as low as 10 – 15 % of the weight in coconut to over 50 % of the weight in sesame seeds and palm kernels (FAO, 1994). African oil bean seed is an oil-bearing seed and its high oil content, which is more accessible at maturity, makes it a good source of vegetable oil for nutritional and industrial purposes (Akindahunsi, 2004).

The colour of the extracted oil samples differed with maturity period. When fully matured (exploded), the oil extracted was light yellow in colour which agreed with the yellow colour reported by Akindahunsi (2004). This colour is similar to that of groundnut oil (yellow). At two months and one-month maturity, the colour of the oils extracted were light brown and brown respectively. This agreed with light brown colour reported by Ikhuoria *et al.* (2008). All the oil samples were bland in flavour/aroma. Akindahunsi (2004) indicated that the oil gave no irritating odour; hence the oil could easily be refined. The oil samples were liquid at room temperature. According to Olotu *et al.* (2004), the oil of *Pentaclethra macrophylla* is richer in unsaturated fatty acids. The liquid state of the oil indicated that there was no loss of double bonds, hence the oil contained both saturated and

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unsaturated fatty acids. Okaka (2010) noted that vegetable oils in general are likely to contain more of the unsaturated fatty acids than animal fats.

The titratable acidity of the African oil bean seed pulp increased with increase in maturity. According to Nzelu *et al.* (2012), acidity of food and food product is due to the presence of organic acid(s) in them. The titratable acidity of fruit tissue varies from 0 to 0.3 % in low acid foods like banana to 2.0 % in Logan berries and over 6.0 % in lemons. Hence, the titratable acidity of the oil seed indicated that African oil bean seed was a low acid food, though the level increased with maturity, which agreed with the conclusion of Lazen *et al.* (1989), that titratable acidity increases with fruit ripening and is useful in determining maturity.

The Fatty Acid Contents of Oils Extracted from African Oil Bean Seeds at different Maturation Periods.

A total of eighteen fatty acids were identified in the African oil bean seed oil samples studied (Table 2). The presence and amount of each identified fatty acid depended on the stage of maturity of the extracted seed. The oil from one-month developed seed had six major (> 9.0 %) fatty acids namely, Hexadecanoic (10.80 %), 9, 12 – Octadecadienoic (15.38 %), 11 – Octadecanoic (15.71 %), Octadecanoic (9.95 %), 9-Octadecenoic (14.50 %) and Heptacosanoic (11.06 %) acids. Out of these six, three (9, 12 – Octadecadienoic, 11 - Octadecanoic and 9-Octadecenoic acids) were predominant (≥ 14 %) and persisted through the developmental stages up to maturity of the seed.

Two of the fatty acids (Hexadecanoic and Heptacosanoic acids) were not traceable in the oil from two months of seed development. In the oil from two months developed (premature) seed, the number of major (> 9.0 %) fatty acids remained at six, but some of these six fatty acids are not exactly major fatty acids observed in the oil from one-month developed seed. At this stage, pentadecanoic (9.69 %) and Heneicosanoic (11.16 %) acids replaced Hexadecanoic (Nil) and Heptacosanoic (Nil) acid as the seed major fatty acids. Also, the predominant (≥ 14 %) fatty acids were only two in the two-month old seeds namely; 9, 12 – Octadecadienoic (14.69 %) and 11 – Octadecanoic (15.59 %) acids. Only five of the major (> 9.0 %) fatty acids observed in two months developed African oil bean seed persisted in the oil up to full maturity (exploded seed) of the seed. These

were 9, 12 – Octadecadienoic (13.41 %), 11 – Octadecenoic acid (14.24 %), Octadecanoic acid (9.19 %), 9-Octadecenoic (12.56 %) and Heneicosanoic (9.62 %).

At this stage of maturity (exploded seed), the most predominant (≥ 14 %) fatty acid was 11 – Octadecenoic (14.24 %). It is followed closely by 9, 12 – Octadecadienoic acid which though is not prominent but had 13.41 % of the fatty acids. 11 – Octadecenoic acid (also known as vaccenic acid) is a naturally occurring *trans* fatty acid found in human milk. It has been reported that it lowers total cholesterol, LDL cholesterol and triglyceride (Wikipedia, 2016). Studies have shown that the African oil bean seed oil is the drying type. Drying oils are triglycerides whose fatty acid constituents have mostly unsaturated bonds. Such oils are found in olive oil, linseed oil, etc and they are important because they help in lowering cholesterol and thus contribute to reducing the risk of heart attack (Enujiugha, 2003; Heaton, 1984).

CONCLUSION

The findings of the study revealed that fully mature (exploded) seeds have high oil yield and are also high in acidity level, hence the oil needs to be refined after extraction to avoid spoilage. The fatty acids content of African oil bean seed varied with maturation periods. However, eight (8) identical fatty acids were identified in both two months and exploded seeds oils, albeit in different quantities.

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