Asian J Agri & Biol. 2018;6(3):373-378.

AJAB

Original Research Article

Fatty acids composition profile evaluation of Palm oil in crude oil polluted environment

Emmanuel Ejiofor[1]*, Ebhohon Shirley[2], Adanma Obike[2], Bliss Onyedikachi[2], Atasie Okechukwu[2], Ajah Obinna[2], Kanu Michael[2], Ndukaku Omeh[2]

[1]Department of Biochemistry, Faculty of Science, Clifford University, Owerrinta, Abia State, Nigeria

[2]Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria

Received:
October 23, 2017

Accepted:
April 18, 2018

Published:
September 30, 2018

**Corresponding author email:*
ejioforemmanuelbiz@gmail.com

Abstract

In this study, the fatty acid profile of oils obtained from palm tree grown on polluted soil in Southern Nigeria. Oil extraction was performed using traditional method. Carotenoid content of palm kernel and palm oil in the test oil showed a significant ($p<0.05$) decrease when compared to the controls. Mores so, acid and peroxide value increased ($p<0.05$) significantly in the test oil when compared to the control. The percentage composition of various fatty acids of palm kernel oil from polluted soil were caprilic 2.99%, capric 52.67%, lauric 16.69%, palmitic 8.06% and stearic 19.57%. Fatty acid percentage composition of palm kernel oil from unpolluted soil were caprilic 2.66%, capric 49.18%, lauric 15.17%, palmitic 8.47%, and oleic acid 0.92%. Fatty acid percentage compositions of palm oil from polluted soil were myristic acid 0.28%, palmitoleic 62.09%, oleic acid 37.62%. Unpolluted soil showed lauric acid 0.36%, palmitic acid 44.57% and oleic 55.05%. The absence of palmitic acid and the reduction of oleic acid could be attributed to the impact of the crude oil spillage on the plant. This study shows that crude oil spillage affects composition of fatty acid and oil chemistry, suggesting the use of oil as indicator for environmental pollution.

Keywords: Crude oil spillage, Fatty acid, Palm kernel oil, Palm oil, Pollution, Southern Nigeria

Introduction

Vegetable oils are biological mixture of plant origin consisting of glycerol with chains of different fatty acid. A fatty acid is the basic building block of body fat (Fasina et al., 2006). Biologically, Oils serves as the basic building block of the linings of cells and of the body's hormones. Fasina et al. (2006) indicated that vegetable oils carry out important roles in food products, and are carriers of fat-soluble vitamins, providing essential fatty acid responsible for growth. Senanayake and Shahidi (2002) reported that the physical and the chemical characteristics of oils are strongly influenced by the nature and concentration of the fatty acids on the triacylglycerol.

Okechalu et al. (2011) reported that one of the important vegetable oil in food industry is palm oil and palm kernel oil. The palm tree bears the palm fruit which belongs to monocotyledon belonging and genus Elaeis. In the Southern part of Nigeria, palm oil is used as a major cooking oil because of its traditional belief and importance. The oil has been referred edible by the FAO/WHO.

Trindade et al. (2005) reported that crude oil spillage contributes majorly to environmental pollution and degradation in the Southern region of Nigeria. More so, studies by Ejiofor et al. (2016) showed that the Southern Nigeria is heavy polluted by heavy metals generated from crude oil exploration. The problems associated with exploration and exploitation of crude oil on the environment has been well documented. The threat to the natural life and environment caused by crude oil products is rapidly increasing (Zienko, 1996). Crude oil modifies the physico-chemical properties and biological properties of the soil (Lebkowska et al., 1995) and contribute to limitation of the productive ability of crops and potentially dangerous for animals and human health (Wyszkowska et al., 2002).

Oil pollution changes the physical, biological and chemical properties of soil, thereby having a negative impact on crops growth and yield (Akaniwor et al., 1995). Crude oil pollution damages soil texture, structure, increases loss of organic matter and important soil nutrients and minerals.

Achuba (2008) reported that crude oil contamination in soil affects the activities of soil enzymes such as dehydrogenase, oxidase, lipases, urease and alkaline phosphatase negatively. The aim of this study was to investigate the fatty acid profile of oil (palm oil and palm kernel oil) obtained from palm tree grown in heavily polluted (crude oil spilled) soil in Southern Nigeria, to ascertain if the pollution affects the fatty acid and estimate if oil can serve as an indicator for environmental pollution in crude oil polluted soil.

Material and Methods

Year and location of study

Study was carried out in 2016, after sampling, laboratory analysis was done at the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Research Laboratory. Fatty acid profiling was done at PZ Industries Laboratory, Aba, Abia State, Nigeria.

Study area

Alesa, Eleme is home to Eleme petrochemical industries and home to a lot of fertilizer industries. Alesa is a major town in Eleme Local Government Area. It is home to Pipelines and Products Marketing Company. Eleme is known to have suffered oil spills in the past and studies have reported adverse effects of these spills on the soils (Abii and Nwosu, 2009).

Umudike a town in Umuahia South Local Government Area, is home to many tertiary institutions and agricultural research institute. Majority of the inhabitant are students and civil servants. The major activities going on in Umudike is subsistence farming. Umudike is also known for her palm trees.

Plant sampling

The vegetable oils (palm oil and palm kernel oil) were obtained from palm fruit grown in palm plantations from Southern Nigeria in Rivers (Alesa, Eleme) coded T_1 for palm kernel oil and T_2 for palm oil which served as test group. We ensured that the plantation was aged one and close to a crude oil spilled pipe line. The control palm fruit was obtained from a palm plantation in Abia (Umudike) free from crude oil spillage. We gave code C_1 and C_2 for palm kernel oil and palm oil respectively. The palm fruits were of the same specie (*Elaeis guineensis*).

Identification of the sample

The species of the palm fruits was authenticated by Dr. Garuba Omosun of the Department of Plant Science and Biotechnology, College of Natural Science, Michael Okpara University of Agriculture, Umudike, Abia State as *Elaeis guineensis* and issued specimen number MOUAU/COLNAS/PSB/15/047.

Extraction of oil from palm fruit and kernel

Briefly, the palm oil was locally processed by cooking the palm fruit for 2hours followed by crushing the mesocarp and sieving to separate the liquid (oil) from slog. The palm kernel oil was extracted by toasting the palm kernel nut using an oven at 60^{O}c as described by Elijah et al. (2013). The extracted oils were labelled accordingly.

Determination of acid, peroxide and carotenoid content of oil

Acid and peroxide value of oil samples, were determined by the method described by AOAC, (1998). Total carotenoid content was determined by the method described by AOCS, 1995.

Characterization/preparation of fatty acid methyl esters (FAMEs)

Fatty acid (FA) composition of the oils was determined as their corresponding methyl esters. Preparation of FAMEs was carried out according to the modified ISO method (BS EN ISO 5508, 1995). 0.1 - 0.2 g of certain oil was dissolved in 10 mL 0.2 mol/L H_2SO_4 prepared in anhydrous methanol. Esterification was performed by refluxing for 30 minutes at 100^{0}C in tightly sealed Pyrex tubes. After cooling at room temperature, 10ml of petroleum ether (40 - 60) was added followed by 10mL of deionized water, mixed gently and allowed to settle until the upper petroleum ether layer becomes clear. The distinct upper layer of methyl esters in petroleum ether was separated carefully in a capped vial and used for analysis. 2µL of the petroleum ether aliquots were injected into the chromatographic column and peaks were recorded for their respective retention times and areas by the data processor unit of the GC. Identification of each individual fatty acid methyl ester was achieved by comparison with authentic reference standards (Merck, Fluka).

Statistical analysis

Data obtained was statistically analysed using student T- test at 95% confidence level using SPSS Ver. 22.

Results and Discussion

Table 1. Showing acid value, peroxide value and carotenoid concentration in palm kernel oil (PKO)

Palm kernel oil	Acid value	Peroxide value	Carotenoids concentration (mg/100g)
T_1	5.11±0.12*	2.14±0.11*	8.43±0.11
C_1	3.18±0.17	1.01±0.11	14.09±0.16**

*significantly higher than control group;
** significantly higher than test group
T_1 – Polluted site; C_1 – Unpolluted site

From the above table, acid value and peroxide value of palm kernel oil from the polluted site was significantly (P<0.05) higher than palm kernel oil obtained from the control site. Carotenoid content was significantly (P<0.05) in the palm kernel oil from unpolluted site when compared to the polluted site.

Table 2. Showing acid value, peroxide value and carotenoid concentration in palm oil (PO)

Palm kernel oil	Acid value	Peroxide value	Carotenoids concentration (mg/100g)
T_2	10.12±0.12*	4.12±0.11*	12.43±0.14
C_2	6.18±0.17	2.12±0.11	28.09±0.12**

*significantly higher than control group;
** significantly higher than test group
T_2 – Polluted site; C_2 – Unpolluted site

From the above table, acid value and peroxide value of palm kernel oil from the polluted site was significantly (P<0.05) higher than palm kernel oil obtained from the control site. Carotenoid content was significantly (P<0.05) in the palm kernel oil from unpolluted site when compared to the polluted site.

Table 3. Fatty acid profile of PKO

Fatty acid (%)	Caprylic acid	Capric acid	Lauric acid	Palmitic acid	Stearic acid	Oleic acid
T_1	2.99	52.67	16.69	8.06	19.57	ND
C_1	2.66	49.18	15.17	8.47	20.44	0.92

ND- Not detected; T_1 – Polluted site; C_1 – Unpolluted site

From the above table, caprylic, capric, lauric, palmitic and stearic acid were detected in palm kernel oil obtained from polluted and unpolluted site. Oleic acid was present in palm kernel oil from unpolluted site but was absent in palm kernel oil from polluted site.

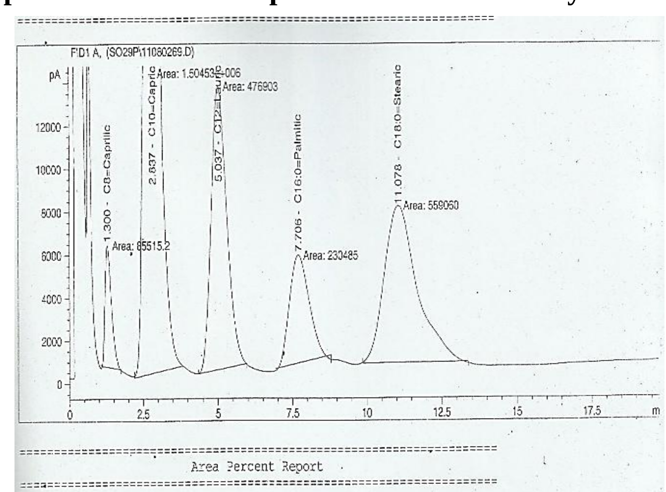
Table 4. Fatty acid profile of PO

Fatty acid (%)	Lauric acid	Myristic acid	Palmitic acid	Palmitoleic acid	oleic acid
T_2	ND	0.2872	ND	62.0901	37.6227
C_2	0.3663	ND	44.5792	ND	55.0544

ND- Not detected; T_2 – Polluted site; C_2 – Unpolluted site

From the above table, oleic acid was present in palm oil obtained from polluted and unpolluted site. Lauric and palmitic acids were present in palm oil from unpolluted site. Myrsitic and palmitoleic acids were present in polluted site.

Fig 1: chromatogram of fatty acid composition of palm kernel oil from polluted site in this study



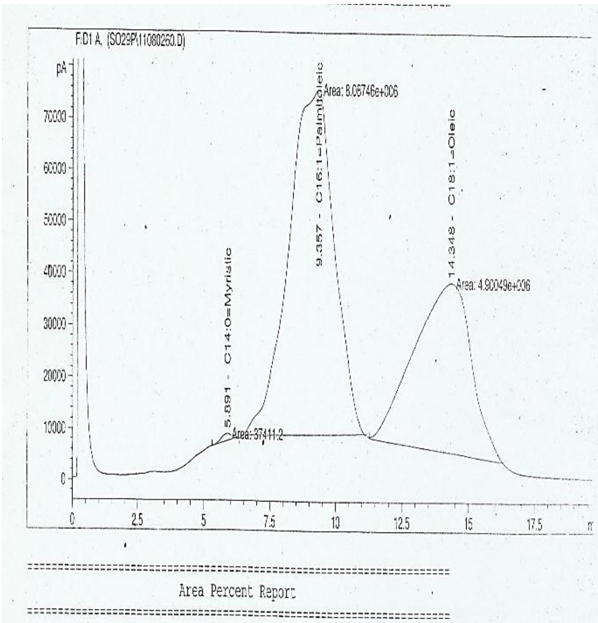


Fig 2: chromatogram of fatty acid composition of palm oil from polluted site in this study

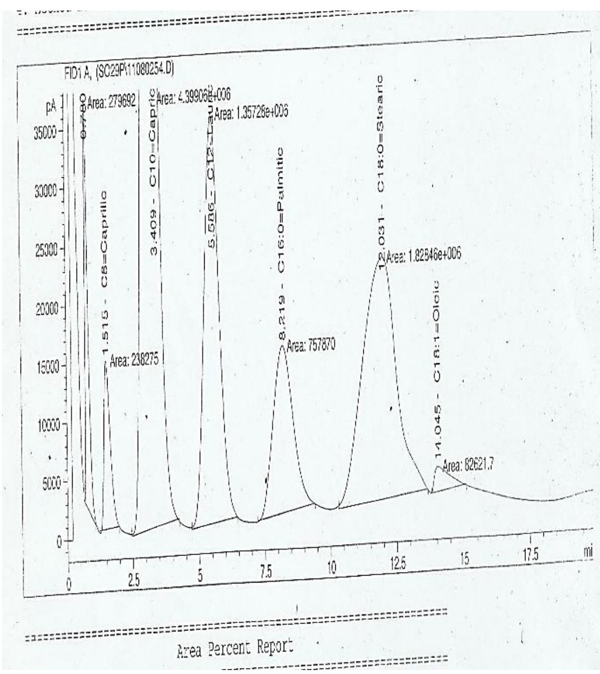


Fig 3: chromatogram of fatty acid composition of palm kernel oil from unpolluted site in this study

Palm kernel oil and palm oil from crude oil spilled soil (polluted soil) and unpolluted soil were analysed for changes in oil chemistry and fatty acids using standard methods. Result for acid value showed a significant ($p<0.05$) increase in the test oil (PO and PKO) when compared to the control. Acid value of oil is strongly used as a measure of oil quality. High acid value of oil has been linked to the inception of rancidity (Woodlat, 1985). The increase in acid value in our test oils can be attributed to the effect of oil spillage. Compounds such as poly aromatic hydrocarbons (PAHs), heavy metals and other organic compounds are elevated in soil and water in crude oil polluted regions, and these compounds can be absorbed by plants. These compounds once inside the plant can be metabolized and generate or potentiate rancidity thus leading to high acid value.

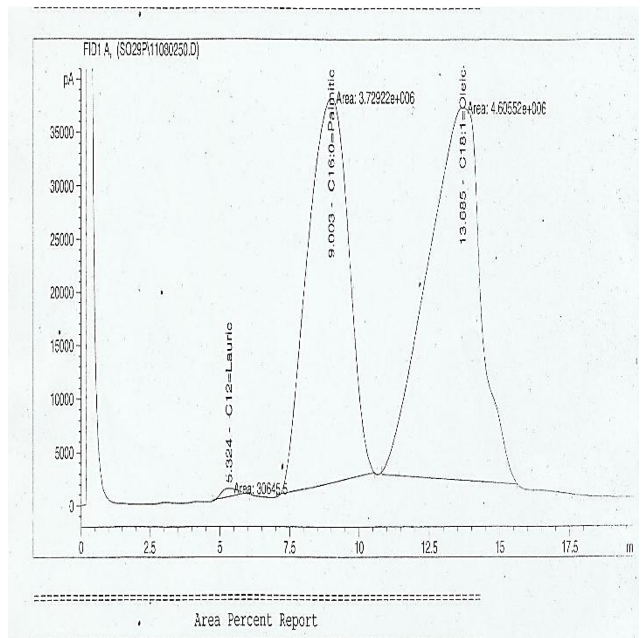


Fig 4: chromatogram of fatty acid composition of palm oil from unpolluted site in this study

Result for peroxide values showed a significant ($p<0.05$) increase in the test oil (PO and PKO) when compared to the control. Peroxide value is one widely used test to determine the extent of oxidation of oils. High peroxide value is an indication of high and fast oxidation of oil. High peroxide values in the test oils can be linked with the damage caused by compound of oil spill absorbed by the plant. These compounds can generate free radicals in the plant which can lead to oxidative stress in plant tissues and cells. Oxidation caused by these compounds can contribute to the high peroxide value seen in the test oil. Also, increase in peroxide value of oil can be linked to an increase in lipoxygenase activity (Gutierrez et al., 1997) which can also be promoted by toxic compounds in oil spill sites.

Carotenoid content was significantly ($p<0.05$) decreased in the test oils compared to control. This can be linked with the harmful compounds of oil spill that find their way through the plant. Ahmed et al. (2015) reported that pollutants from industrial areas can degrade pigments from plants especially fluoride. Other toxicants such as PAHs and heavy metals can induce compounds that can degrade plant pigments. However, decrease in carotenoid concentration is a confirmation of oxidative stress triggered by the harmful compounds derived from the oil spill.

Result for fatty acid analysis showed the presence of caprilic (C8:0), capric (C10:0), lauric (C12:0), palmitic (C16:0), stearic (C18:0) and oleic (C18:1) in the palm kernel oil, while palm oil showed the presence of lauric, myristic (C14:0), palmitic (C16:0) and palmitoleic (C16:1). Result obtained for the palm kernel oil, indicated that pollution did not affect the fatty acid present in the oil sample. The palm kernel oil is derived from kernel which is enclosed by the endocarp, a hard-brown case which is covered by the mesocarp. This suggested that the pollutant may not be able to find their way through the hard endocarp to the kernel, or are absorbed by the soft rich mesocarp.

Fatty acid analysis of palm oil showed a reduction in oleic acid content of the test oil (37.62%) when compared to the control oil (55.05%). The reduction in oleic acid content of PO from polluted site can be attributed the harmful effect of crude oil spillage and age of plant and extent of spillage caused damage to soil. Salvador et al. (2001) reported that reduction of oleic acid in oil of polluted plants could be due to disorders arising in the triacylglycerol biosynthesis which may be induced by pollutants. Also, the reduction in oleic acid in the polluted region can be attributed to inhibition of the disturbance of the activities of enzymes involved in the oleic acid synthesis chain by the toxic compounds from the pollution.

Palmitic acid of palm oil from unpolluted soil is 44.58% which agrees with the report of Breuer *et al.* (1987). Palmitic acid is the major saturated fatty acid present in palm oil, Zambiazi et al. (2007). Palmitic acid absent in the palm oil from polluted region may also be attributed to the degree and time of crude oil spillage and it harmful effect. The palmitoleic acid content of the palm oil from polluted region (62.09%) and it absent in the palm oil from unpolluted soil indicates that oil pollution may be responsible for the conversion of palmitic to palmitoleic fatty acid. The absence of palmitoleic acid in the palm oil from unpolluted soil agrees with the report of Adam et al. (2007), who reported absent of palmitoleic acid in palm oil. Lu et al. (2009) reported that as fruit ripens, the saturated acid decreases and the monounsaturated fatty acid increases. Ethylene which can be gotten from crude oil polluted region can induce ripening. The ethylene which is present in the crude oil could have forced or triggered early ripening of the palm fruit, thus affecting the saturated fats and improving unsaturated fats. This indicates that palm oil from the unpolluted site is better nutritionally compared to oil from the polluted region. Also, the study indicates that oil can serve as marker for environmental pollution studies.

Conclusion

From the result of this study, we concluded that oil spillage depending on the time and degree has negative effects on Palm Tree from the polluted site and affect it major product oil. After oil spillage, the toxic compounds from crude oil are transported from the soil, through the root where they get into important organs of the plants and carry out their negative effects. The oil studied in this research from the polluted states, served as a guide reporting pollution in the area.

Author's contribution

Author EE designed experimental protocol. Author ES wrote first version of manuscript. Author AO carried out plant material sampling, Author BO and AOB performed experimental analysis and fatty acid profiling. Author KM performed statistical analysis. Author NO read and corrected first version of manuscript written. All author approved the final version of manuscript submitted.

Acknowledgement

The authors wish to thank Mr. Ikechukwu Gavin and Miss Chukwu Maureen for technical and typesetting activities respectively.

Conflict of Interest

We declare that no conflict of interest existed. All authors approved the final version of manuscript sent for publication

References

Abii TA and Nwosu PC, 2009. The Effect of Oil-Spillage on the Soil of Eleme in Rivers State of the Niger-Delta Area of Nigeria. Res. J. Envir. Sci. 3: 316-320.

Achuba FI and Peretiemo-Clarke BO, 2007. Effect of spent oil on soil catalase and dehydrogenase activities. Int. Agrophysics. 22: 1-4.

Adam SN, Sulaiman A and Jaarin K, 2007. Fatty acid composition of vegetable oil in Malaysiah. Malaysian. J. Biochem. Mol. Biol. 15: 76- 79

Ahmed CD, Zouari M, Fourati R, Imen S and Abdallah FB, 2015. Oil quality characteristics of Chemlali olive tree (*Olea europaea* L.) grown under air fluoride pollution in arid region in Tunisia. Int. J. Plant Biol. Res. 3: 1041.

Akaniwor JO, Anyaeleso AO and Manago CC, 2007. Effect of different concentrations of crude oil (Bony light) on major food reserves in guinea corn during germination and growth. Sci. Res. Essay. 2: 127- 131.

Association of Official Analytical Chemists (AOAC), 1998. Official method of analysis. Association of Official Analytical Chemists. AOAC, Washington DC, USA

American Oil Chemists Society (AOCS), 1995. Official methods. AOCS, USA

Breuer B, Stuhlfauth T and Fock HP 1987. Separation of fatty acids or methyl esters including positional and geometric isomers by alumina argentation thin-layer chromatography. J. Chromatographic Sci. 25: 302- 306

Ejiofor UE, Omeh YN and Ebhohon SO, 2016. Evaluation of heavy metals content of water bodies at two industrial communities of Eleme and Ewekoro, Southern Nigeria. Nature Env. Pol. Tech. 15: 789- 798

Fasina OO, Hallman CH and Clementsa C, 2006. Predicting Temperature-Dependence Viscosity of Vegetable Oils from Fatty Acid Composition. JAOCS. 83: 899 - 903.

Gutiérrez F, Jímenez B, Ruíz A and Albi MA, 1999. Effect of olive ripeness on the oxidative stability of virgin olive oil extracted from the varieties picual and hojiblanca and on the different components involved. J. Agric. Food Chem. 47: 121-127.

Lebkowska ME, Karwowska M and Mia kiewicz E, 1995. Isolation and identification of bacteria from petroleum derivatives soil. Acta Microbiology Polon. 44: 297

Okechalu JN, Dashen M, Lar PM, Okechalu B and Gushop T, 2011. Industrial oil and fat products. J. of Microbiology and Biotech. Res. 1: 107-112.

Salvador MD, Aranda F and Fregapane G, 2001. Influence of fruit ripening on Cornicabra virgin olive oil; a study for four crop seasons. Food Chem. 73: 45-53.

Senanayake SP and Shahidi F, 2002. Structured lipids: acydolysis of gamma-linolenic acid rich-oils with n-3 polyunsaturated fatty acids. J. of Food Lipids 4: 309 - 323.

Trindade PV, Sobral IE, Rizzo AC, Leite SG and Soriano AU, 2005. Bioremediation of a weathered and a recently oil contaminated soils from Brazil: a comparison study. Chemosphere 58: 515-522.

Wollat E, 1985. The manufacture of soap, other detergents and glycerine, 2nd ed. Ellis Harwood Pub., England

Wyszkowska, J, Kucharski J and Waldowska E, 2002. The influence of diesel oil contamination on soil enzymes activity. Rostl. Výr. 48: 58-62.

Zambiazi RC, Przybylski R, Zambiazi MW and Mendonca B, 2007. Fatty acid composition of vegetable oils and fats. B. CEPPA, 25: 111 - 120.

Zienko J, 1996. Oil substances in natural environment. Ekol. Tech. 4: 18.