African Scientist Vol. 11, No. 1 March 31, 2010
Printed in Nigeria

1595-6881/2010 $12.00 + 0.00

http://www.klobex.org/afs

AFS 2010025/11109

Studies on the physicochemical properties and fatty acid composition of the oil from ripe plantain peel (*Musa paradisiaca*)

A. T. Oladiji*[1], M. T. Yakubu[1], A. S. Idoko[1], O. Adeyemi[2] and M. O. Salawu[1]

[1]Department of Biochemistry, University of Ilorin, Ilorin, Nigeria
[2]Department of Environmental Sciences, Federal University of Petroleum Resources, Effurun. Delta State, Nigeria

(Received March 1, 2010)

ABSTRACT: Oil extracted from ripe peel of *Musa paradisiaca* (plantain) was analyzed for physicochemical properties and fatty acid constituents using standard methods. The results revealed that the acid value, peroxide value and specific gravity were significantly ($p<0.05$) higher than those of soybean oil whereas saponification value, iodine value, ester value, boiling, smoke, flash and fire points were significantly lower than in soybean oil. The percentage yield of the oil from the peel of *M. parasidiaca* fruit was 6%. The component phospholipids of the peel oil included phosphatidyl glycerol and diphosphoglycerol while the neutral lipids were free fatty acids and cholesterol esters. Myristic, lauric and α-Linolenic acids were higher in the peel oil than in the soybean oil whereas palmitic, stearic, oleic and linoleic and acids were lower in the peel oil when compared with the soybean oil. Overall, the results suggest that the oil from the ripe peel of *Musa parasidiaca* may not be a good candidate for conventional oil and may not be a good raw material for soap, paint and food industries.

Key words: *Musa paradisiaca*, Musaceae, physicochemical properties, fatty acids, ripe peel, soybean oil.

Introduction

Musa paradisiaca (family-Musaceae), also known as plantain (English), ogede agbagba, apanda (Yoruba), ayaba (Hausa) and Ogadejioke (Igbo), is a tropical plant that is native to India. The plant consists of long, overlapping leafstalks and bears a stem which is 1.22 to 6.10 m high. The leaves grow to a length of 1.83 m and 0.61 m wide. The fruits grow in clusters, each separate plantain of the cluster being about 1 inch in diameter and somewhat longer than a banana.

Various parts of the plant such as the leaves, roots and fruits have been used for medicinal purposes. For example, the fruit is consumed as food. Again, the leaf juice is used in the treatment of fresh wounds, cuts and insect bites while the leaves act as an arbortifacient. The sap of the plant is used as a remedy for diarrhoea, dysentry, hysteria and epilipsy. A cold infusion of the root is used to treat venereal diseases and anaemia. In addition, the fruit has been raportedly used as antiscorbutic, aphrodisisac and diuretic (1).

Furthermore, the fruits have peels which are discarded as waste after the inner fleshy portion has been eaten. Omole *et al* (2) reported that the peels have the potentials of replacing maize (corn starch) in the diet of snail. As at the time of carrying out this study, information on the oil from *M. paradisiaca* appears to be scanty. Therefore, this study aims to provide information on the physicochemical properties and chemical constituents of the oil from the peel of ripe *M. paradisiaca* fruits.

*Corresponding Author: Email: temidayooladiji@yahoo.com. Phone: +2348033736996

Materials and Methods

Musa paradisiaca peels

Ripe peel of *M. paradisiaca* fruits were obtained from within the mini- and main campuses of the University of Ilorin, Ilorin, Nigeria.

Chemicals and reagents

All the chemicals and reagents used in this study were of analytical grade and were products of British Drug House Laboratory, England.

Extraction and purification of oil from the peel

The peels were cut into pieces, oven dried at 60^{o}C for 72 h to constant weight. The pieces were then pulverized using an electric blender and thereafter stored in polythene bag. The oil was extracted from the resulting powder by adopting the method described by A.O.A.C (3) which entailed using Soxhlet apparatus to extract the oil with petroleum ether at 40-60^{o}C. Next, the method described by Folch *et al* (4) was used to purify the oil. Briefly, 0.73% of NaCl solution was added to the oil solvent mixture in a separating funnel. This separated into two layers: the upper (organic phase), and the lower layer (aqueous phase). The lower phase was run-off, and chloroform: methanol: 0.58% NaCl solution (3:48:47 v/v/v) was added for further purification of the organic phase. This again separated into two layers after which the lower layer was run-off, leaving the upper phase of the mixture containing the purified oil and solvent. The solvent was then driven off by placing the oil-solvent mixture in a bath leaving behind the purified oil.

Determination of the physicochemical properties of the oil

The acid, ester, saponification, iodine and peroxide values were determined using the procedures described by Pearson (5) while the procedures described by Onwuka (6) were adopted for the determination of the specific gravity, boiling point, smoke point, flash point and fire point of the oil.

Determination of lipid content of the oil

The neutral and phospholipid components of the oil were determined using the Thin-Layer Chromatographic (TLC) technique described by Ackman (7). In this method, plates were washed with detergent and dried in the oven. The plates were thereafter coated with Silica gel to a thickness of 0.5nm, air dried again and activated in the oven for 20 minutes at 100^{o}C. Furthermore, the oil was spotted on two of the coated TLC plates (one for neutral lipid and the other for phospholipids) using a capillary tube. The plates were later air-dried and placed in a chromatographic tank containing chloroform: methanol: water (65:25:4 v/v/v), for phospholipids and petroleum ether: diethyl ether: acetic acid (80:20:1 v/v/v) for neutral lipids. The separated spots were visualized by placing the plate in iodine vapour tank for 5 minutes, and the spot outline were marked immediately. The separated lipid components were identified from the calculated R_f values, compared with those of the standard (8).

.

Determination of fatty acid constituents of the oil

In this procedure, the oil was first methylated by dissolving 0.125gm of the oil in 5.0 ml of N-hexane. This was then followed by the addition of 0.5 ml of 5M sodium methoxide and vigorously shaken. The Gas-Liquids Chromatographic technique as described by Pearson (5) was adopted for the determination of the fatty acids in the oil. Methylated oil was then introduced into the injector of GC-Shimadzu-17A (FID) at a temperature of 230ºC, and a detector temperature of 240ºC while the nitrogen gas was maintained at 5.5Psi. The fatty acids were eluted as peaks whose retention time was compared with those of known standards.

Statistical analysis

Data which were expressed as the mean of three replicates were analyzed using the Student's t-test. Differences were considered statistically significant at $P< 0.05$.

Results

The physicochemical analysis of the oil from ripe peel of *M. paradisiaca* fruit revealed that the acid value, peroxide value and specific gravity were significantly ($p<0.05$) higher than their corresponding values in the soyabean oil (Table 1). In contrast, the saponification value, iodine value, ester value, boiling point, smoke point, flash point and fire point were significantly lower than those of the soybean oil. The percentage yield of the oil from the peel of *M. parasidiaca* fruit was 6%. The component phospholipids of the peel oil included phosphatidyl glycerol and diphosphoglycerol while the neutral lipids were free fatty acids and cholesterol esters (Table 2). Fatty acid component analysis of the oil from the ripe peel of *M. paradisiaca* revealed that the peel oil is higher than soybean in lauric and myristic acids whereas the palmitic, stearic, oleic and linoleic acids were lower in the oil from *M. parasidiaca* fruit when compared with that of soybean oil (Table 3).

Table 1: Physicochemical properties of *Musa parasidiaca* peel oil.

Parameters	**Soybean Oil**	***Musa parasidiaca* peel oil**
Peroxide value (meq O^2/kg)	0.06 ± 0.001^a	17.00 ± 1.52^b
Acid value (mg/g)	0.09 ± 0.001^a	0.90 ± 0.12^b
Saponification value (mg/g)	186.50 ± 2.31^a	39.27 ± 3.36^b
Iodine value (g/g)	146.37 ± 0.55^a	33.50 ± 3.90^b
Ester value (mg/g)	186.41 ± 2.14^a	38.37 ± 2.53^b
Specific gravity	0.93 ± 0.08^a	1.92 ± 0.02^b
Boiling point (°C)	220 ± 6.33^a	198.00 ± 4.64^b
Smoke point (°C)	250.00 ± 6.17^a	210.00 ± 5.77^b
Flash point (°C)	270.00 ± 5.67^a	220.00 ± 8.66^b
Fire point (°C)	285.00 ± 5.77^a	235.00 ± 11.54^b

Values are mean of three determinations ± S.E.M
Values for same parameter with different superscripts are significantly different ($P<0.05$).

Table 2: Phospholipid and neutral lipid components of the oil from the peel of *Musa paradisiaca* fruit.

R_f values for soybean oil	**R_f values for the peel oil**	**Reference values**	**Inferences**
0.840	0.833	0.830-0.840	Phosphatidyl glycerol
-	0.101	> 0.91	Di hosphatidyl glycerol
0.420	0.431	0.310-0.500	Free fatty acid
-	0.897	0.895-0.964	Cholesterol ester

Table 3: Fatty acid composition of *Musa parasidiaca* peel oil

Fatty acids	Soybean oil (%)	*Musa parasidiaca* peel oil (%)
Saturated fatty acids		
Lauric acid (12:0)	7.23	78.02
Myristic acid (14:0)	0.10	8.97
Palmitic acid (16:0)	10.30	6.27
Stearic acid (18:0)	3.80	0.52
Monounsaturated fatty acids		
Oleic acid (18:1)	22.80	0.04
Polyunsaturated fatty acids		
Linoleic acid (18:2)	51.00	6.18
α-Linolenic acid (18:3)	6.80	12.30

Discussion

In this study, the quality of the oil from the peel of *M. paradisiaca* fruit was assessed using parameters such as acid, peroxide, iodine, saponification and ester values as well as specific gravity, boiling point, smoke point, flash point and fire point and such values were compared with a conventional oil, soybean oil.

Acid value is an important index of physicochemical property of oil which is used to indicate the quality, age, edibility and suitability of oil for use in industries such as paint (9). According to Demian (10), acid values are used to measure the extent to which glycerides in the oil has been decomposed by lipase and other physical factors such as light and heat. Thus, the higher acid value of the peel oil when compared with that of soybean oil suggests that the peel oil is more susceptible to lipase action. This value (0.90 mg/g) for the peel oil is higher than the 0.6 mg/g proposed by Usoro *et al* (11) for edible vegetable oil. Peroxide value is used as a measure of the extent to which rancidity reactions have occurred during storage. The higher peroxide value of the peel oil also corroborated the fact that the peel oil has less resistance to lipolytic hydrolysis and oxidative deterioration when compared with the soybean oil (12). The peroxide value of the peel oil (17.00 mEq/kg) contrast the findings of Atasie *et al* (13) who got a value of 5.99 mEq/kg for the oil from *Arachis hypogae*. The higher peroxide value of the peel oil indicated a more susceptibility to oxidation than the soybean oil (14). Again, the peroxide value of the oil from the peel of *M. paradisiaca* fruit is outside the range of 0-10mEq/kg stipulated for freshly prepared oil (15). Therefore, it is likely that storage for a long time may lead to rancidity of the oil. Saponification value is an index of average molecular mass of fatty acids in oil sample. The lower value of saponification value in the peel oil suggest that the mean molecular weight of fatty acids is lower than that of soybean oil or that the number of ester bonds is less when compared to that of soybean oil. This might imply that the fat molecules were not intact (16). This is in line with the higher susceptibility to lipase action and other oxidative means (13). Therefore, the extremely low value of saponification of the peel oil may limit its use in the saponification industry. Furthermore, the lower iodine value of the peel oil suggests that the amount of unsaturated fatty acids is lower than that of soybean oil. While the lower ester value of the peel oil suggests fewer amounts of glycerides, the higher value of specific gravity of the peel oil implies that it is 2.08 times denser than the soybean oil.

Boiling point, smoke point, flash point and fire point of oil are parameters used to assess the thermal stability of oil samples (17). The boiling point is the temperature at which the oil boils; the smoke point is the temperature at which cooking oil begins to break down to glycerol and free fatty acids. The glycerol is then further broken down to acrolein which is a component of the bluish smoke. It is the presence of the acrolein that causes the smoke to be extremely irritating to the eyes and throat. The smoke point has also been reported to

marks the beginning of both flavor and nutritional degradation. Therefore, it is a key consideration when selecting a fat for frying, with the smoke point of the specific oil dictating its maximum usable temperature and therefore its possible applications. On the other hand, the flash point is the temperature at which volatiles evolving from the heated oil will flash, but not support combustion whereas the temperature at which the oil supports combustion is the fire point (6). Most vegetable oils have their flash point above 350^{o}C. Therefore, the lower boiling point, smoke point, flash point and fire point of the peel oil when compared with the soybean oil is an indication that the peel oil is less thermally stable than the soybean oil. Coupled with the sticky and gummy nature of the oil, it is unlikely that the oil will be suitable for deep frying. However, if subjected to some form of processing, it may be a good candidate in the cosmetic industries due to its fragrance.

The percentage yield of the oil from the peel of *M. parasidiaca* fruit which was 6% is considered to be very low. Therefore, the oil is classifeid as low yielding. The detection of diphosphatidylglycerol and cholesterol esters in the peel oil is noteworthy as they were not detected in the soybean oil (Table 2). Phospholipids have been reported to be an important component of cell membrane fluidity and functionality while the neutral lipids serve as store of energy and constituents of membrane structure (18). The presence of these classes of lipids may enhance the integrity and functionality of cell membrane if consumed (8). The oil from *Musa parasidiaca* fruit peel contains most of the common fatty acids found in edible oils such as soybean oil. The fruit peel oil contains 93.78% of saturated fatty acids, 0.04% of monounsaturated fatty acids and 18.48% polyunsaturated fatty acids as against 21.43% of saturated fatty acids, 22.80% of monounsaturated fatty acids and 57.80% of polyunsaturated fatty acids (Table 3). Saturated fatty acids can increase the risk of heart diseases from atherosclerosis by raising blood cholesterol (19). But not all saturated fatty acids have the same effect on cholesterol synthesis in the liver. Only those of chain length 12, 14 and 16 (lauric, myristic and palmitic acid) have been shown to elevate blood cholesterol. Of these however, myristic acid elevates cholesterol the most (20). Therefore, the high percentage of these saturated fatty acids may predispose the animals to cardiovascular risk when consumed. In addition, the presence of polyunsaturated fatty acids through the generation of free radicals from the carbon-carbon double bond may prone the animals to disease conditions associated with free radicals (21). The presence of palmitic, linoleic and oleic acid in the oil from the peel of *Musa parasidiaca* fruit notwithstanding the small amount of the fatty acids when compared with soybean oil may still be employed for the purpose of dietary formulation (12). The low percentage of polyunsaturated fatty acids in the oil from the fruit of *Musa parasidiaca* is supported by the low iodine value obtained for the oil in this study.

Overall, the oil from the peel of *M. parasidiaca* fruit is unlikely to be stored for a reasonably long period of time without becoming rancid. It is also not likely to be a good candidate for deep frying and as a raw material in industries like soap and margarine. The peel oil may prone to cardiovascular risk and free radical related diseases when consumed. Finally, the oil from the peel of *Musa parasidiaca* fruit appears not to have the attributes of conventional oil and may not be used as one.

References

1. Gill, LS: Ethnomedicinal uses of plants in Nigeria. University of Benin Press, Benin City, Nigeria,. pp. 169-170, 1992.
2. Omole, AJ, Ajasin, FO, Oluokun, JA, Obi, OO: Performance characteristics of weaned rabbit fed plantain peel as replacement for maize. J. Nutr. Food. 38:559-563. 2008.
3. AOAC: Official Method of Analysis 13th Ed. William Horwitz. Ed. Washington, DC, Association of Official Analytical Chemists, 7: 56-132. 1980.
4. Folch, J, Lee, M, Stanley, GH: A simple method of isolation and purification of lipids from animal tissues. J. Biol. Chem. 226: 497-509. 1957.
5. Pearson, D: The Chemical Analysis of Foods. Churchill Livingstone, Edinburgh, UK. pp. 504-530. 1981.
6. Onwuka, GI: Food Analysis and Instrumentation. Theory and Practice. 1st Edition, Naphthali Prints, Lagos, Nigeria. pp. 1-219. 2005.
7. Ackman, RG: Application of thin-layer chromatography to lipid separation: detection methods. In: Analyses of Fats, Oils, and Derivatives. EG Perkins (ed.) AOCS Press, Illinois. pp. 97-121. 1993.
8. Oladiji, AT, Abodunrin, TP, Yakubu, MT: Some physicochemical characteristics of the oil from *Tetracarpidium conophorum* (Mull. Arg.) Hutch. and Dalz Nut. Nig. J. Biochem. & Mol. Biol. 22(2) 93-98. 2007.
9. Akubugwo, IE, Chinyere, GC, Ugbogu, AE: Comparative studies on oils from some common plant seeds in Nigeria. Pak. J. Nut. 7: 570-573. 2008.
10. Demian, MJ: Principles of Food Chemistry. 2nd Ed. Van Nostrond Reinhold International Company Limited, London, England, pp: 37-38. 1990.
11. Usoro, EU, Suyamsothy, E, Sani, GA: Manual of chemical methods of food analysis. Bencox International Ltd. Lagos, Nigeria. 1982.
12. Popoola, TOS, Yangomodou, OD: Extraction, properties and utilization potentials of cassava seed oil. Biotechnol 5: 38-41. 2006.

13. Atasie, VN, Akinhanmi , TF, Ojiodu, CC: Proximate Analysis and Physico-Chemical Properties of Groundnut (*Arachis hypogaea* L.). Pak. J. Nutr. 8(2): 194-197. 2009.
14. Anyasor, GN, Ogunwenmo, KO, Oyelana, OA, Ajayi, D, Dangana, J: Chemical Analyses of Groundnut (*Arachis hypogaea*) Oil. Pak. J. Nutr. 8(3): 269-272. 2009.
15. Cooks, LV, Reds, BC: Laboratory Handout for Oils and Fats Analyst. (U.S Edition). Academy Press Inc. London. 419-421. 1966.
16. Denniston, KJ, Topping, JJ, Caret, RL: General, Organic and Biochemistry, 4th Ed. McGraw Hill Companies, New York, pp: 432-433. 2004.
17. Catoire, L, Paulmier, S, Naudet, V: Estimation of closed cup flash points of combustible solvent blends. J. Phys. Chem. Ref. Data 35: 9-14. 2006.
18. Zubay, GL, Parson, WW, Vance, SE: Principles of Biochemistry. Wm. C. Brown Publishers. Oxford, England. 1995.
19. Appel, LJ, Moore, TJ, Obarzanek, E, Vollmer, WM, Svetkey, LP, Sacks, FM, Bray, GA, Vogt, TM, Cutler, JA, Windhauser, MM, Lin, PH, Karanja, N, Simons-Morton, D, McCullough, M, Swain, J, Steele, P, Evans, MA, Miller, ER, Harsha, DW: A clinical trial on the effects of dietary patterns on blood pressure. New Engl. J. Med. 336: 1117-1124. 1997.
20. Mensink, RP: Effect of the individual saturated fatty acids on serum lipids and lipoprotein concentrations. Am. J. Clin. Nut. 53(suppl): 711S-714S. 1993.
21. Shields, PG, Xu, GX, Blot, WJ, Fraumeni, JF, Trivers, GE Jnr, Pellizzari, ED, Qu, YH, Gao, YT, Harris, CC: Mutagens from heated Chinese and U. S. cooking oils. J. National Cancer Inst. 87: 836-841. 1995.