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Fatty acid compositions of ether extracts of *Bryophyllum pinnatum* Lam., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn. and *Hilleria latifolia* (Lam.) H. Walt

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Summary

Currently, there is a growing interest in identifying alternative sources of fatty acids due to the present increasing demand for oil-rich botanicals in industrial applications. The main objective of this work was to identify the fatty acid compositions of ether extracts of dried leaves of *Bryophyllum pinnatum* Lam., Ficus exasperata Vahl., *Gossypium herbaceum* Linn. and *Hilleria latifolia* (Lam.) H. Walt. The fatty acids were analyzed by gas chromatography with flame ionization detector. Among the evaluated ether extracts, the higher contents of saturated fatty acids were found in *H. latifolia* (27.96%) with the principal presence of stearic acid compared to the content of the saturated fatty acids in *B. pinnatum* (0.53%), *F. exasperata* (0.04%) and *G. herbaceum* (0.47%). Equally, the result showed that *H. latifolia* contained the highest percentage of unsaturated fatty acids with the predominant presence of oleic acid with the amount of 41.04%. Linoleic acid was also found to have the highest value in *H. latifolia* with the amount of 20.41%. Stearic acid, oleic acid, and linoleic acid were found in all the samples. The extract of *H. latifolia* contained a healthy mixture of different types of fatty acids thus suggesting it as a probable source of suitable fatty acids.

Key words: Fatty acids, food security, *Bryophyllum pinnatum* Lam., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn., *Hilleria latifolia* (Lam.) H. Walt.

Resumen

Composición de ácidos grasos de extractos etéreos de *Bryophyllum pinnatum* Lam., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn. y *Hilleria latifolia* (Lam.) H. Walt

Actualmente, existe un creciente interés en identificar fuentes alternativas de ácidos grasos debido a la creciente demanda actual de productos botánicos ricos en aceite en aplicaciones industriales. El objetivo principal de este trabajo fue identificar las composiciones de ácidos grasos de extractos de éter de hojas secas de *Bryophyllum pinnatum* Lam., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn. y *Hilleria latifolia* (Lam.) H. Walt. Los ácidos grasos fueron analizados por cromatografía de gases con detector de ionización de llama. Entre los extractos de éter evaluados, los mayores contenidos de ácidos grasos saturados se encontraron en *H. latifolia* (27,96%) con presencia principal de ácido esteárico en comparación con el contenido de los ácidos grasos saturados en *B. pinnatum* (0,53%), *F. exasperata* (0,04%) y *G. herbaceum* (0,47%). Igualmente, el resultado mostró que la *H. latifolia* contenía el mayor porcentaje de ácidos grasos insaturados con presencia predominante de ácido oleico con una cantidad de 41,04%. También se encontró que el ácido linoleico tiene el valor más alto en *H. latifolia* con una cantidad de 20,41%. Se encontró ácido esteárico, ácido oleico y ácido linoleico en todas las muestras. El extracto de *H. latifolia* contenía una mezcla saludable de diferentes tipos de ácidos grasos, lo que sugiere que es una fuente probable de ácidos grasos adecuados.

Palabras clave: Ácidos grasos, seguridad alimentaria, *Bryophyllum pinnatum* Lam ., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn., *Hilleria latifolia* (Lam.) H. Walt.

Introduction

Lipids play functional roles as essential components of cell membranes and as major energy fuel in metabolism. They are also precursors of metabolites of some gene regulators and the eicosanoids, which play essential roles in the regulation of many body processes including inflammation. Their derivatives are also involved in the mediation of cell signalling. Fatty acids are the main components of lipids. The essentiality of these fatty acids as dietary components was not recognized until in 1929 when George Burr reported that they were required in the prevention of deficiency diseases that might perhaps occur in rats fed a fat-free diet [1]. This discovery shifted the paradigm that dietary fats were simply energy storage and increased their importance owing to their associated nutritional and health implications. Thus, the biological effects of several categories of fatty acids most especially on immunological, metabolic, and cardiovascular events had stimulated research interests on fatty acids and their metabolites over the last few decades [2-4]. The requirement of non-essential fatty acids by living organisms can be met by biosynthesis while the essential fatty acids which are mostly unsaturated (mono-saturated and poly-saturated) cannot be synthesized by the body and hence they are obtained through diets. The dietary intake of the essential fatty acids occurs mainly through the consumption of plant materials, animals, and oily fish; and thus their assessment is of great interest to the medical community and the public [5].

Plant materials contain many bioactive compounds with medicinal and valuable benefits [6]. These include lipids, phenolics, flavonoids, carotenoids and monoterpenes [7]. Pharmacological properties of different plant materials such as antioxidant, hypotensive, hypoglycemic, and antimicrobial properties have been substantiated through various experimental studies *vis-à-vis* their uses in traditional medicine [8-10]. Moreover, plants had been recognized as one of the major natural sources of essential fatty acids due to their high content of unsaturated fatty acids and economic values. Consecutively, the degree of unsaturation of the fatty acids has increased the use of plant-based oil in various pharmaceutical and nutraceutical applications [11].

However, the availability of essential fatty acid-enriched natural products is affected by the recent diversion of vegetable oil resources and essential oils toward the production of cosmetics and flavoring agents [12]. Moreover, the global concern on climate change and energy security has also increased the development of biofuels and this could unvaryingly pose a global threat to food security and vegetable oil availability [13, 14]. This had stimulated interest in finding alternative sources of essential fatty acids, especially from underutilized plant materials and precludes the eventual negative impact on food security [15]. The present study was aimed at investigating fatty acids compositions of petroleum ether extracts of the dried leaves of *Bryophyllum pinnatum* Lam., *Ficus exasperata* Vahl., *Gossypium herbaceum* Linn. and *Hilleria latifolia* (Lam.) H. Walt.

Methods

Materials

The plant materials used for the study were collected from various locations in the South-Western Region of Nigeria and authenticated by a botanist. Subsequently, the samples were cleaned and dried at room temperature of 30 ± 1 °C. The leafy portions of the dried samples were pulverized and set aside for subsequent ether extraction.

Extraction

Pulverized sample (100 g) of the dried leafy part of each plant material was weighed separately and macerated with 1 L of petroleum ether at a temperature of 30 °C for forty-eight hours. The organic phase was filtered and the ether phase was concentrated to obtain the oil residues. The fatty acids in the extracted oil were trans-methylated by refluxing in acidified methanol.

Trans-methylation

Exactly 0.10 g of the oil was weighted into 10 mL of a fresh solution of 0.20 mol/L H_2SO_4 prepared in methanol. The mixture was tightly sealed and placed in a Water bath at 70 °C for 2 hours under reflux. Afterward, the test tubes were allowed to cool at room temperature. Exactly 10 mL of petroleum ether was added gently. The upper layer containing the methyl esters were carefully separated and transferred into a vial for subsequent gas chromatography analysis.

Instrumentation

Gas chromatography analysis was performed using Agilent Technologies GC-FID (flame-ionization detection) (Model 7890) equipped with Agilent 19091S-433HP-5MS 5% Phenyl Methyl Silox column (30 m×250 μm×film thickness 0.25 μm). Helium was used as carrier gas at a constant rate of 1.5 mL/min. The temperature of the injector and FID was 250 °C. The individual fatty acid was identified by comparison of their respective retention times with that of the internal standards which were prepared by methylation similar to the sample preparation.

Results and discussion

The results of identified fatty acid constituents of the dried leaves of *B. pinnatum* Lam., *F. exasperata* Vahl., *G. herbaceum* Linn. and *H. latifolia* (Lam.) H. Walt and their Kováts retention indices are presented in tables 1 to 3 while the chromatograms of the gas chromatography are presented in figures 1 to 4. A total of three saturated (myristic acid, palmitic acid, and stearic acid) and two unsaturated fatty acids (oleic acid and linoleic acid) were identified in the ether extract of *B. pinnatum* by relative retention times paralleled to those of the standards. The main fatty acid was palmitic acid. This was followed by oleic acid (0.29%) and linoleic acid (0.23%). Fatty acids with the hydrocarbon chain length shorter than Carbon 13 and longer than Carbon 20 were not identified in the ether extract of *B. pinnatum.*

Corresponding observation was found in the fatty acid profile of the ether extract of the leaves of *F. exasperata*. The total content of stearic acid in the ether extract of *F. exasperata* was 0.04% w/w. Stearic acid was the only identified saturated fatty acid in *F. exasperata* (table 2). The most abundant unsaturated fatty acid identified was oleic acid (0.03%) followed by linoleic acid (0.01%). Fatty acids with carbon chains shorter than 16 or longer than 20 were not detected in the ether extract of *F. exasperata* not even in trace amounts. The dominant fatty acid in the ether extract of *G. herbaceum* was lauric acid (0.44%). The most distinct comparison among the plant species was observed in the contents of *F. exasperata* and *G. herbaceum* excluding that *G. herbaceum* contained lauric acid. The ether extract of *H. latifolia* was rich in polyunsaturated fatty acids, constituting 68.73% of the analyzed fatty acids. The major unsaturated fatty acid in the ether extract of *H. latifolia* was oleic acid (41.04%w/w) (table 3). Stearic acid, a saturated fatty acid, was the second most abundant fatty acid comprising 25.56 %w/w of the ether extract. Moreover, *H. latifolia* was the only analyzed plant material that contained pentadecanoic acid and lignoceric acid (table 2).

Table 1. Retention indices of fatty acids in ether extracts from dried leaves of *B. pinnatum* Lam., *F. exasperata* Vahl., *G. herbaceum* Linn. and *H. latifolia* (Lam.) H. Walt.

	B. pinnatum	***F. exasperata***	***G. herbaceum***	***H. latifolia***
Saturated fatty acids				
Lauric acid	-	-	1117	1119
Tridecanoic acid	-	-	-	-
Myristic acid	1312	-	-	-
Pentadecanoic acid	-	-	-	1401
Palmitic acid	1513			
Stearic acid	1701	1698	1700	1699
Arachidic acid	-	-	-	1667
Behenic acid	-	-	-	
Tricosanoic acid	-	-	-	
Lignoceric acid	-	-	-	2055
Unsaturated fatty acids				
Oleic acid	2185	2183	2183	2182
Linoleic acid	2284	2281	2278	2279

Table 2. Percentage composition of saturated fatty acids in ether extracts from dried leaves of *B. pinnatum* Lam., *F. exasperata* Vahl., *G. herbaceum* Linn. and *H. latifolia* (Lam.) H. Walt.

		B. pinnatum	*F. exasperata*	*G. herbaceum*	*H. latifolia*
Lauric acid	C12:0	-	-	0.44	1.05
Tridecanoic acid	C13:0	-	-	-	-
Myristic acid	C14:0	0.06	-	-	-
Pentadecanoic acid	C15:0	-	-	-	1.13
Palmitic acid	C16:0	0.30	-	-	-
Stearic acid	C18:0	0.17	0.04	0.03	25.56
Arachidic acid	C20:0	-	-	-	0.15
Behenic acid	C22:0	-	-	-	-
Tricosanoic acid	C23:0	-	-	-	-
Lignoceric acid	C24:0	-	-	-	0.07
Total		0.53	0.04	0.47	27.96

Table 3. Percentage composition of unsaturated fatty acids in ether extracts from dried leaves of *B. pinnatum* Lam., *F. exasperata* Vahl., *G. herbaceum* Linn. and *H. latifolia* (Lam.) H. Walt.

		B. pinnatum	F. exasperata	*G. herbaceum*	*H. latifolia*
Oleic acid	C18:1 cis-9	0.29	0.03	0.03	41.04
Linoleic acid	C18:2 cis-9, 12	0.23	0.01	0.02	20.41
Total		0.52	0.04	0.05	61.45

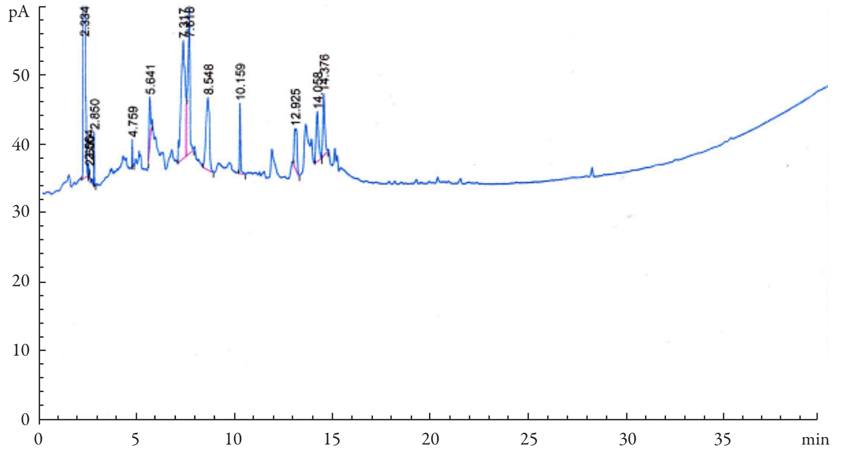

Figure 1. Gas chromatogram of ether extract of the dried leaves of *B. pinnatum* Lam.

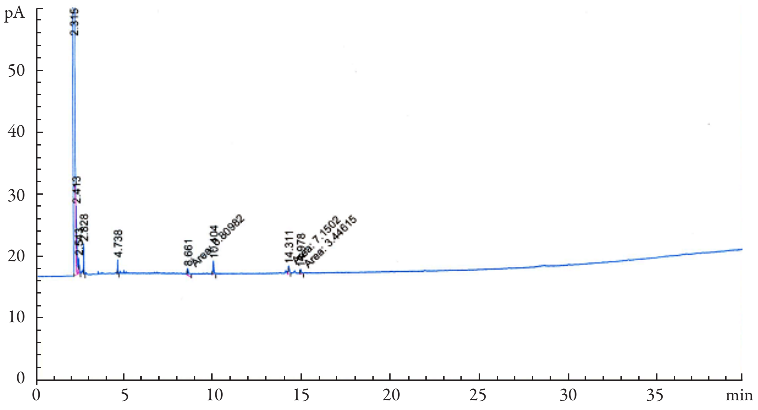

Figure 2. Gas chromatogram of ether extract of the dried leaves of *F. exasperata* Vahl.

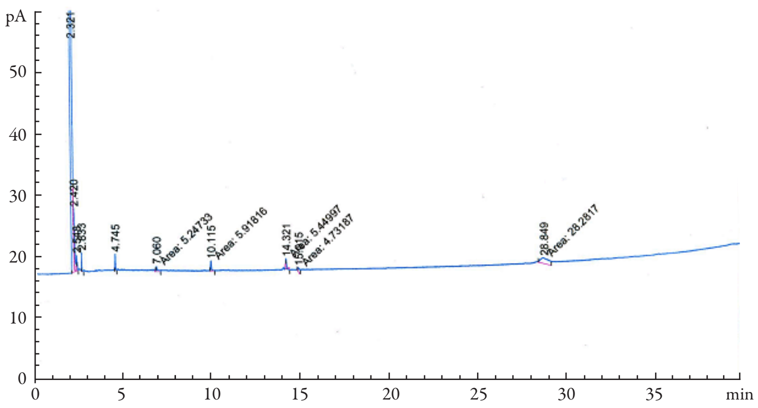

Figure 3. Gas chromatogram of ether extract of the dried leaves of *G. herbaceum* Linn.

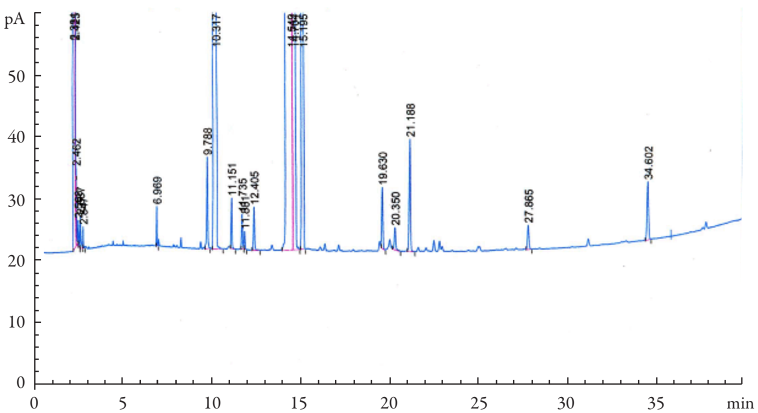

Figure 4. Gas chromatogram of ether extract of the dried leaves of *H. latifolia* (Lam.) H. Walt.

The fatty acid profile of ether extract of *B. pinnatum* presented a high amount of palmitic acid, accounting for 28.57% of the identified fatty acids; oleic acid and linoleic acid were also detected, though, at low concentration. These fatty acids have significant importance in the human diet. Oral administration of the aqueous extract of *B. pinnatum* has been found to have moderately low renal and testicular toxicities [16]. The extract had also been shown to prevent the formation of renal calculi in Lithiatic Rats [17]. However, the probable nutritional benefit should be interpreted with caution due to its contradictory report on cardiac poisoning in grazing animals [18, 19].

The fatty acid profile of the ether extract of *F. exasperata* presented a small amount of stearic acid, linoleic acid, and oleic acid. There have been reports on the traditional use of *F. exasperata* in the management of various ailments including high blood pressure and diabetes and studies validating these claims are on the increase [20-23]; these acclaimed benefits could be associated with the presence of alkaloids, cardiac glycosides, flavonoids, saponins and tannins which had been reported to be present in the plant [24]. The amount of the fatty acid compositions reported in this study could entail that *F. exasperata* might not be a suitable source of fatty acids. Approximately, matching observation was found in the fatty acid profiling of *G. herbaceum,* exclusive of the presence of lauric acid, a fatty acid which had been shown to have a favorable effect on total high-density lipoprotein-cholesterol [25]. In contrast, *H. latifolia* was characterized by exceedingly high percentages of stearic acid, oleic acid and linoleic acid with slight concentrations of pentadecanoic acid, arachidic acid, and lignoceric acid. *H. latifolia* contained the highest amounts of stearic acid, oleic acid, and linoleic acid among the screened plant samples. Its fatty acid profile was quite comparable with coconut oil and peanut oil of high economic values [26, 27]. The results further indicated that *H. latifolia* contained the most balanced ether extract among the analyzed samples as dietary and healthy oils, as it has the most complete profile of fatty acids and the highest concentration of unsaturated fatty acids. Stearic acid accounts for 25.56% of the extract from *H. latifolia* indicating the potential use of the in industrial applications.

The quality of any oils is quantified by the quantity and composition of unsaturated fatty acids, usually oleic and linoleic acids. In fatty acid synthesis, oleic acid is a precursor to linoleic acid. Linoleic acid was in abundance in the leaf of *H. latifolia* although to a lesser extent than oleic acid. Such a relation between oleic acid and linoleic acid had been reported from the studies of the oils obtained from pitanga seeds and peanut [28, 29]. The higher amount of oleic acid with respect to linoleic acid suggests the better-quality of oil from *H. latifolia* with reference to improved shelf life and enhanced flavor. This is because linoleic acid could be more susceptible to oxidative degradation than oleic acid, its more saturated counterpart [30]. The reduced susceptibility of oleic acid to oxidation correspondingly suggests the propensity for its application in the food and cosmetic industries. Besides, oleic acid has been reported to be linked with many beneficial health effects. These include lowering serum lipoprotein levels and blood pressure [31, 32]. Furthermore, oleic acid has been suggested to have immune- mediating properties and anti-inflammatory effects and could enhance insulin production in rat [33-35]. This could suggest the prospective nutritious benefits of *H. latifolia*. Also, high concentrations of the investigated fatty acids could indicate that this *H. latifolia* has a high potential as a source of quality oil which may perhaps complement the existing ones. According to this finding, the *H. latifolia* oil may be a good source of oleic acid and hence it might be valuable for nutritional and pharmaceutical applications.

Conclusion

This study established that the botanicals contain varying amounts of the identified fatty acids. However, the quantity and quality of ether extract of *H. latifolia* were found to be quite comparable with the fatty acid compositions of oils of high economic values such as coconut oil and peanut oil. However, this study was limited to the identification of fatty acid compositions with regard to a few standards. Properties of the refined oil from *H. latifolia* such as color, taste, smell, physicochemical properties, and potential toxicity are therefore suggested to endorse its suitability for human consumption as well as industrial and pharmaceutical applications.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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