



A Chemotaxonomic Approach to the Fatty Acid Content of Some *Acacia* Taxa from Central Sudan

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Abstract

The aim of the present study was to evaluate the composition of fatty acids of mature seeds of some *Acacia* taxa (*Acacia mellifera*, *A. nilotica* ssp. *adansonia*, *A. nilotica* ssp. *nilotica*, *A. oerfota*, *A. polyacantha* ssp. *campylacantha*, *A. enegal* var. *senegal*, *A. seyal* var. *seyal* and *A. sieberiana* var. *sieberiana*) from Central Sudan in order to reveal their potential classification to be used as taxonomic markers. Results showed that *Acacia* seed oils were mainly unsaturated fatty acids ranging in content between 51.20% to 86.90%, whereas, saturated fatty acids ranged between 12.49% to 48.80%. Oleic acid was the major fatty acid 24.24% - 80.19%, followed by linoleic (5.70% - 58.73%). Palmitic acid was the dominant saturated fatty acid 12.39% - 19.2%, followed by stearic acid 0.0% - 34.52%. The results showed some relationships between the *Acacia* taxa with respect to fatty acid contents. *Acacia* seed oils showed a remarkable uniformity in terms of their higher content of oleic acid and linoleic acid. It is proposed that this can be of chemo-taxonomical interest and their quantities may indicate closer or more distant relationships between the considered taxa. The highest degree of pairing affinity was observed between *A. oerfota* and *A. mellifera* (92.58%), followed by *A. oerfota* and *A. sieberiana* (89.93%) and between *A. niloticas* sp. *adansonia* and *A. sieberiana* (88.54%). Hence it is suggested that *A. mellifera* and *A. sieberiana* are the most closely related, as also *A. oerfota* and *A. senegal*.

Keywords

Fatty Acid Profile, *Acacia* Taxa, Taxonomic Marker, Pairing Affinity, Seeds, Sudan

Subject Areas: Plant Science

1. Introduction

Seed oils of plants of Leguminosae have been investigated and it has attracted interests of researchers [1]-[7].

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But, very scant information is available on the fatty acid composition of *Acacia* genus, particularly in Sudan. Variation in oil content and fatty acid composition of the seed oil of *Acacia* species collected from the northwest zone of India were observed by Khan *et al.*, 2012 [8]. Content and composition of fatty acids of seed lipids can serve as taxonomic markers in higher plants [9]-[12].

Seed oils with a substantial amount of very long chain of fatty acids have attracted attention because of their value for industrial purposes. Furthermore, these compounds can be of chemotaxonomic significance [13].

The aim of this study is to identify and differentiate some *Acacia* taxa with respect to fatty acid content. In order to achieve this goal, the following objectives were set 1) Quantitative determination of fatty acids from seed oil by Gas Chromatography; 2) Evaluation of pairing affinity (or similarity Index) between eight interrelated taxa of studies *Acacia* based on fatty acid composition of seeds as taxonomic markers.

2. Materials and Methods

2.1. Materials

Acacia under study (8 taxa): *Acacia mellifera*, *A. niloticas* sp. *adansonia*, *A. nilotica* ssp. *nilotica*, *A. oerfota*, *A. polycantha* ssp. *campylacantha*, *A. senegal* var. *senegal*, *A. seyal* var. *seyal* and *A. sieberiana* var. *sieberiana*.

The voucher specimens were kept at Herbarium of Botany Department, Faculty of Science and Technology, Omdurman Islamic University. The identification of the studied taxa was done according to AL-Amin, 1990 [14].

2.2. Seeds Collection

The taxa under investigation were brought from Soba Research Centre, Khartoum. Seeds were collected from various areas of West Sudan. These seeds were identified by the plant taxonomist of Soba Research Forests, Ustaz Hassan Al-Bager, Ministry of Science and Technology, Khartoum.

2.3. Fatty Acids Content

2.3.1. Preparation of Methyl Ester for Gas Chromatography

Seed oils were extracted from *Acacia* taxa studied according to Official Method of Analysis (AOAC) (1984) [15]. Fatty acids were determined according to Christie (1990) [16]. The samples were prepared by dissolving 1 ml of oil from each sample in eight round-bottomed flasks (100 ml) in 6 ml of 0.5 M NaOH (Methanolic) and shaken well. Then, 6 ml of 1% methanolic H₂SO₄ was added and shaken well, after that the mixture left overnight at 50°C. Two ml. n-hexane were added and shaken. Enough saturated sodium chloride was added to level of the neck flask. 1 ml of the upper layer was taken into a glass stoppered tube. Then, anhydrous Sodium sulphate were added to 1 ml n-hexane to remove the moisture. The top n-hexane phase was transferred into a vial and injected into Gas Chromatograph equipped with the capillary column.

2.3.2. Conditions for GC

Ashimadz (GC-2010) Gas chromatograph apparatus (Japan).

Sample volume (inj)	0.5 ml
Column	PEGA 10%.
Column temp	240°C.
Injection	280°C.
Detection	220°C.
Carrier gas	Nitrogen
Flow rate	1.5 ml/min.
Attenuation	16 × 10.
Detector	FID (flame ionization detector).
Chart speed	1u n/mw

2.4. Pairing Affinity (PA) Values between Studied Taxa of *Acacia* Seeds Based on Distribution of Fatty Acids

The method of Pairing Affinity (or similarity Index) described by Sokal and Sneath (1963) [17] was used to analyze the data of fatty acid composition and determine the Pairing Affinity (PA) between the two taxa of *Acacia* species. The degree of Pairing Affinity between the two taxa was calculated according to the following formula:

$$\text{Pairing Affinity (PA)} = \frac{\text{Fatty acids common to A to B}}{\text{Total Fatty acids in A and B}} \times 100$$

3. Results and Discussion

Fatty acids profile for n-hexane extract of seed oil from selected eight *Acacia* taxa (*Acacia mellifera*, *A. niloticas* sp., *Adansonia*, *A. nilotica* ssp. *nilotica*, *A. oerfota*, *A. polyacantha* ssp. *campylacantha*, *A. Senegal* var. *senegal*, *A. seyal* var. *seyal* and *A. sieberiana* var. *sieberiana*) were determined by using GC.

The fatty acids methyl ester composition of the studied taxa are shown in **Table 1**. The following fatty acids were identified: palmitic, stearic, oleic, linoleic and arachidonic acids. Six fatty acids detected were identified in *A. polyacantha*, five fatty acids were identified in *A. mellifera*, *A. oerfota*, *A. senegal* and *A. seyal*, four acids detected were identified in *A. nilotica* ssp. *nilotica* and three fatty acids detected were identified in *A. nilotica* ssp. *adansonia* and *A. sieberiana* var. *sieberiana*.

Table 2 shows that the total saturated fatty acids of eight *Acacia* taxa studied ranged between 12.4% to 48.80%. Lowest value noticed in *Acacia oerfota*, whereas the highest value obtained by *Acacia sieberiana*. Stearic acid in seed oil of *A. sieberiana* was the predominantly saturated fatty acids. On the other hand, the total of unsaturated fatty acids ranged between 51.20% to 86.90%. *A. sieberiana* got the lowest value, and the highest value gained by *Acacia oerfota* (81.19%). Oleic acid in seed oils of *A. mellifera* (63.45%) and *A. senegal* (60.80%) were the predominantly unsaturated fatty acids.

The chemotaxonomic importance and potential of fatty acids in this genus was confirmed by this study. Differences in fatty acid patterns illustrate some chemotaxonomic relationships between the genera members studied. Since the fatty acid patterns of *Acacia* taxa seed oils showed a remarkable uniformity in terms of their content, oleic-linoleic acid pattern, oleic-palmitic pattern and linoleic-stearic pattern. It is proposed that this can be of chemotaxonomical interest and their quantity may indicate closer or more distant relationships between the considered members of the genus. Our results on *Acacia* taxa, seed fatty acids are in good agreement with report of Bagci and Sahin, 2004 [18].

Acacia taxa can be classified according to unsaturated: saturated ratio as the following patterns: 1:1 pattern: *A. sieberiana*; 3:1 *A. seyal*; 4:1 *A. nilotica*, *A. polyacantha*, *A. Senegal*; 5:1 *A. mellifera* and 7:1 *A. oerfota*.

Table 1. Fatty acids methyl ester composition of eight *Acacia* taxa.

<i>Acacia</i> taxa	Palmitic acid C16:0	Stearic acid C18:0	Oleic acid C18:1	Linoleic acid C18:2	Arachidonic acid C20:0	Unidentified
<i>Acacia mellifera</i>	13.3630	-	63.4540	6.3620	1.513	15.3080
<i>Acacia nilotica</i> ssp. <i>Adansonia</i>	17.0127	-	24.2481	58.7392	-	-
<i>Acacia nilotica</i> ssp. <i>Nilotica</i>	15.4188	5.1125	26.9570	52.5117	-	-
<i>Acacia oerfota</i>	12.3940	-	80.1910	5.7040	1.0510	0.6610
<i>Acacia polyacantha</i> ssp. <i>Campylacantha</i>	14.1225	5.3630	37.8340	37.3476	5.0004	0.3326
<i>Acacia enegal</i>	19.2000	-	60.8000	14.9000	5.1000	0.0720
<i>Acacia seyal</i> var. <i>seyal</i>	15.2173	8.6405	32.0828	40.0736	3.9858	-
<i>Acacia sieberiana</i> var. <i>sieberiana</i>	14.2590	34.5233	-	51.2176	-	-

C: No of carbon atoms in fatty acids.

Fatty acids in *Acacia* taxa can also be classified according to some relationships as follows:

1) Linoleic-oleic type fatty acid pattern in *A. nilotica* ssp. *adansonia* (2:1), *A. nilotica* ssp. *Nilotica* (2:1), *A. seyal* var. *seyal* (1:1) and *A. polyacantha* ssp. *campylacantha*, (1:1).

2) Oleic-palmitic type:

A. mellifera (5:1), *A. oerfota* (6:1), *A. senegal* (3:1).

3) Linoleic-Stearic type: *A. sieberiana* var. *sieberiana* (1.5:1).

Since the fatty acids patterns of *Acacia* seed oils showed a remarkable uniformity in terms of their higher content of the oleic (except *A. sieberiana*) and Linoleic acids. It is proposed that this can be of chemotaxonomical interest and their quantity may indicate closer more distant relationships between the considered taxa of genus.

The results of pairing affinity between the eight taxa based on the results of free fatty acid analyses have been summarized in **Table 3**. Cluster pairing affinity (or similarity index) between eight interrelated studied taxa of *Acacia* genus was evaluated on the basis of fatty acid composition (**Table 1**) of seeds as taxonomic markers to assess the phylogenic interrelationships and plant affinity. Considerable amount of homology was observed in sub-species belonging to the same species.

The highest degree of pairing affinity between *A. oerfota* and *A. mellifera* (92.58%), followed by *A. oerfota* and *A. sieberiana* (89.93%), and between *A. nilotica* ssp. *adansonia* and *A. sieberiana* (88.54%). Hence *A. mellifera* and *A. sieberiana* are the most closely related, as also *A. oerfota* and *A. senegal*.

Table 2. Contents of total saturated and unsaturated fatty acids.

<i>Acacia</i> taxa	Total Saturated Fatty Acids	Total Unsaturated Fatty Acids
<i>Acacia mellifera</i>	13.4	71.3
<i>Acacia nilotica</i> ssp. <i>Adansonia</i>	17	83.0
<i>Acacia nilotica</i> ssp. <i>Nilotica</i>	20.5	79.5
<i>Acacia oerfota</i>	12.4	86.9
<i>Acacia polyacantha</i> ssp. <i>campylacantha</i>	19.5	80.2
<i>Acacia Senegal</i>	19.2	80.8
<i>Acacia seyal</i> var. <i>seyal</i>	23.9	72.2
<i>Acacia sieberiana</i> var. <i>sieberiana</i>	48.8	51.2

Table 3. Results of pairing affinity between the eight taxa based on of fatty acids content.

	<i>A. nilotica</i> ssp. <i>nilotica</i>	<i>A. sieberiana</i> var. <i>sieberiana</i>	<i>A. mellifera</i>	<i>A. polyacantha</i> spp. <i>campylacantha</i>	<i>A. senegal</i> var. <i>senegal</i>	<i>A. seyal</i> var. <i>seyal</i>	<i>A. oerfota</i>	<i>A. nilotica</i> ssp. <i>Adansonia</i>
<i>A. nilotica</i> ssp. <i>nilotica</i>	100	82.61	84.62	77.45	79.76	75.81	86.77	81.23
<i>A. sieberiana</i> var. <i>sieberiana</i>		100	88.02	80.60	82.90	78.95	89.93	84.36
<i>A. mellifera</i>			100	82.45	84.94	80.66	92.58	86.52
<i>A. polyacantha</i> spp. <i>campylacantha</i>				100	77.75	73.79	84.75	79.16
<i>A. Senegal</i> var. <i>senegal</i>					100	76.11	87.69	81.52
<i>A. seyal</i> var. <i>seyal</i>						100	83.08	77.57
<i>A. oerfota</i>							100	88.54
<i>A. nilotica</i> ssp. <i>adansonia</i>								100

The high oleic fatty acid was extracted from *Acacia oerfota* seed oil (80.19%), *A. mellifera* (63.45%) and in *A. Senegal* var. *senegal* strongly indicates its prospects for commercial extraction.

A number of studies suggest that the unsaturated fatty acid component of Leguminosae seed oils resemble each other and oleic and linoleic acids were the main components in seed oil.

4. Conclusion

Acacia species are the potential renewable natural resources in Africa, including Sudan. The identification of the fatty acids will be of great help to understand the importance of the seeds of these species to humanity and the chemotaxonomic affinity of the studied taxa. It was concluded from this study that *Acacia* taxa could be classified according to their fatty acid composition to unsaturated and saturated ratio or might be classified according to fatty acid pattern (linoleic acid-oleic acid type, oleic-palmitic type and linoleic-stearic type). The highest degree of pairing affinity was between *Acacia oerfota* and *A. mellifera* (92.58%) and between *A. oerfota* and *A. sieberiana* (89.93%). The patterns of distribution of genetic diversity among populations of these taxa should be examined for future breeding programmes.

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