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Determination of Flavonoids in Sudanese Honey Samples and Plant Sources Collected from Different Places in Sudan

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Abstract – **This investigation was carried out, for the determination of plant source and flavonoids in some honey samples collected from different localities of Sudan depending on pollen grains mixed with honey. Honey samples were prepared by worm water, acetolysis method, stained with basic fuchsine and suspended in glycerin for microscopic examination .Pollen grains were compared with those of similar pollen with other references .The predominant plant species in the honey samples from Damazeen was *Azadirachta indica,* Gabl Abu-Garin *Hyphaena tobacco*, Sinnar Wad Hashim, Alfaw and Tallha forests: *Helianthus annus*. In Eldewaim: *Ziziphus spina-christi*. In Gaddarif: *Acacia seyal* var *seyal* and in Khartoum: *Medicago sativa* were the source of pollen in the honey samples. For the determination of flavonoids concentration, HPLC was used. Some standards like Hesperetin, Queretin, Kaempferol, Apigenin and Isorhamnetin were used. In a honey sample of Gable Abugarin, two types of flavonoids were detected: Querctrin 6.8 mg/100g and Kaempfrol 1.5 mg/100g.In the honey sample of Tallha area, the Hesperetin 1.97 mg/100g was detected. Gaddarif area: Isorhamnetin 1.217 mg/100g was detected and Khartoum: Isorhamnetin 0.904 mg/100g was detected. In honey samples of Sinnar-Wad Hashim, Eldewaim, AL-faw areas some Peaks of flavonoids were encountered in small concentration but not detected because of the apparent shortness of their detectors. In a honey sample of Eldamazeen flavonoids were not detected.**

Keyword – **Determination, Flavonoids, Plant Sources, Honey, Sample and Areas.**

I. INTRODUCTION

Honey is the most important primary product of beekeeping quantities, from both a quantitative and an economic point of view. It was also the first bee product used by humankind in ancient times. The history of the use of honey is parallel to the history of man. It is the natural sweet substance produced by honey bees from the nectar of blossoms or from secretions of living parts of plants. Honey bees make honey to use and store as food, and humans exploited these trails. It was probably discovered by humans tasting the sweet substance in honeycombs from the hollows of a tree, log, or cave. Thus, it is one of the earliest forms of sweeteners and long precedes the use of cane and beet sugar [1]. Beekeeping for the purpose of obtaining honey is an ancient art, at least as early as the Egyptians (2000-5000 years ago) who used honey in medicine, and nutrition. The chemical composition of honey is complex, and according to the earlier report [2]. It contains about 181substances, including sugars, proteins moisture, vitamins, minerals, hydroxymethylfurfural (HMF), enzymes, flavonoids, phenolic acids, volatile compounds etc., However, the main constituents of honey are moisturized, glucose, fructose, sucrose, minerals, and proteins [3]. The antioxidant properties of honey are well known, because it contains a number of compounds with antioxidant properties such as flavonoids, phenolic acids, proteins, amino acids, ascorbic acid, HMF, and some enzymes [4]. The most important classes of antioxidant polyphenols are the flavonoids and phenolic acids; it is these substances in tea, wine, fruits and vegetables that are most responsible for the antioxidant characteristics, and thus the healthy image of these foods. Flavonoids are widely distributed in plants fulfilling many functions. Flavonoides are the most important plant pigments for flower coloration producing yellow or red/blue pigmentation in petals. Those colors are a mean to attract pollinator animals. Flavonoides secreted by the root of their host plant help *Rhizobia* in the infection stage of their symbiotic relationship with legumes like peas, beans, clover, and soy. Rhizobia living in soil are able to sense the flavonoids and this triggers the secretion of nod factors, which in turn are recognized by the host plant and can lead to root hair deformation and several cellular responses such as ion fluxes and the formation of a root nodule They also protect plants from attacks by microbes, fungi and insects [5]. Flavonoides such as the catechins are the most common group of polyphenolic compounds in the human diet and are found ubiquitously in plants [6]. Sudan, the largest country in Africa, with its different climatic conditions ranging from Sahara and sub-Sahara, savannah and tropical regions possesses a tremendous wealth of terrestrial plants which contribute to the economy of the country. Medicinal plants represent an important part of these resources with great potentialities and research in this field is encouraged by different institutions in public and private sectors. Sudanese floral honey in the last decades gained a solid ground and interest in the field of commerce and research, but the available honey products of different origins lack documentation in the literature about their composition and properties. The present research was undertaken Due to the lack of scientific researches and information about of flavonoids and plant sources of some honey bee to determine the flavonoids in some Sudanese honey.

Samples and the botanical origin of some Sudanese honey from different places in Sudan

II. Materials and Methods

Experimental

Honey samples: Most of the samples were collected from various locations situated in different geographical regions of the Sudan. The honey samples namely, Blue Nile State, Sinnar State, White Nile State, Gaddarif State and Khartoum State.

1. Blue Nile State: Eldamazeen town denoted as A1 and Gable Abu-Garin denoted as A2.

2. Sinnar State: One sample from apiary of Ministry of Forests wad Hashim denoted as B.

3. White Nile State: Apiary of the Faculty Agriculture and Natural Resources, University of Bakht Al-Ruda-Eldueim denoted as C1 and Tallha forest denoted as C2.

4. Gaddarif State: Faw area denoted as D1 and Gaddarif town denoted as D2.

5. Khartoum State: One sample from the Apiary of the Faculty of Agriculture University of Khartoum denoted as E.

Methodology:

1. Pollen grain analysis of honey: Ten grams of honey from a well shaken reserve-stock was taken from each honey sample and diluted with warm water, centrifuged and the supernatant liquid was decanted.

2. Acetolysis Technique: The pollen grain was extracted from the honey sample according to the standard acetolysis method of [7].Five ml of glacial acetic acid, was added to the pollen residue, centrifuged and decanted. The acetolysis mixture 9ml acetic anhydride and 1ml cons. Sulfuric acid was added to the pollen residue in drops, kept in a water bath for 15 minutes, centrifuged and decanted.

3. Staining: The pollen grains were stained with basic fuchsine.

4. Mounting: The pollen grains were suspended in glycerin and reserved in plastic vials from which sub-samples were taken for microscopic examination. One or two drops of the pollen suspension were mixed with one drop of glycerol gel in a glass slide; the cover slide was sealed with fingernail polish.

5. Microscopic examination: The prepared voucher slide was examined under the high power using magnification X400 was used for counting the number of pollen grains per each prepared slide.

6. Pollen identification: The identification of various pollen grains in each voucher slide was undertaken with the aid of the identification keys and pollen photomicrographs presented by El Ghazali [8] and [9]. Identification of pollen grains was confirmed by comparing them with pollen reference collection deposited at the Botany Department Faculty of Science, University of Khartoum. Sudan.

7. Pollen frequencies: The pollen classification used for expressing pollen grains frequencies was that of [10].

1- Very frequent or predominant pollen (more than 45%).
2- Frequent or secondary pollen (16 – 45%).
3- Rare or important minor pollen (3-15%).
4- Sporadic or minor pollen (less than 3%).

Flavonoids analysis:

1. Solvents and chemicals:

- Acetonitrile HPLC grade (99.8%), from Scharlau / Spain.
- Methanol HPLC grade (99.9%), from Scharlau / Spain.
- Apigenin HPLC grade – from Applichem / Germany.
- Hesperetin HPLC grade – from Applichem / Germany.
- Isorhamnetin HPLC grade – from Applichem / Germany.
- Quercetin HPLC grade – from Applichem / Germany.
- All other chemicals used were either of analytical grade or general purpose reagents.

2. Preparation of standards: The stock solution (1000 µg/ml) for each standard was prepared by weighing 25 mg of standard, dissolved in methanol (in acetonitrile for kaempferol) and the volume completed to 25 ml in a volumetric flask with methanol. The working standard solutions were prepared by diluting the stock solution (1000 µg/ml) to contain concentrations 2.5 µg/ml, 50 µg/ml and 100 µg/ml for quercetin, and 5 µg/ml, 25 µg/ml, 50 µg/ml and 100 µg/ml for each of kaempferol, hesperetin, apigenin and isorhamnetin.

3. Preparation of honey sample: Five grams of each honey sample were dissolved in 10 ml deionized water, adjusted to pH 2 with HCl (1N), and passed through the solid phase extraction (SPE) Column (C18) - 500 mg.

4. Solid phase extraction procedure:

Column preparation: The C18 column was rinsed with 3 ml methanol HPLC grade + 3 ml acetonitrile (HPLC grade) + 3 ml deionized water at a flow rate 1 ml/min (9 ml of this solvent in 9 min), the column was then rinsed with 3 ml of deionized water (at pH = 2) +10ml of deionized water at a flow rate 1 ml/min (13 ml of this solvent in 13 min.).

5. Sample purification or cleanup process: Samples were applied on top of the column and the solvents were drawn through the column bed by a syringe. The column was washed with 3 ml deionized water (at pH = 2) + 10 ml Deionized water at 1 ml/min flow rate. The adsorbed materials were then collected by 2 ml methanol (HPLC grade) + 1 ml acetonitrile HPLC grade) at 1 ml/min flow rate. The samples were filtered through a 0.45 µm membrane syringe filter, and collected in a 10 ml glass vial, and kept in the refrigerator for HPLC analysis.

6. HPLC conditions: The chromatographic separation was conducted using an isocratic and gradient systems.

7. The gradient system: The standard mixtures (50 µL from each standard) and the cleaned honey samples were analyzed using waters (600) HPLC linked with a computer-controlled system. Sample (20 µL) was injected using a manual injector. The flavonoids were detected using a water (2996) photodiode array detector (PDA), the column used was a reversed phase C18 column (15 cm x 0.46 cm). For analysis by (PDA) detection, UV spectra were recorded from 210 - 400 NM at a resolution 1.2 NM. In particular, the chromatograms were monitored at 340

NM and 290 NM. The mobile phase was composed of 5% acetic acid in deionized water (solvent A*), and acetonitrile HPLC grade (solvent B**), at a constant solvent flow rate1 ml/min. * Solvent A = 5% acetic acid in deionized water. ** Solvent B = Acetonitrile HPLC grade (99.8%). The following gradient was used: The gradient system, Table I.

The isocratic system the mobile phase was composed of 5% acetic acid in deionized water (solvent A*), and methanol HPLC grade (solvent B**), at a flow rate 1.5 ml/min.*Solvent (A) = 65%. **Solvent (B) = 35%.

8. Identification and quantification of flavonoids in honey sample extracts:

The mentioned flavonoids were identified and quantified according to the gradient system. In order to identify each peak in the chromatograms of honey extracts, retention times of all peaks were compared with those of flavonoids standards. The flavonoids were quantified using the external standard method (Three to five working standards of quercetin, hesperetin, kaempferol, apigenin and isorhamnetin). A plot of peak heights against concentration of each standard was done. Regression analysis data were obtained. The standards (quercetin, kaempferol, apigenin and isorhamnetin) were recorded at 340 NM, while hesperetin was recorded at 290 NM. The flavonoids were quantified against their respective standards.

III. Results and Discussion

1. Pollen Grain Content:

Pollen types were encountered in the eight honey samples collected from different localities in Sudan. The various pollen types identified up to various taxonomic levels are depicting in Table II. The results showed that the total pollen grains were 437 Damazeen areas, 288 Gable Abu-grain, 214 Wad hashim, 97 Eldewaim, 94 Alfaw, 67 Gaddarif, 56 Khartoum and the lowest total from Talha area 22 Table III. The total means of pollen grains were 87.4 Damazeen areas , 58 Gable Abu-grain, 42.8 Wad Hashim, 19.4 Eldewaim, 4.4 Talha area, 18.8alpha, 13.4 Gaddarif and 11.2 Khartoum Table IV and Figure I.

The most important families were detected in honey samples are:

- Damazeen area: Meliaceae *Azadirachta indica* (Neem local name).
- Gable Abu Garin: Arecaceae *Hyphaene thebaica* (Doum local name).
- Sinnar Wad hashim, Talha area, Alfaw area Asteraceae *Helianthus annus* (Sun flower).
- Eldewaim: Rhamnaceae *Ziziphus spina-christi* (Sider local name).
- Gaddarif: Mimosaceae *Acacia seyal var seyal* (Sunt local name).
- Khartoum: Fabaceae *Medicago sativa* (Alfalfa).

Table V and Figures (II, III, IV, V, VI, VII, VIII, IX and X) and plates (I, II, III, IV, V, VI, VII and VII).

2. Flavonoids analyses:

Identification and quantification of honey flavonoids were done using High Performance Liquid Chromatography (HPLC) with photo diode array detector (PDA) at 290 nm for Hesperetin and 340 nm for Queretin, Kaempferol, Apigenin and Isorhamnetin Table VI. In honey sample of Gable Abu-garin two types of flavonoides were detected; Querctrin 6.8 mg/100g and Kaempfrol 1.5 mg/100g.In honey sample of Talha area the Hesperetin 1.97 mg/100g was detected, Gaddarif area and Khartoum Isorhamnetin was detected in concentrations 1.217 mg/100g and 0.904 mg/100g respectively. In honey samples of Sinnar Wad Hashim, Eldewaim, AL-faw area some peaks of flavonoids were encountered in small concentrations but not detected because of the apparent shortness of their detectors. In honey sample of Eldamazeen no flavonoids were detected.

Eight honey samples examined from the different localities in Sudan. Forty – one Pollen families were identified out of these samples examined. In Nigeria 50 and 56 pollen grains were identified in 6 and 7 honey samples respectively [11] and [12]. These studies clearly demonstrated the relatively higher number of pollen families revealed from Nigeria (Tropical West African Country) honey samples compared to the Sudanese ones, which may be attributed to differences in the vegetation cover, environmental conditions or even to the activity of various honey bee species. In Sudanese honey, the highest number of pollen grains of the Eldamazeen honey sample was 437, in Nigerian honey, the highest number were 42 [11] and 29 [12]. The number of pollen grains identified from each of the honey samples may vary not only between samples of different regions, but also the variation may be within the same region. In honey sample of Damazeen area the families: Meliaceae, Mimosaceae and Malvaceae were contributed and the honey sample of Gable Abu garin the families were Asteraceae, Areaceae and Poaceae, although they are in the same area but are different in their families. The potential pollen load in the Khartoum honey sample was four families were detected: Fabaceae *Medicago sativa*, Convolvulaceae *Ipomoea cordofana* Malvaceae and Mimosaceae. In Sinnar Wad Hashim honey sample three families were reported, Mimosaceae, Asteraceae and Poaceae. Eldewaim honey sample include three families: Mimosaceae, Asteraceae and Poaceae. In Talha area honey sample showed three families were detected Meliaceae, Mimosaceae and Asteraceae. In Alfaw area three families were found Mimosaceae, Asterceae and *Justicia straiata*. Gaddarif sample has two families Mimosaceae *Acaicia seyal* and Acanthaceae. All the honey sampling sites of the present study are located in low Rainfall woodland savanna. This finding agrees with the results obtained by Andorews [13] and [14].The most important families were contributed in honey samples with their identified and quantified flavonoids as follows:

- Damazeen area: Meliaceae *Azadirachta indica* (Neem) with no flavonoids.
- Gable Abu garin: Arecaceae *Hyphaene thebaica* (Doum) with flavonoids Querctrin 6.8 mg/100g and Kaempfrol 1.5 mg/100g.

- Talha area: Asteraceae *Helianthus annus* (Sunflower). With flavonoids Hesperetin 1.97 mg/100g,
- Alfaw area and Sinnar Wad hashim Asteraceae *Helianthus annus* (Sunflower) with some beaks of flavonoids were encountered in small concentrations but not detected because of the apparent shortness of their detectors.
- Eldewaim: Rhamnaceae *Ziziphus spina-christi* (Sider).
- Gaddarif: Mimosaceae *Acacia seyal var seyal* (Sunt) with flavonoides Isorhamnetin 1.217 mg/100g.
- Khartoum: Fabaceae *Medicago sativa* (Alfalfa) with flavonoids Isorhamnetin 0.904 mg/100g.

This finding agree with the results obtained by El-Ghazali [15] who reported that flavonoids were found in families Fabiaceae *Medicago sativa*, Rhamnacea Hyphaene thebaica, Ziziphus spina-christi, Meliaceae Azadirachta indica, Mimosaceae Acacia nilotica.

IV. Conclusion

- The results showed that the total pollen grains were: 437, 288, 214, 97, 94, 67, 56 and 22 in Damazeen, Gable Abu-garin, Wad hashim, Eldewaim, Alfaw, Gaddarif, Khartoum and Talha area respectively.
- The family Mimosaceae was the most prevalent or dominant in honey samples.
- Two types of flavonoids (Querctrin 6.8 mg/100g and Kaempfrol 1.5 mg/100g) were detected in Gable Abu-garin sample, and in honey sample of Talha area the Hesperetin 1.97 mg/100g was detected, Gaddarif area and Khartoum Isorhamnetin was detected in concentrations 1.217 mg/100g and 0.904 mg/100g respectively.
- In honey samples of Wad Hashim, Eldewaim and AL-faw area flavonoids were found in low concentrations.

Recommendations

1- Any locality should be covered every month or every season to cover seasonal variations through all year round.
2- The limited samples of the Sudanese honeys should be verified by collecting more samples.
3- Honey sample of Damazeen *Azadirachta indica* should be verified without flavonoids.
4- Honey samples of Wad hashim, Eldewaim and Al-faw should be verified by obtaining and providing a wide range of flavonoids standards.

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Table I: The following gradient was used: The gradient system

Time, min.	Flow, mL/ min.	A, %	B, %
Initial	1:00	95	5
15	1:00	85	15
25	1:00	85	15
40	1:00	78	22
70	1:00	78	22
80	1:00	75	25
90	1:00	95	5

Table II: Number of pollen content and plant species of eight honey samples collected from different locations in Sudan

Families	A1	A2	B	C1	C2	D1	D2	E	Total
Meliaceae *Azadirachta indica*	426	0	0	0	5	0	0	0	431
Mimosaceae *Acacia spp*	9	0	4	2	1	4	0	1	21
Mimosaceae *seyal* var *seyal Acacia*	0	0	0	0	0	0	60	0	60
Malvaceae	2	0	0	0	0	0	0	3	5
Asteraceae	0	13	0	0	0	0	0	0	13
Asteraceae *Helianthus annus*	0	0	207	0	16	53	0	0	276
Arecaceae *Hyphaene thebaica*	0	269	0	0	0	0	0	0	269
Poacae	0	6	3	0	0	0	0	0	9
Poacae *Sorghum bicolor*	0	0	0	14	0	0	0	0	14
Rhamnaceae *Ziziphusspina-christi*	0	0	0	81	0	0	0	0	81
Juticia striata	0	0	0	0	0	37	0	0	37
Acanthaceae	0	0	0	0	0	0	7	0	7
Convolvulacea *Ipomoea cordofana*	0	0	0	0	0	0	0	25	25
Fabaceae *Medicago sativa*	0	0	0	0	0	0	0	27	27
Total	437	288	214	97	22	94	67	56	1275
Mean	29.13	19.6	14.2	6.4	1.4	6.2	4.4	3.7	
±Sd	109.81	89.09	53.33	20.93	4.22	16.04	15.46	9.36	

A1- Eldamazeen
A2- Eldamazeen-Gable Abugarin
B- Sinnar-Wad Hashim
C1- Eldewaim
C2- Eldewaim-Talha area
D1- AL-faw area
D2- Gaddarif Area
E- Khartoum

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Table III: Means pollen content and plant species of eight honey samples collected from different locations in Sudan

Families	A1	A2	B	C1	C2	D1	D2	E
Meliaceae *Azadirachta indica*	85.2	0	0	0	1	0	0	0
Mimosaceae *Acacia spp*	1.8	0	0.8	0.4	0.2	0.8	0	0.2
Mimosaceae *Acacia seyal* var *seyal*	0	0	0	0	0	0	12	0
Malvaceae	0.4	0	0	0	0	0	0	0.6
Asteraceae	0	2.6	0	0	0	0	0	0
Asteraceae *Helianthus annus*	0	0	41.4	0	3.2	10.6	0	0
Arecaceae *Hyphaene thebaica*	0	53.8	0	0	0	0	0	0
Poacae	0	1.6	0.6	0	0	0	0	0
Poacae *Sorghum bicolor*	0	0	0	2.8	0	0	0	0
Rhamnaceae *Ziziphus spina-christi*	0	0	0	16.2	0	0	0	0
Juticia striata	0	0	0	0	0	7.4	0	0
Acanthaceae	0	0	0	0	0	0	1.4	0
Convolvulacea *Ipomoea cordofana*	0	0	0	0	0	0	0	5
Fabaceae *Medicago sativa*	0	0	0	0	0	0	0	5.4
Total	87.4	58	42.8	19.4	4.4	18.8	13.4	11.2
Mean	6.24	4.14	3.06	1.38	0.31	1.34	0.95	0.8
±Sd	3.82	0	0	0	0.71	0	0	3.82

A1- Eldamazeen
A2- Eldamazeen-Gable Abugarin
B- Sinnar-Wad Hashim
C1- Eldewaim
C2- Eldewaim-Talha area
D1- AL-faw area
D2- Gaddarif Area
E- Khartoum

Table IV: Percentage contribution of the different plant families to the pollen content of eight honey samples collected from different location in the Sudan

Honey / Family	A1	A2	B	C1	C2	D1	D2	E
Meliaceae *Azadirachta indica*	97.5	0	0	0	22.7	0	0	0
Mimosaceae *Acacia spp*	2.06	0	1.8	2.1	4.5	4.25	0	1.8
Mimosaceae *Acacia seyal* var *seyal*	0	0	0	0	0	0	89.5	0
Malvaceae	0.46	0	0	0	0	0	0	5.3
Asteraceae	0	4.5	0	0	0	0	0	0
Asteraceae *Helianthus annus*	0	0	96.7	0	72.7	56.38	0	0
Arecaceae *Hyphaene thebaica*	0	93.4	0	0	0	0	0	0
Poacae	0	2.1	1.4	0	0	0	0	0
Poacae *Sorghum bicolor*	0	0	0	14.4	0	0	0	0
Rhamnaceae *Ziziphus spina-christi*	0	0	0	83.5	0	0	0	0
Juticia striata	0	0	0	0	0	39.36	0	0
Acanthaceae	0	0	0	0	0	0	10.4	0
Convolvulaceae *Ipomoea cordofana*	0	0	0	0	0	0	0	44.6
Fabaceae *Medicago sativa*	0	0	0	0	0	0	0	48.2

A1- Eldamazeen
A2-Eldamazeen-Gable Abugarin
B- Sinnar-Wad Hashim
C1- Eldewaim
C2- Eldewaim-Talha area
D1- AL-faw area
D2- Gaddarif Area
E- Khartoum

Table V: Percentages, predominant and frequent of the pollen content and plant species of eight honey samples collected from different locations in the Sudan

Locality	Pollen types	Percentages %	Frequency Class
ELdamazeen	Meliaceae *Azadirachta indica*	97.5	Predominant
	Mimosaceae *Acacia spp*	2.06	Sporadic
	Malvaceae	0.46	Sporadic
Gabl Abu-garin	Fabaceae	2.1	Sporadic
	Asteraceae	4.5	Rare
	Arecaceae *Hyphaene thebaica*	93.4	Predominant
Sinnar Wad hashim	Mimosaceae *Acacia spp*	1.8	Sporadic
	Asteraceae *Helianthus annus*	96.7	Predominant
	Poacae	1.4	Sporadic

Eldueim	Mimosaceae *Acacia spp*	2.1	Sporadic
	Rhamnaceae *Ziziphus spina-christi*	83.5	Predominant
	Sorghum bicolor	14.4	Rare
Tallha Forest	Fabaceae	22.7	Frequent
	Mimosaceae *Acacia spp*	4.5	Rare
	Asteraceae *Helianthus annus*	72.7	Predominant
ALfaw	Mimosaceae *Acacia spp*	4.25	Rare
	Asteraceae *Helianthus annus*	56.38	Predominant
	Juticia striata	39.36	Frequent
Gaddarif	Mimosaceae *Acacia seyal* var *seyal*	89.5	Predominant
	Acanthaceae	10.4	Rare
Khartoum	Mimosaceae *Acacia spp*	1.8	Sporadic
	Malvacea	5.3	Rare
	Convolvulaceae *Ipomoea cordofana*	44.6	Predominant
	Fabaceae *Medicago sativa*	48.2	Predominant

- Very frequent or predominant pollen (more than 45%).
- Frequent or secondary pollen (16 – 45%).
- Rare or important minor pollen (3-15%).
- Sporadic or minor pollen (less than 3%).

Table VI: Concentration of some flavonoids (mg/100g) calculated in honey samples

Flavonoides	A1	A2	B	C1	C2	D1	D2	E
Quercitrin	-	6.8	+	+	-	+	-	-
Isorhamnetin	-	-	+	+	-	+	1.217	0.904
Kaempferol	-	1.5	+	+	-	+	-	-
Hesperetin	-	-	+	+	1.97	+	-	-

- Not Detected.
A1 - Eldamazeen
A2 -Gable Abugarin
B -Sinnar-Wad Hashim
C1- Eldewaim
+ Faint concentration
C2-Eldewaim-Talha area
D1- AL-faw area
D2- Gaddarif Area
E- Khartoum

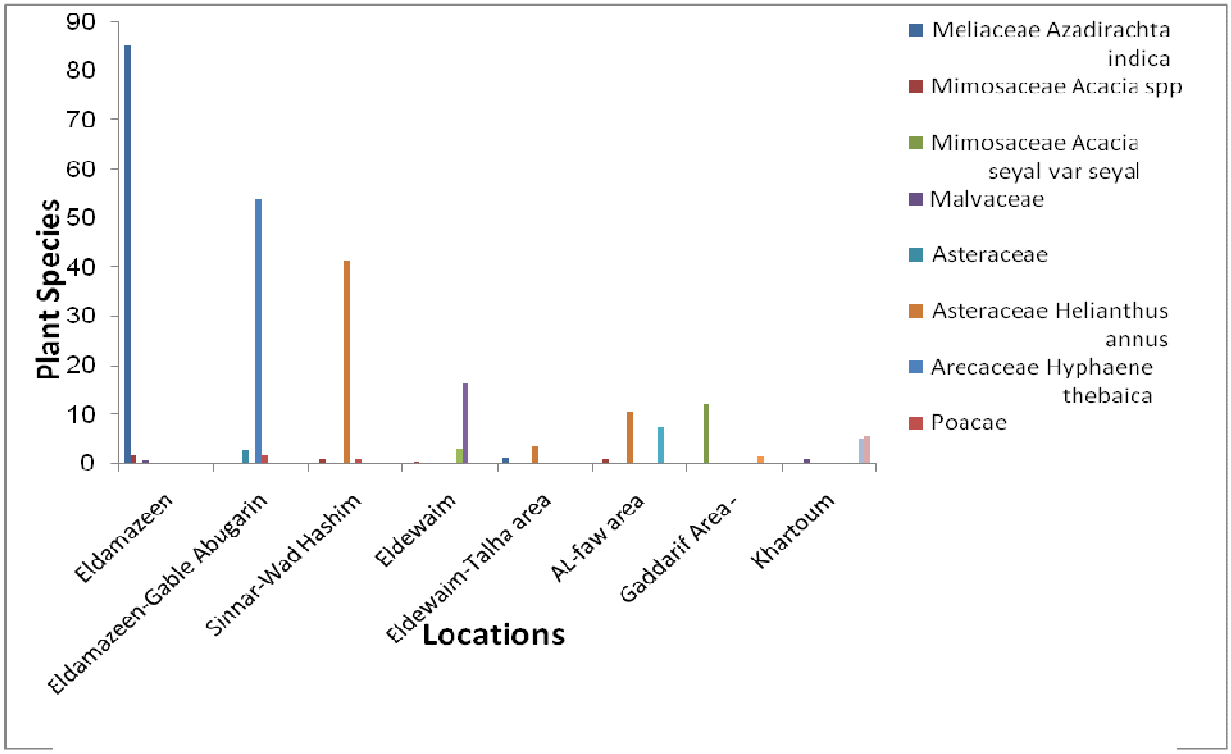

Fig.II. Means pollen content and plant species of eight honey samples collected from different locations in the Sudan

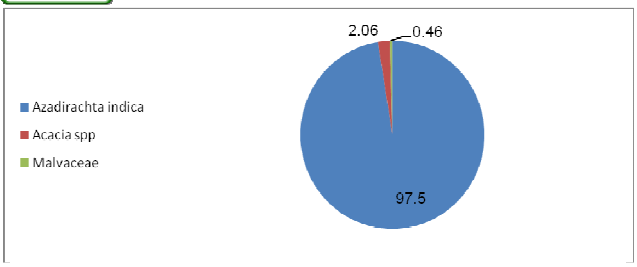

Fig III: Percentage contribution of the different plant families to the pollen content of Gable Abu-garin honey sample

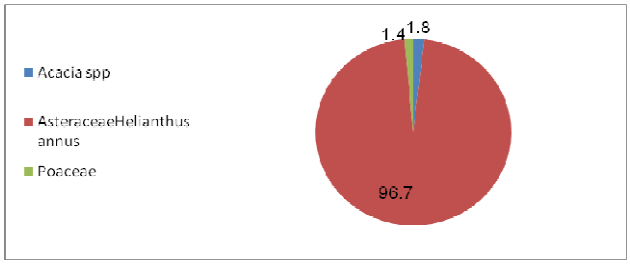

Figure IV: Percentage contribution of the different plant families to the pollen content of the wad Hashim honey sample

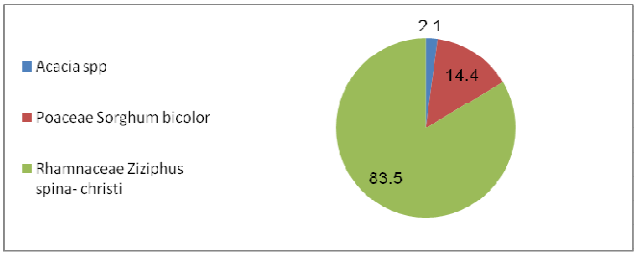

Fig.V. Percentage contribution of the different plant families to the pollen content of the Eldewaim honey sample

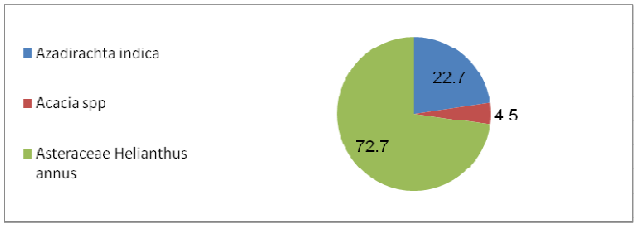

Fig.VI. Percentage contribution of the different plant families to the pollen content of the Talha area honey sample

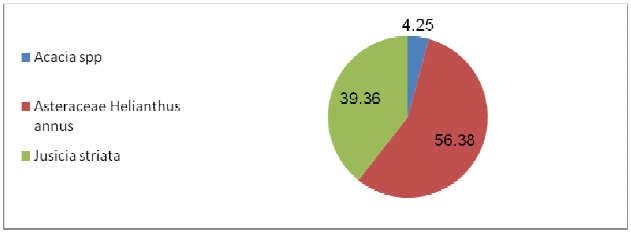

Fig.VII. Percentage contribution of the different plant families to the pollen content of the AL-faw area honey sample

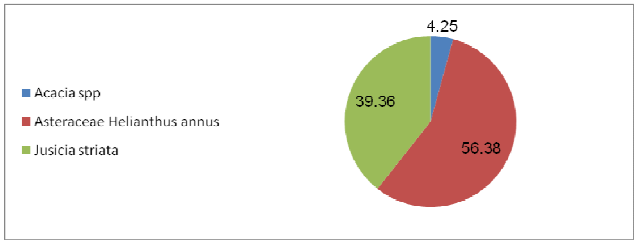

Fig.VIII. Percentage contribution of the different plant families to the pollen content of the AL-faw area honey sample

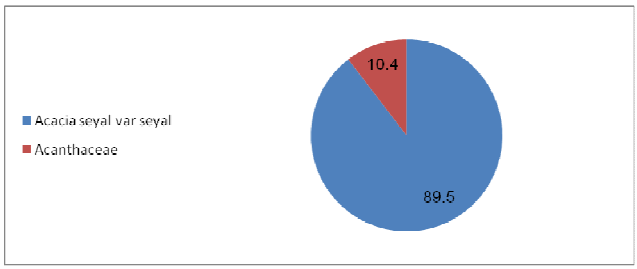

Fig.IX. Percentage contribution of the different plant families to the pollen content of the Gaddarif honey sample

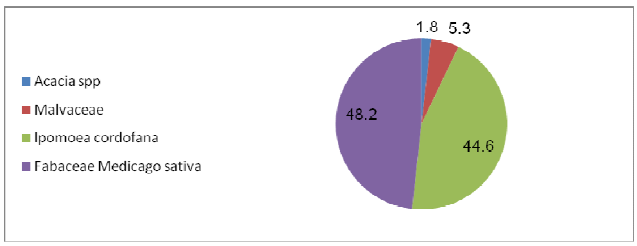

Fig.X. Percentage contribution of the different plant families to the pollen content of the Khartoum honey sample

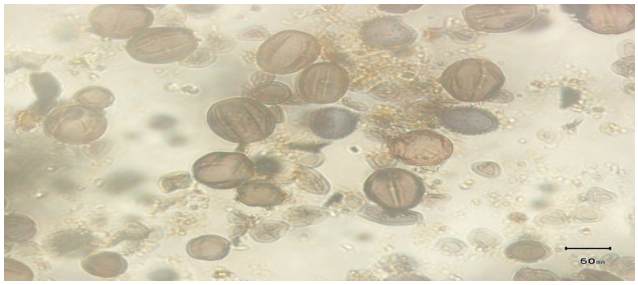

Plate I: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from Eldamazeen: Meliaceae Azadirachta indica

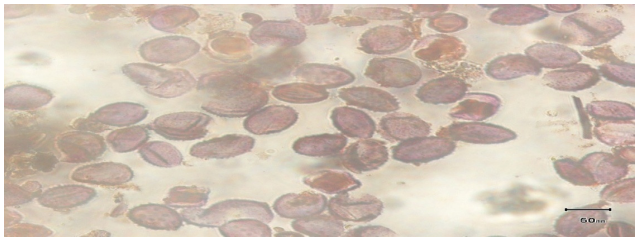

Plate II: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from: Eldamazeen- Gable Abugarin: Arecaceae Hyphaene thebaica

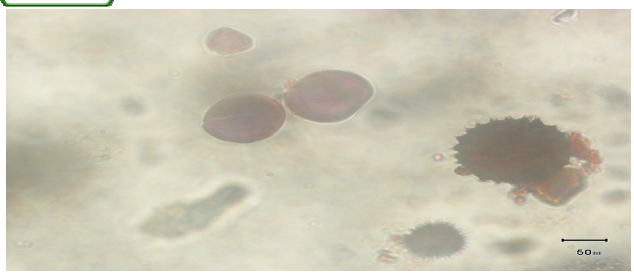

Plate III: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from Sinnar-Wad Hashim: Asteraceae Helianthus annus

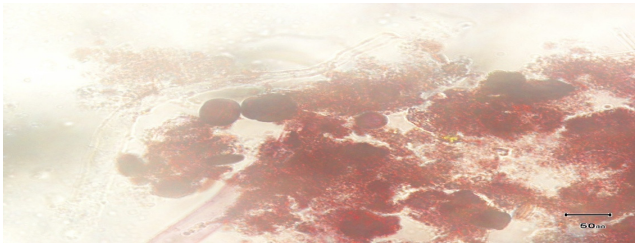

Plate IV: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from Eldewaim: Rhamnaceae Ziziphus spina-christi

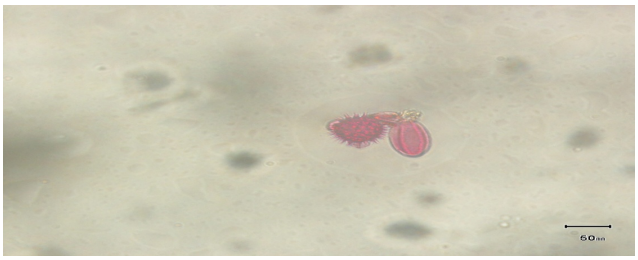

Plate V: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from: Eldewaim-Talha area Asteraceae Helianthus annus

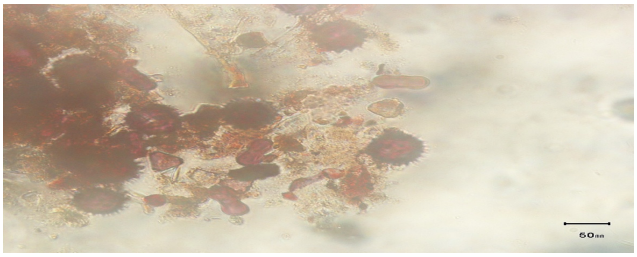

Plate VI: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from: AL-faw area Asteraceae Helianthus annus

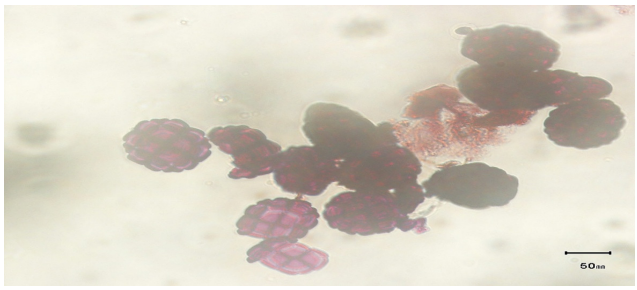

Plate VII: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from Gaddarif area: Acacia seyal var seyal

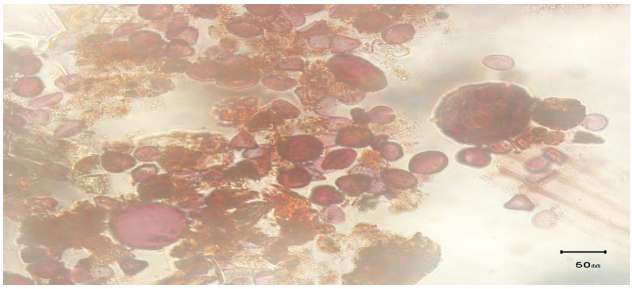

Plate VIII: Photomicrographs of pollen grains showing quantitative and qualitative variation of honey sample collected from Khartoum: Fabaceae Medicago sativa