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# Phytochemical and Biological Activities of the *Frankenia* genus Frankeniaceae: A Review

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**Abstract**

IN RECENT YEARS, the world has become increasingly interested in medicinal plants. As a result, this research was conducted to identify the therapeutic value of the genus *Frankenia* and its relationship with its phytochemical constituents and biological activities. *Frankenia* is considered one of the most important medicinal plants that are rich in phytochemical constituents with biological activities. *Frankenia* is a flowering plant (Angiosperm) belonging to the family Frankeniaceae. *Frankenia* species are rich in secondary metabolites such as tannins, proanthocyanidin, phenolic acids, phenolic acid derivatives, flavonoids, flavonoids sulphated, trace lignans along with their sulphated derivatives, traces of alkaloids and other bioactive compounds. These secondary metabolites showed promising therapeutic values, such as antioxidant, anti-cancer, hepatoprotective, anti-Alzheimer's disease, anti-inflammatory, antidiabetic, anti-bacterial, anti-fungal, neuroprotective, antiparasitic, cytotoxic, and antiviral activities. This review aims to provide an overview of the phytochemistry and biological activities of Frankeniaceae recently.

**Keywords:** Frankeniaceae, phytochemical constituents, pharmacological potential.

## Introduction

Frankeniaceae is a family of halophytic shrubs, subshrubs and herbs [1]. The family's 70-80 species are mostly halophytic. [2]. It is a family of 4 or 5 genera with approximately 75-90 species found worldwide under dry climatic conditions, such as deserts and sandy coastal areas. The Frankeniaceae family is close to Tamaricaceae and Caryophyllaceae [3]. The leaves of both families are opposite, with entire margins and no stipules. This family belongs to the Caryophyllales order, the Eudicot subclass, the Magnoliophytes class, the Spermatophyte subdivision, and the Tracheophytes division, and Frankeniaceae, has small leaves. In Frankeniaceae, the scarious membrane connects the short petioles of each leaf pair as in Caryophyllaceae. In both families, the inflorescence is frequently a dichotomous cyme [4]. The Frankeniaceae family contains numerous secondary metabolites with potential medical benefits, such as tannins, proanthocyanidin, phenolic acids, phenolic acid derivatives, flavonoids, and trace lignans, with promising pharmacological action as antioxidant, hepatoprotective, Al Alzheimer's disease, anti-inflammatory, antidiabetic, anti-microbial, and neuroprotectiv activities.

Recently, Frankeniaceae contains one genus *Frankenia* [3], which belongs to this family: *F. juniperoides (Hieron.) M.N. Correa, F. laevis* L., *F. latior, F. leonardoru., F. microphylla* Cav.,*F. montana (Brochmann, Lobin & Sunding) Rivas).* The Frankeniaceae family has only one genus, *Frankenia.*, and all species are halophytes (there are approximately 80 species). It is also known as Sea Heath or Millah [5]. In Phytochemistry, *Frankenia* spp. contains many secondary metabolites such as tannins, proanthocyanidin, ellagic acid, and flavonoids with their sulphated derivatives [1]. *F. pulverulenta's* phytochemical properties were investigated. According to the findings of this study, the most prevalent components include gallic acid, catechin, quercetin, quercetin galloyl glucoside, procyanidin dimer, flavonoid sulphate, and others [6].

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## Methods

This study used databases from PubMed, ScienceDirect, Scopus, Web of Science, SciFinder, and Google Scholar, as well as books, theses, and official websites. ChemDraw professional 15.0 software was used to draw all chemical structures.

## Results

*Distribution*

Frankeniaceae are halophytes that are distributed from the Mediterranean region in the desert, all species are found in desert, rocky salty soil, and dry environments [7].

*Phytochemical constituents*

Frankeniaceae contains several secondary metabolites and is of therapeutic importance. Investigationsin the genus *Frankenia* and its different species have resulted in the isolation and identification of many secondary- metabolites belonging to flavonoids, fatty acids, essential oils, sterols, phenolic acids, phenolic derivatives, and other compounds, which are listed in Tables 1-6.

*Essential oil components*

The main constituent of essential oil found in aerial parts of *F.pulverulenta* was identified using Gas Chromatography/Mass Spectrometry (GC/MS) as 92.7% of the total oil. Cyrophyllene (32.5%), cadinene (8.4%), alloaromadendrene (7.1%), copaene (6.9%), and ledol (5.3%). were the main constituents identified [8]. Steam distillation was used to recover the primary volatile oil components from the aerial parts of *F. laevis,* representing 91.5% of the oil constituents. The most abundant component was hexadecanoic acid (19.8%), followed by methyl linoleate (16%), (E, E)-farnesyl acetate (9.5%), (E)-nerolidol (8.9%), and benzyl benzoate (6.2%). Table (1) and Fig. (1).

*Flavonoids*

*Frankenia* is characterised by flavonoid sulphate as 3,7-di-sdium sulphate kaempferol and 3,7-di-sodium sulphates quercetin, this compound was isolated from the aqueous alcohol of *F. laevis* L. extract. and identification by ESI-MS and NMR [10]. Identification of many compounds, such as procyanidin dimers, catechin, quercetin, flavonoid-sulphated and quercetin hexose by LC-MS and HPLC preparation from the shoots and roots of *F. pulverulenta* L [11]. Catechin and epigallocatechino-3-gallate compounds have been identified by HPLC analysis of *F. thymifolia* shoot extract. based on the retention times and peak spectral characteristics compared to standards [12]. Quercetin 3-*O*-methyl ether, quercetin 3'-*O*-β-D galactopyranoside, quercetin 3'-O-β-D-glucoside, quercetin and naringenin were reported in different fractions of aerial parts of *F. thymifolia* Desf and identified by NMR spectra [13]. Table (2) and Fig.(2).

*Phenolic and phenolic acid derivatives*

Using LC-DAD-ESI-MS in negative mode on the ethyl acetate fraction of the whole plant of *F. pulverulenta*, gallic acid was found to be a phenolic component. [11]. methyl gallate 3,4-dimethyl ether extraction and isolation by ($CHCl_3$/MeOH 80:20) and eluted with MeOH from air-dried aerial parts of *F. thymifolia* using a Sephadex LH-20 column. [13]. Novel phenolic anionic conjugates were identified from the aqueous alcohol extract of *F. laevis* L. Their structures were mostly determined using ESI-MS and NMR spectroscopy. [14].

Using preparative silica gel column chromatography, the methyl esters of s 4,5-dimethoxy-3-hydroxybenzoic acid were separated from the *F. thymifolia* root ethyl acetate extract. This was confirmed by 1D and 2D NMR analyses (COSY, HSQC, HMBC, Bruker Avance spectrometer), UV, IR, and positive and negative modes [15]. Using an HPLC assay, six phenolic acids—trans-2-hydroxycinnamic acid, salicylic acid, vanillic acid, chlorogenic acid, and 2,5-dihydroxybenzoic acid—were identified from *F. thymifolia* shoot extracts. [12]. Table (3) and Fig.(3).

*Fatty acids composition determined by gas chromatography–mass spectrometry*

The major fatty acid identified from the shoot of *F. thymifolia,* was, palmitic acid. GC/MS analysis of the *F.thymifolia* shoot led to the identification of many fatty acids ,such as lauric, myristic, stearic, and behenic acids, as saturated fatty acids and monounsaturated fatty acids , such as oleic, elaidic ,and palmitoleic, as well as polyunsaturated fatty acids, such as linoleic,cis linoleic and α-linolenic [12]. The gas chromatography-mass spectrophotometry method was used to identify bioactive components of the extract of whole plants of *F.hirsuta* ,such as fatty acids, such as palmitic acid, stearic acid, behenic acid,linoleic acid, and tetracosanoic acid [16]. The fatty acids detected in the extract of *F. pulverulenta* leaves by GC/MS were palmitic acid and gamolenic acid [17]. Octanoic acid,12,15-octadecadienoic acid, methyl ester, nonanoic acid, and octadecanoic acid were also reported in the methanolic extracts of the leaves of *F. aucheri* Jaub by GC/MS [18]. Table (4) and Fig. (4).

*Sterols*

Few sterols have been isolated and identified from *Frankenia* such as 5,6-secosteroid is the first B-ring isolated by NMR spectroscopy and MS techniques from *F.foliosa*, which grows in Australia's desert zone [19]. Ethyl iso-allocholate was identified F.*aucheri* leaves and *F. pulverulenta* leaves, and 2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-ly)

propanoic acid was detected in *F. pulverulenta* leaves only by GC/MS [17][18]. Table (5) and Fig.(5).

*Miscellaneous substances:*

Using GC/MS analysis, many compounds from different *Frankenia* species with different organs, such as roots, whole plants, and leaves were identified these compounds listed and illustrated in Table (6) and Fig.(6).

*Biological activities of the chemical constituents of Frankenia:*

Many biological activities have been assigned to *Frankenia* species based on *in vivo* and *in vitro* studies, including anti-diabetic, antimicrobial, anti-inflammatory, neuroprotective, and hepatoprotective effects. It is critical to highlight the medicinal value of these species. Table (7)

*Antioxidant activity*

Anti-oxidant activity was evaluated by five assays : RSA–DPPH(2,2-diphenyl-1-picrylhydrazyl radical scavenging activity) RSA–ABTS( 2,20-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid radical scavenging activity)FRAP(ferric reducing antioxidant activity)CCA( copper chelating activity), and ICA( iron chelating activity) for extract of *F. laevis* L aerial parts to the methanolic and dichloromethane fractions, which resulted in the methanolic extract being most effective in ABTS and DPPH, but the dichloromethane extract was highly effective in ICA and CCA activity[20].

*In vitro* antioxidants evaluations with many different assays were performed on methanol and dichloromethane extracts of aerial parts as 2,2-diphenyl-1-picrylhydrazyl (DPPH) and2,20-azino-bis (3-ethylbenzothiazoline-6-sulonic acid (ABTS) radical-scavenging, iron reducing power, copper, and iron chelation, resulting in the methanolic extract being most effective in all assays except dichloromethane extract, which is highly effective in iron chelating ability [21].

Total phenolic and flavonoid contents were studied the aerial parts of *F. thymifolia* to assess their antioxidant activity. This was accomplished using a 1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical test and a -Carotene/linoleic acid bleaching assay, which resulted in the aerial parts of *F. thymifolia* showing anti-oxidant activity [13].

The phenolic component was studied in the aerial parts of *F. laevis* to determine antioxidant activity using DPPH, ABTS, superoxide radical scavenging, and iron-reducing tests,which resulted in *F. laevis* shoots exhibiting the highest antioxidant capacity. [22].

The antioxidant capacity of *F. pulverulenta* shoot and root fractions was evaluated using six solvents in four *in vitro* assays (DPPH, ABTS, Fe-chelating activity, and ORAC). In addition, the neuroprotective activity of the ethyl acetate (EtOAc) fraction was evaluated, which resulted in the high phenolic content of the ethyl acetate shoot and root fractions, indicating that they were extremely efficient antioxidants [11].

The antioxidant activity of the aerial parts of *F. triandra* extracts was evaluated by different assays such as Free-radical ABTS scavenging activity, β-Carotene-linoleic acid assay, nitric oxide scavenging assay, Iron III to iron II reductive capacity, and metal chelating activity, which resulted in the aerial parts of *F. triandra* extracts having potent antioxidant activity [23].

*F. thymifolia* aerial and root parts were used to evaluate the antioxidant and neuroprotective properties by measuring radical scavenging ability against DPPH radicals, metal Chelating Activity (MCA), and ORAC assays, which result in root fraction most effective against DPPH and ABTS, while the ICA test was higher in aerial part fractions than in root [24].

The total phenolic and flavonoid content of *F. thymifolia* Desf shoots were studied. GC– MS and HPLC analyses of this species led to the identification of many components. The antioxidant activity was evaluated by DPPH radical-scavenging activity, iron reducing power, and β-carotene bleaching test (BCBT). The methanol fraction of *F. thymifolia* has the highest level of phenolic compounds, resulting in potent antioxidant activity [12].

*Anti-inflammatory activity*

The anti-inflammatory activity of the *F.triandra* aerial part extracts was assessed by inhibiting secretory phospholipase A2, 2dHGPC, and Triton X-100. Lipoxygenase (LOX) and cyclooxygenase (COX) activity inhibition, hyaluronidase activity inhibition, and human red blood cell (HRBC) membrane stabilization. Soxhlet extraction and maceration yield two hydroalcoholic extracts of *F. triandra*. Both extracts exhibited significant anti-inflammatory activity, but Hyaluronidase is more active in soxhlet extract. Extracts from *F. triandra* demonstrated a notable inhibition of the other two major AA pathway enzymes, COX-2 and LOX, although not being active against sPLA2. Furthermore, there was not a single hazardous extract [23].

*Antimicrobial activity*

The bactericidal and fungicidal properties of the essential oil extracted from the aerial parts of *F. pulverulenta* L. were assessed against *Penicillium simplicissimum* and *Escherichia coli*, resulting in *F. pulverulenta* L essential oil exhibiting antimicrobial activity against bacteria and fungi [8].

By using four common pathogenic bacteria—*Pseudomonas aeruginosa, Escherichia coli, Klebsiella oxytoca* (a gramme-negative bacteria), and *Staphylococcus aureus* (a gramme-positive bacteria). The antibacterial activity of *F. thymifolia* extracts was assessed. The disc diffusion method was used for this evaluation, and the fractions most active against bacteria were ethyl acetate and *n*-butanol [13].

The antimicrobial activity of *F. hirsuta* extract was evaluated using the disk diffusion method, which was used to assess the susceptibility of 17 bacteria and 1 fungus, including *Bacillus, Candida, Enterobacter, Enterococcus, Escherichia coli, Klebsiella, Listeria, Pseudomonas, Salmonella*, and *Staphylococcus* species. This resulted in *F. hirsuta* extract having antimicrobial activity against all bacteria studied, except *E. coli* and *E. aerogenes*. [16].

The antibacterial activity of the aerial parts of *F. laevis* was tested against four human pathogenic microorganisms, including Gramme-positive bacteria. *Micrococcus luteus, Staphylococcus aureus* sp. *aureus,* and Gramme-negative bacteria *Salmonella enterica* ssp. *Arizonae* with *Escherichia coli* and *F. laevis* extracts exhibited significant antimicrobial activity against the bacteria studied [22].

The major phenolic and fatty acid compositions of *F.thymifolia* Desf were determined and tested for antibacterial activity using an agar disk diffusion assay to evaluate the antibacterial activity of the extracts from the shoots of both the polar and apolar fractions against five human pathogenic bacteria. These bacteria included Gramme-positive cocci, such as *Staphylococcus aureus* and *Enterococcus faecium*, and Gramme-negative bacteria, such as *Escherichia coli* (DH5α), *salmonellatyphi* and *P. aeruginosa*. The effectiveness of each antifungal was determined by measuring the diameter of the growth inhibition zone surrounding the disks, which resulted in the *F. thymifolia* Desf chloroform fraction being the most active among all strains studied. [12].

The antibacterial and antifungal activity profiles of *F. laevis* essential oil were evaluated against gramme-positive bacteria, gramme-negative bacteria, and phytopathogenic fungi, *F. laevis* essential oil showed significant antibacterial activity, but no antifungal activity was determined [9].

The antibacterial efficacy of *F. triandra* tinctures and aqueous extracts was assessed against both multi-resistant Gramme-positive and Gramme-negative bacteria, which resulted in the ethanolic extract having more bactericidal activity than the aqueous extract [25].

The extract of *F. pulverulenta* L. (Frankeniaceae) was examined for anti- type 1 Herpes simplex virus (HSV-1), *F. pulverulenta* extract had antiviral activity [26].

*Neuroprotective activity*

Neuroprotective activity was evaluated using the PC12 Cell Line of *F. pulverulenta* shoots and roots,and the most effective fraction was ethyl acetate for shoot and root neuroprotective activity. [11].

Neuroprotective activity was evaluated using the PC12 Cell Line of *F. thymifolia* aerial and root parts. The most effective fraction was ethyl acetate for shoot and root neuroprotective activity [24].

*Antiparasitic activity*

The aerial organs of *F. thymifolia* extract were assessed for anti-parasitic activity against the promastigote stage of *Leishmania amazonensis*, *Leishmania donovani* strains, epimastigote stage of *Trypanosoma cruzi,* and trophozoite stage of *Acanthamoeba castellanii* str. Neff, chloroform, ethyl acetate, and *n*-butanol fractions of *F. thymifolia* extract are active against *Acanthamoeba castellanii, Leishmania amazonensis,* and inactive against *Leishmania donovani* and *Trypanosoma cruzi* [13].

*Antidiabetic activity*

*In vitro* antidiabetic activity against type 2 diabetes was evaluated by α-glucosidase and α-amylase in the *F. laevis* extract. In the methanol and dichloromethane fractions from the aerial parts, dichloromethane and methanol extracts inhibited α-glucosidase, but the dichloromethane extract was more effective than the methanol extract [21].

*In vitro* antidiabetic activity was evaluated type2 diabetes by (α-glucosidase- α-amylase) of halophyte *F. laevis* L extracts of methanol and dichloromethane from leaves, flowers, and stems. Dichloromethane and methanol extracts inhibited α-glucosidase, but dichloromethane extract was more effective than methanol extract [20].

*Cytotoxic activity*

Dichloromethane extract of the *F. laevis* aerial parts exhibited significant selective cytotoxicity against hepatocarcinoma (HepG2) cells. Hepatocellular carcinoma was assessed by measuring the cytotoxic potential of *F. laevis* extracts of methanol and dichloromethane aerial parts in human hepatocellular cancer (HepG2) cells. [20].

cytotoxicity potential was measured against human hepatocarcinoma (HepG2) cells in extracts of methanol and dichloromethane from *F. laevis* L leaves, stems, and flowers, dichloromethane extract of Significantly specific cytotoxicity against HepG2 cells was observed in the aerial portions of *F. laevis* [21].

*Miscellaneous activities*

According to the literature, when evaluated on Vero cells using a plaque reduction assay, both methanolic and acetonic extracts of *F. pulverulenta* inhibited and reduced HSV-1 infection. [27].

The aerial parts of the *F. laevis* extract were studied to evaluate the tyrosinase inhibitory properties that resulted in *D. carota* and *F. laevis* being the most active halophytes [22].

*Photograph of the Frankenia hirsuta* (Fig. 7)

## Conclusions

As previously reported, there are many different bioactive compounds in the Frankeniacea family, including flavonoids and many flavonoid sulphates, phenolic acids and phenolic acid derivatives, lignin sulfates, and essential oil and fatty oils in this family to play important role in the potent effect of antioxidant, antidiabetic, Alzheimer's disease, neuroprotective effect, anti-microbial, anti-parasitic and cytotoxic effect. very few studies are reported on *Frankenia hirsuta* worldwide. Nowadays, recommended researchers are interesting on investigation the pharmacological profile of compounds in *Frankenia hirsuta* to use these compounds for treating human health problems.

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*Conflicts of interests*

There are no conflicts to declare.

*Funding statement*

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*Author`s contributions*

All authors contributed to the study conception and design. Material preparation, data collection and Writing – original draft, Methodology, Formal analysis, Conceptualization, corresponding author. were performed by A. H. Z .and supervision, Conceptualization and revision by S.E. the first draft of the manuscript was revision by K. R .and M.A.E. Where A.M.E., designed and prepared the figures and all authors commented on previous versions of the manuscript.

*Ethical approval*

Serial number MP (3364) Approval valid 21/9/2023 and don't use any animals in this review.

**TABLE 1. Volatile components of the *Frankenia* genus**

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| 1 | Hexadecanoic acid | Aerial parts | *F. laevis* | [9] |
| 2 | Methyl linoleate | Aerial parts | *F. laevis* | [9] |
| 3 | (E, E)-farnesyl acetate | Aerial parts | *F. laevis* | [9] |
| 4 | (E)-nerolidol | Aerial parts | *F. laevis* | [9] |
| 5 | Benzyl benzoate | Aerial parts | *F. laevis* | [9] |
| 6 | β-caryophyllene | Aerial parts | *F. pulverulenta* | [8] |
| 7 | Cadinene | Aerial parts | *F. pulverulenta* | [8] |
| 8 | Alloaromadendrene | Aerial parts | *F. pulverulenta* | [8] |
| 9 | Copaene | Aerial parts | *F. pulverulenta* | [8] |
| 10 | Ledol | Aerial parts | *F. pulverulenta* | [8] |

**TABLE 2. Flavonoids from the *Frankenia* genus**

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| | | **I-Flavan3-ol** | | |
| **1** | Procyanidin B1 | Root | *F. pulverulenta* | **[11]** |
| **2** | Catechin | Aerial parts | *F.pulverulenta* | **[11][12]** |
| | | Shoot | *F. thymifolia* | |
| **3** | Epigallocatechin-3-*o*-gallate | Shoot | *F. thymifolia* | **[12]** |
| | | **II-Flavonol** | | |
| **4** | Quercetin | Root | *F.pulverulenta* | **[11[13]** |
| | | Aerial parts | *F. thymifolia* | |
| **5** | Quercetin 3-*O*-methyl ether | Aerial parts | *F. thymifolia* | **[13]** |
| **6** | Quercetin 3'-*O*-β-D galactopyranoside | Aerial parts | *F. thymifolia* | **[13]** |
| **7** | Quercetin 3'-*O*-β-D-glucoside | Aerial parts | *F. thymifolia* | **[13]** |
| **8** | 3,7-di-sodium sulphate kaempferol | Whole plant | *F. laevis* | **[10]** |
| **9** | 3,7-di-sodium sulphates quercetin | Whole plant | *F. laevis* | **[10]** |
| | | **III-Flavanone** | | |
| **10** | Naringenin | Aerial parts | *F. thymifolia* | **[13]** |

**TABLE 3. Phenolic and phenolic acid derivatives of *Frankenia***

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| **1** | Gallic acid | Aerial parts and roots | *F. pulverulenta* | **[11]** |
| **2** | Methyl gallate 3,4-dimethyl ether | Aerial parts | *F. thymifolia* | **[13]** |
| **3** | Gallic acid-3-methyl ether-5-sodium sulphate | whole plant | *F. laevis* | **[14]** |
| **4** | Acetophenone-4-methyl ether-2-sodium sulphate | whole plant | *F. laevis* | **[14]** |
| **5** | Ellagic acid-3,3'-dimethyl ether-4,4'-di-sodium sulphate | whole plant | *F. laevis* | **[14]** |
| **6** | Ellagic acid-3-methyl ether-4-sodium sulphate | whole plant | *F. laevis* | **[14]** |
| **7** | 4,5-dimethoxy-3-hydroxybenzoic acid methyl ester | Root | *F. thymifolia* | **[15]** |
| **8** | Chlorogenic acid | Shoot | *F. thymifolia* | **[12]** |
| **9** | 2,5-dihydroxybenzoïc acid | Shoot | *F. thymifolia* | **[12]** |
| **10** | Vanillic acid | Shoot | *F. thymifolia* | **[12]** |
| **11** | Trans cinnamic acid | Shoot | *F. thymifolia* | **[12]** |
| **12** | Trans-2-hydroxycinamic acid | Shoot | *F. thymifolia* | **[12]** |
| **13** | Salicylic acid | Shoot | *F. thymifolia* | **[12]** |

**TABLE 4. Fatty acids reported from the *Frankenia* genus by GC /MS**

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| 1 | Palmitic acid | Shoot | *F. thymifolia* | [12] |
| | | Whole plant | *F.hirsuta* | [16] |
| | | Leaves | *F. Pulverulenta* | [17] |
| 2 | Lauric acid | Shoot | *F. thymifolia* | [12] |
| 3 | Myristic acid | Shoot | *F. thymifolia* | [12] |
| 4 | Stearic acid | Shoot | *F. thymifolia* | [12] |
| | | Whole plant | *F.hirsuta* | [16] |
| 5 | Behenic acid | Shoot | *F. thymifolia* | [12] |
| | | Whole plant | *F.hirsuta* | [16] |
| 6 | Oleic acid | Shoot | *F. thymifolia* | [16] |
| | | Whole plant | *F. hirsute* | [12] |
| 7 | Elaidic acid | Shoot | *F. thymifolia* | [12] |
| 8 | Palmitoleic acid | Shoot | *F. thymifolia* | [12] |
| 9 | Linoleic acid | Shoot | *F. thymifolia* | [12] |
| | | Whole plant | *F. hirsute* | [16] |
| 10 | Cis, cis-linoleic acid | Shoot | *F. thymifolia* | [12] |
| 11 | α-linolenic acid | Shoot | *F. thymifolia* | [12] |
| 12 | Tetracosanoic acid | Whole plant | *F. hirsute* | [16] |
| 13 | Octanoic acid | Leaves | *F. aucheri* | [18] |
| 14 | 12,15Octadecadiynoic acid | Leaves | *F. aucheri* | [18] |
| 15 | Nonanoic acid | Leaves | *F. aucheri* | [18] |
| 16 | Octadecanoic acid | Leaves | *F. aucheri* | [18] |
| 17 | Gamolenic acid | Leaves | *F. pulverulenta* | [17] |

**TABLE 5. Sterols from the *Frankenia* genus**

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| 1 | 5,6-secosteroid | Whole plant | *F.foliosa* | [19] |
| 2 | Ethyl iso-allocholate | Leaves | *F. aucheri* | [18] |
| | | | *F.pulverulenta* | [17] |
| 3 | 2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-ly) propanoic acid | Leaves | *F. pulverulenta* | [17] |

**TABLE 6. Miscellaneous substances reported from the *Frankenia* genus**

| No. | Compounds name | Plant parts | Species | Ref. |
|---|---|---|---|---|
| 1 | Pinoresinol 4-sulfate | Roots | *F.thymifolia* | [15] |
| 2 | 1,2,3,4,5,7-hexamethoxynaphthalene | Roots | *F.thymifolia* | [15] |
| 3 | Dihydrotecomanine | Leaves | *F.pulverulenta* | [17] |
| | | | F. *aucheri* | [18] |
| 4 | 5,7-Dodecadiyn-1,12-diol | Leaves | *F.pulverulenta* | [17] |
| 5 | Benzene, 1,3,5-trimethyl | Whole plant | *F.hirsuta* | [16] |
| 6 | Furancar-boxaldehy De, 5-(hydroxymethyl) | Whole plant | *F.hirsuta* | [16] |
| 7 | Nonadecene | Whole plant | *F.hirsuta* | [16] |
| 8 | Eicosane | Whole plant | *F.hirsuta* | [16] |
| 9 | Benzoic acid (3,4,5-trimethoxy) | Whole plant | *F.hirsuta* | [16] |
| 10 | 2H-1, Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl) | Whole plant | *F.hirsuta* | [16] |
| 11 | Vitamin E | Whole plant | *F.hirsuta* | [16] |
| 12 | Oxirane (hexadecyloxy)methl1 | leaves | *F.aucheri* | [18] |
| 13 | Methanone ,1,3-dithian-2-ylphenyl- | Leaves | *F.aucheri* | [18] |
| 14 | 2-Acetylamino-3-hydroxy-propionic acid | Leaves | *F.aucheri* | [18] |
| 15 | 6-Acetyl-â-d-mannose | Leaves | *F.aucheri F.pulverulenta* | [17] [18] |
| 16 | 2,5-Dimethylhexane-2,5-dihydroperoxide | Leaves | *F.aucheri* | [18] |
| 17 | Desulphosinigrin | Leaves | *F.aucheri* | [18] |
| 18 | Pterin-6-carboxylic acid | Leaves | *F.aucheri* | [18] |
| 19 | 2-Oxazolamine, 4,5-dihydro-5-(phenoxymethyl) -N-(phenylamine 3 | Leaves | *F.aucheri* | [18] |
| 20 | N, N′-Bis carbobenzyloxy-lysine methyl (ester) | Leaves | *F.aucheri* | [18] |
| 21 | 3-O-methyl-d glucose | Leaves | *F.aucheri* | [18] |
| 22 | Phthalic acid, butyl tetradecyl ester | Leaves | *F.aucheri* | [18] |
| 23 | Oxiraneundecanoic acid, 3-pentyl-, methyl ester, and cis- | Leaves | *F.aucheri* | [18] |
| 24 | Phthalic acid, isobutyl octadecyl ester | Leaves | *F.aucheri* | [18] |
| 25 | Corynan-17-ol,18,19-didehydro-10-methoxy-, acetate (ester) | Leaves | *F.aucheri* | [18] |
| 26 | 6-epi-shyobunol | Leaves | *F.aucheri* | [18] |
| 27 | 4H,5H-Pyrano[4,3-d]-1,3-dioxin, tetrahydro-8amethyl | Leaves | *F.Pulverulenta* | [17] |
| 28 | 3-tert-Butyl-5-chloro-2hydroxybenzophenone | Leaves | *F.Pulverulenta* | [17] |
| 29 | 3,6,9,12, -Tetraoxatetradecan-1-ol, 14-[4-(1,1,3,3-tetramethyl | Leaves | *F.Pulverulenta* | [17] |
| 30 | Dithiocarbamate, S-methyl, N-(2-methyl-3-oxobutyl) | Leaves | *F.Pulverulenta* | [17] |
| 31 | 1, 8-Di-(4-nitrophenylmethyl)-3,6-diazahomoadamantan-9-one | Leaves | *F.Pulverulenta* | [17] |
| 32 | Pyrrolizin-1,7-dione-6-carboxylic acid,methyl(ester) | Leaves | *F.Pulverulenta* | [17] |
| 33 | Formamide, N-Methyl-N-4-[1-(pyrrolidinyl)-2-butynyl] | Leaves | *F.Pulverulenta* | [17] |
| 34 | N-Clooct-4-enylacetamide | Leaves | *F.Pulverulenta* | [17] |
| 35 | 12-Hydroxy-14-methyl-oxa-cyclotetradec-6-en-2-one | Leaves | *F.Pulverulenta* | [17] |
| 36 | 11,13-Dihydroxytetradec-5-ynoic acid, methyl ester | Leaves | *F.Pulverulenta* | [17] |
| 37 | 2-(2-Methyl-propenyl)-cyclohexanone oxime | Leaves | *F.Pulverulenta* | [17] |
| 38 | 2-Oxabicyclo [3.3.0] oct-7-en-3-one, 7-(1-hydroxypentyl)- | Leaves | *F.Pulverulenta* | [17] |
| 39 | 1-Propyl-3,6-diazahomoadamantan-9-ol | Leaves | *F.Pulverulenta* | [17] |

| | | | | |
|---|---|---|---|---|
| 40 | α-D-Glucopyranoside, O-α-D-glucopyranosyl-(1. Fwdarw-3)-β | Leaves | *F.Pulverulenta* | [17] |
| 41 | 3-O-Methyl-d-glucose | Leaves | *F.Pulverulenta* | [17] |
| 42 | β-D-Glucopyranose, 4-O-β-D-galactopyranosyl- | Leaves | *F.Pulverulenta* | [17] |
| 43 | Curan, 16,17-didehydro-, (20xi)- | Leaves | *F.Pulverulenta* | [17] |
| 44 | 1, 8-Diethyl-3,6-diazahomoadamantan-9-ol | Leaves | *F.Pulverulenta* | [17] |
| 45 | Curan-19,20-diol,16,17-didehydro, (19S) | Leaves | *F.Pulverulenta* | [17] |
| 46 | Gibberellic acid | Leaves | *F.Pulverulenta* | [17] |
| 47 | Strychane, 1-acetyl-20α-hydroxy-16-methylene- | Leaves | *F.Pulverulenta* | [17] |
| 48 | 2,7-Diphenyl-1,6-dioxopyradazino [4,5:2',3'] pyrrolo[4',5'-d] pyrid | Leaves | *F.Pulverulenta* | [17] |
| 49 | Dasycarpidan-1-methanol, acetate (ester) | Leaves | *F.Pulverulenta* | [17] |

**TABLE 7. Biological activities of *Frankenia* species**

| Species | Tested sample | Reference |
|---|---|---|
| | **Antioxidant activity** | |
| *F. laevis* | Methanolic - dichloromethane fractions of the aerial parts | [20] |
| *F. laevis* | Methanolic - dichloromethane fractions of the aerial parts | [21] |
| *F.thymifolia* | Chloroform- ethyl acetate and n-butanol of the 70% ethanol extract | [13] |
| *F. laevis* | Ethanolic extracts of the aerial parts | [22] |
| *F.pulverulenta* | Methanolic extracts of shoot and roots | [11] |
| *F. triandra* | Ethanolic extract of aerial parts | [23] |
| *F.thymifolia* | Methanolic 80%extracts of aerial and root parts | [24] |
| *F.thymifolia* | Chloroform/methanol/water (12/5/3) extracts of shoot | [12] |
| | **Anti-inflammatory activity** | |
| *F. triandra* | Ethanolic extract of air-dried aerial parts | [23] |
| | **Antimicrobial activity** | |
| *F.pulverulenta* | Essential oil from aerial Parts | [8] |
| *F.thymifolia* | Chloroform- ethyl acetate and n-butanol of the 70% ethanol extract | [13] |
| *F. hirsuta* | Absolute ethanol extract | [16] |
| *F. laevis* | Aqueous ethanol (50%, v/v) extract | [22] |
| *F.thymifolia* | Chloroform/methanol/water (12/5/3) extracts of shoot | [12] |
| *F. laevis* | Essential oils from the aerial parts | [9] |
| *F. triandra* | Ethanolic extracts of plant | [25] |
| *F.pulverulenta* | Methanolic extract of plant | [26] |
| | **Neuroprotective activity** | |
| *F.pulverulenta* | Methanolic extracts of shoot and roots | [11] |
| *F.thymifolia* | Methanolic 80%extracts of aerial and root parts | [24] |
| | **Antiparasitic activity** | |
| *F.thymifolia* | Chloroform- ethyl acetate and n-butanol of the 70% ethanol extract | [13] |
| | **Antidiabetic activity** | |
| *F. laevis* | Methanolic -dichloromethane fractions of the aerial parts | [21] |
| *F. laevis* | Methanolic - dichloromethane fractions of the aerial parts | [20] |
| | **Cytotoxic activity** | |
| *F. laevis* | Methanolic - dichloromethane fractions of the aerial parts | [20] |
| *F. laevis* | Methanolic - dichloromethane fractions of the aerial parts | [21] |
| | **Other activities** | |
| *F.pulverulenta* | Methanolic - acetonic extracts of whole plant | [27] |
| *F. laevis* | Aqueous ethanol (50%, v/v) extract | [22] |

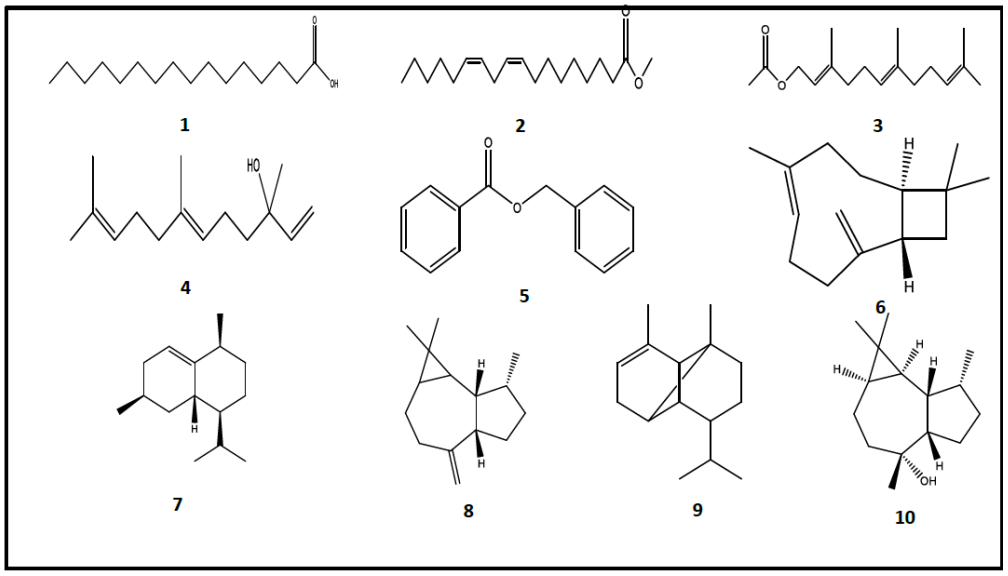


**Fig. 1. Structures of volatile components of the *Frankenia* genus**

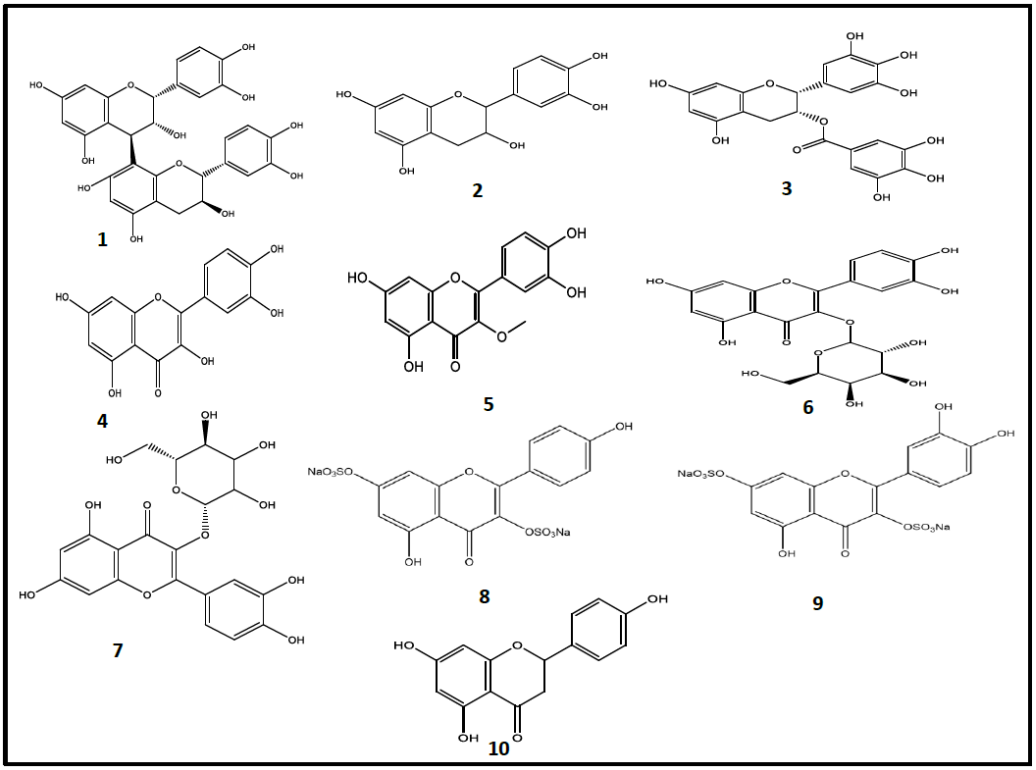


**Fig. 2. Structure of flavonoids from the *Frankenia***

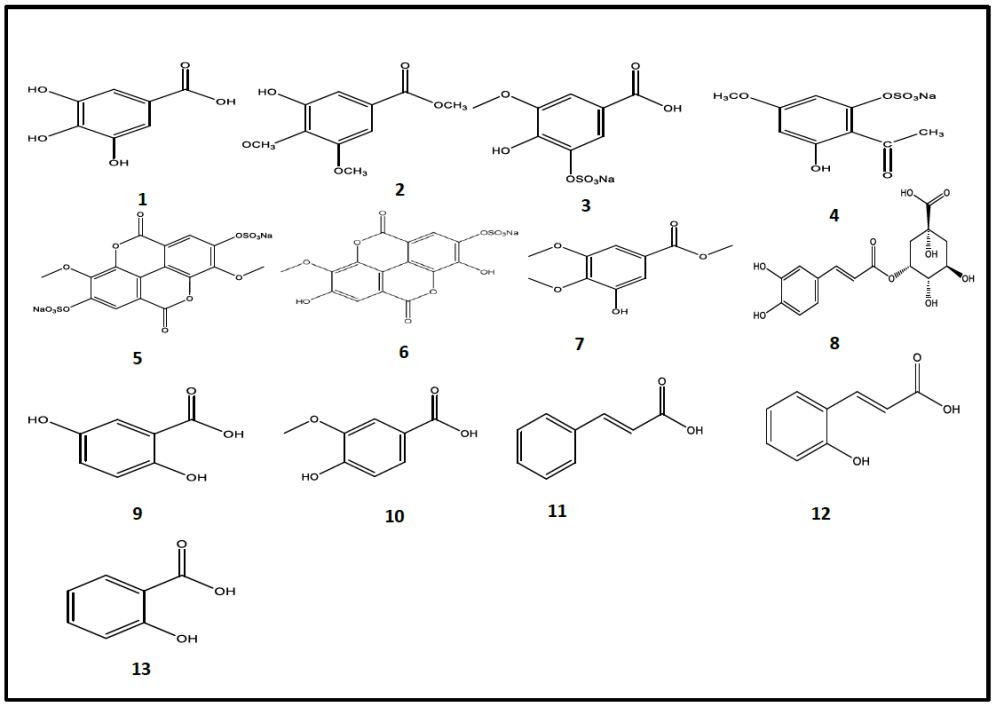


**Fig. 3. Structures of phenolic and phenolic acid derivatives from the *Frankenia* genus**

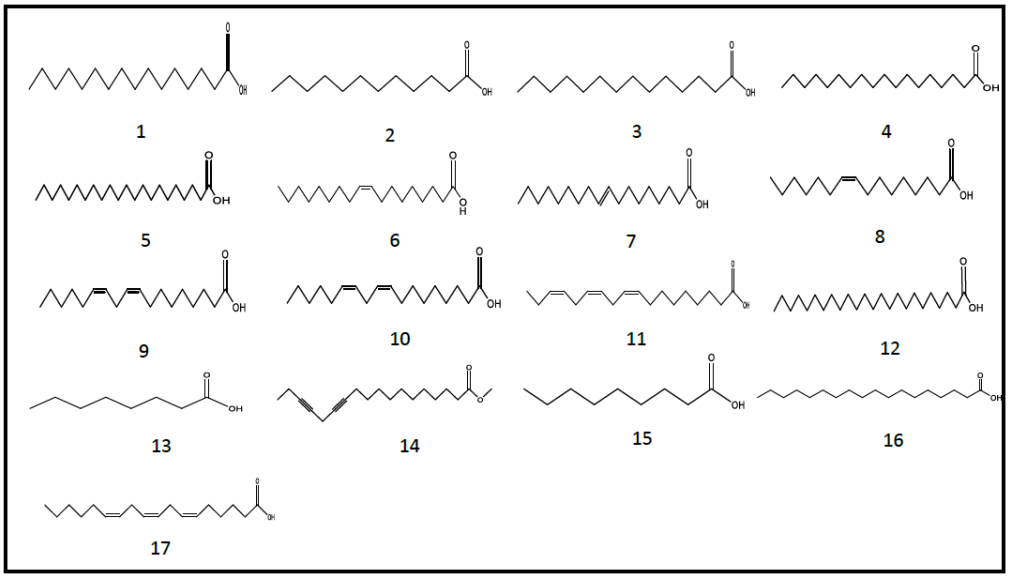


**Fig. 4. Structures of fatty acids from the *Frankenia* genus**

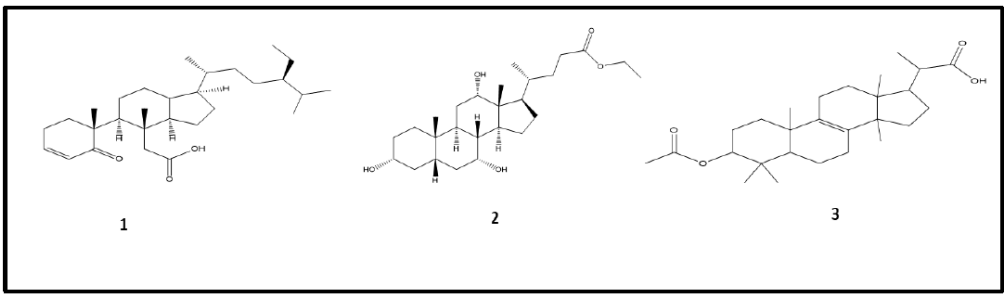


**Fig. 5. Structure of sterols from the Frankenia genus**

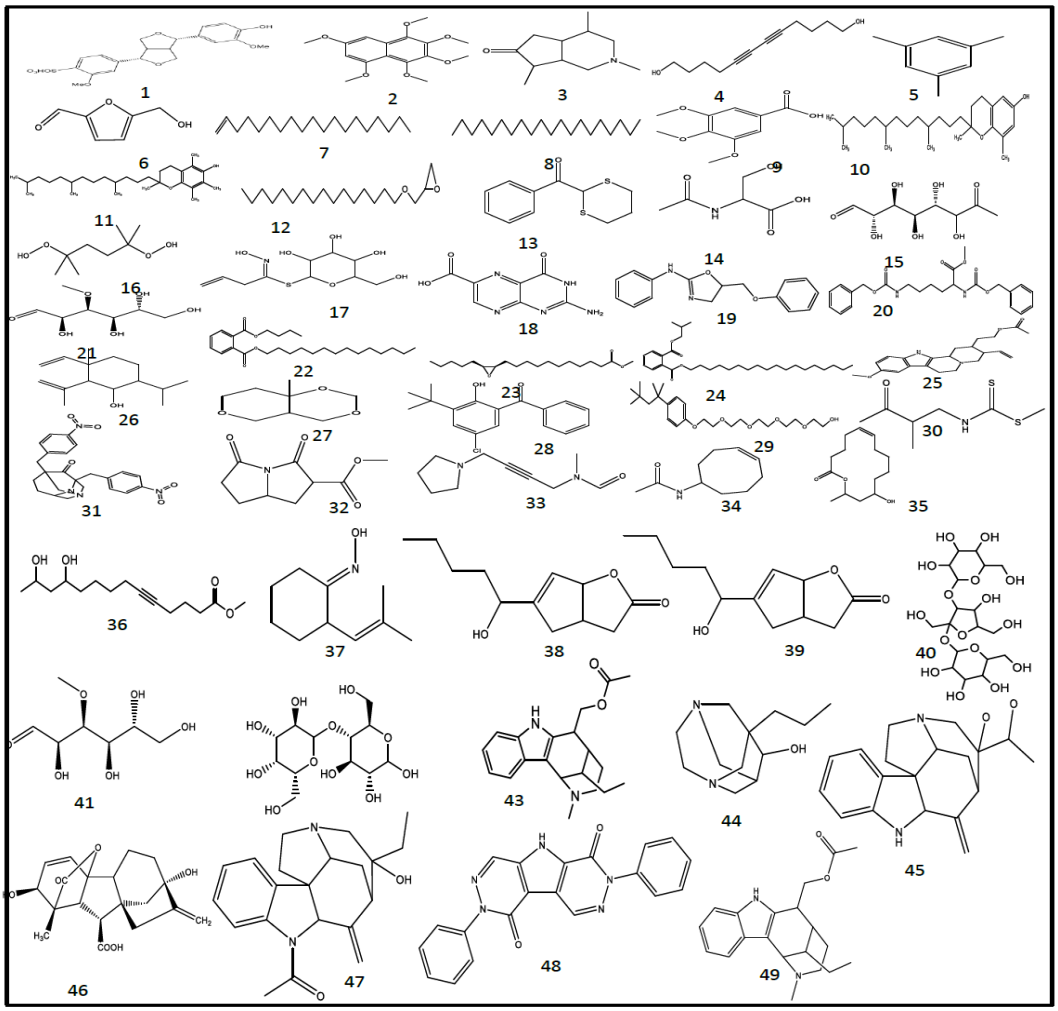

**Fig. 6. Structures of other compounds in the *Frankenia* genus**

**Fig. 7. Photograph of *Frankenia hirsuta***

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## الانشطه الكميائيه النباتيه البيولوجيه لجنس فرانكنيا العائله البخوريه

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**الملخص**

في السنوات الأخيرة، أصبح العالم أكثر اهتماما بالنباتات الطبية. ونتيجة لذلك، أجري هذا البحث للتعرف على القيم العلاجية لجنس فرانكنيا وعلاقته بين مكوناته الكيميائية النباتية وأنشطته البيولوجية. والتي تعتبر من أهم النباتات الطبية الغنية بالمكونات الكيميائية النباتية والتي لها نشاط بيولوجي. فرانكينيا نبات مزهر (كاسية البذور) من عائلة فرانكينيا. أنواع فرانكينيا غنية بالأيضات الثانوية مثل العفص، والبروانثوسيانيدين، والأحماض الفينولية، ومشتقات حمض الفينول، والفلافونويدات، والقشور النزرة إلى جانب مشتقاتها الكبريتية، وآثار القلويدات وغيرها من المركبات النشطة بيولوجيا. أظهرت هذه المستقلبات الثانوية قيمًا علاجية واعدة مثل نشاط مضاد للأكسدة، ونشاط وقائي للكبد، ومرض الزهايمر، ونشاط مضاد للالتهابات، ونشاط مضاد لمرض السكر، ونشاط مضاد للبكتيريا، ونشاط محمي للأعصاب، ونشاط مضاد للطفيليات، ونشاط سام للخلايا، ونشاط مضاد للفيروسات. تهدف هذه المراجعة إلى تقديم لمحة عامة عن الكيمياء النباتية والنشاط البيولوجي الذي ينتمي إلى العائله البخوريه في السنوات الأخيرة.

**الكلمات الدالة:** العائله البخوريه، المكونات الكيميائية النباتية، القوه الدوائيه