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Medicinal plants used in Jeddah, Saudi Arabia: Phytochemical screening

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ABSTRACT

Ethnobotanical and phytochemical studies are useful to discover new drugs. Phytochemical screening is an important step in the detection of the bioactive components existing in medicinal plants that are used in traditional medicine. Very few phytochemical studies investigating medicinal plants used in traditional medicine exist in Saudi Arabia. Eighty-five medicinal plants used in traditional medicine in Jeddah, Saudi Arabia are investigated here for the first time. This research aims to screen of 85 medicinal plants used in traditional medicine in Jeddah for the presence of secondary metabolites, and to answer the following question: Is the ethnomedicinal importance of medicinal plants used in Jeddah conform to their secondary metabolite content. Ethnobotanical fieldwork took place in Jeddah from August 2018 to September 2019. Eighty-five different plant species belonging to 37 families were identified. Screening of 85 medicinal plants was performed for the presence of alkaloids, glycosides, flavonoids, tannins, saponins and resins using standard methods. The most commonly distributed phytochemical compounds among medicinal plants used were glycosides (82%; 70 species), tannins (68%; 58 species), alkaloids (56%; 48 species), saponins (52%, 44 species) and flavonoids (35%; 30 species). On the other hand, the least commonly distributed compounds were resins (31%; 26 species). All the six groups of secondary metabolites were found in seeds of *Cuminum cyminum* L., *Pimpinella anisum* L. and *Trigonella foenum-graecum* L. It can be said that the ethnomedicinal importance of these 85 medicinal plants used in Jeddah conform to their secondary metabolite content. More research should be carried out on the quantitative analysis of phytochemicals in these 85 medicinal plants used in traditional medicine in Jeddah. Furthermore, there is a need to focus phytochemical screening on ethnobotanical studies to complete research into traditional medicine which leads to the discovery of new drugs.

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1. Introduction

Medicinal plants are an important source of medicines which are effective in the therapy of various diseases, especially in traditional medicine (Bako et al., 2005; Borokini and Omotayo, 2012). Different parts of the plant are used in traditional medicine, including barks, flowers, fruits, leaves, resins, rhizomes, roots, seeds, and stems (Alqethami et al., 2017). The medicinal value of these plant

lies on certain chemical effective compounds in different parts of the plant which produce a specific physiological effect in the human body (Kumar and Satapathy, 2011). Plant compounds are bioactive compounds found naturally in plants. These plant substances are often divided into primary and secondary metabolites (Balandrin et al., 1985).

Primary metabolites are essential to plants and are involved in the primary metabolic processes of plant cell building and retention (Briskin, 2000). They are widely distributed in nature and occur in one form or another in all organisms. Among higher plants they are often located within seeds and vegetative storage organs. They are widely used as foods like carbohydrates or food additives, as well as raw industrial resources. For example, fatty acids and plant oils used to produce soaps and cleansers (Balandrin et al., 1985).

On the other hand, secondary metabolites are essential, due to their medicinal value (Borokini and Omotayo, 2012), which can be defined as biological active compounds, found in plant, derived

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from primary metabolites and have pharmacological effects in the human body (Balandrin et al., 1985; Bernhoft et al., 2010). Secondary metabolites are not specifically necessary for the plant's basic photosynthetic or respiratory metabolism such primary metabolites (Theis and Lerdau, 2003; Bernhoft et al., 2010), but many of them seem to have ecological function and important roles in plants such as protection, chemical defenses from microorganism, insect or even higher predators, also as pollinator attractants (Balandrin et al., 1985; Bernhoft et al., 2010). Based on chemical structure, secondary metabolites could be classified into a range of different groups, which largely distinct in terms of the essence of their ecological functions (Kennedy and Wightman, 2011). The most important phytochemical groups in this regard are alkaloids, glycosides, flavonoids, tannins, saponins and resins which have medicinal properties.

Plants which are found to be medicinally effective and frequently traditionally administered may include substances that are possible drug candidates. Therefore, they should be intensively reviewed. In different countries, scientific research of medicinal plants has been conducted due to their effective role to health care (Heinrich et al., 1998; Cunningham, 1993; Gazzaneo et al., 2005; Cai et al., 2006; Aqil et al., 2006). The active compounds differ from plant to plant due to their biodiversity and they produce a definite physiological action on the human body (Edeoga et al., 2006; Borokini and Omotayo, 2012). Moreover, the distribution of these chemical compounds in the different plant parts differs (Bako et al., 2005; Borokini and Omotayo, 2012). Thus, the medicinal content in medicinal plants is affected primarily by cultivation period, season of collection (Nalawade and Tsay, 2004). Therefore, phytochemical screening must be carried out regularly, even on plants whose secondary metabolites are known.

This work focus on one of the Saudi Arabian cities with highest population growth, Jeddah. Aiming to screen of 85 medicinal plants used in traditional medicine in Jeddah for the presence of secondary metabolites, and to answer the following question: Is the ethnomedicinal importance of medicinal plants used in Jeddah conform to their secondary metabolite content. The choice of 85 medicinal plants for this study was based on a recent study carried out by Alqethami et al. (2020) where it was reported that there are 85 different medicinal plants traditionally used in Jeddah.

2. Methods

2.1. Study area

Jeddah is the second-largest city in the Kingdom of Saudi Arabia (KSA). It is situated on the western coast of KSA at latitude 29.21 north and longitude 39.7 east, in the center of the east coast of the Red Sea, 12 m above sea level. Jeddah's urban boundary is about 1765 km². The climate in Jeddah is a desert climate with high humidity, the average annual temperature is approximately 28 °C, and in summer temperatures can rise to 40 °C. It has Red Sea's biggest seaport (UN-Habitat, 2018).

2.2. Plant collection and identification

Samples of 85 different plants (Table 1) were collected based on ethnobotanical fieldwork which took place over a year in Jeddah, from August 2018 to September 2019. The ethical guidelines of the American Anthropological Association (2012) and the Code of Ethics of the International Society of Ethnobiology (2006) were followed. Approval from the Ethics Committee of the Unit of Biomedical Ethics Research Committee, King Abdulaziz University, was obtained (Reference No 671-19). Plant specimens were mounted

and were identified in the King Abdulaziz University herbarium (KAUH) using specimens of herbarium, Flora of KSA (Chaudhary, 1999, 2000, 2001) and the Flora of KSA (Migahid, 1978). Voucher specimens were deposited in KAUH. Identification was validated by authors. Nomenclature and families follow Catalogue of Life (2015). The list was cross-checked with the online checklist of the Flora of KSA (Thomas, 2011), as well as with (Chaudhary, 1999, 2000, 2001).

2.3. Preparation of plant extracts

Plant materials were prewashed, dried and grinded to get a homogeneous sample (Thangaraj, 2016). For different extraction, plant powdered was divided into two sections: Aqueous extraction and solvent extraction (Fig. 1).

2.3.1. Aqueous extraction

Two hundred ml of distilled water was mixed with five grams of plant samples. This mixture was heated for 20 min with continuous stirring at 30–40 °C. The aqueous extract was filtered by Whatman No.1 filter paper (Yadav and Agarwala, 2011).

2.3.2. Solvent extraction

Ten grams of plant material was taken in one hundred ml of solvent (solvents used were methanol and ethanol) in a conical flask, plugged with cotton and then kept for 24 h and filtered using Whatman No. 1 filter paper (Thangaraj, 2016).

2.4. Chemicals and reagents

Methanol, ethanol, hydrochloric acid (HCl), glacial acetic acid, ferric chloride (FeCl₃), concentrated sulphuric acid (H₂SO₄), magnesium ribbon, Hager's reagent, sodium hydroxide solution (NaOH) and distilled water.

2.5. Phytochemical analysis

Qualitative analysis of phytochemical contents was performed according to published methods as following; alkaloids (Pandey and Tripathi, 2014; Yadav et al., 2014; Thangaraj, 2016), glycosides (Parekh and Chanda, 2007; Yadav and Agarwala, 2011; Pandey and Tripathi, 2014), flavonoids (Kumar et al., 2007; Pandey and Tripathi, 2014), tannins (Kumar et al., 2007; Parekh and Chanda, 2007; Yadav et al., 2014), resin (Ukoha et al., 2011; Aldhebiani and Mufarah, 2017) and saponin (Parekh and Chanda, 2007; Ukoha et al., 2011; Yadav et al., 2014). Each plant sample was analyzed 3 times.

2.5.1. Detection of alkaloids

(Hager's test)

Ethanol extract was dissolved in a few ml dilute Hydrochloric acid and filtered. Few drops of Hager's reagent (saturated aqueous solution of picric acid) were added to 2 ml of filtrate. A prominent yellow precipitate indicates the test as positive (Pandey and Tripathi, 2014; Yadav et al., 2014; Thangaraj, 2016).

2.5.2. Detection of glycosides

(Kellar – Kiliani test)

One ml of glacial acetic acid, one ml of FeCl₃ and one ml of H₂SO₄ were added to two ml of filtrate (ethanol extract). A green-blue color indicates the presence of glycosides (Parekh and Chanda, 2007; Yadav and Agarwala, 2011).

Table 1

A comprehensive inventory of phytochemical screening of the 85 medicinal plants used in traditional medicine in Jeddah including scientific name, family, voucher specimen number, common name(s), part(s) tested. (+) = Present/(–) = Absent.

Scientific name (family, voucher specimen)	Common name	Part tested	Alkaloid	Glycosides	Flavonoid	Tannins	Saponin	Resin
<i>Allium cepa</i> L. (Amaryllidaceae, AQJ_2)	Onion	Bulb	–	+	+	–	–	–
<i>Allium sativum</i> L. (Amaryllidaceae, AQJ_1)	Garlic	Bulb	–	+	–	–	+	–
<i>Aloe vera</i> (L.) Burm.f. (Asphodelaceae, AQJ_3)	Aloe	Leaves	–	+	–	+	–	–
<i>Anastatica hierochuntica</i> L. (Brassicaceae, AQJ_4)	Flower of Mariyam	All plant	+	+	–	+	+	–
<i>Anethum graveolens</i> L. (Apiaceae, AQJ_5)	Dill-weed	Leaves	–	+	–	+	+	–
		Seed	–	+	+	–	–	–
<i>Angelica sinensis</i> (Oliv.) Diels (Apiaceae, AQJ_6)	Dong Quai	Stem	+	+	–	–	+	–
<i>Apium graveolens</i> L. (Apiaceae, AQJ_7)	Wild Celery	Leaves	–	+	–	+	–	–
<i>Aucklandia costus</i> Falc. (Asteraceae, AQJ_8)	Costus	Root	+	+	–	+	+	–
<i>Azadirachta indica</i> A.Juss. (Meliaceae, AQJ_9)	Neem	Leaves	–	+	–	+	–	–
<i>Beta vulgaris</i> L. (Amaranthaceae, AQJ_10)	Beet	Root	+	+	+	+	–	–
<i>Boswellia sacra</i> Flückiger-Dupiron (Burseraceae, AQJ_11)	Frankincense	Resin	+	–	–	–	+	+
<i>Camellia sinensis</i> (L.) Kuntze (Theaceae, AQJ_12)	Tea	Leaves	–	+	+	+	–	–
<i>Carum carvi</i> L. (Apiaceae, AQJ_13)	Caraway	Seed	+	+	+	+	–	+
<i>Chenopodium quinoa</i> Willd. (Amaranthaceae, AQJ_14)	Quinoa	Seed	+	–	+	–	+	+
<i>Cinnamomum cassia</i> (L.) Presl (Lauraceae, AQJ_15)	Cinnamon	Bark	+	–	+	+	–	–
<i>Cinnamomum tamala</i> (Buch-Ham.) Th. G. G. Nees (Lauraceae, AQJ_16)	Indian bay leaf	Leaves	+	+	–	+	+	–
<i>Citrus aurantium</i> L. (Rutaceae, AQJ_18)	Orange	Fruit	+	+	+	+	–	–
<i>Citrus limon</i> (L.) Burm. fil. (Rutaceae, AQJ_17)	Lemon	Fruit	–	+	+	+	–	–
<i>Coffea arabica</i> L. (Rubiaceae, AQJ_19)	Arabian Coffee	Seed's peel	–	+	–	+	–	–
<i>Commiphora gileadensis</i> (L.) C. Christ. (Burseraceae, AQJ_21)	Balsam of Gilead	Stem	+	–	–	+	+	–
<i>Commiphora myrrha</i> (Nees) Engl. (Burseraceae, AQJ_20)	Myrrha	Resin	–	–	–	+	+	+
<i>Coriandrum sativum</i> L. (Apiaceae, AQJ_22)	Coriander	Leaves	–	+	–	+	+	–
<i>Crocus sativus</i> L. (Iridaceae, AQJ_23)	Saffron crocus	Stigma in flower	+	+	–	–	–	–
<i>Cucumis sativus</i> L. (Cucurbitaceae, AQJ_24)	Garden cucumber	Fruit	+	+	–	–	–	–
<i>Cuminum cyminum</i> L. (Apiaceae, AQJ_25)	Cumin	Seed	+	+	+	+	–	+
<i>Curcuma longa</i> L. (Zingiberaceae, AQJ_26)	Turmeric	Rhizome	+	+	–	+	+	–
<i>Daucus carota</i> L. (Apiaceae, AQJ_27)	Carrot	Root	+	+	+	–	–	–
<i>Elettaria cardamomum</i> (L.) Maton (Zingiberaceae, AQJ_28)	Cardamom	Fruit	–	+	–	+	–	–
<i>Eruca vesicaria</i> (L.) Cav. (Brassicaceae, AQJ_29)	Salad rocket	Leaves	–	+	–	+	+	–
<i>Ficus carica</i> L. (Moraceae, AQJ_30)	Common fig	Fruit	+	+	–	+	–	–
<i>Foeniculum vulgare</i> Mill. (Apiaceae, AQJ_31)	Fennel	Seed	+	+	+	–	+	–
<i>Glycyrrhiza glabra</i> L. (Fabaceae, AQJ_32)	Licorice	Root	–	+	–	+	+	+
<i>Helianthus annuus</i> L. (Asteraceae, AQJ_33)	Common sunflower	Seed	–	+	+	–	–	+
<i>Hibiscus sabdariffa</i> L. (Malvaceae, AQJ_34)	Roselle	Flowers	+	–	–	+	–	+
<i>Hordeum vulgare</i> L. (Poaceae, AQJ_35)	Barley	Seed	+	–	–	–	–	–
<i>Hyphaena thebaica</i> (L.) Mart. (Arecaceae, AQJ_36)	Doom palm	Seed	–	+	–	+	–	–
<i>Lavandula atriplicifolia</i> Benth. (Lamiaceae, AQJ_37)	Lavender	Flowers	–	+	–	–	+	–
<i>Lawsonia inermis</i> L. (Lythraceae, AQJ_38)	Henna	Leaves	–	+	–	+	–	+
<i>Lepidium sativum</i> L. (Brassicaceae, AQJ_39)	Garden cress	Seed	+	+	+	+	–	+
<i>Linum usitatissimum</i> L. (Linaceae, AQJ_40)	Flax	Seed	+	–	–	–	+	+
<i>Luffa aegyptiaca</i> Mill. (Cucurbitaceae, AQJ_41)	Sponge gourd	Fruit	+	+	+	–	+	–
<i>Lupinus albus</i> L. (Fabaceae, AQJ_42)	Lupin	Seed	+	+	–	+	–	+
<i>Malus pumila</i> Mill. (Rosaceae, AQJ_43)	Apple	Fruit	–	+	+	+	–	–
<i>Matricaria aurea</i> (L.) Sch. Bip. (Asteraceae, AQJ_44)	Golden Chamomile	Flowers	+	+	–	+	+	–
<i>Mentha spicata</i> L. (Lamiaceae, AQJ_45)	Mint	Leaves	+	+	+	+	–	–
<i>Momordica charantia</i> L. (Cucurbitaceae, AQJ_46)	Bitter melon	Fruit	+	+	–	–	+	–
<i>Moringa oleifera</i> Lam. (Moringaceae, AQJ_47)	Moringa	Leaves	–	+	–	+	–	–
<i>Morus nigra</i> L. (Moraceae, AQJ_48)	Black Mulberry	Leaves	–	+	–	+	–	+
<i>Myristica fragrans</i> Houtt. (Myristicaceae, AQJ_49)	Nutmeg	Seed & Fruit	+	+	–	–	–	+
<i>Myrtus communis</i> L. (Myrtaceae, AQJ_50)	Myrtle	Leaves	–	+	–	+	+	–
<i>Nigella sativa</i> L. (Ranunculaceae, AQJ_51)	Nigella	Seed	+	–	+	+	+	–
<i>Ocimum americanum</i> L. (Lamiaceae, AQJ_52)	Hoary basil	Leaves	+	+	–	–	–	–
<i>Ocimum basilicum</i> L. (Lamiaceae, AQJ_53)	Basil	Leaves	–	+	–	–	+	–
<i>Olea europaea</i> L. (Oleaceae, AQJ_54)	Olive	Leaves	–	–	–	+	+	+
		Fruit	–	–	+	–	+	–
<i>Origanum syriacum</i> L. (Lamiaceae, AQJ_55)	Syrian oregano	Leaves	+	+	–	–	–	–
<i>Panax ginseng</i> C.A.Mey. (Araliaceae, AQJ_56)	Ginseng	Root	+	+	+	–	+	+
<i>Petroselinum crispum</i> (Mill.) Fuss (Apiaceae, AQJ_57)	Parsley	Leaves	+	+	–	+	–	–
<i>Phoenix dactylifera</i> L. (Arecaceae, AQJ_58)	Date palm	Fruit	–	+	–	–	–	–
<i>Pimpinella anisum</i> L. (Apiaceae, AQJ_59)	Anise	Seed	+	+	+	+	+	+
<i>Piper nigrum</i> L. (Piperaceae, AQJ_60)	Black Pepper	Seed	+	+	–	+	–	–
<i>Pistacia lentiscus</i> L. (Anacardiaceae, AQJ_61)	Mastic	Resin	+	+	–	+	+	+
<i>Plectranthus aegyptiacus</i> (Forssk.) C.Chr. (Lamiaceae, AQJ_62)	Silver spur flower	Leaves	–	+	–	–	–	–
<i>Prunus mahaleb</i> L. (Rosaceae, AQJ_63)	Mahaleb cherry	Seed	+	+	–	–	+	+
<i>Psidium guajava</i> L. (Myrtaceae, AQJ_64)	Guava	Leaves	–	–	–	+	–	+
<i>Punica granatum</i> L. (Lythraceae, AQJ_65)	Pomegranate	Peel	+	+	–	+	+	–

(continued on next page)

Table 1 (continued)

Scientific name (family, voucher specimen)	Common name	Part tested	Alkaloid	Glycosides	Flavonoid	Tannins	Saponin	Resin
<i>Rosa damascena</i> P. Mill. (Rosaceae, AQJ_66)	Damask rose	Flowers	–	+	+	+	–	–
<i>Salvadora persica</i> L. (Salvadoraceae, AQJ_67)	Arak	Stem	–	+	–	+	–	–
<i>Salvia officinalis</i> L. (Lamiaceae, AQJ_68)	Garden sage	Leaves	+	+	–	+	–	–
<i>Salvia rosmarinus</i> Schleid. (Lamiaceae, AQJ_69)	Rosemary	Leaves	+	+	–	+	+	+
<i>Senegalia senegal</i> (L.) Britton (Fabaceae, AQJ_70)	Gum Arabic tree	Resin	–	+	–	–	+	+
<i>Senna alexandrina</i> Mill. (Fabaceae, AQJ_71)	Senna	Leaves	–	+	+	+	+	–
<i>Senna italica</i> Mill. (Fabaceae, AQJ_72)	Italian Senna	Fruit	–	+	–	+	+	–
<i>Seriphidium herba-alba</i> (Asso) J. Soják (Asteraceae, AQJ_73)	White Wormwood	Leaves	–	+	–	+	+	+
<i>Sesamum indicum</i> L. (Pedaliaceae, AQJ_74)	Sesame	Seed	+	–	+	–	–	–
<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry (Myrtaceae, AQJ_75)	Cloves	Flower buds	+	–	+	+	–	+
<i>Tamarindus indica</i> L. (Fabaceae, AQJ_76)	Tamarind	Fruit	–	+	–	+	+	–
<i>Thymus vulgaris</i> L. (Lamiaceae, AQJ_77)	Common thyme	Leaves	–	+	–	–	+	–
<i>Trachyspermum ammi</i> (L.) Sprague (Apiaceae, AQJ_78)	Ajwain	Seed	+	+	+	+	–	–
<i>Trigonella foenum-graecum</i> L. (Fabaceae, AQJ_79)	Fenugreek	Seed	+	+	+	+	+	+
<i>Tripleurospermum auriculatum</i> (Boiss.) Rech. fil. (Asteraceae, AQJ_80)	Mayweed	Leaves	+	+	–	+	+	–
<i>Vigna radiata</i> (L.) R. Wilczek (Fabaceae, AQJ_81)	Green Gram	Seed	+	+	–	–	+	–
<i>Vitellaria paradoxa</i> C.F.Gaertn. (Sapotaceae, AQJ_82)	Shea	Seed	+	+	+	–	–	+
<i>Vitis vinifera</i> L. (Vitaceae, AQJ_83)	Grape	Fruit	–	–	–	+	–	–
<i>Zingiber officinale</i> Roscoe (Zingiberaceae, AQJ_84)	Ginger	Root	–	+	+	+	+	–
<i>Ziziphus spina-christi</i> (L.) Desf. (Rhamnaceae, AQJ_85)	Christ's thorn jujube	Leaves	+	–	–	+	+	–
Total of species	–	–	48	70	30	58	44	26



Fig. 1. Plants extraction.

2.5.3. Detection of flavonoids

(Shinoda test)

A piece of magnesium ribbon and one ml of concentrated HCl were applied to two–three ml of (methanol extract) filtrate. The solution's pink-red or red coloration indicates the presence of flavonoids (Kumar et al., 2007).

(Alkaline Reagent test)

Few drops of NaOH solution were added to a few ml of (methanol extract) filtrate, and then a few ml of diluted HCl was added. Flavonoid existence suggests a yellow solution with NaOH that becomes colorless after adding diluted HCl (Pandey and Tripathi, 2014).

2.5.4. Detection of tannins

(Braymer's test)

Few drops of FeCl₃ (10%) solution were applied to two–three ml of (ethanol extract) filtrate. The existence of tannins suggests a solution of greenish grey or dark blue color (Kumar et al., 2007; Parekh and Chanda, 2007; Yadav et al., 2014).

2.5.5. Detection of saponins

(Foam test)

Five ml of distilled water was mixed to five ml of filtrate (aqueous extract) with vigor shaking. The existence of saponins suggests a stable froth (Parekh and Chanda, 2007; Ukoha et al., 2011; Yadav et al., 2014).

2.5.6. Detection of resins

(Precipitate test)

Twenty ml distilled water was added to fifteen ml of filtrate (ethanol extract). A precipitate indicating the presence of resins (Ukoha et al., 2011; Aldhebiani and Mufarah, 2017).

3. Results

A total of 85 different medicinal plants belong to 37 families used in the traditional treatment in Jeddah were tested for the

presence of the phytochemical content including alkaloids, glycosides, flavonoids, tannins, saponins and resins (Table 1). The most commonly distributed compounds among medicinal plants used in the traditional treatment in Jeddah were glycosides (82%; 70 species), tannins (68%; 58 species), alkaloids (56%; 48 species), saponins (52%, 44 species) and flavonoids (35%; 30 species). On the other hand, the least commonly distributed compounds were resins (31%; 26 species; Fig. 2). All species of Apiaceae, Lamiaceae, Zingiberaceae, Fabaceae and Asteraceae in the current study had glycosides. Plants representing Apiaceae in this study had the highest number of phytochemicals groups. All the six groups of chemical compounds were found in seeds of *Cuminum cyminum* L., *Pimpinella anisum* L. and *Trigonella foenum-graecum* L.

Thirteen various parts of plants were tested including (all plant, bark, bulbs, flowers, fruits, leaves, peel of seeds, peel of fruits, resins, rhizomes, roots, seeds and stems). Most of plant species were tested one part of the plant only, while two species were tested two parts of the plant used in medicine. Out of the 70 species had glycosides, the most parts of these species had glycosides were leaves (33%; 24 species) followed by seeds (22%; 16 species) and fruits (17%; 12 species). Of the 58 species which had tannins, most of the tannins were found in leaves (40%; 23 species) followed by fruits and seeds (16%; 9 species each). Of the 48 species that had alkaloids, the majority of alkaloids were found in seeds (37%; 18 species) followed by leaves (18%; 9 species) and fruits (12%; 6 species). Out of the 44 species had saponins, the most parts of these species had saponins were leaves (29%; 13 species) followed by seeds (22%; 10 species) and fruits (11%; 5 species). Of the 30 species which had flavonoids, the most parts of these species had flavonoids were seeds (47%; 14 species) followed by fruits (17%; 5 species) and roots (13%; 4 species). Out of 26 species had resins, the most parts of these species had resins were seeds (42%; 11 species) followed by leaves (23%; 6 species) and resins (15%; 4 species; Fig. 3).

4. Discussion

Traditional uses in folk medicine are justified scientifically. The reasons behind using these medicinal plants in traditional treatment in Jeddah could be either cultural or chemical reasons, or both. In the light of the findings of the current study, the chemical reasons are highlighted. Secondary metabolites including glycosides, tannins, alkaloids, saponins, flavonoids and resins contribute significantly towards medicinal as well as physiological activities (Yadav and Agarwala, 2011). Glycosides were the most commonly

distributed compounds among these medicinal plants. As well as, all species of Apiaceae, Lamiaceae, Zingiberaceae, Fabaceae and Asteraceae in this study had glycosides. Glycosides have wide medicinal efficacy as they exist in almost all medicinal plants (Yadav et al., 2014). According to previous studies, it has been shown that glycosides have sedative and digestives properties (Galvano et al., 2004; Güçlü-Üstündağ and Mazza, 2007), anti-cancer (Zhou et al., 2013) and expectorant (Kabera et al., 2014). Therefore, these could be reasons for these families which are considered the most commonly used families and have a high number of uses that are reported in traditional treatment in Jeddah (Alqethami et al., 2020).

The second most commonly distributed compounds among medicinal plants used in folk medicine in Jeddah were tannins. Tannins possess extremely stringent effects. They help in wound healing and inflamed mucosal membranes (Yadav et al., 2014). The tannin containing plant extracts are used as astringents, against diarrhea, as diuretics, against stomach and duodenal tumors, and as anti-inflammatory, antiseptic, and hemostatic pharmaceuticals (Khanbabae and van Ree, 2001). Alkaloids, saponins and flavonoids are also present in medicinal plants used in traditional medicine in Jeddah. Alkaloids have beneficial effects. They are also known as their sedative properties and they have a powerful effect on the nervous system (Renu, 2005). Saponins have been used for medicinal reasons in plants. Most herbal medicines include saponin (Lacaille-Dubois and Wagner, 1996; Kareru et al., 2008). Flavonoids have antioxidant potentials hence could offer protection against heart disease and cancer (Noroozi et al., 1998). Resins were also found but least common in these medicinal plants. Many resins are antimicrobial and aid in healing wounds (Bernhoft et al., 2010). Hence, the presence of these groups seems to support the efficacy of the use of these medicinal plants in ethnomedicinal practice in Jeddah.

According to Alqethami et al. (2020) most popular medicinal species have wide medicinal uses in traditional medicine in Jeddah were *Zingiber officinale* Roscoe, followed by *Mentha spicata* L., *Pimpinella anisum*, *Cuminum cyminum* and *Foeniculum vulgare* Mill. These plants were also widely used in herbal medicine. All the six groups of chemical compounds were found in the seeds of *Cuminum cyminum* and *Pimpinella anisum*, which agree with findings of previous studies by (Mushtaq et al., 2014; Al-Snafi, 2016; Islam et al., 2016). In addition, four group of chemical compounds were found together in *Zingiber officinale*, which were glycosides, flavonoid, tannins and saponin; a similar finding was reported by (Zeeshan et al., 2018). In *Mentha spicata* all of alkaloids, glycosides, flavonoids and tannins were found, this result is in agreement with

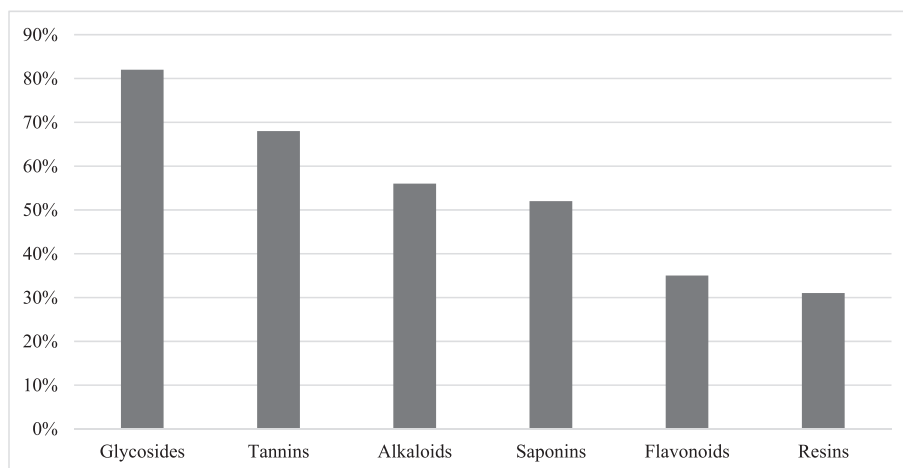


Fig. 2. The percentage of distribution of phytochemical groups among medicinal plants used in the traditional treatment in Jeddah.

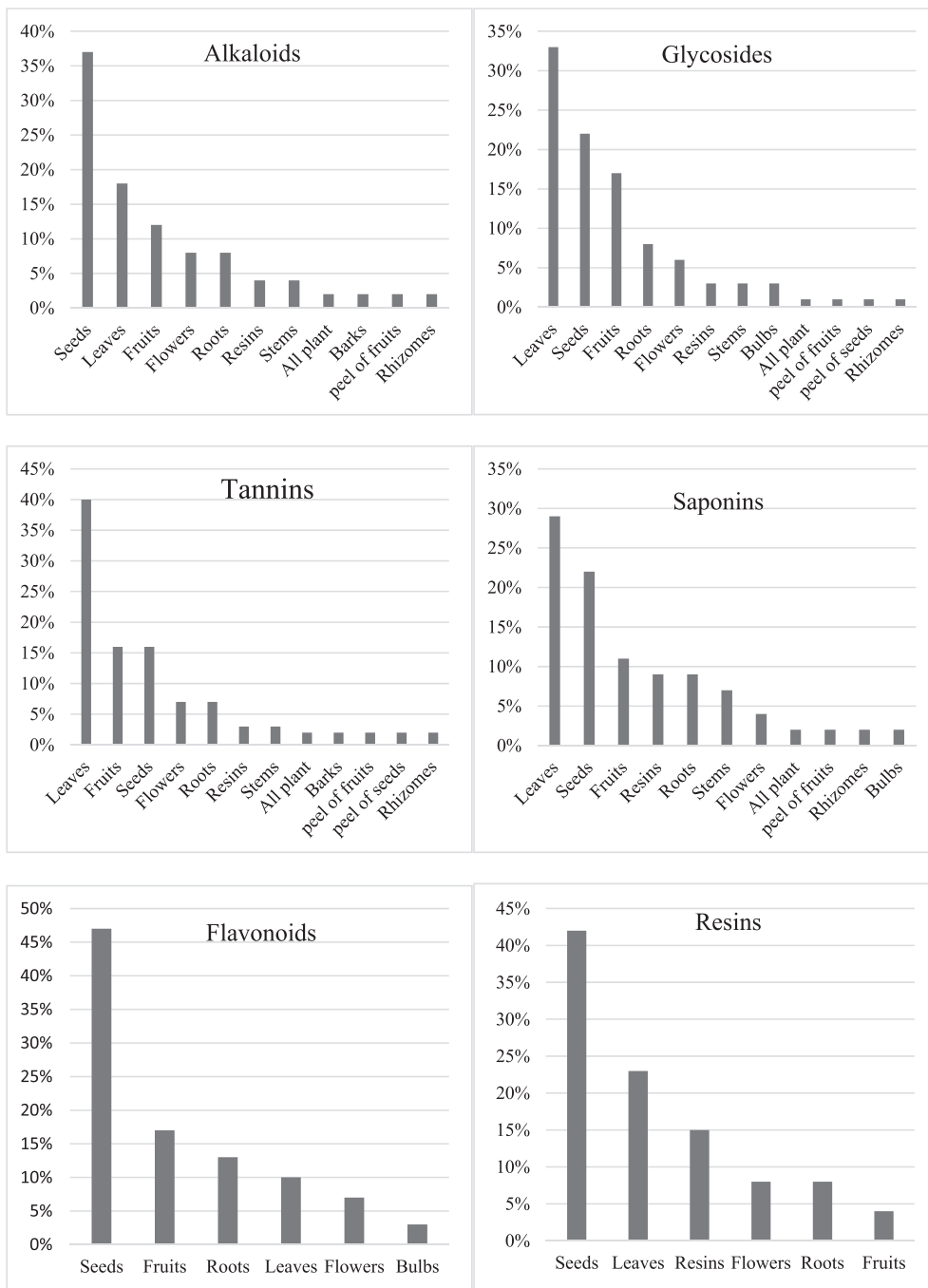


Fig. 3. The percentage of distribution of each phytochemical group among different parts of plants.

the finding reported by Khan et al. (2011). On the other hand, all of alkaloid, glycosides, flavonoid and saponin were found in *Foeniculum vulgare*, which is in agreement with findings by Beyazen et al. (2017). Hence, the presence of all the six groups of secondary metabolites or the most of them in these five plants could explain why these plants are the most popular medicinal species used in Jeddah.

There are striking similarities in the phytochemical components of plants belonging to the same family. For example, in the current study, Apiaceae was represented by 11 species, all of which tested positive for the presence of glycosides, eight of these species contain alkaloid, eight had tannins, seven contain flavonoid, six contain saponin and only three of these species had Resin. Another

example is Lamiaceae, which was represented by 9 species, all of which tested positive for the presence of glycosides. In contrast, all of them lacked resin except one species contain resin. Furthermore, the two species that represent the Arecaceae (*Hyphaene thebaica* (L.) Mart. and *Phoenix dactylifera* L.) contain glycosides and tannins, while they lacked alkaloid, flavonoid, saponin and resin.

On the other hand, there are relatively wide differences in the secondary metabolites of plants belonging to the same family. For example, the three representatives of the Myrtaceae had relatively wide differences in the secondary metabolites they contain. This observation is the same for the two species representing the Amaranthaceae. The similarity and wide diversity in the distribution of secondary metabolites among plants in the same family,

as revealed in this study, are of taxonomic importance. As a result, the use of phytochemical constituents in plants as a taxonomic tool in classification has wide acceptability (Borokini and Omotayo, 2012).

Secondary metabolites were found in different parts of plants. Leaves and seeds were parts of plants that have the most secondary metabolites compared with other plant parts. Leaves were the most parts have glycosides, tannins and saponins and this conforms with the report of (Aththorick and Berutu, 2018). According to Tripathy (2015) leaves are rich in therapeutically active secondary metabolites and essential oils. In contrast, seeds were the most parts have alkaloids, flavonoids and resins. As Shirley (1998) found that, the majority of seeds are rich in flavonoids. This could explain that why leaves and seeds are the most parts were used in traditional medicine in Jeddah (Alqethami et al., 2020). Plant parts that contain a lot of secondary metabolites will be widely used in traditional medicine (Aththorick and Berutu, 2018).

5. Conclusion

The findings of this study show a wide diversity in secondary metabolite spread between the 85 medicinal plants used in traditional medicine in Jeddah. In addition, it can be said the ethnobotanical importance of these 85 medicinal plants conform to their secondary metabolite content. Therefore, more research should be carried out on the quantitative analysis of phytochemicals in these 85 medicinal plants used in traditional medicine in Jeddah. For example, estimating the phytochemicals which have antioxidant. Furthermore, there is a need to focus on phytochemical screening on ethnobotanical studies to complete research into traditional medicine which leads to the discovery of new drugs.

6. Notes

The present study was conducted as a part of the doctoral dissertation work by Afnan Alqethami and supervised by Amal Aldhebani which focused on the diversity of medicinal plants traditionally used in Jeddah city in Saudi Arabia.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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