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Research Article

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Proximate composition, mineral content and secondary metabolites of three medicinal wild *Fagonia* species

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ABSTRACT

Proximate composition of the aerial parts of three *Fagonia* species (*Fagonia arabica* L., *F. mollis* Delile and *F. cretica* L.) collected from different habitats were analyzed. Macro- and micro-elements as well as some secondary metabolites were estimated. The obtained results revealed that *F. creticus* contains appreciable levels of nutritive components considering that its nutritional value (351.06 kcal/100g dry wt.) was remarkably higher than that of *F. arabica* and *F. mollis* (327.99 and 293.07 kcal/100g dry wt., respectively). The concentration of Na was relatively the highest among the other estimated macroelements in the studied species followed by K, Ca and Mg, respectively while Fe was the highest microelement followed by Cu, Mn and Zn, respectively. The phytochemical composition revealed that methanolic extract of *F. creticus* was the richest in total alkaloids and flavonoids, while *F. arabica* found to be the richest in total phenolics and tannins.

KEYWORDS: *Fagonia*, zygophyllaceae, phytochemical, minerals, bioactive compounds

INTRODUCTION

Plants are valuable sources of a wide range of secondary metabolites, which are used as pharmaceuticals, agrochemicals, flavors, and additives. Medicinal plants are the nature's gift to human to help them pursue a disease-free health life. Plants have been used as drugs by humans since thousands of years ago. As a result the accumulated experience from the past generations, today, all the world have an extensive knowledge of herbal medicine. Two thirds of the newly identified chemicals yearly were extracted from higher plants and 75% of the world population used plants for therapy and prevention [1, 2]. The Medicinal values of plants are dictated by their phytochemical constituents [3]. Plants extracts contain many chemical compounds that are biologically active within the human body [4]. Plant derived substances have recently become of great interest owing to their versatile applications [5].

Many substances that we use in our daily life are plant products that could be used as drugs, flavorings, rubber, paint base, non-petroleum oils, gums and sizing starches are also derived from plants, most important of all, is the edible plant product, that are the food base of human culture [6].

The genus *Fagonia* (Zygophyllaceae) is represented in Egypt by 18 species according to Tackholm [7], while Boulos [8] illustrated that this genus is represented by only 15 species. The species of this genus are characterized by palmate compound leaves, stiff stipules and purple flowers. It is found on dry calcareous rocks, sandy plains and desert wadis. It is widely distributed worldwide in North Africa, Spain, Balearic Islands, Sicily, Malta, Greece, Pakistan. In Egypt it occurs in the Mediterranean coastal strip, the oases of the western desert, all the deserts of Egypt and the entire Sinai Peninsula [8]. Species of genus *Fagonia* were extensively studied by many researchers regarding their medicinal uses, since these plants are known to be antitumor, antioxidant, analgesic, astringent, febrifuge and prophylactic against small-pox agents. Species of *Fagonia* were also used for the treatment of cancer in the indigenous system, fever, asthma, urinary discharges, toothache, stomach troubles and kidney diseases [9, 10]. This genus is a rich source of triterpenes and saponins. Pharmacological studies of their aqueous extracts on animal have shown anticancer and some other important activities [11]. Methanolic extract of *Fagonia cretica* possessed anti-diabetic activity and have potential to reduce kidney damage, which would be helpful to reduce the kidney damage in patients suffering from long-term diabetes. It is suggested that active constituents of *Fagonia cretica* such as quinovic acid should be separated and evaluated for its efficacy in certain based therapies [12].

Scientific studies indicated that medicinal plants contain promising phytochemical compounds that could be developed for treatment of many health problems. Most plants carry a large number of unidentified compounds which can be really useful for making new drugs. Therefore, today efforts have been directed towards the discovery, isolation and development of natural products from various medicinal plants and animal sources [13-16]. The objectives of this research were to determine the proximate composition, mineral content and secondary metabolites of three wild medicinal species of genus *Fagonia* naturally growing in the different habitats of study area to evaluate their economic potentialities and to use them in various purposes as a raw natural resource.

MATERIALS AND METHODS

Preparation of Plant Material

The investigated *Fagonia* spp (Family, Zygophyllaceae) in the present study were collected from different habitats of the study area, these species are growing naturally in the Western Mediterranean coastal belt, Cairo-Suez Desert Road as well as Wadi Hagul region. The selected species of genus *Fagonia* include: *Fagonia arabica* L., *Fagonia cretica* L. and *Fagonia mollis* Delile. The identification of species was done according to Boulos [8]. The studied species were dried at room temperature and ground into a powder using a blender.

In the flowering stage, plant sample of the studied species were handly cleaned, washed several times with distilled water, dried at 55 to 60 °C (maximum) in a forced air oven for a maximum of 24 hours to reduce moisture content prior to grinding, then preserved in well stoppered bottles.

Phytochemical Analysis

The moisture content, dry matter, crude fiber, lipid content, ash and crude protein of *Fagonia* species were analyzed according to AOAC [17]. The total nitrogen was determined by the Kjeldahl method [18]. Glucose was determined based on the method of Feteris [19]. Sucrose was determined according to Handel [20]. Polysaccharides were estimated by the method of Thyumanavan and Sadasivam [21].

The method of extraction of different elements in the present study was described by Allen *et al*. [22]. Sodium and potassium were determined in sample by Flame Photometer (Model PHF 80 B Biologie Spectrophotometer), while calcium, magnesium, copper, zinc, iron and manganese were estimated using atomic absorption spectrometer (Perkin-Elmer, Model 2380. USA). These elements were expressed as mg g^{-1} dry weight.

The content of total phenolic and tannins were determined spectrophotometrically according to methods of Sadasivam and Manickam [23] and Van Buren & Robinson [24], respectively. Saponins content was estimated according to Obadoni and Ochuko[25], while the content of flavonoids was determined according to Boham and Kocipai-Abyazan [26]. The alkaloids were extracted with 10% acetic acid in ethanol and determined according to the method of Harborne [27].

RESULTS AND DISCUSSION

Proximate Composition

The proximate chemical composition of shoot system of each the studied *Fagonia* species is presented in Table 1. The moisture content of the investigated *Fagonia* species exhibited a narrow range of variation. It varied from 9.26% in *F. mollis* to 13.77 % in *F. criticus*. The mean value of moisture content of *F. arabica* was 10.41%. The highest percentage of dry matter was recorded in *F. mollis* (90.74%), followed by *F. arabica* (89.59%), then the lowest value was recorded in *F. criticus* (86.23%). The usability and quality of food or forage such as the texture, taste, appearance and stability of foods depends on the amount of water they contain. Therefore, moisture content plays a key role in ensuring quality in many industries including food, pharmaceuticals and chemicals [28].

Dietary fiber is naturally present in vegetables, fruits, cereals and forage. The amount and composition of fibers differ from plant to plant [29]. Dietary fiber includes polysaccharide, lignin and associated plant materials. A fiber-rich diet is lower in energy density, often has a lower fat content, is larger in volume and is richer in micronutrients [30]. The results in (Table 1) showed considerable variations in the crude protein, fat, fiber, ash and carbohydrate contents among the three studied *Fagonia* species. The highest crude fiber and ash content was recorded in *F. mollis* (18.69 and 11.68%, respectively) while the lowest was in *F. creticus* (9.23 and 7.58%, respectively). On the contrary, the percentage of lipid varied between 2.91% in *F. mollis* and 4.63% in *F. arabica*. Lipids play an important role in living organisms as sources of energy, as structural components of membranes and/or as storage products of cells. The nutritional value of food and the human's health are affected by the variety and quantity of the lipids [31].

Table 1: Proximate constituent in the selected *Fagonia* species

Nutrients	*Fagonia arabica*	*F. creticus*	*F. mollis*
Moisture content %	10.41±0.87	13.77±1.15	9.26±0.77
Dry matter %	89.59±5.47	86.23±6.19	90.74±7.56
Total ash %	9.22±0.77	7.58±0.63	11.68±0.97
Crude fiber %	14.57±1.21	9.23±0.77	18.69±1.56
Crude lipid %	4.63±0.39	3.66±0.31	2.91±0.24
Crude protein %	9.34±0.78	11.67±0.97	6.19±0.52
Total nitrogen %	1.49±0.12	1.87±0.16	0.99±0.08
Carbohydrates (mg g^{-1} dry weight)			
Glucose	1.13±0.09	1.85±0.15	0.89±0.07
Sucrose	9.67±0.81	12.54±1.05	7.44±0.62
Total soluble sugar	29.68±2.47	38.55±2.21	12.43±1.04
Polysaccharides	133.47±7.12	167.49±9.64	88.67±5.39
Calculated parameters			
Total Carbohydrates (mg g^{-1} dry weight)	622.4±11.64	678.6±13.41	605.3±8.57
Nutritive Value (Cal $100g^{-1}$)	327.99±11.04	351.06±9.82	293.07±6.87
Total digestible nutrients %	59.18±2.37	56.75±2.11	60.11±1.89

The results in (Table 1) showed obvious variation in total nitrogen content in the studied *Fagonia* species. The highest percentage was recorded in *F. creticus* (1.87%), while the lowest value was estimated in *F. mollis* (0.99%). The protein content varied from 6.19% in *F. mollis* to 11.67% in *F. creticus*. The majority of living tissues and organs need proteins and other elements as their building blocks. Therefore, on a global basis, plant protein foods contribute over 60% of the per capita supply of protein, on average [32].

The obtained results indicated that, the values of glucose ranged from 0.89 mg/g dry weight in *F. mollis* to 1.85 mg/g dry weight in *F. creticus*. On the other hand, the highest contents of sucrose were recorded in *F. creticus* (12.54 mg/g dry weight), while the lowest values were estimated in *F. mollis* (7.44 mg/g dry weight). The highest values of the total soluble sugars were recorded in *F. creticus* (38.55 mg/g dry weight), followed by *F. arabica* (29.68 mg/g dry weight), while the lowest value was recorded in *F. mollis* (12.43 mg/g dry weight). The values of polysaccharides ranged between 88.67 mg/g dry weight in *F. mollis* to 167.49 mg/g dry weight in *F. creticus* as shown in (Table 1).

Carbohydrates are energy-providing feed components composed of carbon, hydrogen, and oxygen. They should make up about 75 percent of an animal's diet. Carbohydrates are not stored in the body and they must be provided in the animal's diet every day [33]. The highest total carbohydrates content was recorded in *F. creticus* (678.6 mg/g dry plant) followed by *F. arabica* (622.4 mg/g dry plant) and the lowest was in *F. mollis* (605.3 mg/g dry plant) (Table 1). On the other hand, the total digestible nutrient (TDN) is only an approximate measure of the food energy available to animals after digestion losses have been deduced [34]. The obtained data showed that, there were no variable differences between the total digestible nutrients' percent of the three studied *Fagonia* species where the highest total digestible nutrients were in *F. mollis* (60.11 %) followed by *F. arabica* (59.18 %), while the lowest value was in *F. creticus* (56.75 %).

The nutritive value of any plant depends upon its content of nutrients producing energy as well as its content of nutrients essential to the body, but the chemical analysis alone is of limited use to evaluate the nutritive value of plants, especially those containing secondary compounds [35]. The aerial parts of *F. creticus* expressed the highest nutritional value among the other *F.* species. The obtained results showed that *F. creticus* contains appreciable levels of nutritive content considering that the nutritional value of its leaves (351.06 kcal/100 g dry weight) was remarkable higher than the other species of *F. arabica* and *F. mollis* (327.99 and 293.07 kcal/100 g dry weight, respectively).

By comparing the obtained results to those of other plant species in the Egyptian flora, for instance, the nutritive value of *Atriplex* species, *Medicago sativa* and *Trifolium alexandrinum* found to be higher than those of the studied *Fagonia* species [1, 36-40], while the nutritive values of the studied species of *Fagonia* genus were higher than the species studied by Maswada [41] and Hendriks *et al*. [42].

Macro and Micro Elemental Analysis

Two classes of nutrients are considered essential for plants: macronutrients and micronutrients. Macronutrients (N, P, K, Mg, etc.) are the building blocks of crucial cellular components like proteins and nucleic acids. Micronutrients, including iron, zinc, manganese, and copper, are required in very small amounts as cofactors for enzyme activity [43]. The concentrations of the macro- (K^+, Ca^{++}, Mg^{++}, Na^+) and micro-elements (Fe, Mn, Zn, and Cu) estimated in the three studied species are shown in Figures 1 and 2. It is obvious that the concentration of Na was relatively the highest among the other estimated macroelements in the studied species followed by K, Ca and Mg, respectively while Fe was the highest microelement followed by Cu, Mn and Zn, respectively. The concentrations of sodium, potassium, calcium and magnesium of *F. creticus* (13.09, 12.09, 10.69 and 7.19 mg g^{-1}, respectively) were higher than those of the other studied *Fagonia* species. The concentrations of sodium, potassium, calcium and magnesium in *F. arabica* were 10.66, 2.84, 3.47 and 2.53 mg g^{-1} while those of *F. mollis* were 7.80, 3.75, 4.25 and 2.11 mg g^{-1}, respectively. Dastagir *et al*. [44]

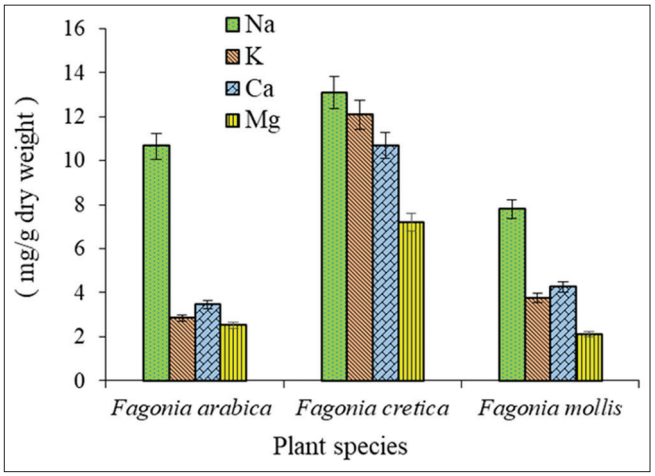

Figure 1: The macro- elements concentrations in the studied *Fagonia* species

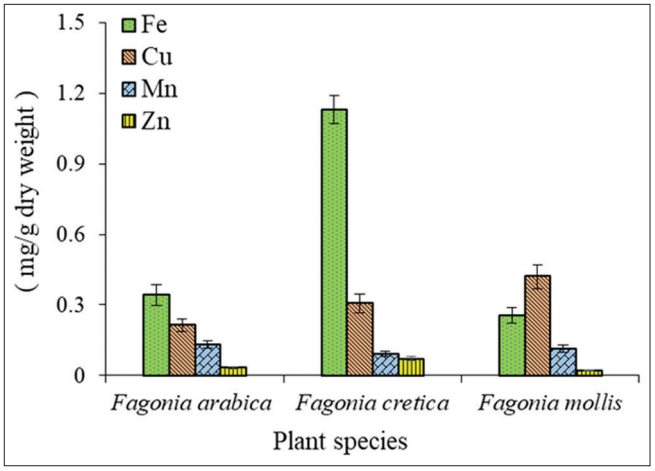

Figure 2: The micro- elements concentrations in the studied *Fagonia* species

reported that Ca, K and Mg contents were high in *F. cretica* which differed from the present findings, also recorded less Na content. While, the present results comparable with other workers as Zafar *et al.* [45] and Jabeen *et al.* [46] in the aerial parts of *F. indica*.

Regarding the micro-elements, *F. creticus* had the highest iron concentration of 1.13 mg g^{-1} followed by *F. arabica* (0.34 mg g^{-1}) while *F. mollis* showed the lowest concentrations of 0.26 mg g^{-1}. On the contrary, *F. mollis* had the highest copper concentration of 0.42 mg g^{-1} followed by *Fagonia creticus* (0.31 mg g^{-1}) while *F. arabica* showed very low concentration of 0.21 mg/g (Figure 2). AI-Rumaih *et al.* [47] and Dastagir *et al.* [44] reported high Fe and low Cu contents in *F. cretica* which differed from the present investigation, as well as Shad *et al.* [48] who reported low Cu contents in *F. arabica*. These results agree with the findings of Zafar *et al.* [45] on *F. indica*.

F. arabica had the highest manganese concentration of 0.13 mg g^{-1} followed by *F. mollis* (0.11 mg g^{-1}) while *F. creticus* showed the lowest concentrations of 0.09 mg g^{-1}. On the contrary, *F. creticus* had the highest zinc concentration of 0.07 mg g^{-1} followed by *F. arabica* (0.04 mg g^{-1}) and *F. mollis* showed the lowest concentrations of 0.03 mg/g (Figure 2). In the present study *Fagonia* species had Mn content in the range of 0.09-0.13 mg g^{-1} and Zn content in the range of 0.03-0.07 mg g^{-1} that differed from the findings of Dastagir *et al.* [44] who reported higher Mn and Zn contents in *F. cretica*.

Trend of accumulation of macro nutrients in studied *Fagonia* species showed little variation as given below: Na > Ca > K > Mg in *F. arabica* and *F. mollis*, Na > K > Ca > Mg in *F. cretica* while the trend of accumulation of micro nutrients in the same plants showed remarkable variation as given below: Fe > Cu > Mn > Zn in *F. arabica* and *F. cretica*, Cu > Fe > Mn > Zn in *F. mollis*. Climatic and atmospheric changes imposed serious effects on plants like the changes occur in the availability of certain nutrients [49] therefore, the mineral contents vary from plant to plant on one hand and from place to place on another hand.

Quantitative Determination of Some Bioactive Secondary Compounds

The dry and saline habitat of the studied *Fagonia* species is considered as precursor for them to synthesize many secondary metabolites such as phenolics, flavonoids, alkaloids, saponins and many other compounds that have protective and medicinal properties [50]. Methanol was used for the extraction of the active ingredients of the studied plants. The concentrations of the secondary metabolites in the studied *Fagonia* species are presented in Figure 3.

The present results showed that the content of phenolics, alkaloids, flavonoids, saponins and tannins were in range of 4.38-9.62, 3.32-4.43, 5.11-7.16, 5.87-8.14 and 6.66-12.44 mg g^{-1} dry wt., respectively (Figure 3). *Fagonia creticus* was found to be the richest in total alkaloids and flavonoids, while *F. arabica* was found to be the richest among the other studied *Fagonia*

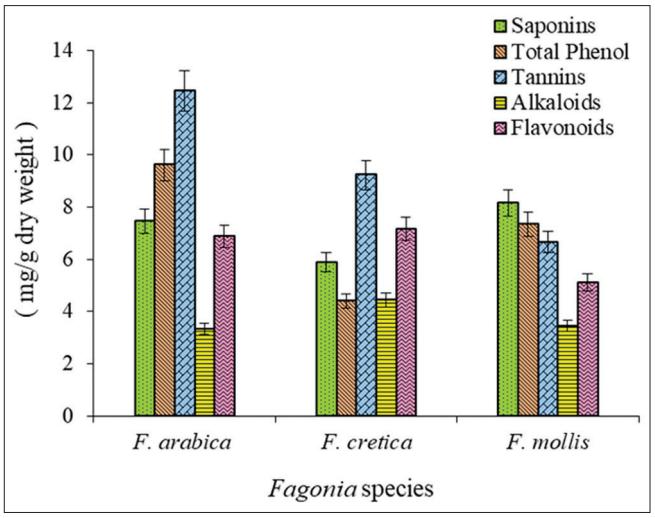

Figure 3: Comparison between the bioactive secondary compounds in the studied *Fagonia* species

species in total phenol and tannins. These results were in consistency with those reported by Canty *et al.* [51] and Kara and Sürmen [52] on rangeland and pasture plants.

The content of antinutritional factors in plant depends on secondary metabolites and varies with plant species, phenological period and environmental conditions Poutaraud *et al.* [53]. According to Sodipo *et al.* [54] most phytochemicals serve as natural antioxidants, antibiotics, and herbicides which are used as biologically active compounds against microbial invasion and infections. In this research, appreciable quantities of phenolics, alkaloids, flavonoids were obtained in the studied species of genus *Fagonia* (Figure 3). According to literature, alkaloids have a wide range of pharmacological activities including antimalarial, anticancer [55], antibacterial [56] and antihyperglycemic activities [57]. Flavonoids are known to have antioxidant effects and have been shown to inhibit the initiation, promotion, and progression of tumors [58]. Phenolic compounds are widely distributed in plant tissues, particularly contributing color, flavor, and astringency to fruits, as well as contribute little to the physiological and/or ecological functions of the plant [59].

CONCLUSION

Weeds are not just plants out of place but it properly regarded useful to humans. Therefore, proximate composition, mineral content and secondary metabolites of the aerial parts of three *Fagonia* species (*Fagonia arabica*, *F. mollis* and *F. cretica*) were analyzed. *Fagonia* species are rich by products of secondary metabolites, and therefore, are used in several purposes such as medical uses, agricultural uses. In addition, species of *Fagonia* contain suitable amounts of protein, fats and elements, and therefore can add amounts of this plant to feed in dry areas

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