Vol. 15(2), pp. 96-107, February, 2021
DOI: 10.5897/JMPR2020.7040
Article Number: 316067A66153
ISSN 1996-0875

http://www.academicjournals.org/JMPR

ACADEMIC JOURNALS
Journal of Medicinal Plants Research

Full Length Research Paper

Occurrence of calcium oxalate crystals in some wild plants used in traditional medicine in Saudi Arabia

Mohamed El-Zaidy* and Abdulaziz A. Alsahli

Department of Botany and Microbiology, College of Science, King Saud University, P. O. Box 2455, Riyadh 11451, Saudi Arabia.

Received 16 September, 2020; Accepted 1 February, 2021

Plants are widely used in traditional medicine, but could be detrimental to patients, due to the presence of some harmful substances such as calcium oxalate (CaOx) C_2CaO_4 crystals. The presence, morphology and distribution of CaOx crystals were investigated in 60 wild, herbal plant species from the Al Qussim Region, Saudi Arabia. This was done via light microscopy of transverse sections of stems and leaves using light microscopy. Different types of CaOx crystals were found in only 24 of the plant species studied, the rest had no CaOx crystals. The stems of 12 plant species under study contained different types of CaOx crystals, with crystal sand being the most common. In the leaves of four plant species, druses and solitary crystals were the most frequently found types. In addition, eight species had different types of crystals in their respective stems and leaves. *Rumex vesicarius* had the most crystals in both its stems and leaves from all investigated species, followed by *Asphodelus tenuifolius*.

Key words: Ca-oxalate crystals, light microscope, plant leaves, stems, Al Qussim Region.

INTRODUCTION

Calcium oxalate (CaOx) crystals frequently occur in higher plants (plants of relatively complex or advanced characteristics, especially vascular plants, including flowering plants and gymnosperms (Hudgins et al., 2003). Calcium oxalate crystals are present in nearly all plant organs including roots, stems, leaves and seeds (Ilarslan, 2001). These crystals were generally widely distributed in the mesophyll and epidermal cells of leaves (Franceschi and Horner, 1980), as well as in the stem cortex and pith cells (Doaigey, 1991). Furthermore, these crystals occur in a variety of defined shapes. For example, as druse, raphides, prismatic, styloid, and sand crystals (Gębura and Winiarczyk, 2016). The shape and distribution of CaOx crystals is characteristic to each plant family and can be used in taxonomical identification (Molano-Flores, 2001). For example, Druses and styloids were observed in stem epidermal cells, pith cells, and leaf mesophyll cells of *Vernonia amydaline* (Asteracae) (Nwosu et al., 2013), while rhomboidal crystals were found in axial parenchyma and multiseriate ray cells of the secondary xylem of *Quercus* species (Fagaceae) (Serdar and Demiray, 2012).

*Corresponding author. E-mail: melzaidy@ksu.edu.sa. Tel: 00966114675878.

Calcium oxalate crystals are reported as a storage from of both calcium and oxalic acid function in the regulation of calcium levels in plant tissues (Franceschi and Nakata, 2005), protecting plants against herbivory (Molano-Flores, 2001), provide mechanical support to structures, facilitate light gathering and reflection (Franceschi and Horner, 1980), and can detoxify heavy metals in plant tissues (Nakata, 2003).

Calcium oxalate crystals have a diagnostic value, in that their presence or absence and dimension are of significant value in the identification of crude drugs (Jackson and Snowdon, 1968). Furthermore, they help in the detection of adulterants in herbal drugs (Lersten and Horner, 2006). For example, Tripathi et al. (2015) noted that CaOx crystals in edible plants can lead to kidney stones in humans. Saganuwan (2010) identified 150 medicinal plant species used in the treatment of various human diseases in the Arabian Peninsula. However, as previously stated these plants could be detrimental to patients due to the presence of harmful substances, such as CaOx crystals. As a result, this study was conducted to investigate the occurrence of CaOx crystals in several wild medicinal herbal plants from the Al Qussim Region in Saudi Arabia, which has a high level of herbal plant use and recent studies do not exist in this research topic. This study will be of value to determine which plants contain these crystals that may have harmful effects on patients.

MATERIALS AND METHODS

Study area

The province Al Qussim (Figure 1) is located in the center of Saudi Arabia approximately 400 km northwest of Riyadh, the capital. The climate is desert continental, hot and dry in summer, cold and rainy in winter, the summer temperature is 45°C, which reaches 3°C below zero in winter, and the average annual rainfall is 145 mm (Wikipedia, 2020).

Plant collection

Sixty herbal plant species from the Al Qussim Region in Saudi Arabia were randomly selected from 150 plant species collected in spring of 2018 to be screened for the presence of CaOx crystals. They were taxonomically identified by a King Saud University Herbarium (KSUH) staff member. Voucher specimens were also deposited at this herbarium. The whole plant was collected.

Plant material preparation

A few representative mature fresh samples of leaves and stems of each species were fixed in FAA solution (10% formaldehyde, 50% ethyl alcohol, 5% acetic acid, and 35% distilled water) overnight at room temperature and then samples were kept in 70% ethyl alcohol until prepared for microscopy (Doaigey et al., 1997).

Plant tissue preparation

Permanent cross sections of leaves and stems were prepared using the paraffin wax method of Doaigey et al. (1997). A rotary microtome (Leica RM 2135) was used to prepare 15 to 20 µm sections. The components of crystals were confirmed using the method of Pizzolato (1964). Samples were examined and photographed under a light microscope (Leitz Labor Lux D with camera Moticam 2000).

RESULTS AND DISCUSSION

Species containing no CaOx crystals

Screening the transverse sections of stems and leaves revealed that 36 (60%) of the 60 examined species did not contain any type of CaOx crystals. These plant species can be used with safety precautions based on the results indicated by the references mentioned in Table 1.

Species containing different types of CaOx crystals

The 24 species were found to have one or more types of CaOx crystals in the transverse sections of stems (Table 2 and Figures 2 and 3), transverse sections of leaves (Table 3 and Figure 4), and in the transverse sections of stems and leaves (Table 4 and Figures 5 to 7). This agrees with the results obtained by Doaigey (1991), Gębura and Winiarczyk (2016) and Konyar et al. (2014). Their results showed that the most dominant type of crystal found in the transverse sections of stems and leaves were Druses.

Species containing different types of CaOx crystals in stems

From the results mentioned in Table 2, there were 12 herbal plant species found to contain different types of CaOx crystals in the transverse sections of the stems only. This may be due to the nutrient content of the plant organ and the presence of mechanisms that prevent the formation of calcium oxalate in a plant organ, and it does not form in the other (Coté, 2009). The morphology and distribution of crystals is constant within a species. This indicates that their presence, morphology and distribution in a species are under genetic control (Ilarslan, 2001; Franceschi and Nakata, 2005); and the location, size and other properties of crystals may be effected by physical, chemical and biological conditions such as light, temperature, pH, ion concentration and herbivory (Franceschi and Horner, 1980; Molano Flores, 2001; Kuo-Huang et al., 2007).

Crystal sand (Figures 2A, C, G and 3C, D, H) and solitary crystals (Figures 2B, 3A and E) were the most common in this set of plant species. The distribution of crystal sand idioblasts was very rare in *Aizoon hispanicum*, *Anastatica hierochuntica*, *Bassia eriophora*, *Picris babylonica*, *Reseda lutea* and *Tripleurospermum*

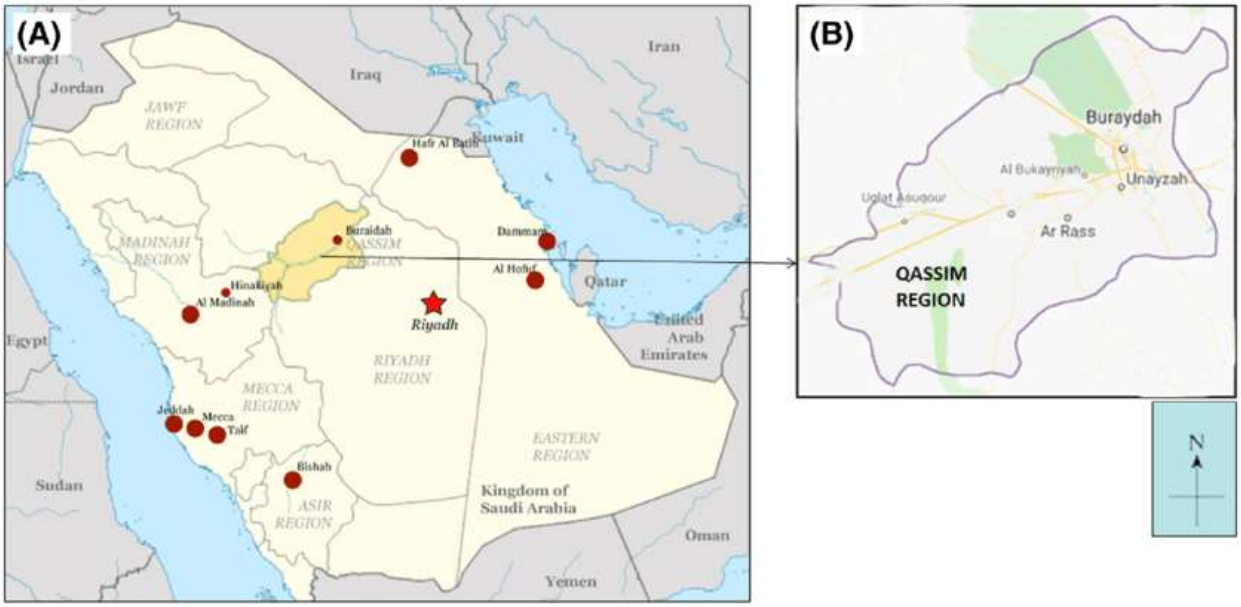

Figure 1. (A) Map of Saudi Arabia showing (B) location of collection sites at Al Qassim region in yellow (B). (Rasheed et al., 2019).

auriculata species. In addition, the distribution of solitary crystals idioblasts was very rare in *Arnebia decumbens*, *Astragalus schimperi*, *B. eriophora* and *T. auriculata,* and rare in *Erucaria hispanica* and *Sclerocephalus arabicus*. This indicates that their occurrence, morphology and spreading in a species are under genetic mechanism (Ilarslan, 2001; Franceschi and Nakata, 2005). Druse type crystals were also found to be very rare in *A. hispanicum* and *S. arabicus*, and rare in *Herniaria hirsuta* (Figures 2D, E, F, H and 3F, G), which corresponds with that observed by Nwosu et al. (2013) in stem of *V. amygdalina.* The last type of crystal found commonly was of raphides (Figure 3B). Idioblasts was very frequent in *Lepidium sativum,* a result that is contrary with Wu and Kuo-Huang (1997), who examined calcium crystals in the leaves of *Humulus scandens* and found calcium carbonate crystals only in its leaves. The leaves of the above mentioned plant species can be used safely by humans and grazing animals as they do not contain any CaOx crystals, and stems can also be used without adverse effects for the patients if used moderately based on the references indicated in the Table 2.

Species containing different types of CaOx crystals in leaves

Leaves of four species (*Agaricus arvensis, Medicago laciniata, Reichardia tingitana* and *Savignya parviflora*) were studied. These plant species showed different types of crystals in the transverse section of their leaves. Although druse crystals idioblasts were the most common crystals in this set of plant species, they were very rare in *M. laciniata* and *R. tingitana,* and rare in *S. parviflora* plant (Figure 4B, C and E). These results agreed with those of Nwosu et al. (2013), who observed druses in the leaf mesophyll cells of *V. amygdalina.* The solitary crystals idioblasts were less common, and found to be very rare in *A. arvensis* and *S. parviflora* (Figure 4A, F). Crystals sand were the least common type with a rare distribution in *R. tingitana* (Figure 4D). All types of crystals occurred relatively infrequently, except for druses in the leaves of the *S. parviflora* that is not found in other species investigated. Patients can use leaves of *S. parviflora* moderately and animals because druses and solitary crystals showed rare and very rare distribution and the stems can be used safely because they were CaOx free based on the references indicated in Table 3.

Species containing different types of CaOx crystals in leaves and stems

Eight species (Table 4) contained all types of CaOx crystals in their leaves and stems. Crystal sand was the most common type in the leaves and stems in these 8 species (Figure 6A, C, F and 7C, G, F, H), followed by solitary (Figures 6B and 7B, E) and druses crystals (Figure 6D and 7A, D). These results are similar to Doaigey (1991), Nwosu et al. (2013), and Konyar et al. (2014) who observed druse crystals in the stem and leaves of *Saponaria officinalis*. Least were the raphide crystals (Figure 6E). The idioblasts distribution of CaOx crystals in this group of eight plants was very rare, except in *Chenopodium album* (many idioblasts) and *Rumex vesicarius* (very idioblasts).

Table 1. Plants containing no CaOx crystals in transverse sections of both leaves and stems.

Species	Economic importance
Ammi majus	Traditional and folk medicine (Batanouny, 1999). Poison (Doaigey, 1991).
Anisosciadium lanatum	Edible and additive (Alaried and Al-Faraj, 1995), grazed.
Anthemis scrobicularias	Traditional and folk medicine (Hassan, 1995), grazed.
Calendula micrantha	Traditional and folk medicine (Boon and Smith, 2004), additive grazed.
Chrozophora plicata	Traditional and folk medicine (Al-Shanawani, 1996), grazed poison.
Cotula anthemoides	Traditional and folk medicine (Al-Zoght and Al-Sheikh, 1999).
Diplotaxis acris	Traditional and folk medicine (Al-Qura'n, 2010), edible grazed.
Eremobium aegyptiacum	Grazed (Dossari, 2010).
Euphorbia arabica	Traditional, folk medicine and poison (Al-Shanawani, 1996).
Euphorbia granulata	Traditional and folk medicine (Al-Sayd, 2009).
Fagonia indica	Traditional and folk medicine (Al-Zoght, 1990), grazed (Al-Ataa, 2011).
Gastrocotyle hispida	Traditional, folk medicine and grazed (Boulus, 1983).
Gymnarrhena micrant	Traditional, folk medicine and grazed (Algamal, 1995).
Hippocrepis constricta	Traditional, folk medicine and grazed (Al-Sodany et al., 2011).
Horwoodia dicksoniae	Traditional, folk medicine and edible (Fawzy et al., 2012), additive grazed (Omar, 2007).
Koelpinia linearis	Traditional and folk medicine (Smanla, 2013), edible (Al-Ataa, 2011), and grazed (Koul et al., 2000).
Lepidium aucheri	Traditional and folk medicine (Akbar and Al-Yahya, 2011), edible and additive (Al-Takrouri et al., 2008).
Linaria haelava	Traditional and folk medicine and grazed (Lahlob, 1992).
Malva parviflora	Traditional, folk medicine and poison for cattle (Abu Rumaila, 1988), edible (Hashim and Mahmud, 1988).
Matthiola livida	Traditional and folk medicine.
Matthiola longipetala	Traditional and folk medicine (Chaieb, 2011).
Neurada procumbens	Traditional and folk medicine edible (Qureshi, 2012), grazed (Dossari, 2010).
Picris abyssinica	Traditional and folk medicine (Al-Shanawani, 1996), grazed.
Plantago amplexicaulis	Traditional and folk medicine (Al-Shanawani, 1996; Akbar and Al-Yahya, 2011), grazed (Dossari, 2010).
Pteranthus dichotomus	Traditional and folk medicine (Alrawy, 1976), grazed and poison for cattle (Omar, 2007).
Rumex pictus	Traditional and folk medicine (Abutbul et al., 2005), edible (Doaigey and Wahibi, 2006); grazed (Omar, 2007).
Reseda stenostachya	Traditional and folk medicine (Al-Zoght, 1990; Al-Shanawani, 1996), edible (Al-Zoght, 1990).
Salvia deserti	Traditional and folk medicine (Pirbalouti et al., 2012).
Scabiosa oliveri	Foraged by bees (Hossain et al., 2012).
Schimpera arabica	Traditional, folk medicine, edible and grazed (Akbar and Al-Yahya, 2011).
Silene arabica	Traditional and folk medicine (Aljohany, 2007), grazed (Omar, 2007).
Sonchus oleraceus	Traditional, folk medicine and edible (El-Ghazali et al., 2010).
Stipa capensis	Grazed and poison for sheep (Mandaville, 2011).
Stipagrostis plumosa	Grazed (Daur, 2012).
Trigonella hamosa	Traditional and folk medicine (Bouaziz et al., 2009), grazed (Umadevi et al., 2012).
Trigonella stellate	Traditional and folk medicine (El-Ghazali et al., 2010; Al-Rumaih and Al-Rumaih, 2008), grazed (El-Ghazali et al., 2010), poison (Tawaha, 2006).

Results indicate that 62.5% of the plant species contained CaOx crystal idioblasts in the transverse sections of stems, while 37.5% of plant species contained crystals in their leaves. This is contrary to the results obtained by Anitha and Sandhiya (2014), who reported that the CaOx crystals were distributed more in the leaves of plants than in their stems, but in our results calcium oxalate crystals in this group are distributed in stems more than leaves.

Conclusion

As there was no previous study explaining the presence of CaOx crystal in plants used in folk medicine in Saudi Arabia except for the study of Doaigey (1991), which studied the presence of CaOx crystal in some known poisons plant, the results of the present study revealed that 60% of the 60 examined species did not contain any type of CaOx crystals, hence it can be used safely and completely by humans and livestock, while taking the required precaution. 20% of this 60 plants contained crystals idioblasts in their transverse sections of stems. The leaves of this group of plants can be used safely and completely by humans and livestock, and their stems are used with caution. 6.7% of plants contained crystals in their leaves, therefore, its leaves should be used with

Table 2. Herbal plants containing different types of CaOx crystals in transverse sections of stems.

Species	Crystals		Economic importance
	Type	Distribution	
Aizoon hispanicum	D Cr	(vr)	Traditional, folk medicine and grazed (Middleditch, 2012), edible (Alali et al., 2007).
Anastatica hierochuntica	Cr	(vr)	Traditional and folk medicine (Ihsanullah, 2012).
Arnebia decumbens	S	(vr)	Traditional and folk medicine (Al-Shanawani, 1996; Omar, 2007), Grazed.
Astragalus schimperi	S	(vr)	Traditional, folk medicine and grazed (Abu-Dahab and Afifi, 2007).
Bassia eriophora	S Cr	(vr)	Traditional and folk medicine (Al-Shanawani, 1996).
Erucaria hispanica	S	(r)	Grazed (Dossari, 2010).
Herniaria hirsuta	D	(r)	Traditional and folk medicine (Al-Shanawani, 1996; Atmani and Khan, 2000).
Lepidium sativum	R	(vf)	Traditional and folk medicine (Qubaisi, 2007), edible (Adam et al., 2011).
Picris babylonica	Cr	(vr)	Traditional, folk medicine edible and grazed (Dossari, 2010).
Reseda lutea	Cr	(vr)	Traditional, folk medicine, edible, additive, grazed (Doaigey and Wahibi, 2006).
Sclerocephalus arabicus	D S	(vr) (r)	Traditional and folk medicine (Abutbul et al., 2005).
Tripleurospermum auriculata	S Cr	(vr)	Traditional and folk medicine (Tariq et al., 1987), edible, additive and grazed (Al-Saeed, 2001).

D = Druses, R = Raphides, Cr = Crystal sand, S = Solitary, vf = very frequent, f = frequent, r = rare, vr = very rare.

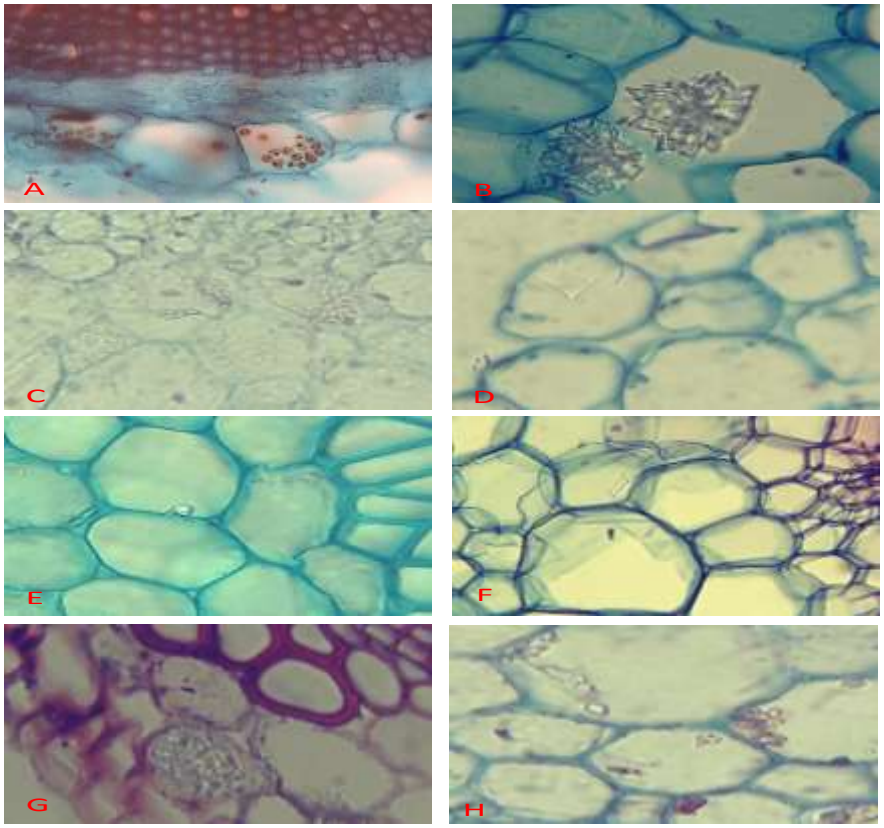

Figure 2. Plants contain different types of calcium oxalate crystals in stems. A- *Aizoon hispanicum* 25X Crystal sand. B- *Aizoon hispanicum* 40 X Druses. C- *Anastatica hierochuntica* 40 X Crystal sand. D- *Arnebia decumbens* 40 X Solitary. E- *Astragalus schimperi* 40 X Solitary. F- *Bassia eriophora* 40 X Solitary. G- *Bassia eriophora* 40 X Crystal sand. H- *Erucaria hispanica* 40 X Solitary.

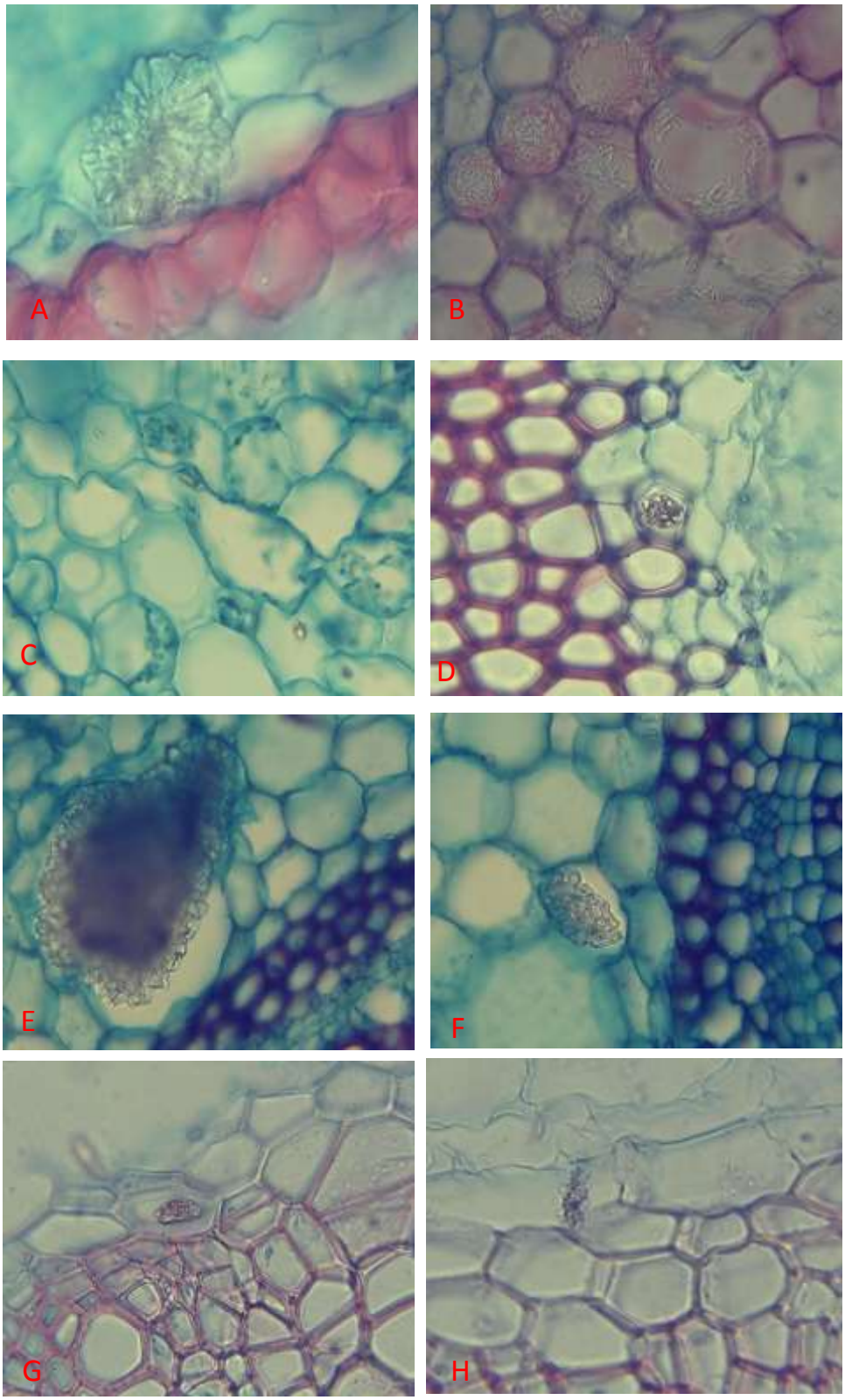

Figure 3. Plants contain different types of calcium oxalate crystals in stems. A- *Herniaria hirsuta* 40 X Druses. B- *Lepidium sativum* 40 X Raphids. C- *Picris babylonica* 40 X Crystal sand. D- *Reseda lutea* 40 X Crystal sand. E- *Sclerocephalus arabicus* 25 X Druses. F- *Sclerocephalus arabicus* 25 X Solitary. G- *Tripleurospermum auriculata* 40 X Solitary. H- *Tripleurospermum auriculata* 40 X Crystal sand.

Table 3. Herbal plants containing different types of CaOx crystals in transverse sections of leaves.

Species	Crystals		Economic importance
	Type	Distribution	
Anagallis arvensis	S	(vr)	Traditional and folk medicine (Al-Oudat, 1982), poison (Doaigey, 1991).
Medicago laciniata	D	(vr)	Traditional and folk medicine (Mahasneh, 2002), grazed (Villegas et al., 2006).
Reichardia tingitana	D Cr	(vr)	Traditional and folk medicine (Sawsan, 2012), edible and grazed (Mohamed and Adam, 1980).
Savignya parviflora	D S	(r) (vr)	Edible (Akbar and Al-Yahya, 2011), grazed (Middleditch, 2012).

D = Druses, R = Raphides, Cr = Crystal sand, S = Solitary, vf = very frequent, f = frequent, r = rare, vr = very rare.

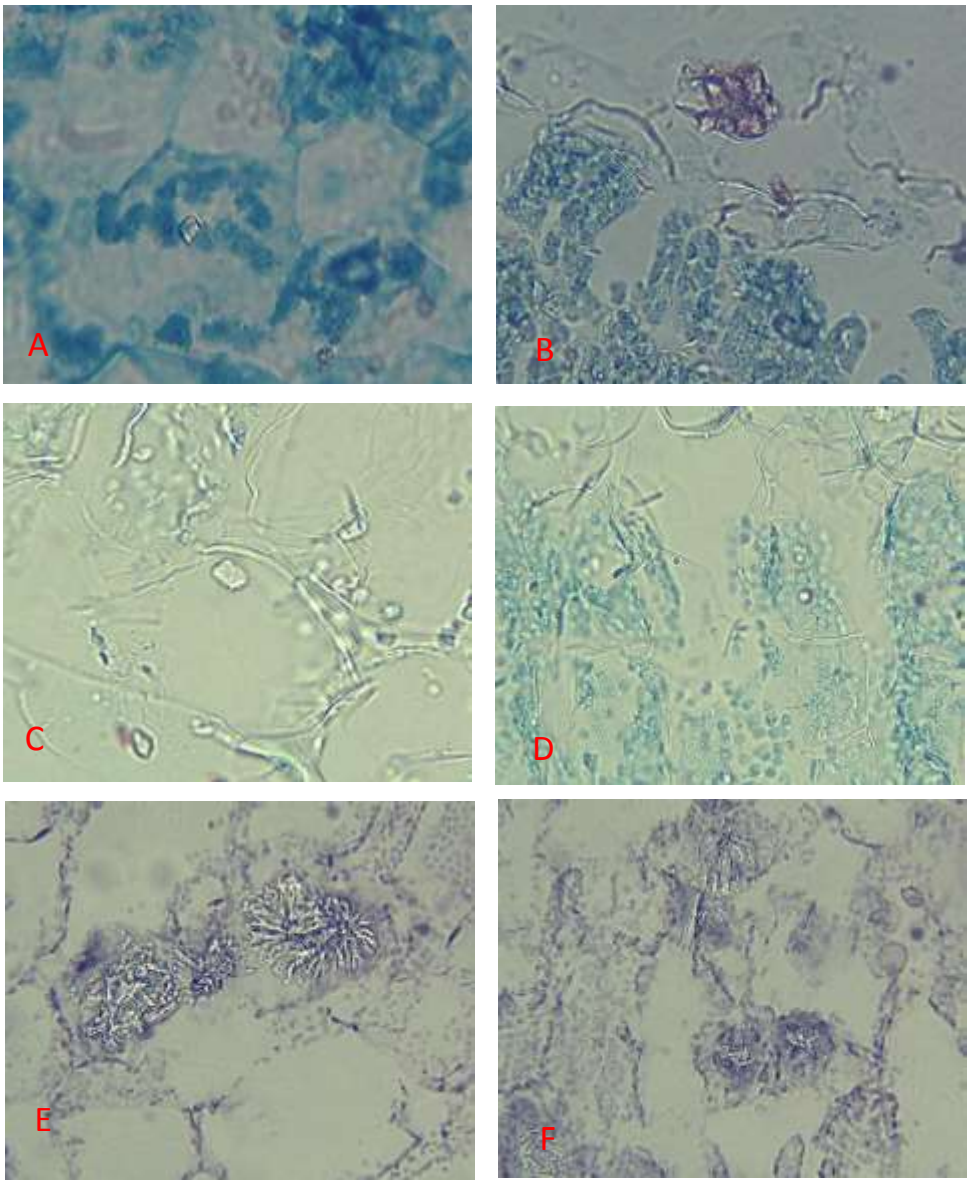

Figure 4. Herbal plants contain different types of calcium oxalate crystals in its leaves. A- *Anagallis arvensis* 40 X Solitary. B- *Medicago laciniata* 40 X Druses. C- *Reichardia tingitana* 40 X Druses. D- *Reichardia tingitana* 40 X Crystal sand. E- *Savignya parviflora* 25 X Druses. F- *Savignya parviflora* 25 X Solitary.

Table 4. Herbal plants containing different types of CaOx crystals in transverse sections of both leaves and stems.

Species	Crystals				Economic importance
	Stems		leaves		
	Types	Distribution	Types	Distribution	
Asphodelus tenuifolius	S	(r)	R S Cr	(r) (vr)	Traditional and folk medicine (Qureshi et al., 2010; Al-Shanawani, 1996); additive and foraged by bees (Mandaville, 2013, 1990, 2011).
Bassia muricata	Cr	(vr)	S	(vr)	Traditional, folk medicine and grazed (Akbar and Al-Yahya, 2011).
Chenopodium album	S Cr	(vr)	D Cr	(f)	Traditional and folk medicine (Al-Shanawani, 1996; Abdel-Sattar et al., 2000); edible (Gesinski and Nowak, 2011; Yildirim et al., 2001) grazed.
Echium horridum	S Cr	(vr)	Cr	(vr)	Traditional, folk medicine and grazed (El-Shazly et al., 1999).
Emex spinosa	R Cr	(vr) (r)	D	(r)	Traditional and folk medicine (Al-Shanawani, 1996), edible and grazed (Al-Ataa, 2011).
Paronychia arabica	D	(r)	D	(r)	Traditional and folk medicine (Sakkir et al., 2012) grazed (Omar, 2007).
Rumex vesicarius	D S Cr	(r)	D S Cr	(vf) (vr) (r)	Traditional and folk medicine (Al-Zoght, 1990; Salamah et al., 1989), edible and additive (Al-Zoght, 1990).
Solanum nigrum	Cr	(vr)	Cr	(vr)	Traditional and folk medicine (Aboul-Enein et al., 2012), grazed and poison (Doaigey, 1991).

D = Druses, R = Raphides, Cr = Crystal sand, S = Solitary, vf = very frequent, f = frequent, r = rare, vr = very rare.

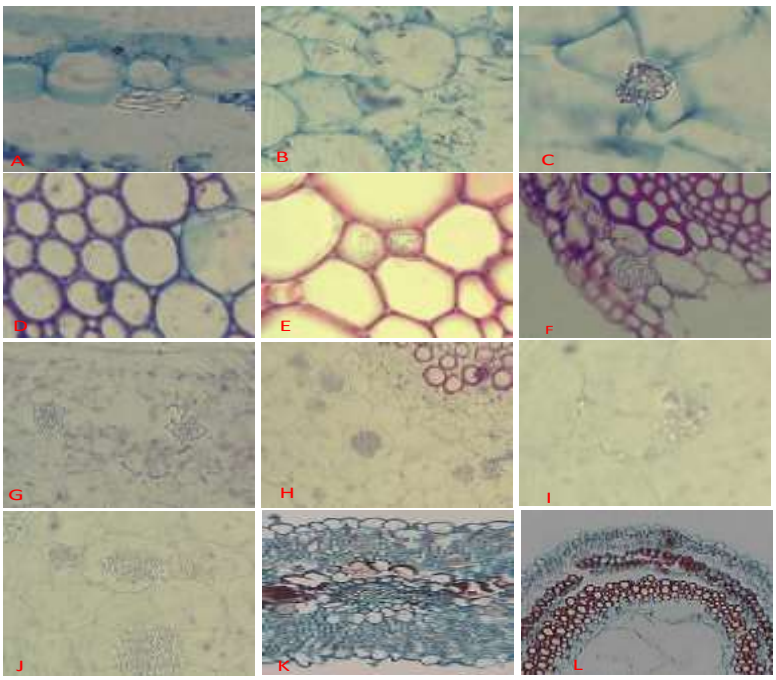

Figure 5. Herbal plants contain different types of calcium oxalate crystals in both its leaves and stems. A- *Asphodelus tenuifolius* leaves 40 X Raphids. B- *Asphodelus tenuifolius* leaves 40 X Solitary. *C- Asphodelus tenuifolius* leaves 40 X Crystal sand. D- *Asphodelus tenuifolius* stems 40 X Solitary. E- *Bassia muricata* leafs 40 X Solitary. F- *Bassia muricata* stem 40 X Crystal sand. G- *Chenopodium album* leaf 40 X Druses. H- *Chenopodium album* leaf 40 X Crystal sand. I- *Chenopodium album* stem 40 X Solitary. J- *Chenopodium album* stem 40 X Crystal sand. K- *Paronychia arabicum* Leaf 25 X Druses. L- *Paronychia arabicum* stem 5 X Druses.

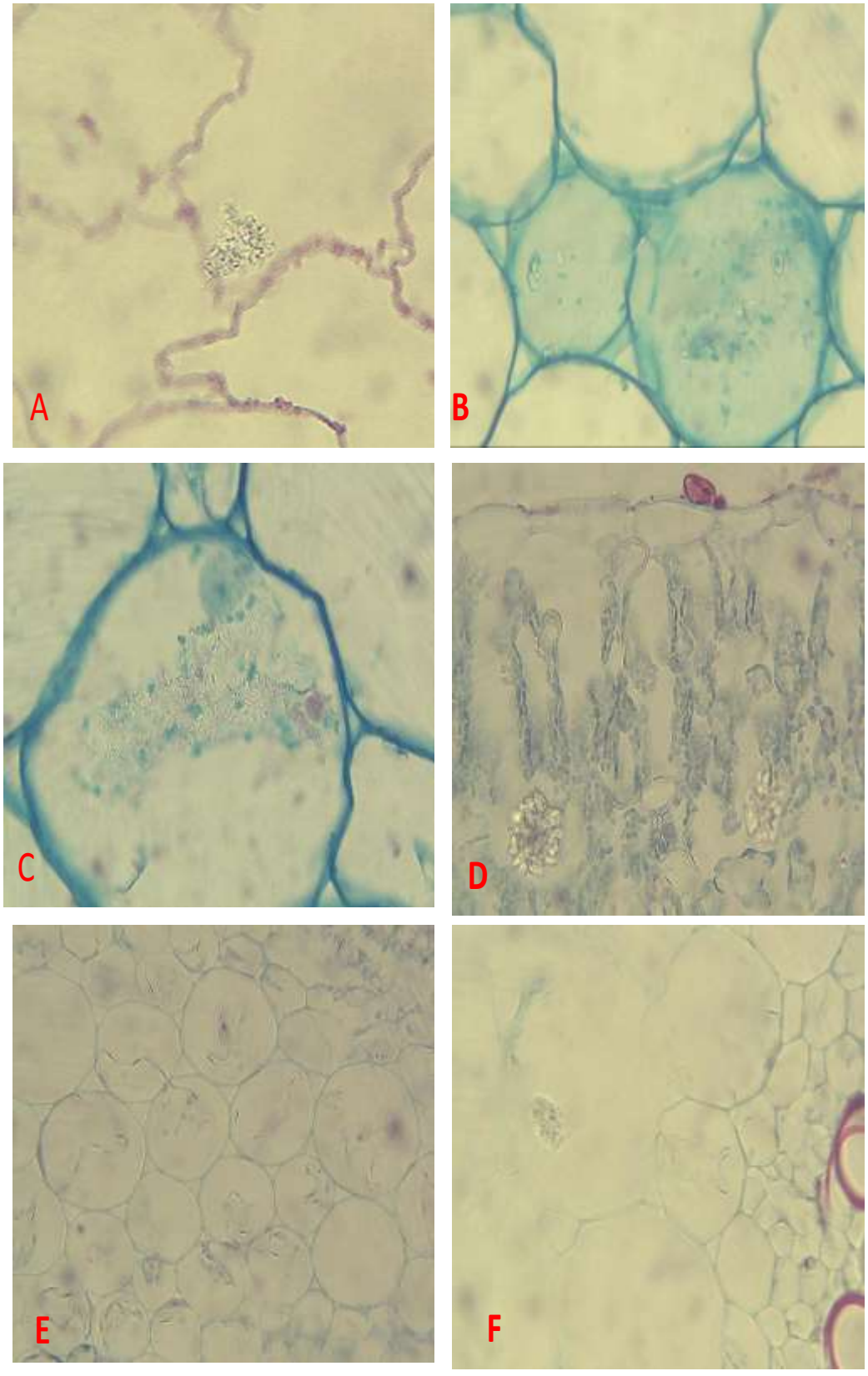

Figure 6. Herbal plants contain different types of calcium oxalate crystals in both its leaves and stems. A- *Echium horridum* leaf 25 X Crystal sand. B- *Echium horridum* stem 25 X Solitary. *C- Echium horridum* stem 25 X Crystal sand. D- *Emex spinosa* Leaf 25 X Druses. E- *Emex spinosa* stem 25 X Raphids. F- *Emex spinosa* stem 25 X Crystal sand.

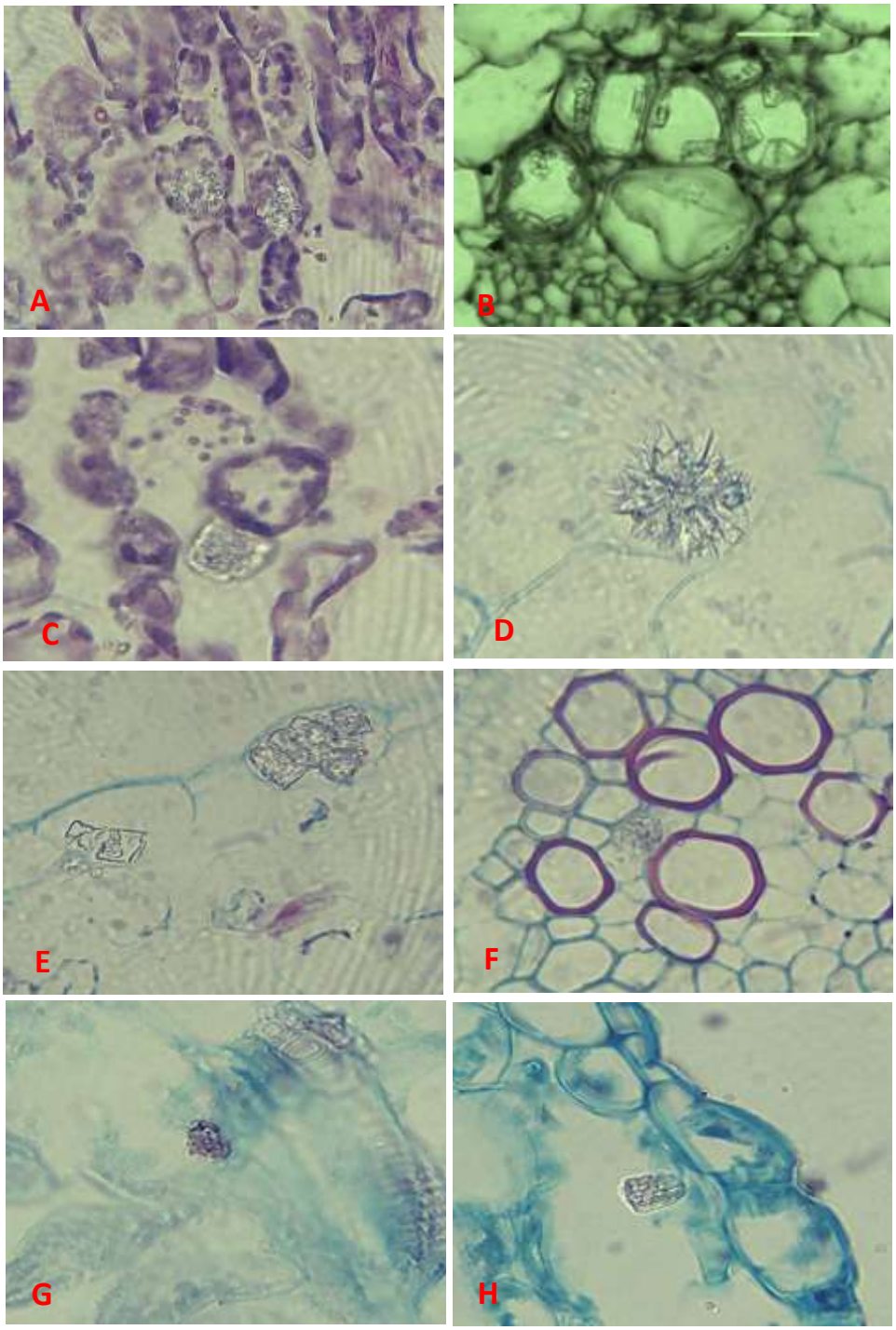

Figure 7. Herbal plants contain different types of calcium oxalate crystals in both its leaves and stems. A- *Rumex vesicarius* Leaf 40 X Druses. B- *Rumex vesicarius* Leaf 40 X Solitary. C- *Rumex vesicarius* Leaf 25 X Crystal sand. D- *Rumex vesicarius* Stem 25 X Druses. E- *Rumex vesicarius* Stem 25 X Solitary. F- *Rumex vesicarius* Stem 25 X Crystal sand. G-*Solanum nigrum* leaf 40 X Crystal sand. H- *Solanum nigrum* stem 40 X Crystal sand.

extreme caution in patients, and its stems can be safely used by humans and grazing animals. Further, 13% of plants contain CaOx crystal in their leaves and stems, hence its leaves and stems should be used with extreme caution in patients. The types of crystals that were found include: druses, raphides, crystal sand and solitary crystals. It is recommended that more toxicological and biochemical studies be conducted to determine the

chemical components, active substances and their impact on humans.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors thank the Deanship of Scientific Research and RSSU at King Saud University for their technical support of the article editing.

REFERENCES

Abdel-Sattar E, Kohiel M, Shehata I, Rashwan O, El-Askary H (2000). Phenolic (constituents of gymnarrhena micrantha dese. Bulletin of Faculty of Pharmacy, Cairo University 38(1):137-140.

Aboul-Enein AM, El-Ela FA, Shalaby EA, El-Shemy HA (2012). Traditional medicinal plants research in Egypt: studies of antioxidant and anticancer activities. Journal of Medicinal Plants Research 6(5):689-703.

Abu Rumaila B (1988). Poisonous plants in the Jordanian environment (natural pasture and surrounding areas). (In Arabic). First Edition edn. University of Jordan Press., Oman, Jordon.

Abu-Dahab R, Afifi F (2007). Antiproliferative activity of selected medicinal plants of Jordan against a breast adenocarcinoma cell line (MCF7). Scientia Pharmaceutica 75(3):121-146.

Abutbul S, Golan-Goldhirsh A, Barazani O, Ofir R, Zilberg D (2005). Screening of desert plants for use against bacterial pathogens in fish. The Israeli Journal of Aquaculture – Bamidgeh 57(2):71-80.

Adam SI, Salih SA, Abdelgadir WS (2011). "In vitro" Antimicrobial Assessment of *Lepidium sativum* L. Seeds Extracts. Asian Journal of Medical Sciences 3(6):261-266.

Akbar S, Al-Yahya M (2011). Screening of Saudi plants for phytoconstituents, pharmacological and antimicrobial properties. Australian journal of medical herbalism 23(2):76-88.

Alali FQ, Tawaha K, El-Elimat T, Syouf M, El-Fayad M, Abulaila K, Nielsen SJ, Wheaton WD, Iii JOF, Oberlies NH (2007). Antioxidant activity and total phenolic content of aqueous and methanolic extracts of Jordanian plants: an ICBG project. Natural Product Research, 21(12):1121-1131.

Alaried IA, Al-Faraj (1995). Wild plants eaten in Saudi Arabia. (In Arabic). Education College, Riyadh, Saudi Arabia.

Al-Ataa AA (2011). Book of Al-Ataa for Wild and Agricultural Plants. (In Arabic). First Edition edn. China Paper Industries Factory and Printing Press, Al-Hasa, Saudi Arabia.

Algamal SA (1995). Medicinal plants. (In Arabic). General Directorate of Agricultural Culture., Cairo, Egypt.

Aljohany HA (2007). Systematic Study on Some Member of the Genus *Silene* L. (Caryophyllaceae) In Saudi Arabia. Faculty of Science, King Saud University. , Alriyadh, Saudi Arabia.

Al-Oudat M (1982). Poisonous plants in Syria. (In Arabic). Journal of Life Sciences, Society of Life Sciences in the Syrian Arab Region, Damascus, Syria.

Al-Qura'n SA (2010). Ethnobotanical and Ecological Studies of Wild Edible Plants in Jordan. Libyan Agriculture Research Center Journal International 1(4):231-243.

Alrawy NY (1976). poisonous plants in the Republic of Iraq. (In Arabic). Arab Scientific Research Journal, Baghdad 3(12):111-137.

Al-Rumaih MM, Al-Rumaih MM (2008). Influence of ionizing radiation on antioxidant enzymes in three species of Trigonella. American Journal of Environmental Sciences 4(2):151. doi:10.3844/ajessp.2008.151.156 .

Al-Saeed AA (2001). Pasture Management: Foundations and Applications. (In Arabic). King Saud University Press. Alriyadh, Saudi arabia.

Al-Sayd AB (2009). Dictionary of medicinal herbs in the Arab world. (In Arabic). First Edition edn. Alpha Publishing and Distribution, Cairo.

Al-Shanawani MA (1996). Plants used in Saudi folk medicine. (In Arabic). King Abdulaziz City for Science and Technology, Riyadh, Saudi arabia.

Al-Sodany YM, Mosallam HM, A. S, Bazaid SA (2011). Vegetation analysis of Mahazat Al-Sayd Protected Area: The second Largest Fenced Nature Reserve in the World. World Applied Sciences Journal 15(8):1144-1156.

Al-Takrouri HR, Touqan SK, Ahmad MN (2008). medicinal plants and wild plants used in fodder in the Northern Jordanian Badia Society. (In Arabic). Jordanian Journal of Agricultural Sciences 4(4).

Al-Zoght MF (1990). Wild plants in Jubail and Yanbu. (In Arabic). Second Edition edn. Royal Commission for Jubail and Yanbu, Riyadh, Saudi arabia.

Al-Zoght MF, Al-Sheikh AM (1999). Wild plants dispersed in Riyadh region, King Saud University. (In Arabic). Scientific Publishing and Printing, , Riyadh, Saudi arabia.

Anitha R, Sandhiya T (2014). Occurrence of calcium oxalate crystals in the leaves of medicinal plants. International Journal of Pharmacognosy 1(6):389-393.

Atmani F, Khan S (2000). Effects of an extract from Herniaria hirsuta on calcium oxalate crystallization *in vitro*. Bju International 85(6):621-625.

Batanouny KH (1999). Wild Medicinal Plants in Egypt. Egypt, Academy of Scientific Research and Technology, International Union for Conservation (IUCN).

Boon H, Smith M (2004). The Complete Natural Medicine Guide to the 50 Most Common Medicinal Herbs. 2nd, ed edn. Toronto, Ontario, Canada, Robert Rose Inc.

Bouaziz M, Dhouib A, Loukil S, Boukhris M, Sayadi S (2009). Polyphenols content, antioxidant and antimicrobial activities of extracts of some wild plants collected from the south of Tunisia. African Journal of Biotechnology 8(24):7017-7027.

Boulus L (1983). Medicinal Plants of North Africa (Medicinal Plants of the World No.3) Amazon Incorporation.

Chaieb I (2011). Research on insecticidal plants in Tunisia: review and discussion of methodological approaches. Tunisian Journal of Plant Protection 6(2):109-125.

Coté GG (2009) Diversity and distribution of idioblasts producing calcium oxalate crystals in Dieffenbachia seguine (Araceae). American Journal of Botany 96(7):1245-1254.

Daur I (2012). Plant flora in the rangeland of western Saudi Arabia. Pakistan Journal of Botany 44:23-26

Doaigey AR (1991). Occurrence, type, and location of calcium oxalate crystals in leaves and stems of 16 species of poisonous plants. American journal of botany 78(12):1608-1616.

Doaigey AR, Melagy AM, Abdel Fattah MJ (1997). The basics of preparing plant samples (in arabic). First Edition edn. Riyadh, Saudi Arabia, Dar Al-Khuraiji Publishing.

Doaigey AR, Wahibi MH (2006). Explanation of botanical terms. (In Arabic). Second Edition edn. King Saud University, Riyadh, Saudi Arabia, Scientific Publishing and Printing Press.

Dossari HM (2010). Wild plant in the eastern region. (In Arabic). Second Edition. edn. King Abdul Aziz Press for Science and Technology, Riyadh, Saudi Arabia.

El-Ghazali GE, Al-Khalifa KS, Saleem GA, Abdallah EM (2010). Traditional medicinal plants indigenous to Al-Rass province, Saudi Arabia. Journal of Medicinal Plants Research 4(24):2680-2683.

El-Shazly A, Abdel-All M, Tei A, Wink M (1999). Pyrrolizidine Alkaloids from Echium rauwolfii and Echium horridum (Boraginaceae). Zeitschrift für Naturforschung C54(5-6):295-300. doi:10.1515/znc-1999-5-601.

Fawzy GA, Al-Taweel AM, Abdel Baky NA, Marzouk SM (2012). Cytotoxic and renoprotective flavonoid glycosides from Horwoodia dicksoniae. African Journal of Pharmacy and Pharmacology 6(15):1166-1175.

Franceschi VR, Horner HT (1980). Calcium oxalate crystals in plants. The Botanical Review 46(4):361-427. doi:10.1007/bf02860532.

Franceschi VR ,Nakata PA (2005). Calcium oxalate in plants: Formation and Function. Annual Review of Plant Biology 56(1):41-71.doi:10.1146/annurev.arplant.56.032604.144106.

Gębura J, Winiarczyk K (2016). A study on calcium oxalate crystals in Tinantia anomala (Commelinaceae) with special reference to ultrastructural changes during anther development. Journal of plant research 129(4):685-695.
Gesinski K, Nowak K (2011). Comparative analysis of the biological value of protein of Chenopodium quinoa Willd and Chenopodium album L. Part I. Amino acid composition of the seed protein. Acta Scientiarum Polonorum Agricultura 10(3):47-56.
Hashim S, Mahmud MJ (1988). Iraqi plants and herbs between folk medicine and scientific research. (In Arabic). First edition edn. Baghdad, Iraq, Dar al-Thawra Press.
Hassan MH (1995). Plants in Arabic poetry. (In Arabic). Deanship of Library Affairs, King Saud University, Riyadh, Saudi Arabia.
Hossain MK, Hassan MM, Parvin MN, Hasan MM, Islam MS, Haque MA (2012). Antimicrobial, cytotoxic and thrombolytic activity of Cassia senna leaves (family: Fabaceae). Journal of applied pharmaceutical science 2(06):186-190.
Hudgins J, Krekling T, Franceschi VR (2003). Distribution of calcium oxalate crystals in the secondary phloem of conifers: a constitutive defense mechanism? New Phytologist 159(3):677-690.
Ihsanullah D (2012). Chemical properties of the medicinal herb Kaff Maryam (Anastatica hierochuntica L.) and its relation to folk medicine use. African Journal of Microbiology Research 6(23):5048-5051.
Ilarslan H (2001). Calcium Oxalate Crystals in Developing Seeds of Soybean. Annals of Botany 88(2):243-257. doi:10.1006/anbo.2001.1453.
Jackson BP, Snowdon DW (1968). Powdered vegetable drugs; an atlas of microscopy for use in the identification and authentication of some plant materials employed as medicinal agents. Churchill.
Konyar ST, Öztürk N, Dane F (2014). Occurrence, types and distribution of calcium oxalate crystals in leaves and stems of some species of poisonous plants. Botanical studies 55(32):1-9.
Koul S, Razdan Tk, Andotra CS, Kalla Ak, Koul S, Taneja SC, Dhar Kl (2000). Koelpinin-A, B and C - three triterpenoids from Koelpinia linearis. Phytochemistry 53(2):305-309.
Lahlob MF (1992). Flavonoid, Phenylpropanoid and Iridoid Glycosides of Linaria haelava [Forssk] Dil. Mansoura Journal of Pharmaceutical Sciences 8(1):78-95.
Lersten NR, Horner HT (2006). Crystal Macropattern Development in Prunus serotina (Rosaceae, Prunoideae) Leaves. Annals of Botany, 97(5):723-729. doi:10.1093/aob/mcl036.
Mahasneh AM (2002). Screening of some indigenous Qatari medicinal plants for antimicrobial activity. Phytotherapy Research 16(8):751-753. doi:10.1002/ptr.1037.
Mandaville JP (1990). Flora of Eastern Saudi Arabia. Kegan Paul International London.
Mandaville JP (2011). Bedouin ethnobotany: plant concepts and uses in a desert pastoral world. University of Arizona Press.
Mandaville JP (2013). Flora Of Eastern Saudi Arabia. Routledge. doi:10.4324/9780203038208.
Middleditch BS (2012). Kuwaiti Plants: Distribution, Traditional Medicine, Pytochemistry, Pharmacology and Economic Value, vol 2. Elsevier.
Mohamed MG, Adam SEI (1980). The Effect of Three Indigenous Plants on Goats and Sheep. University of Khartoum, Khartoum, Sodan
Molano-Flores B (2001). Herbivory and Calcium Concentrations Affect Calcium Oxalate Crystal Formation in Leaves ofSida (Malvaceae). Annals of Botany 88(3):387-391. doi:10.1006/anbo.2001.1492
Nakata PA (2003) Advances in our understanding of calcium oxalate crystal formation and function in plants. Plant Science 164(6):901-909. doi:10.1016/s0168-9452(03)00120-1.
Nwosu S, Stanley H, Okerentugba P (2013). Occurrence, types and location of calcium oxalate crystals in Vernonia amydaline Del.(Asteracae). International Journal of Science and Nature 4:533-537.
Omar SAA (2007). Vegetation in Kuwait. A comprehensive guide to the botanical environment in Kuwait desert. (In Arabic). Kuwait Institute for Scientific Research. Kuwait.
Pirbalouti AG, Malekpoor F, Hamedi B (2012) Ethnobotany and antimicrobial activity of medicinal plants of Bakhtiari Zagross mountains, Iran. Journal of Medicinal Plants Research 6(5):675-679.
Pizzolato P (1964). Histochemical recognition of calcium oxalate. Journal of Histochemistry and Cytochemistry 12(333).
Qubaisi H (2007). Dictionary of herbs and medicinal plants. . (In Arabic). Seventh Edition. edn. Scientific Book House. , Beirut, Lebanon.
Qureshi R. (2012). Medicinal flora of hingol national park, Baluchistan, Pakistan. Pakistan Journal of Botany 44 (2):725-732.
Qureshi R, Bhatti GR, Memon RA (2010). Ethnomedicinal uses of herbs from northern part of Nara desert, Pakistan. Pakistan Journal of Botany 42(2):839-851.
Rasheed Z, Ahmed AA, Salem T, Al-Dhubaibi MS, Al Robaee AA, Alzolibani AA (2019) Prevalence of Leishmania species among patients with cutaneous leishmaniasis in Qassim province of Saudi Arabia. BMC public health 19(1):384.
Saganuwan A (2010) Some medicinal plants of Arabian Pennisula. Journal of Medicinal Plants Research 4(9):767-789.
Sakkir S, Kabshawi M, Mehairbi M (2012). Medicinal plants diversity and their conservation status in the United Arab Emirates (UAE). Journal of Medicinal Plants Research 6(7):1304-1322.
Salamah AA, Hassan HM, Nassar TM (1989) Antibacterial wild flowering plants in Saudi Arabia. J King Saud Univ Science 1(1):2
Sawsan AO (2012). Experimental Cassia senna intoxication in Lohmann broiler chicks. Journal of Medicinal Plants Research 6(17). doi:10.589/7jmpr11.1656.
Serdar B, Demiray H (2012). Calcium oxalate crystal types in three oak species (Quercus L.) in Turkey. Turkish journal of biology 36 (4):386-393.
Smanla AT (2013). A Brief Introduction to Traditional Tibetan Medicine in Ladakh. Medicinal Plants. Yuthog Foundation for Tibetan Medicine. , Ladakh, India.
Tariq M, Mossa J, Al-Yahya M, Al-Meshal I, Al-Badr A (1987) Phytochemical and Biological Screening of Saudi Medicinal Plants Part-10* A Study on Saudi Plants of Family Compositae. International Journal of Crude Drug Research 25(1):17-25.
Tawaha KA (2006). Cytotoxicity evaluation of Jordanian wild plants using brine shrimp lethality test. Jordan journal of applied science natural sciences 8(1):12.
Tripathi N, Bose C, Basu S, Das N, Maitra S (2015). Raphides in Food–An Unsafe Menu. Journal of Plant Biochemistry and Physiology 2(143):2.
Umadevi M, Rajeswari R, Rahale CS, Selvavenkadesh S, Pushpa R, Kumar KS, Bhowmik D (2012). Traditional and medicinal uses of Withania somnifera. The pharma innovation 1(9, Part A):102.
Villegas MDC, Rome S, Mauré L, Domergue O, Gardan L, Bailly X, Cleyet-Marel J-C, Brunel B (2006). Nitrogen-fixing sinorhizobia with Medicago laciniata constitute a novel biovar (bv. medicaginis) of S. meliloti. Systematic and Applied Microbiology 29(7):526-538. doi:10.1016/j.syapm.2005.12.008.
Wikipedia (2020) Al-Qassim Province, Saudi Arabia. https://en.wikipedia.org/wiki/Al-Qassim_Province.
Wu CC, Kuo-Huang LL (1997). Calcium crystals in the leaves of some species of Moraceae. Botanical Bulletin of Academia Sinica 38.
Yildirim E, Dursun A, Turan M (2001). Determination of the nutrition contents of the wild plants used as vegetables in Upper Coruh Valley. Turkish Journal of Botany 25(6):367-371.