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STOMATA STRUCTURE ON THE FRUIT EPIDERMIS IN WILD FRUIT SPECIES

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SUMMARY

In crop plants, the leaves considerably serve as carbon sinks, as well as stems, roots, flowers, fruits, and seeds with photosynthetic activities. Concerning plant fruits, their photosynthetic activity mostly results from the anatomy of the fruit, its growth and development, and the surrounding microclimate. At the early stage, the fruits normally contain the highest score of chlorophyll and stomata and thin cuticles. However, some species keep stomata in their fruits even after ripening, but most species miss stomata disintegrating chloroplasts and miss functionality. The collection of different wild fruit species came from various areas of Iraq. The epidermis of fruits, as obtained by peeling the exocarp, had this study examine the epidermis, stomata, crystals, and trichomes. The study revealed the scattering of the stomata in the epidermis of the exocarp in the fruits of some species, while none in others. Moreover, the stomata vary among the plant species, with the study categorizing the wild fruit species into four groups. The collected different wild fruit species were *Alcea rosea*, *Alhagi maurorum*, *Citrullus colocynthis*, *Convolvulus arvensis*, *Malvastrum coromandelianum*, *Ocimum campechianum*, *Physalis angulata*, *Portulaca oleracea*, *Prosopis glandulosa*, *Rubus ulmifolius*, and *Withania somnifera*. The anticlinal wall of epidermal cells also differed among the different fruit species between straight and wavy. Likewise, the druse crystals appear in the species *Portulaca oleracea,* and various types of trichomes were evident in the different wild fruit species under study.

Keywords: Fruit species, fruit types, stomata, epidermis, crystals, trichomes

Key findings: The wild fruit species collection continued from the different areas of Iraq. The study showed diverse shapes and diffusion of the stomata in the epidermis of some species. However, in some wild fruit species, the epidermis missed the stomata.

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INTRODUCTION

In green plants, permanent parts exist that are vital and play a crucial role in different life processes of plants, such as those involved in gas exchange, photosynthesis, transpiration, and respiratory processes. Additionally, many stomata occur on leaves' surface, most of which are prevalent on the lower side of the leaves (Metcalfe and Chalk, 1950; Kumar *et al.,* 2023).

Concerning fruits, their photosynthetic activity has control from various features, including anatomy, physiology, the microclimate surrounding the fruits, and their development. At the early phase of evolution, the fruits generally contain thin cuticles with the highest level of chlorophyll and the maximum density of functional stomata (Rodriguez-Casado, 2016).

Fruits are the chief crop plant products, and their utilization is necessary as human food. In addition to vitamins, minerals, and fibers, some phytochemicals are also in the fruits. These biochemicals are mostly noteworthy as useful to human health, reducing the danger of a broad range of cancers, cardiovascular diseases, and other food-related diseases, possibly through their antioxidant potential (Rodriguez-Casado, 2016).

Even though the stomata appear in the exodermis layer of fruits, their density is 10 to 100 times lower than in the epidermis of plant leaves (Aschan and Pfanz, 2003). Sui *et al.* (2017) stated that, for instance, in some fruits, the stomata are functional until the fruit ripens, while after that phase, the stomata density becomes less and also non-functional, turning into lenticels covered by wax.

According to past research on the ontogeny and structure of stomata on the leaves and stems of some angiosperms, the fruits are one of the vital plant organs (Evert, 2006). Several detailed structural and developmental studies have also progressed on the fruits of different crop plants, and they also reported the same structure and pattern of stomata in plant leaves and fruits (Inamdar and Patel, 1971; Patel *et al.,* 1976; Dave *et al.,* 1979; Reddy and Shah, 1981).

The main research aimed to assemble and investigate the information on the anatomical features of stomata, i.e., types, distance, and stomatal shapes in the fruits affiliated with different types of plant genera.

MATERIALS AND METHODS

The collection of fruits of different wild plant species was successful from various regions of Iraq (Figure 1). The collected different wild fruit species were *Alcea rosea* L., *Alhagi maurorum* Medik., *Citrullus colocynthis* (L.) Schrad., *Convolvulus arvensis* L., *Malvastrum coromandelianum* (L.) Garcke, *Ocimum campechianum* Mill., *Physalis angulata* L., *Portulaca oleracea* L*., Prosopis glandulosa (Neltuma glandulosa* Torr*.), Rubus ulmifolius* Schott 1818, and *Withania somnifera* (L.) Dunal (Table 1, Figure 2).

In obtaining the epidermis of all these wild fruits, the peeling of the exocarp with mechanical scraping used a razor blade, followed by washing them with distilled water and putting them in 10% KOH. Later, passing through an alcohol series for 10–15 min., they sustained staining of 1% safranin in alcohol for approximately 30–45 min. The excess stain, washed off with distilled water, proceeded dehydration by alcohol series (70%, 95%, and 100%) and cleared with pure xylene for 10 min. Finally, the placement of epidermal samples on the slides succeeded in mounting by cover slides with the Dextrin Plasticizer Xylene (D.P.X.) artificial mounting medium. All the permanent slides reached examination by an Olympus BH2 light microscope and were photographed using an Olympus CH3 camera.

RESULTS AND DISCUSSION

The type of fruits of the genera under study appears in Figure 1. The *Alcea rosea* fruit type is achene-shaped and a polygonum (Khalaf and AL-Hadeethi, 2020); *Alhagi maurorum* fruits are glabrous (Schutte, 2012); and the *Citrullus colocynthis* fruit is smooth, spherical, and bitter tasting (Eidi *et al.,* 2015). The *Convolvulus arvensis* fruit forms a capsule and

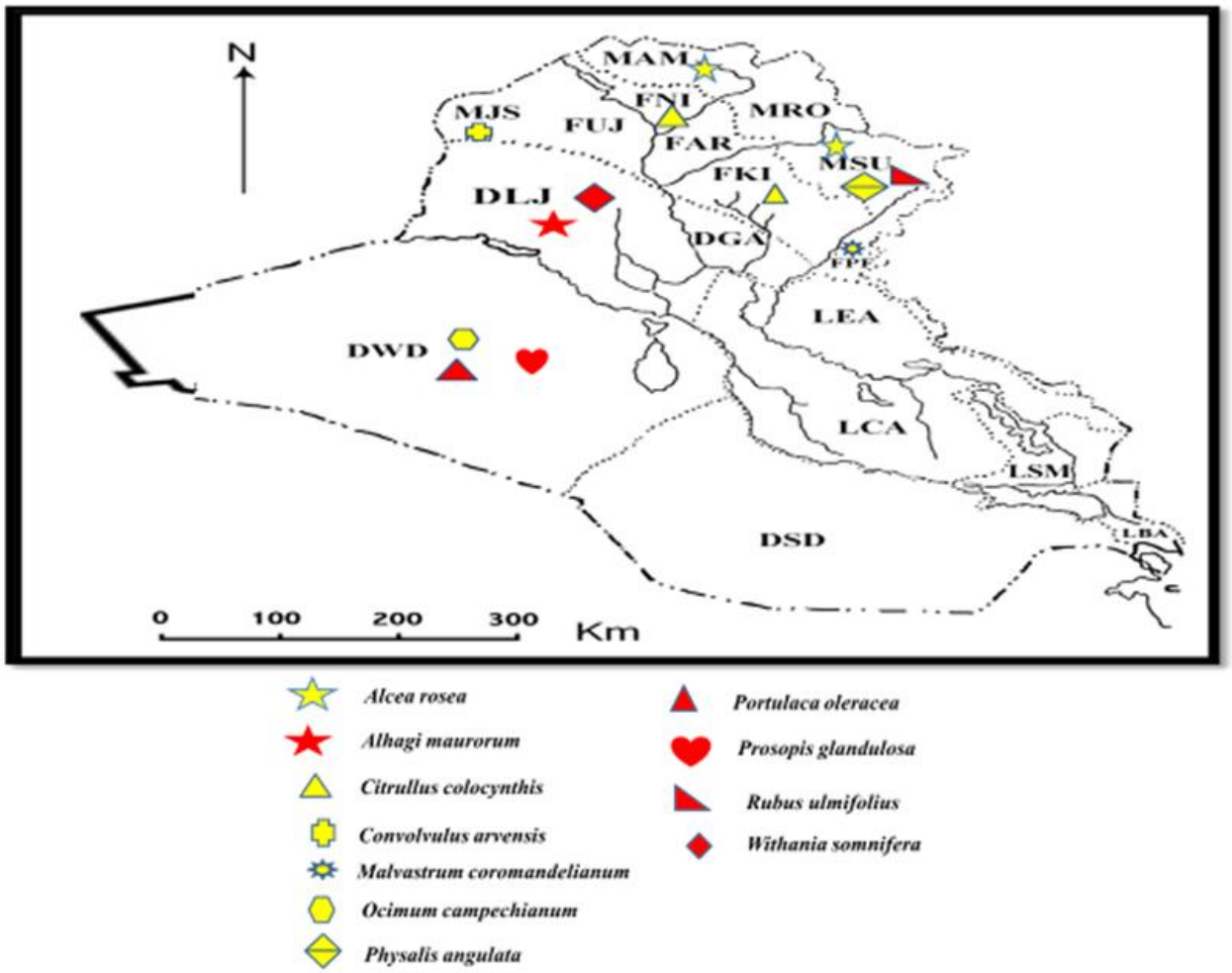

Figure 1: The Regions of Iraq visited to collect the species under study.

Table 1. Details of collected specimens from North and Middle Regions of Iraq.

No.	Species	County code*	Family	Collector numbers
1	*Alcea rosea*	MSU, MAM,	Malvaceae	M. AL-Hadeethy 50
2	*Alhagi maurorum*	DLJ	Fabaceae	M. AL-Hadeethy 33
3	*Citrullus colocynthis*	FNI, FKI	Cucurbitaceae	M. AL-Hadeethy 24
4	*Convolvulus arvensis*	MJS	Convolvulaceae	M. AL-Hadeethy 56
5	*Malvastrum coromandelianum*	FPF	Malvaceae	M. AL-Hadeethy 33
6	*Ocimum campechianum*	DWD	Lamiaceae	M. AL-Hadeethy 55
7	*Physalis angulata*	MSU	Solanaceae	M. AL-Hadeethy 63
8	*Portulaca oleracea*	DWD	Portulacaoleracea	M. AL-Hadeethy 22
9	*Prosopis glandulosa*	DWD	Fabaceae	M. AL-Hadeethy 52
10	*Rubus ulmifolius*	MSU	Rosaceae	M. AL-Hadeethy 30
11	*Withania somnifera*	DLJ	Solanaceae	M. AL-Hadeethy 62

*Sulaemaniea Province (MSU), Amadiyah Province (MAM), Nineuah Province (FNI), Kirkuk Province (FKI), Jabalsinjar District (MJS), Persian Foothills District (FPF), Western Desert District (DWD), Lower Jazira District (DLJ).

Figure 2. The shape of fruits of the different wild fruit species under study.

is light brown (Wunderlin *et al.,* 2021); the *Malvastrum coromandelianum* fruit is a discoid capsule (WFO, 2025); the *Ocimum campechianum* fruit is a capsule (Rosas, 2005); and the *Physalis angulata* has yellow-orange fruits borne inside a balloon-like calyx (Arenas *et al*., 2013). The *Portulaca oleracea* fruit is a dehiscent capsule, globular, topping the basis of two sepals (Parker, 2018); the *Prosopis glandulosa* fruit is a long, yellowish-brown pod (Simpson, 1988); and the *Rubus ulmifolius* is a blackberry fruit (Marticorena and Quezada, 1985). Finally, the *Withania somnifera* fruit is a hairless spherical berry (Kumar *et al.,* 2023).

The study revealed the scattering of stomata of different wild fruit species in the epidermis of the exocarp. These stomata were notable in the species, viz., *Alhagi maurorum, Alcea rosea, Citrullus colocynthis, Convolvulus arvensis*, *Ocimum campechianum*, *Portulaca oleracea*, and *Withania somnifera*. However, the stomata were lacking in the species *Malvastrum coromandelianum*, *Physalis angulata*, *Prosopis glandulosa*, and *Rubus ulmifolius*. Furthermore, the stomata shape varies with the different species, being categorized into four different groups (Figure 3).

Group 1: Anomocytic type—in this type, the stomata were free from the subsidiary cells, and the number of epidermal cells varied, from 4 to 8 in different stomata, and appeared in the species *Alcea rosea*, *Convolvulus arvensis*, and *Ocimum campechianum*. Reports of the same results have also come from Bhatia *et al*. (2014).

Group 2: Anisocytic type—this type of stomata has three subsidiary cells, wherein one is smaller than the other two, and was evident in the species *Portulaca oleracea* (Chowdhary *et al*., 2013).

Group 3: Paracytic type—this type of stomata has two subsidiary cells parallel to the longitudinal axis of the stomata; it occurred in the species *Alhagi maurorum* (Kumar *et al.,* 2023).

Group 4: Actinocytic type—this type of stomata has many subsidiary cells (6–10). It also spreads around the stomata and forms a flower-like shape, found in the species *Withania somnifera*.

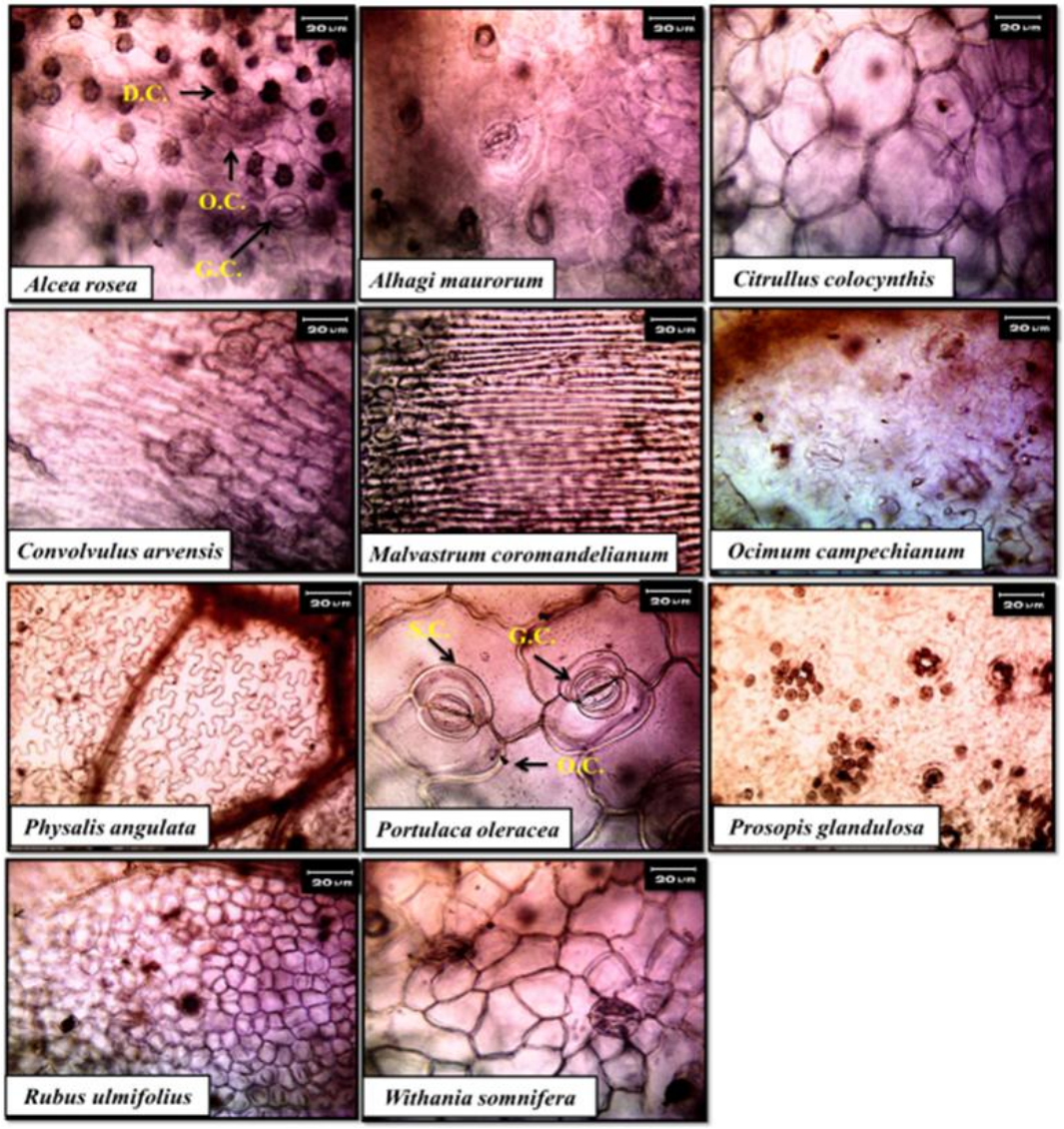

Figure 3. Surface view of the fruit's epidermis in the different wild fruit species showing the stomata and the appendices. D.C.: druces crystals, O.C.: ordinary epidermal cell, G.C.: guard cell, S.C.: subsidiary cell.

The anticlinal wall of the epidermal cells also varied among the different studied species from straight to wavy. The anticlinal wall appeared straight in the species, i.e., *Alcea rosea*, *Alhagi maurorum*, *Citrullus colocynthis*, *Malvastrum coromandelianum*, *Rubus ulmifolius,* and *Withania somnifera*. However, the anticlinal wall was wavy in the species *Convolvulus arvensis*, *Ocimum campechianum*, *Physalis angulata*, *Portulaca oleracea*, and *Prosopis glandulosa*.

In the studied species, the inner epidermis cells have thin walls and are elongated. These features usually appeared in the young fruits, except for the species *Convolvulus arvensis*, *Malvastrum coromandelianum*, and *Rubus ulmifolius*. The inner wall of epidermal cells seemed to be in a 'parquetry pattern,' with lignified walls and many developed pits, and this type often appeared in mature fruits. These results were greatly analogous to past findings, which also

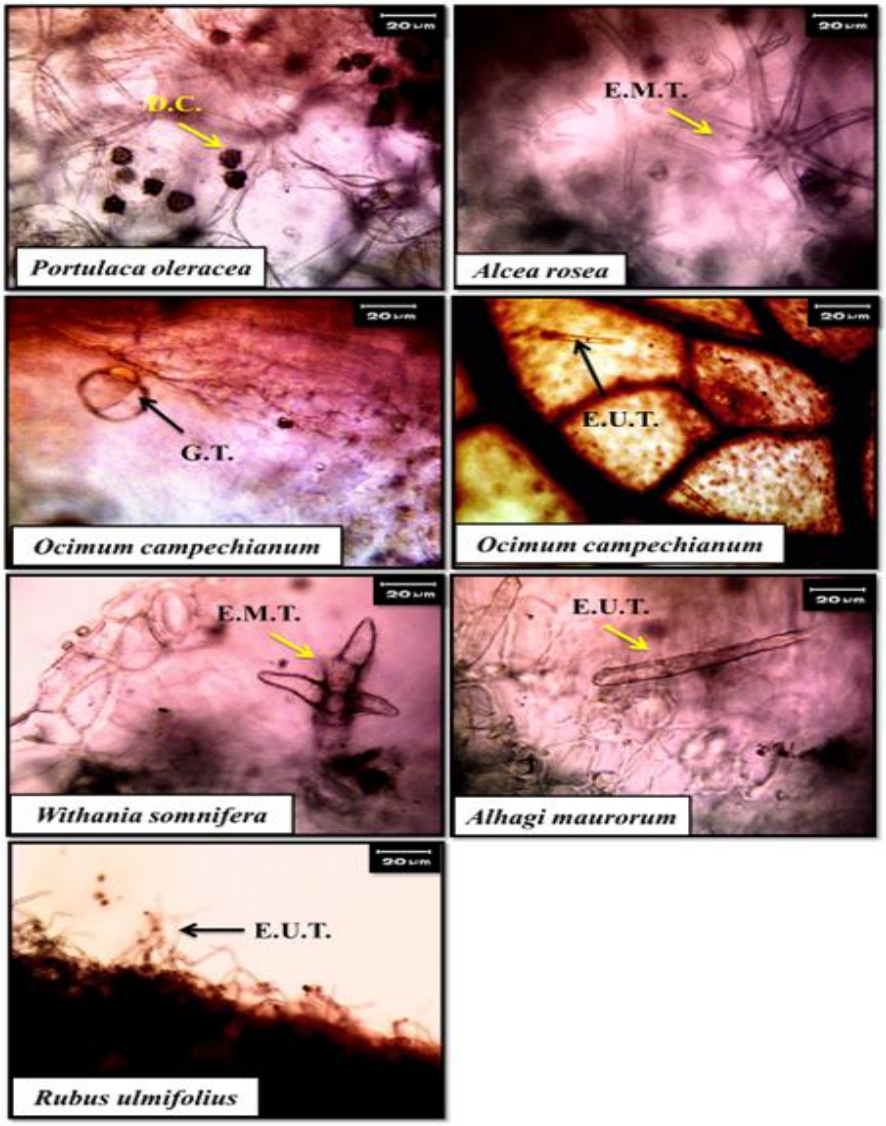

Figure 4. Surface view of the fruit's epidermis in the different wild fruit species showing the varied types of trichomes. D.C.: druces crystals, E.M.T.: eglandular multicellular trichomes, G.T.: glandular trichomes, E.U.T.: eglandular unicellular trichomes.

observed similar features of inner epidermis cells in different fruit species (Patel *et al.,* 1976; Duan *et al.,* 2022).

Similarly, through the study, some tested species found appendices in their epidermis, such as druces crystals appearing in the species *Portulaca oleracea* (Figure 3). Kumar and Kaur (2018) also reported similar features in the epidermis of different fruit species. The presented study further revealed the branched star unglandular trichomes emerged in the species *Alcea rosea*; dendroid unglandular trichomes arose in the species *Withania somnifera*; unicellular uniseriate unglandular trichomes occurred in the species *Ocimum campechianum*, *Alhagi maurorum,* and *Rubus ulmifolius*; and glandular trichomes materialized in the species *Ocimum campechianum* (Figure 4). Past studies also enunciated the different types of trichome shapes in the diverse fruit species (Sinha, 1971; Maddi *et al.,* 2019; Hassan *et al.,* 2022).

CONCLUSIONS

The promising study revealed that the anatomy of the fruit epidermis of some fruit species occurred significantly, being carried out for the first time in Iraq. The different anatomical characteristics bore intensive scrutiny, in addition to ecological data, and it will highly favor the cultivation of these species. The species studied are available in Iraqi environments and are easy to obtain; hence, we recommend using the species in medicine and producing medicinal herbs to treat various diseases by knowing their anatomical structure and the property of each one from this research.

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