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MORPHOLOGICAL AND ANATOMICAL RESEARCH OF *HELIANTHUS TUBEROSUS* L. INFLORESCENCE

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Abstract. For the first time the features of an external and internal structure of inflorescences of Jerusalem artichoke's (*Helianthus tuberosus* L.) from Asteraceae family has been investigated. As a result of researches macro- and microscopic diagnostic signs which can be used for the identification of medicinal vegetable stuff and the development of the QCT (quality control technique) project were revealed.

Key words: *Helianthus tuberosus,* inflorescence, floret, involucre,morphology, anatomy

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Introduction

In recent years the prevention of various diseases becomes of topical interest due the complicated ecological situation. Drug plants are the source of BAS complexes which reveal various ranges of action.

Jerusalem artichoke or tuberiferous sunflower (*Heliantnus tuberosus* L.) is a perennial plant from Asteraceae family (Тахтаджян 1987). In Russia and Ukraine the species is known as a girasol, while in Europe it is called 'Jerusalem artichoke'. *H. tuberosus* is well known in traditional and folk medicine thanks to retardant action on organism aging. It also contains harmful substances preventing different diseases (Кочнев *и др.* 2002).

H. tuberosus is well cultivated as technical, fodder and dietary crop. It grows on all types of soils without use of mineral and organic fertilizers. It is frost-resistant, low-maintenance species which is not affected by pests and diseases. Moreover it does not accumulate nitrates, heavy metals and radioactive nuclides in areas with technical pollution (Поскребышева 2000; Seiler 2007).

In traditional medicine broths and grass infusions, as well as girasol tubers are used in the treatment of diabetes, atherosclerosis, diseases of gastrointestinal tract and cardiovascular system, acute and chronic hepatitis, and also in cosmetic for removing skin defects. The leaves and the flowers of a girasol are used for treatment of articulate diseases such as arthritis, arthrosis, bursitis, osteochondrosis, radiculitis, gout, and stabilization of the musculoskeletal system after traumas, arteriosclerosis of vessels of lower extremities (Лавренов *и др.* 2001).

From the chemical point of view H. tuberosus is most fully studied (Kays & Nottingam 2008.). Girasol's tubers contain proteins (up to 3,2% from the weight of dry substance), pectin substances (up to 11% from the weight of dry substance), amino acids, organic and fatty acids, and such elements as iron, silicon, zinc. The girasol is more than 3 times richer than potato, carrot and beet by content of vitamins of B-B_1 and B_2 groups, ascorbic acid. A unique carbohydrate complex based on the fructose and its polymers (fructooligosaccharides and inulins) distinguishes the girasol from other vegetables. The grass and blossoms of *H. tuberosus* are studied a little less. The research on girasol flowers and inflorescences presents obvious scientific interest because these parts are often successfully used in medicine as separated types of feedstock (Державна фармакопея України 2008).

Completing above-mentioned results we studied an external and internal structure of the leaflets of inflorescence's involucre, ray and middle florets and the bracts of *H. tuberosus* to establish its diagnostic macro- and micromorphological features.

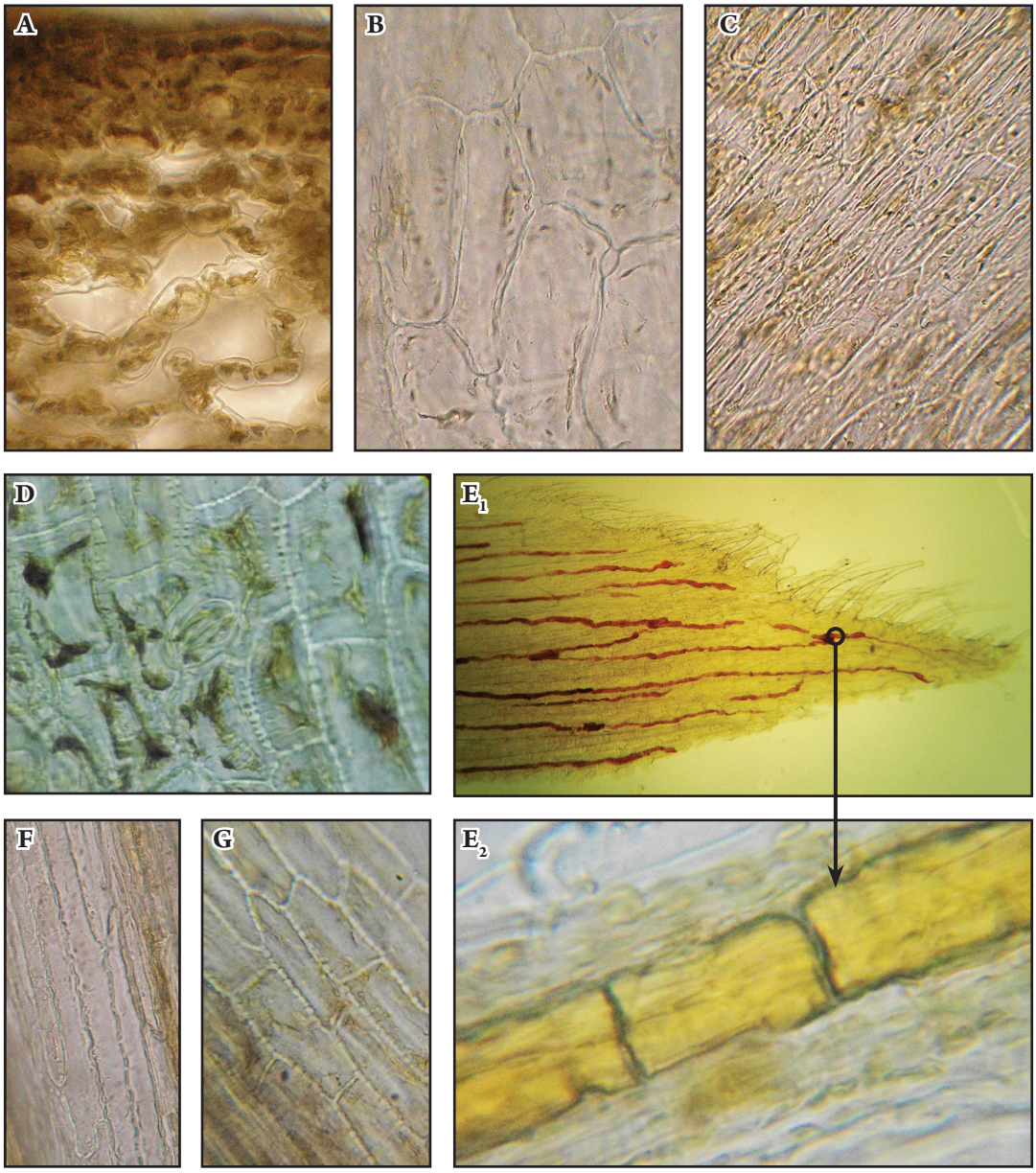


Fig. 1. Microscopic features of involucre leaflets (**A-D**) and the bracts (**E-F**) of *Helianthus tuberosus*: **A** – cross section through the involucre leaflet; **B** – adaxial epidermis among the veins of the involucre leaflet; **C** – adaxial epidermis over the veins of the involucre leaflet; **D** – abaxial epidermis of the involucre leaflet; **E** – the fragment of the bract with lacticifers; **F** – adaxial epidermis of the bract, **G** – abaxial epidermis of the bract.

Material and methods

Anthodiums were gathered for research on the experimental lots in the Kharkov region, village Tishki. The stocking of feedstock was carried out during the blossoming period at the end of September 2011. After that anthodiums were dried on aerated shaded place.

The fresh and fixed material was used for identification the macro- and the microscopic features of flowers, bracts and involucres of inflorescences. The structure of the involucres'

leaflets was studied on cross sections and from a surface, epiderm of flowers and bracts – only from a surface applying standard methods (Барыкина *и др.* 2004; Сербин *и др.* 2006; Evert 2006; Rudall 2007). There were used magnifying glass, binocular microscope MBS-9, MBI-6 LOMO microscope with ×80, ×120, ×300 and ×600 magnifications.

Diagnostic features were photographed using digital camera Olympus FE-140. Then photos were processed using Adobe Photoshop CS5 2.1 software.

Results and discussion

As a result of researches the main features of anthodium were described. The size of apical inflorescences varies from 5 to 10 cm in diameter. Involucre of anthodium is tiled, 3-layered. Its leaflets are thin, lanceolate, with sharp tip, rigid, densely fibrous on edge and ends. Leaflets of the first row are unbent down, and the second and the third row are adjoined to flowers. Leaflets are about 12-14 mm in length and 2-3 mm in width. Bracts are scarious, pubescent from the outer edge. Ray florets are falsely ligulate, yellow, female or sterile, up to 30 mm in length, usually in number of 10-20 pieces. Median flowers are tubular, bisexual, 13-18 mm in diameter. Synantherous androecium consists of 5 stamens. Cenocarpous gynoecium is formed by 2 pistils. Stigmas are two-lobed, with pinnate lobes covered by papillae (Fig. 2 E-G). Calyx is represented by two very small awl-shaped sepals.

Leaflets of involucres on a cross section have dorsiventral structure (Fig. 1 A). Palisade mesophyll consists of 3 layers, its cells are small, roundish or elongated. Spongy mesophyll consists of 5-6 layers, its cells are small, roundish and T-shaped, grouping in chains and forming very large blind pits.

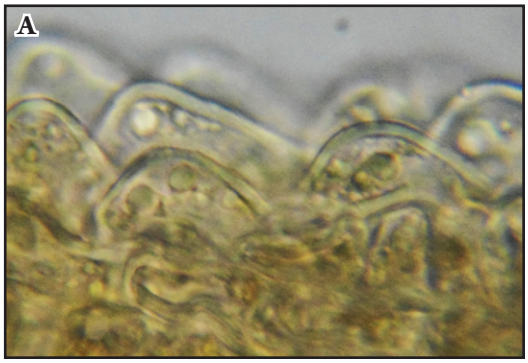
Epidermal cells are enlarged, oval, and thin-walled, they are covered with a thin folded cuticle (Fig. 1). The cells are strongly extended along the veins, they have straight walls, sometimes a little bit sinuous (Fig. 1 C). From outward side epidermal cells are thick-walled with dark brown content (Fig. 1 D). Stomata are thick, very large and oval.

Leaflets of involucres are pubescent from both sides but on it edges hairs are more often founded. At the basis of leaflets hairs are short, 2- and 3-cellular (Fig. 3). Near the middle rib pubescence is denser, there hairs are longer, straight or bent on the top, 5-7-cellular; their 2-3 basic cells are parenchymatous, and the others are extended (Fig. 3 E). At the tips of leaflets are sparsely pubescent, hairs are smaller, often break off. Among large covering hairs on the stalks also occasionally occur short, 5-7-cellular, glandular hairs (Fig. 3 A). 3-4-cellular short hairs with the wide basis are met over an internal and external surface of leaflets (Fig. 3 C, D).

Adaxial epidermis of bracts consists of strongly extended cells with thin, a little bit sinuous walls. While abaxial epidermis consists of oval cells with more or less straight, and clearly conspicuous thickened walls (Fig. 1 G). The edges of bracts are densely pubescent by three types of trichomes: 3-4-cellular capitate (Fig. 3 A), covering (Fig. 3 C, D) and multicellular (Fig. 3 E) hairs. On superficial preparations there are noticed articulate lacticifers with brown contents (Fig. 1 E).

Adaxial epidermis of tepals' edges is presented by parenchymatous cells with loop-like thin emergences of the cell walls (Fig. 2 B) which also forms papillae on the tip of tepal (Fig. 2 A). Abaxial epidermis on the edge is formed by parenchymatous cells of irregular shape with poorly thickened walls. Near the centre of tepal abaxial cells have thin, strongly sinuous walls. On abaxial surface large stomata of anomocytic type sparsely occur. There are glandular trichomes on a short bicellular stalk with a roundish multicellular head (Fig. 3 F).

Adaxial epidermis of the tepals from tubular flowers is papillate, the cells are extended, thin-walled, poorly sinuous-walled. The cells of abaxial epidermis are strongly extended, with thin and straight walls. The epidermis on a pharynx and sprockets contains 3-4-cellular simple hairs (Fig. 3 C, D), while in the central part of calyx the multicellular glandular hairs occur very sparsely (Fig. 3 A). Abaxial epidermis of tepals from tubular flowers is presented by narrow, extended cells with thin straight walls.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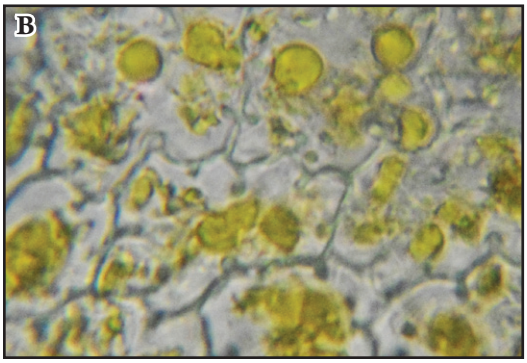
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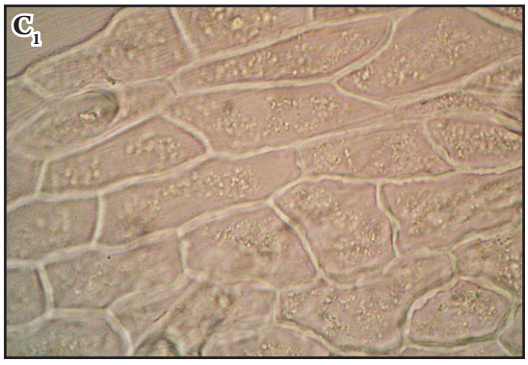
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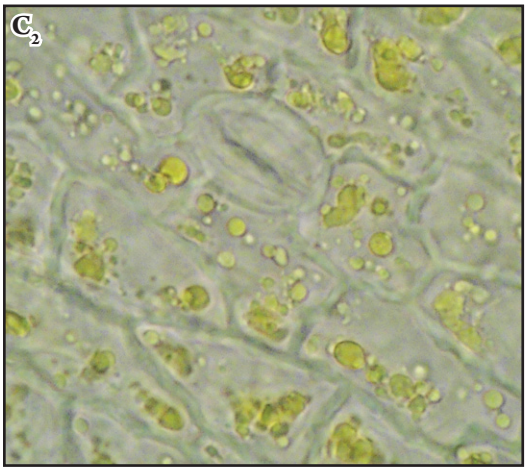
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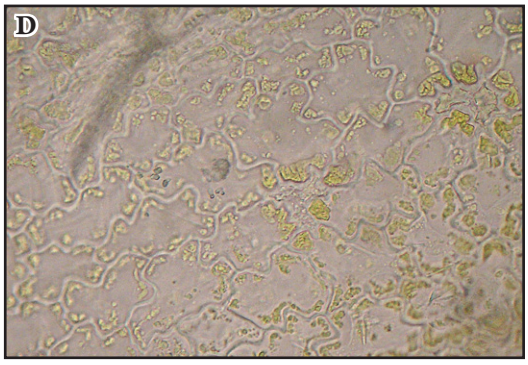
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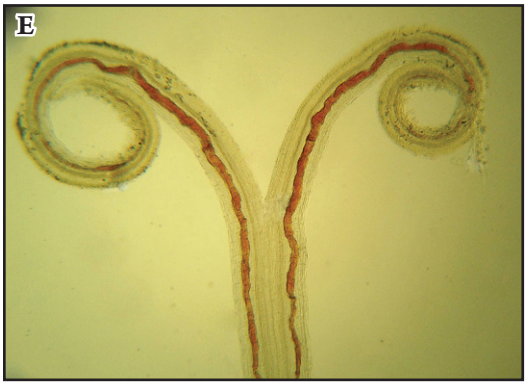
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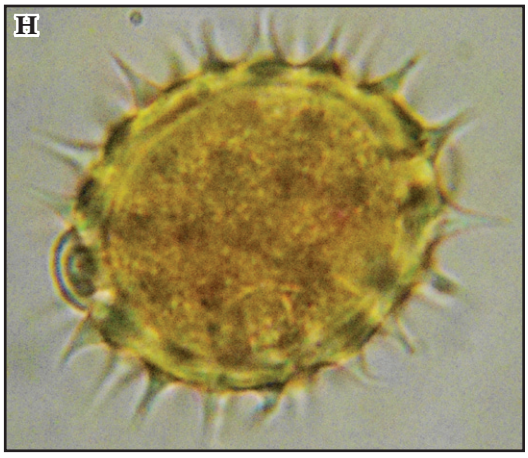
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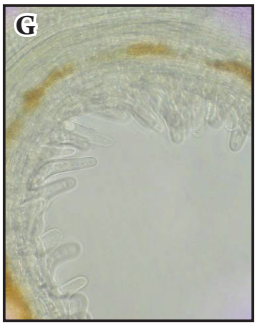
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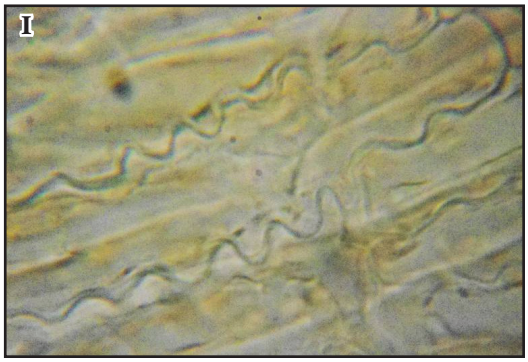

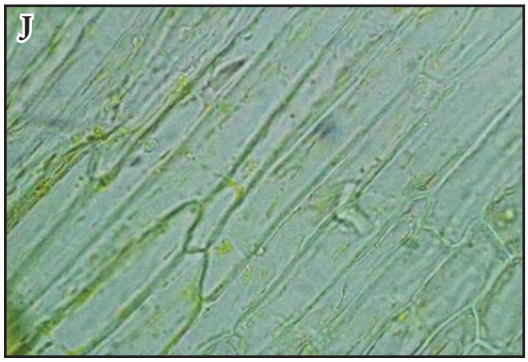

◄ **Fig. 2.** Microscopic features of ray (**A-G**) and tubular (**H, I**) flowers, and the pollen grain (J) of *Helianthus tuberosus*: **A** – papillate top epidermis of the perianth of ray flower; **B** –looplike cells of adaxial epidermis of the perianth of ray flower; **C** – abaxial epidermis near the edge of the tepal from ray flower; **D** – abaxial epidermis near the middle of the tepal from ray flower; **E-G** – stigma; **H** – pollen grain. On current page: **I** – adaxial epidermis of the perianth of tubular flower; **J** – abaxial epidermis of the perianth of tubular flower.

Pharynx on abaxial surface is densely pubescent by 2-4-cellular (Fig. 3 C, D) and glandular hairs (Fig. 3 A). In the central part of calyx and on the sprockets the hairs are absent; however the sprockets are densely covered with papillate emergences.

Pollen grains (Fig. 2 H) are three-furrowed, goldish. Surface sculpture is prickly; thorns are extended and pointed, they are located in regular intervals. In outlines from a pole and equator the pollen grains are almost roundish or little equatorially extended. The furrows are short, deckle-edged, with often poorly noticed contours and dull ends.

Conclusions

For the first time the anatomic structure of flowers and the leaflets of involucres of *Helianthus tuberosus* inflorescences has been studied. The main diagnostic macroscopic features of anthodium are: a) presence of two types of the flowers (bisexual tubular and sexless false-ligulate); b) filmy bracts with slantwise cut tips. The main microscopic signs are: a) special shape of epidermal cells of calyx, bracts and leaflets of involucres; b) presence of articulate lacticifers in all parts of anthodium; c) 4 types of trichomes (glandular multicellular; 3-cellular with a collapsed basic cell; 3-4-cellular covering; multicellular glandular with a spherical head); d) three-furrowed, thorny pollen grins. The obtained data can be used for standardization of medicinal raw materials.

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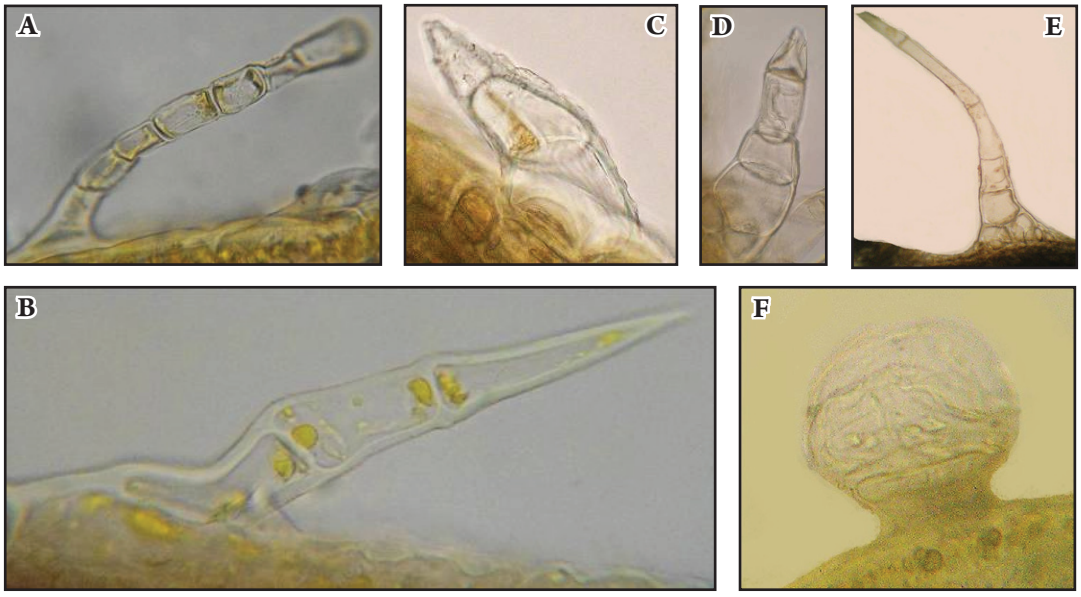

Fig. 3. The types of trichomes of *Helianthus tuberosus* inflorescences: **A** – multicellular glandular; **B** – 3-cellular with collapsed basal cell; **C, D** – covering 3-4-cellular; **E** – 5-7-cellular bent; **F** – glandular with short bicellular stalk and roundish multicellular head.