ANATOMY AND SURFACE MICROMORPHOLOGY OF TOMATILLO FRUIT (*PHYSALIS IXOCARPA* BROT.)

BARBARA DYKI, LESZEK S. JANKIEWICZ, MIROSŁAWA STANIASZEK

Research Institute of Vegetable Crops
ul. Konstytucji 3 Maja 1/3, 96-100 Skierniewice, Poland

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ABSTRACT

The fruit structure of tomatillo, a new vegetable crop in Poland, has not been yet investigated. The surface of the fruit as seen in SEM shows amorphous and cristalline wax-like deposits. Almost every fourth or fifth epidermal cell has a small appendix covered with cuticle and wax-like substance. No trichomes were found. The anatomical structure of the fruit is similar to that of several other Solanaceae species. The epidermis shows polygonal, tabular cells with a large nucleus. Subepidermis is composed of 1-4 layers of collenchyma-like cells, sometimes very flattened and compressed. The pericarp contains thin-walled round cells increasing in size toward the center. The cells originating from placentae are very large and elongated radially, frequently irregular. The vessels are situated centrally in the vascular boundle and are surrounded by parenchyma with the phloem strands at the periphery of it. Some fruits show microcracks extending from the epidermis throughout collenchyma-like layer.

KEY WORDS: fruit anatomy, SEM surface micromorphology, fruit microcracks, *Physalis ixocarpa*.

INTRODUCTION

The tomatillo (*Physalis ixocarpa Brot.*) is widely cultivated in Mexico from the precolumbian time and it is there an indispensable vegetable for preparing hot souces with chili and for other dishes (Estrada-Trejo et al. 1994). It is also cultivated in Russia, in home gardens from the time of Vavilov expeditions (Medvedev 1958). Some years ago, it was introduced to Poland,where it is used mostly in hot peperonates with zucchini, garlic and onion or for preparing sweet jams.The plant appears to be very resistant to fungus diseases and native pests in Poland and grows well when is cultivated from transplants similarly like field tomatoes (Jankiewicz et al. 1989). Also in USA tomatillo attracts recently the attention of horticulturists (Moriconi et al. 1988, Cantwell et al. 1992).

The biology of tomatillo has been little investigated and we have not found in the literature any paper on its anatomy and surface micromorphology. However, the anatomy of the closely related ornamental species *Ph. alkekengi* L. was investigated by Kaniewski (1966) and by the authors cited by him. The description of fruit anatomy of several other *Solanaceae* species was given by Ważyńska (1967) and Roth (1977). Surface micromorphology of fleshy fruits was studied by several authors (Martin and Juniper 1970, Fogle and Faust 1975, 1976, Freeman et al. 1979, Underhill and Simons 1993).

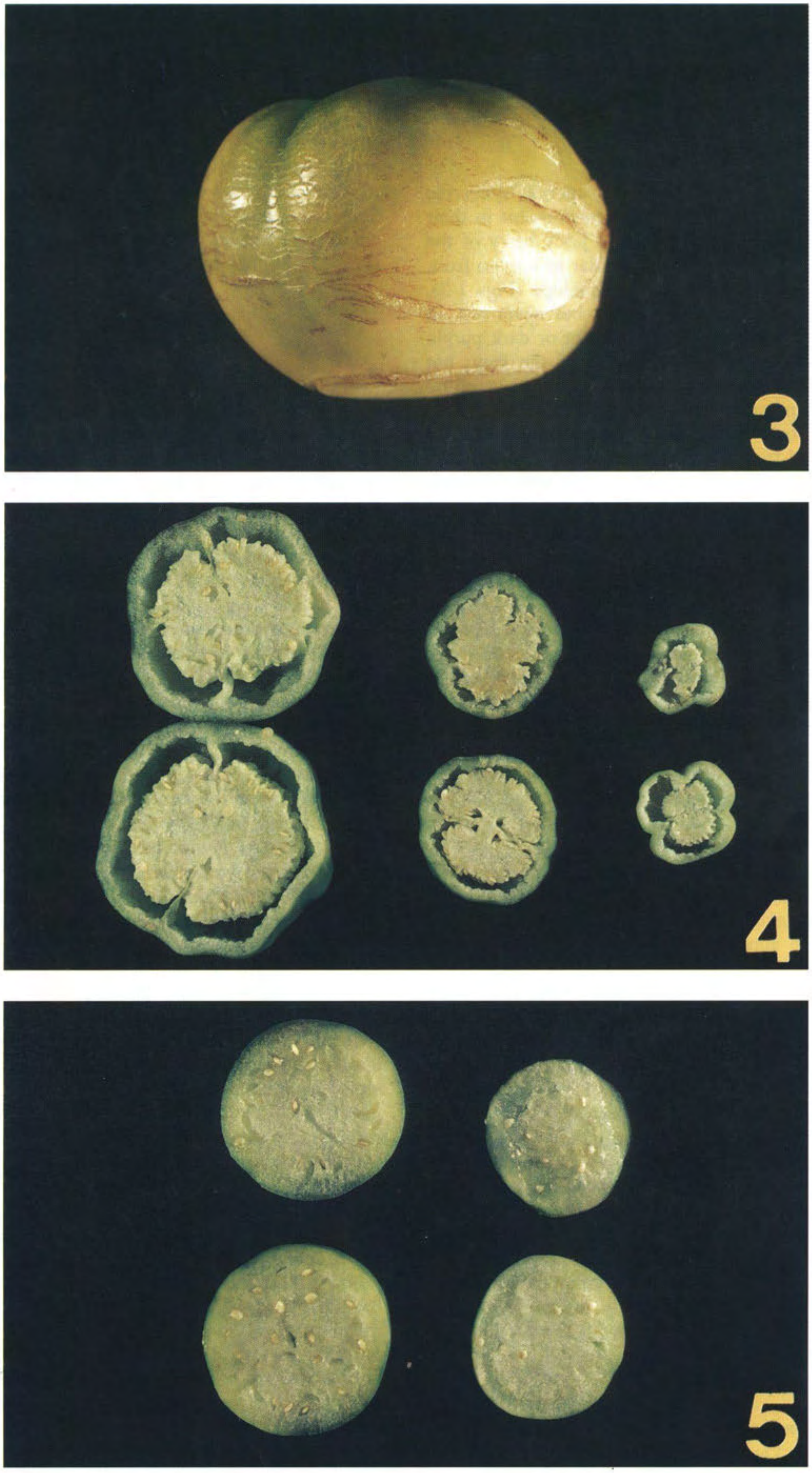
The microcracks of fleshy fruits of nectarine were investigated in detail by Nguyen-The (1991). He has found that the cracks are usually not deep, reaching only the junction between the cuticle and the cell wall. Fogle and Faust (1976) indicate, that nectarine clones which show no minute cracks under scanning electron microscope (SEM) also do not have deep cracks while grown in the field. Surface microcracks are usually a preferred entry for the pathogenic fungi (Nguyen-The et al. 1989). Healing of such microbreakages in tomato fruit was observed by Dean and Kollatukudy (1976) and by Fleuriet and Deloire (1982).

The aim of this work was to describe the anatomy and surface microstructure of tomatillo fruit. There was also a question wheather there is any anatomic difference between tomatillo fruits susceptible and resistant to cracking.

MATERIAL AND METHODS

The plants from which the fruits were taken for investigation were grown in the experimental field of the Agricultural University in Warsaw. Five plants were randomly chosen to take from them 5-6 ripen fruits for anatomical and surface micromorphology investigation. The fragments of fruits, mostly from their equatorial part were fixed in CrAF and dehydrated in series of ethanol solutions and finally in acetone. Fixed and dehydrated material used for SEM investigation, was CO_2 critical point dried and then coated with a gold – palladium by sputtering. The observations of tomatillo fruits surface were made with Jeol ISM -1 scanning electron microscope. The another part of fixed and dehydrated material was embedded in paraffin according to a standard procedure. Paraffin sections were stained with 2% water soluble safranin and 1% light green alcohol solutions. Photographic documen-

Figs 1-2. The fruits of tomatillo (natural size).
Fig. 1. The flower, the ovary is superior.
Fig. 1A. The fruits in the calice envelope.
Fig. 2. Ripen fruit with the calyx envelope stripped off.



Figs 3-5. The fruits of tomatillo (natural size).
Fig. 3. The fruit with microcracks and deep cracks.
Fig. 4. Empty spaces between the pericarp and the placentae of young fruit.
Fig. 5. The complete coalescence of the tissues orginating from the pericarp and from the placentae in the fruits of another plant.

tation was made with the NU 1 Zeiss light microscope and in Jeol scanning electron microscope.

RESULTS

The tomatillo fruits originates from the superior, syncarpic ovary composed of three or two carpels concrescent in their lateral parts (Figs 1 and 6). The fruit is a juicy berry of the diameter 3-7 cm. It is externally very similar to tomato fruit, except that it is covered with the calyx envelope (Figs 1-3). The fruit is green, yellow or yellow green but never red. In some tomatillo plants the fruit has dark violet or dark purple blush which may cover the whole surface of the fruit, but usully it extends only on those parts which are not covered by the calyx envelope. In some plants the blush is dotted.

In the fruits of some individual plants the tissues of the pericarp are seperated from those originating from the placentae by the empty space (Fig. 4) whereas in the fruits of other plants the tissues of pericarp coalesce completly with those of placentae and it is difficult to find any distinct border between them (Fig. 5).

Surface micromorphology of the fruit.

The contours of epidermal cells are clearly visible beneath the cuticular layer of the fruit. The epidermal cells are polygonal (Fig. 7). About every fourth or fifth cell has the papillar appendix (Fig. 7 and 8). No trichomes were found on tomatillo fruit. Amorphous or crystalline wax-like deposits were observed on the surface of the cuticule (Fig. 9). Such deposits were also present on the surface of papillar appendices. The chemical nature of these deposits was not determined.

The anatomical structure of the fruit.

The epidermal cells are tabular with large nuclei, their walls are thick, especially the external ones, which are covered with a thick layer off cuticle, (Fig. 10). Cuticle layer is present also on the appendices. Below the epidermis there are 1-4 layers of the thick-walled, flattened collenchyma – like cells (Fig. 10). In fruits of some plants these cells were very flattened and pressed together (Fig. 11). The deeper layers of the pericarp are composed of the thin walled cells which become larger and larger and more round toward the center (Fig. 12). Usually the pericarp consists of about 12 cell layers. The most internal cells of the pericarp (close to the vascular bundles) are very large, frequently radially elongated or irregular (Fig. 12).

The vascular bundles of the pericarp have the central strand of the xylem vessels surrounded by parenchyma cells and few phloem strands scattered throughout the margin of the bundle (Fig. 14). The seeds are embeded in parenchyma oryginating from placentae filling the locular cavities. The cells of it are also very large, frequently radially elongated and irregular (Fig. 12 and 13). They never became gelatinous (the difference with tomato fruit).

The microcracs.

The problem of cracking is serious in tomatillo fruits (Fig. 3). Inclination to cracking probably depends on the genetic properties of a plant. There are different types of cracks: large and minute (Fig. 3). Usually the formation of large cracks is preceded in tomatillo by the presence of microcracks (Fig. 16) – the breaks of epidermis and subepidermal layers of collenchymatous tissue (Fig. 15). There seems to be a structural difference between the fruits from plants prone to fruit cracking and those which do not show this defect. The cracking fruits have the stratum of subepidermal collenchyma composed of about 3-4 layers of very flat pressed cells, (Fig. 15), whereas the noncracking fruits show the stratum of collenchyma cells of only 1-2 layers containing well visible protoplasts (Fig. 10).

The microcracks in tomatillo are usually long (Fig. 16). Sometimes they cross each other. In some cases the microcracks are covered with amorphous wax-like substance (Fig. 17), so they may be supposed to be already healed.

DISCUSSION

We have not found any data in the literature on the anatomy of tomatillo fruit except some general remarks that the locules are filled with parenchymatous tissue which does not become gelatinous during ripening. The fruit of a related species *Physalis alkekengi* is very small and develops from the ovary formed usually of two carpels, it contains sclerenchymatic concretions in the pericarp which are lacking in tomatillo (Kaniewski 1966).

In the epidermis of tomatillo the fruit trichomes have not been found, whereas on tomato fruit there are different types of them, however, not in all cultivars (Roth 1977). In tomatillo fruit many epidermal cells show papillae. In some tomato cultivars similar structures occur (Roth 1977).

The pericarp of tomatillo is very similar to that of *Solanum* described by Roth (1977). The fruits of both these plants contain few layers of flattened collenchyma-like cells below the epidermis. They show also gradual increase of the cell size in pericarp toward the center. Such pericarp structure is quite common also in fleshy fruits of other species (Esau 1965, Roth 1977). As it was mentioned tomatillo fruit locular cavities are filled with parenchyma which does not become gelatinous. Probably due to this fact tomatillo fruit is richer in dry mass than tomato and therefore suitable for the production of jam and peperonata.

The structure of vascular bundles of tomatillo pericarp differs in some way from those described by Roth (1977) as typical for *Solanaceae*. She writes: "The vessels are interspersed between the phloem elements and the latter are scattered over the entire vascular bundle". In tomatillo the vessel strand is situated centrally in the bundle and is surrounded by parenchyma. Only at the periphery of the bundle one may observe scattered phloem strands.

One of the aim of this work was to recognize what are the differences in the structure between the fruits which crack easily and those which do not show such tendency. We have found the differences between them: the cracking fruits have more numerous subepidermal collenchyma-like layers composed of more pressed cells. Probably the superficial layers of the non-cracking fruits are more elastic and that is why they easier adapt to the changes in fruit volume caused by the rain or other factors. However, this finding may be considered only as an indication for the future detailed investigation.The microcracks of tomatillo are similar to those of lyche (*Litchi chinensis*) pericarp in which they extend throught the subepidermal stratum exposing the underlying tissue for drying and fungal penetration (Underhill and Simmons 1993). In tomato the wounds on the fruit surface are healed by the formation of a suberine layer and not by new cutin deposit (Dean and Kolattukudy 1976). We have not observed the healing process in detail, however, the picture 16 and 17 suggest advanced healing process.

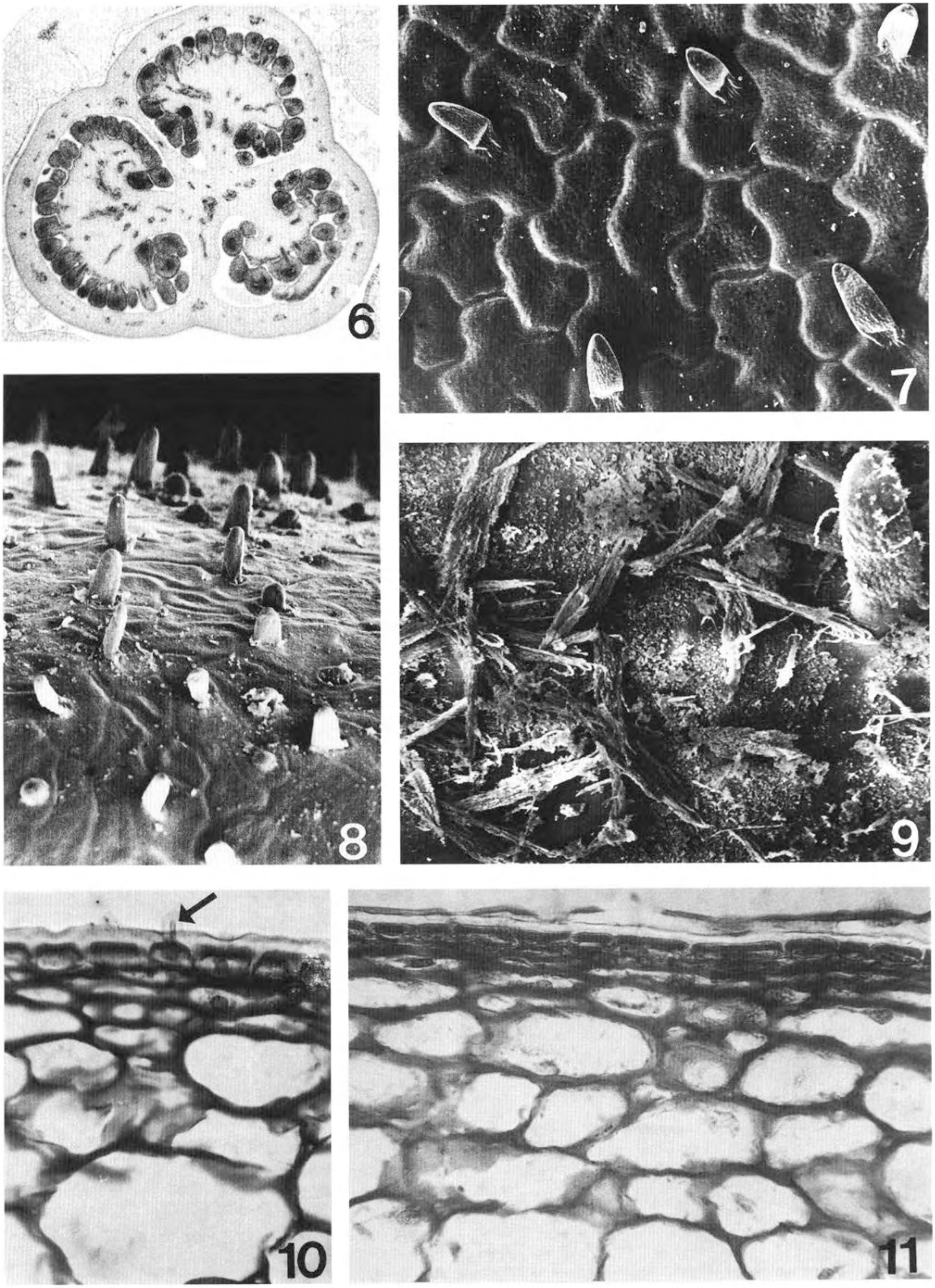
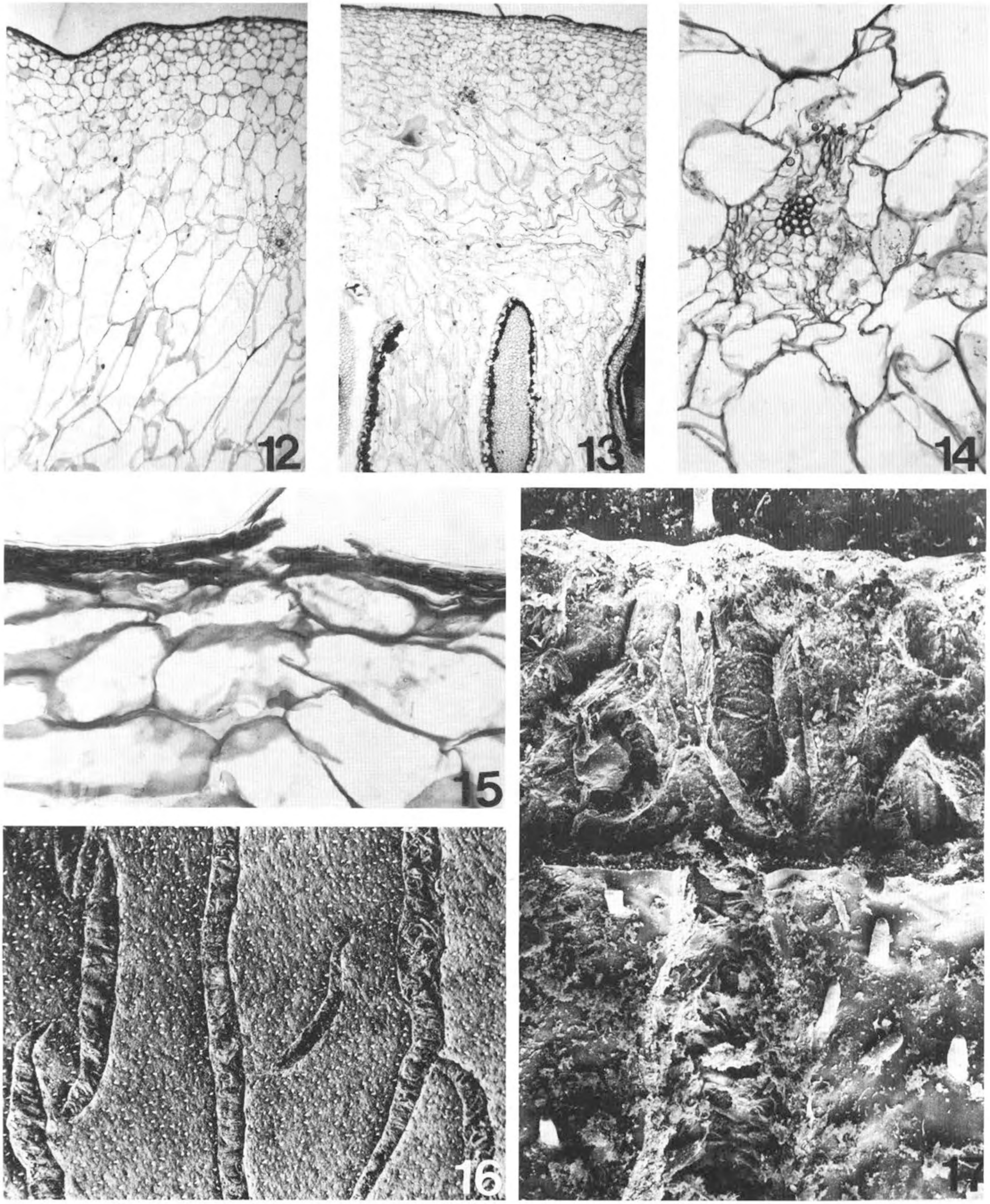


Fig. 6. A young fruit originating from the ovary composed of three carpels. x 25.

Figs 7-9. The surface of the fruit in SEM. Figs 7 and 8. The epidermal cells. x 2000, visible the cells with papillae. Fig. 9. The wax like deposits. x 6000.

Figs 10-11. The tissues of the fruit on the cross section in light microscope. Fig. 10. Superficial layers of the pericarp, the papilla marked with an arrow. x 600. Fig. 11. Very flattened subepidermal cells in cracking fruit. x 600.



Figs 12-15. The tissues of the fruit on the cross section in light microscope. Fig. 12. The structure of the pericarp and of the tissues originating from placentae. x 280. Fig. 13. The same as in Fig. 12 but with the seeds. x 180. Fig. 14. The vascular bundle. x 450. Fig. 15. The cross – section of a microcrack, the epidermis and the subepidermal layers broken. x 750.

Figs 16 and 17. The microcracks in SEM. Fig. 16. The microcracks. x 100. Fig. 17. The fragment of microcracks. x 1000

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ANATOMIA OWOCU MIECHUNKI POMIDOROWEJ (*PHYSALIS IXOCARPA BROT*) I MIKROMORFOLOGIA JEGO POWIERZCHNI

STRESZCZENIE

Struktura owocu miechunki pomidorowej – nowego warzywa w Polsce, nie była dotychczas badana. Powierzchnia owocu widziana w skaningowym mikroskopie elektronowym wykazuje obecność bezpostaciowych i krystalicznych złogów substancji przypominającej wosk. Co czwarta lub piąta komórka epidermy posiada mały wyrostek pokryty kutykulą i substancją podobną do wosku. Nie stwierdzono występowania włosków na powierzchni owocu. Struktura anatomiczna owoców miechunki jest zbliżona do struktury owoców mięsistych szeregu innych gatunków roślin psiankowatych. Komórki epidermy są płytowe, wielokątne, o dużym jądrze. W pokładzie subepidermy znajdują się 1-4 warstwy grubościennych komórek kolenchymatycznych. Niekiedy są one bardzo płaskie sprasowane. W perykarpie występują cienkościenne, okrągłe komórki o tym większych rozmiarach im głębiej są położone. Komórki pochodzące z łożyska są bardzo duże i wydłużone w kierunku promienistym, często mają nieregularne kształty. W wiązce przewodzącej naczynia ksylemu są położone centralnie i są otoczone tkanką miękiszową, a pasma floemu znajdują się na peryferiach miękiszu wiązki. Owoce niektórych roślin wykazują powierzchowne drobne spękania – pęka epiderma i warstwy subepidermalne odsłaniając głębsze tkanki perykarpu. Spękania takie, w pewnych warunkach, mogą prowadzić do powstania spękań głębokich.

SŁOWA KLUCZOWE: anatomia owocu, mikromorfologia powierzchni owocu, pękanie owoców, miechunka pomidorowa.