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THE MICROSTRUCTURE OF SELECTED APPLE VARIETIES

Grażyna Pierzynowska-Korniak[1], Ryszard Zadernowski[1], Józef Fornal[2], Jarosław Nesterowicz[1]
[1]Chair of Food Plant Chemistry and Processing, University of Warmia and Mazury in Olsztyn, Poland
[2]Centre for Agrotechnology and Veterinary Sciences, Polish Academy of Sciences, Olsztyn, Poland

ABSTRACT

Scanning microscopic analysis cell structure of 8 apple cultivars was carried out. For each variety, skin and flesh, cut and broken preparation was made to research microstructure of apple tissue. The results revealed differences in shape, cell size, thickness of cellular wall, distribution and size intracellular spaces and other fruit texture features of apple varieties tissue. In microscopic picture some varieties of apple were found. Some dependence between structure of apple tissue and sensory assessment of fruit was found too.

Key words: apples, microstructure, scanning electron microscopy

INTRODUCTION

The selection of new apple cultivars for common utilisation (farming) is aimed at the improvement of tree breeding properties, fruit sensory properties and storage utility including endurance to mechanical forces during harvest and fruit transportation.

The described apple fruit sensory differences do not only result from different chemical composition but also from differences in the structure of skin and flesh tissue. This paper includes research into apple fruit microstructure of the varieties grown in Poland and was made to complement poor information available in references on this subject.

The purpose of the work was to determine fruit cell structure of the apple selected varieties related to their sensory assessment.

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MATERIALS AND METHODS

Materials

The following apple cultivars were the subject of the research: *Bancroft*, *Boiken, Cortland*, *Idared, Jonagold, Lobo, Mc Intosh* and *Melrose* originating from the experimental orchard of the University of Warmia and Mazury in Olsztyn.

Analytical methods

The apple tissue samples were extracted from apple fruit with the use of a cork borer with a 10 mm diameter from an intensively red-coloured part of a fruit. From the extracted cylinder, an outer part (epiderma) and an inner part of the 3 mm thickness from the middle of the cylinder (parenchyma) were cut or broken off. The preparations were preserved according to the procedure described by Kim and Hung [5] and microscopic analysis was performed after samples' drying to a critical point (Balzers Union) and coated with coal and gold powder (JEOL JEE 4X) with the use of a scanning electronic microscope - JEOL JSM 5200 at the acceleration voltage of 10 keV.

A brief sensory assessment was done according to Barylko-Pikielna [1].

RESULTS AND DISCUSSION

It has been established that the ripened fruit parenchyma cells are diameter ranged between 50 and 500 micrometers and diameter of intercellular spaces, occupying 20 to 30% of the tissue volume, ranged between 210 and 350 micrometers [8]. They are loosely set in a net-like construction [4]. Cellulose fibres, imbedded into amorphous polysaccharide matrix, form the skeleton basis of tissue. Individual cells are connected with a shapeless layer - the middle lamella. The above two factors determine apple fruit texture because any change of the above factors during storage or transportation are immediately clearly noticeable [2].

Apple skin and its waxy coat are of significant importance during transportation and storage. Its mechanical resistance is directly related to apple fruit damage. Skin is a layer through which gas exchange between the flesh and the environment is conducted. The sensory properties of the skin and the flesh are unique for each individual apple fruit variety (Table 1).

	Varieties of apple							
Property	**Cortland**	**Jonagold**	**Lobo**	**Mc Intosh**	**Idared**	**Boiken**	**Melrose**	**Bancroft**
Size	large, very large	large, very large	large, very large	average	average	average	average, large	average
Shape	spherical, regular	spherical and conical, regular	Slightly flattened	oval	spherical, very regular	spherical and conical	regular, ribbed	spherical, slightly flattened
Colour: **skin** **flesh**	green with a striped redness white	orange and red redness creamy	reddish and red white	purple with violet coat white	bright reddish redness white	green and yellow carmine redness white	pink red redness white and greenish	green with a striped redness white with green
Texture: **skin** **flesh**	average thickness delicate juicy	thick, strong thick grains hard, firm	average strength soft, juicy	average, flexible soft, juicy	strong, compact juicy	average thickness juicy, compact	thick, strong compact, juicy	Relatively thick strong compact, juicy

Figure 1a and 1b illustrates the skin structure of *Cortland* apple variety. The waxy coat (cuticula) covering the surface of the epidermis is very thin and their thickness does not exceed 5-10 micrometers. The flattened cells of epidermis, filled with cell contents, are of irregular shape and size. Large number of spherical cellular elements, of the 0.1-0.5 micrometers diameter, is visible. Partial stratification of hypodermic cells, which revealed the pectin elements of the middle lamella, could also be observed. Figure 1c (cut preparation) and 1d (broken preparation) illustrates the flesh structure consisting of large parenchyma cells. The flattened cells of parenchyma of the 100-150 micrometers in diameter in the cut preparation and especially the large amount of intact cells in the broken preparation, according to the suggestion of Lapsey et. al [7], proof of the large degree of pulp softness.

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Figure 1a. Microstructure of the skin apple *Cortland* - cut preparation

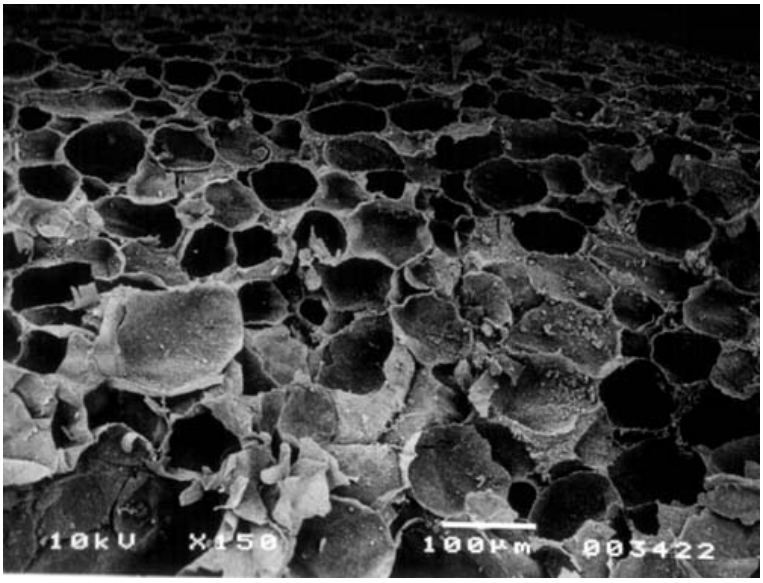

Figure 1b. Microstructure of the skin apple *Cortland* - broken preparation

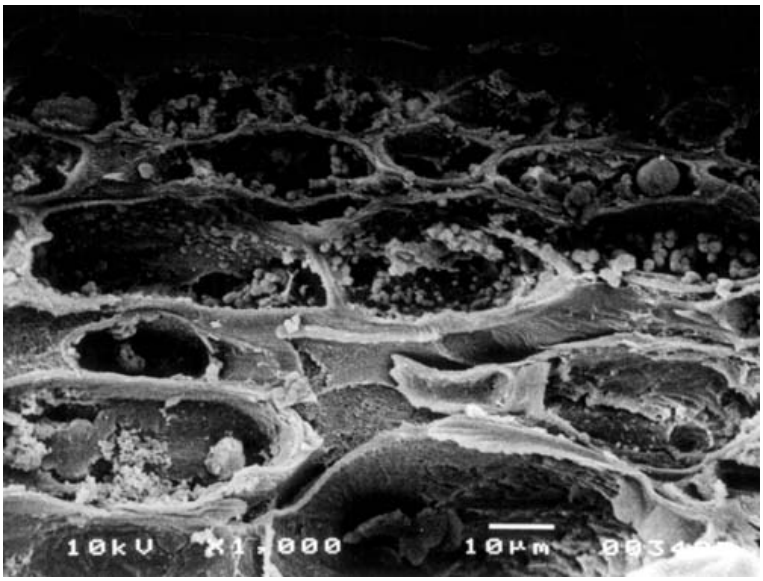

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Figure 1c. Microstructure of the flesh apple *Cortland* - cut preparation

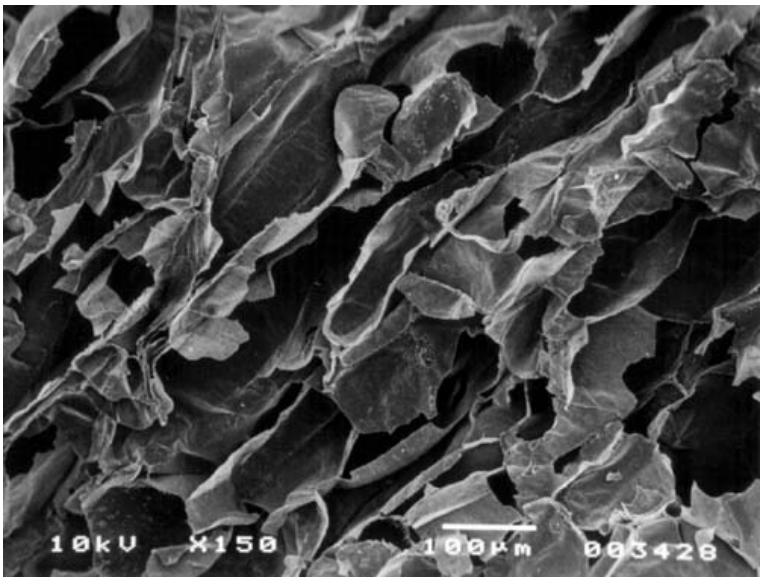
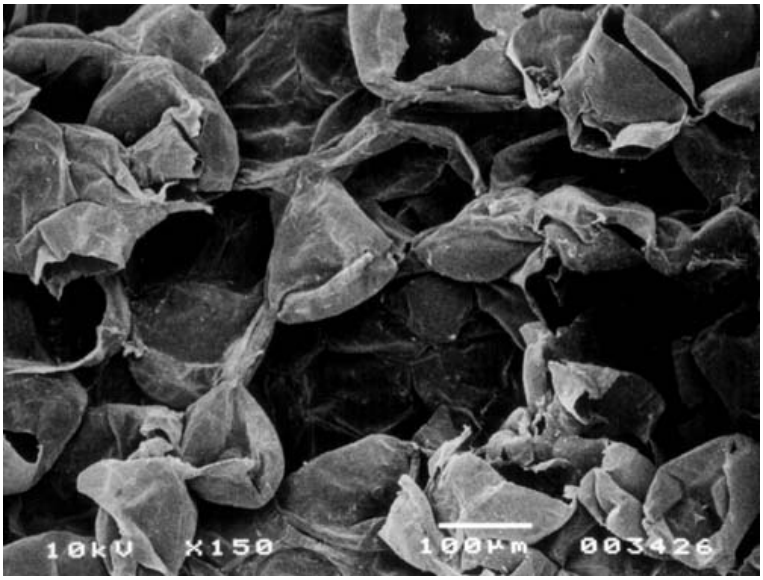


Figure 1d. Microstructure of the flesh apple *Cortland* - broken preparation



Jonagold apple fruit feature a significantly thicker wax cuticle of almost 20 micrometers in thickness and, additionally, much thicker layers of epidermis cells (Figure 2a and 2b). Sensory assessment with a hard skin impression confirmed the above. A similar impression is obtained in the case of parenchyma cell structure, where in both cut (Figure 2c) and broken (Figure 2d) preparations open cells prevail. This fact is related to the strong cohesiveness of individual cells, which results in breaking not separation, when cut or broken. The above should then be related to lower degradation of pectin and cellulose material, which are responsible for holding the inner apple fruit compact structure [6].

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Figure 2a. Microstructure of the skin apple *Jonagold* - cut preparation

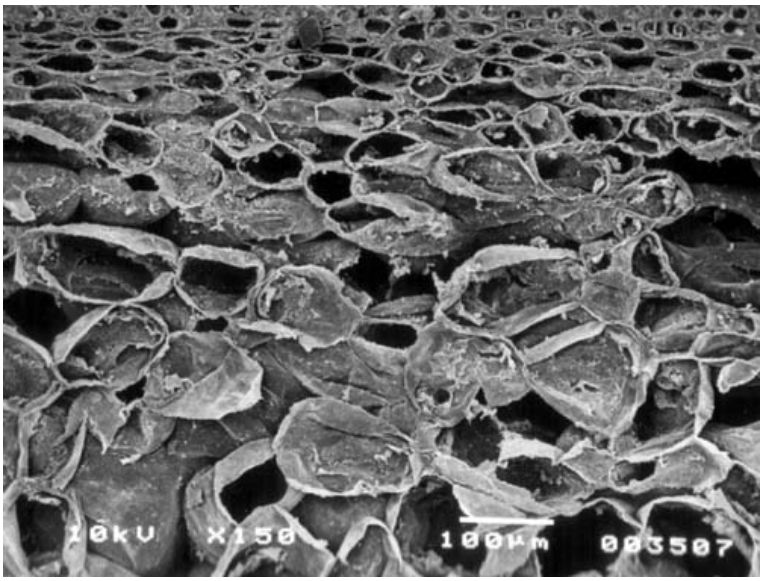

Figure 2b. Microstructure of the skin apple *Jonagold* - broken preparation

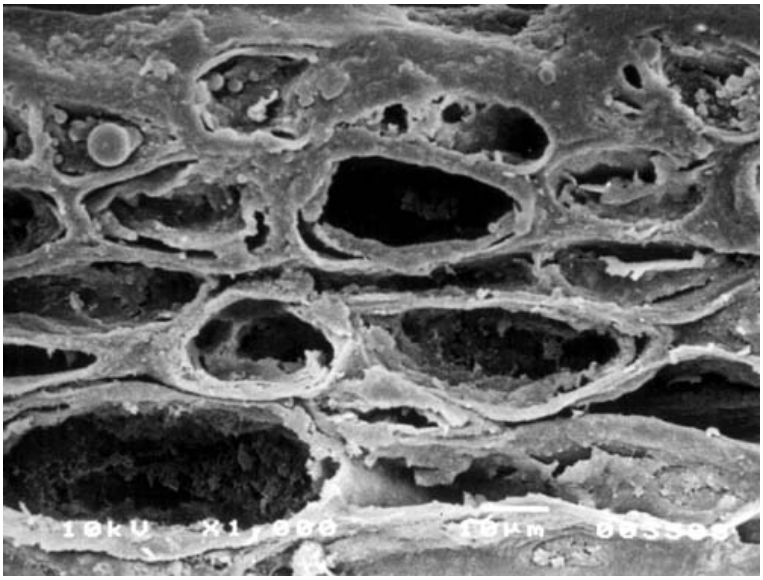

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Figure 2c. Microstructure of the flesh apple *Jonagold* - cut preparation

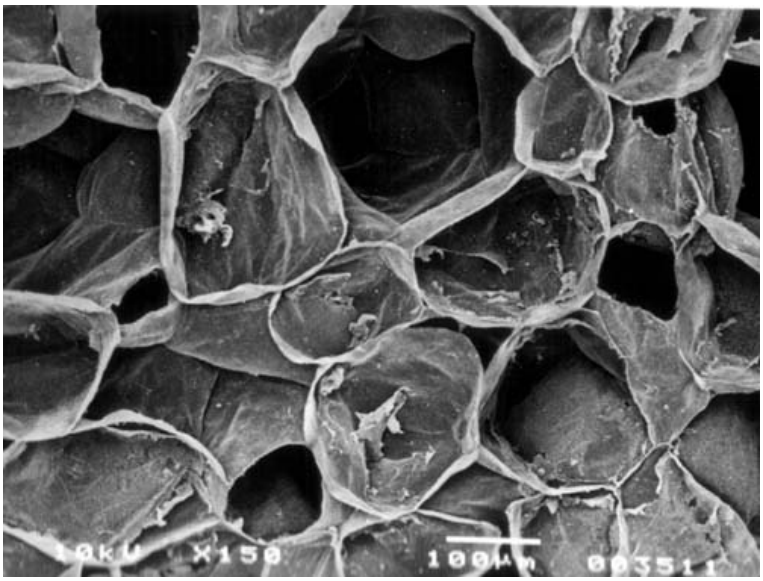
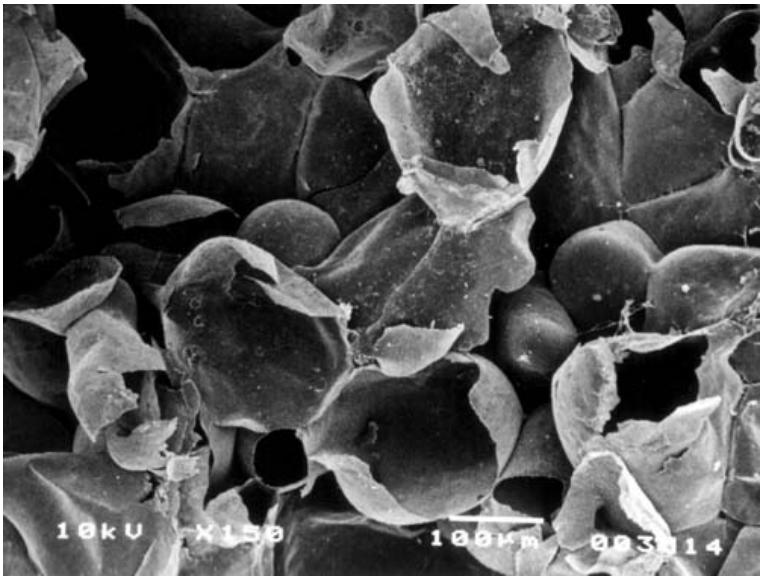


Figure 2d. Microstructure of the flesh apple *Jonagold* - broken preparation



Lobo apple variety has its wax cuticle as thick as the *Jonagold* variety and features very flattened layer of epidermal cells and significantly weakened hypodermic structure (Figure 3a and 3b). The lack of compactness between individual cells and empty spaces among cells may prove the mechanical damage of apple fruit in the place of sample extraction. According to Kim and Hung [5], such empty spaces among loosely connected cells are the sign of significant tissue greasiness. The picture of microstructure of the inner epidermal cell structure also differs from the above description. Significantly thinner cell walls surround closed or opened vacuoles, having much less spherical inclusions in comparison with the previously described apple varieties (protein crystalloid, tiny starch grains) [3]. A net-like character of the observed globoidal structures is clearly visible, which may be proof of a different chemical composition. The fruit flesh of this variety has a regular structure in the cut preparation (Figure 3c) with the majority of round cells, visible in cross-section, with a 120 micrometers diameter. The microscopic picture of the broken preparation (Figure 3d) allows the classification of fruit of this variety as soft and delicate. The above statement is related to the presence of caved-in cells which reveal numerous intercellular spaces.

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Figure 3a. Microstructure of the skin apple *Lobo* - cut preparation

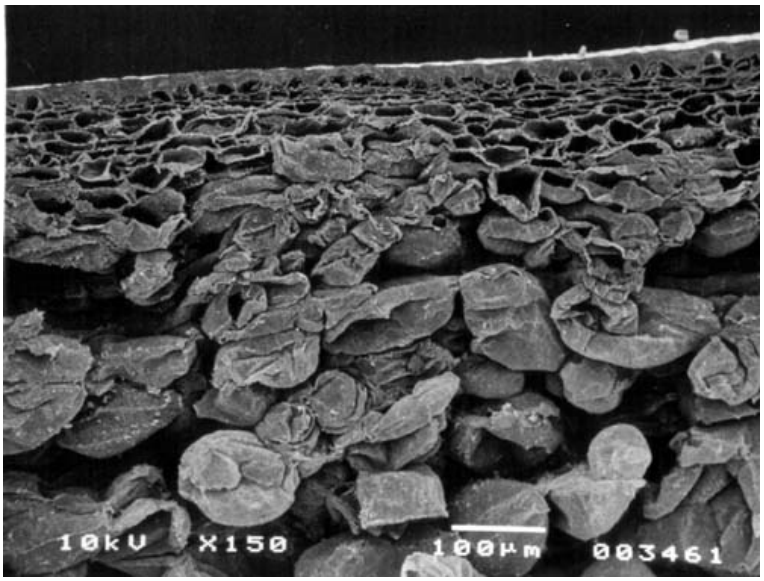

Figure 3b. Microstructure of the skin apple *Lobo* - broken preparation

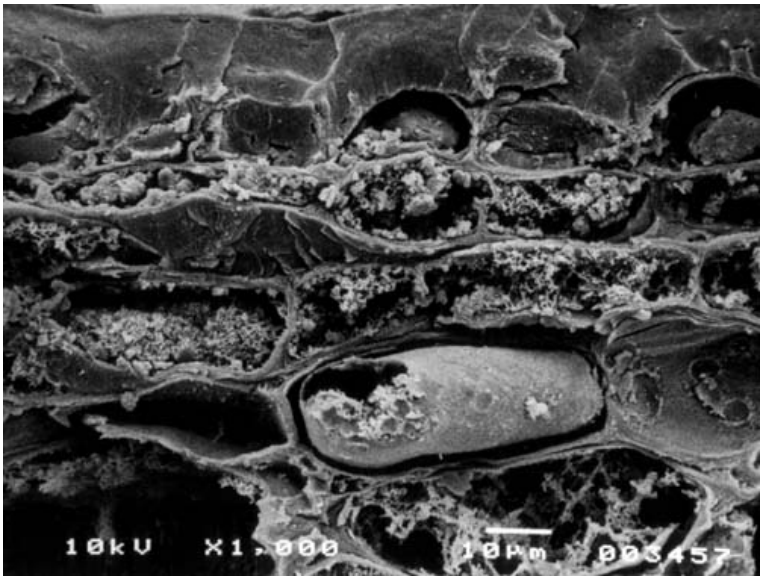

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Figure 3c. Microstructure of the flesh apple *Lobo* - cut preparation

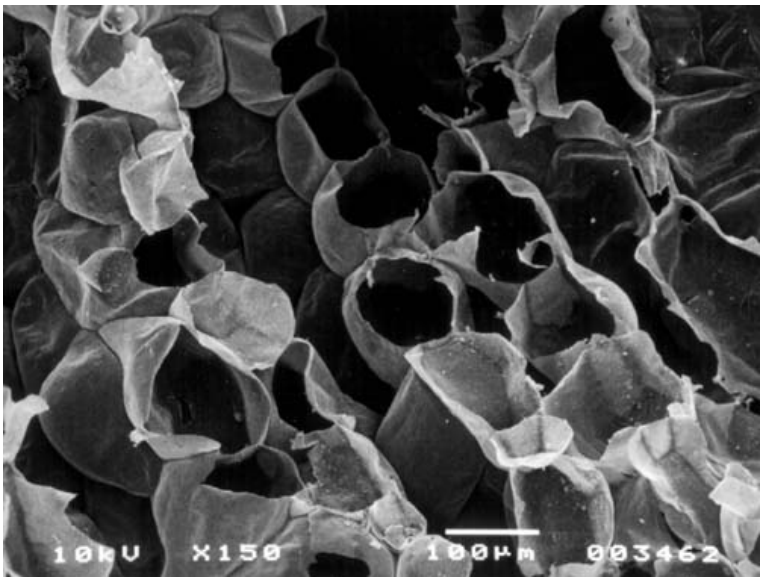
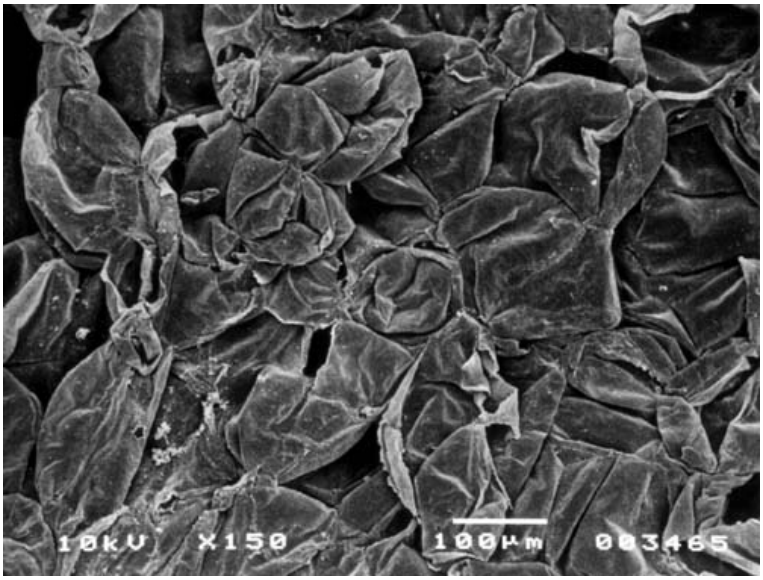


Figure 3d. Microstructure of the flesh apple *Lobo* - broken preparation



The sensory assessment in case of the *Mc Intosh* variety is similar (Figure 4a-d). Additionally, figure 4a suggests a clear skin easiness to separate and figure 4c and 4d illustrate slightly better flesh firmness than in the case of the *Lobo* apples.

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Figure 4a. Microstructure of the skin apple *Mc Intosh* - cut preparation

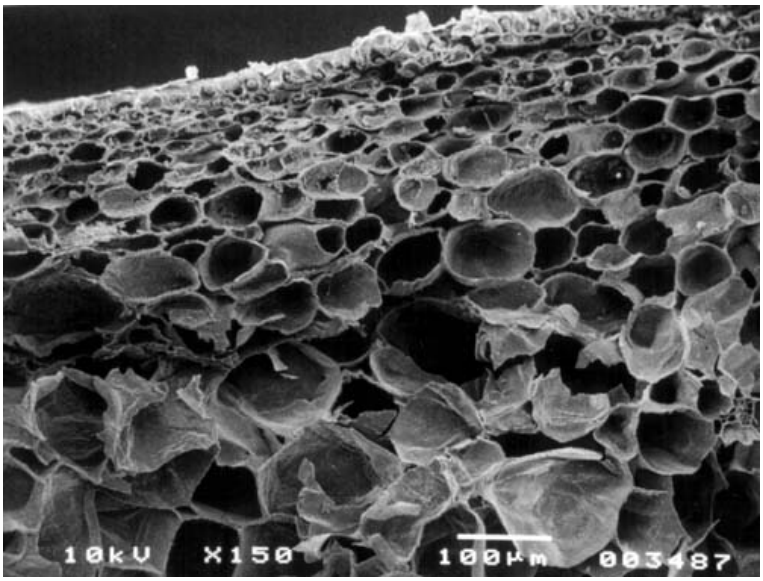

Figure 4b. Microstructure of the skin apple *Mc Intosh* - broken preparation

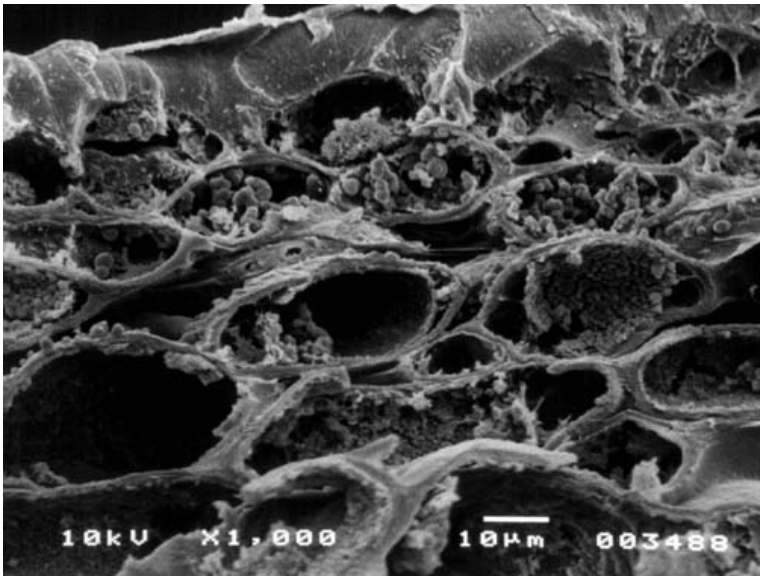

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Figure 4c. Microstructure of the flesh apple *Mc Intosh* - cut preparation

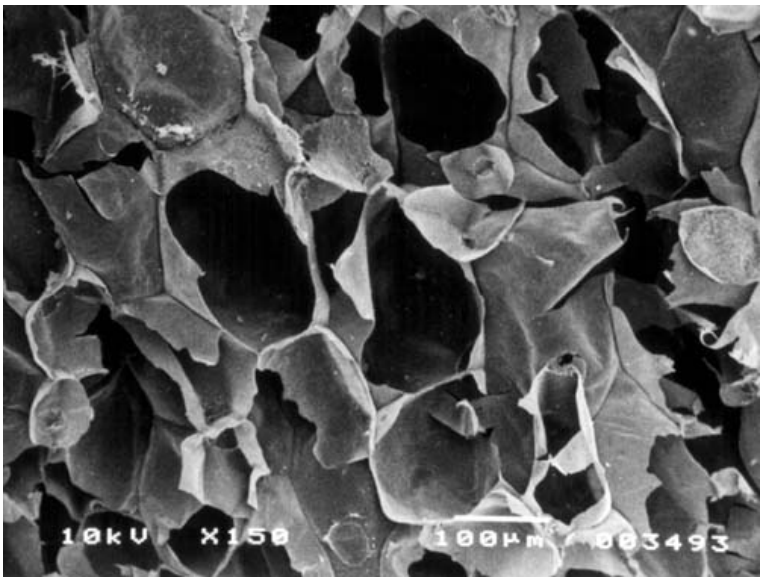
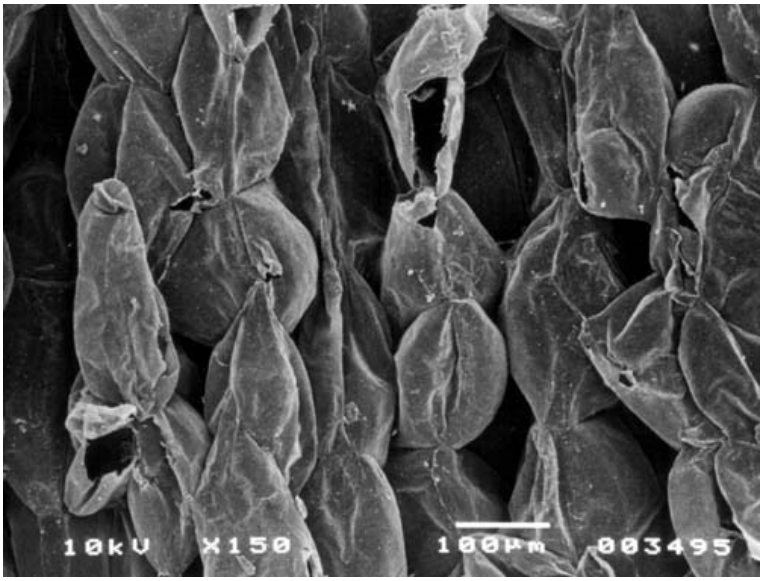


Figure 4d. Microstructure of the flesh apple *Mc Intosh* - broken preparation



The fruit microstructure of the *Idared* variety is similar to the *Cortland* and the microstructure of the fruit of *Boiken* to the *Jonagold* variety. In case of the *Idared* apples, significantly thicker epidermis and hypodermis layer and the clearly visible separation between the skin and the flesh, are worth attention.

The *Melrose* variety differs due to the cellular wall's thickness and large parenchyma cell diameter, whereas the *Bancroft* apples due to very regular in shape epidermal cells with numerous fine-grained structures of 1-3 micrometers in diameter.

CONCLUSIONS

The cellular structure of the skin and the flesh is one of the factors determining the fruit texture features, unique for a given variety. In research with the use of electronic microscopy techniques, shape, cell size, cellular wall thickness, presence and size of intercellular spaces, the presence of various inclusions as well as determination of cell compactness degree may describe texture features. Dependence between the sensory assessments, like the size of fruit, some property of texture (firmness, hardness) and the apple microstructure was found. These were very expressive on the broken preparation of flash *Cortland* and *Lobo* apple varieties, which in sensory value occurs soft and delicate.

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Correct interpretation of the results in electronic microscopy technique application requires the knowledge of events occurring during sample preparation. The above skill is of major importance, especially in case of a heterogeneous material such as fruit.

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Grażyna Pierzynowska-Korniak
Chair of Food Plant Chemistry and Processing
University of Warmia and Mazury in Olsztyn
Pl. Cieszynski 1, 10-957 Olsztyn, Poland
Ph./fax (+48 89) 523 34 66
e-mail: gkorniak@uwm.edu.pl

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