Scanning Electron Microscopy of the Oat Kernel[1]

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ABSTRACT

The detailed structures of the lemma, palea, rachilla segment, pericarp, aleurone layer, and starchy endosperm of the oat kernel were studied by electron scanning microscopy. The presence of microorganisms in the crease area of the caryopsis and adjacent palea are illustrated.

Some of the general features of oat-kernel structure were described by Winton and Winton (1), Bonnett (2,3), and Bawtree and Gordon (4). The present study concerns details of hulls, pericarp, and endosperm of oat kernels; detailed pictures of those structures were obtained by scanning electron microscopy.

MATERIALS AND METHODS

The whole grain was *Avena sativa* L., Orbit cultivar, from the 1970 crop grown in Madison, Wis. We examined the glumes, the groat (caryopsis after removal of lemma and palea), and transversal sections of the groat (in the middle and at the germ end). The samples were mounted on circular (9-mm. diam.) specimen holders with an adhesive, coated with graphite, and covered with a 200 to 300 A gold layer. The specimens were examined in a Cambridge Stereoscan electron microscope at 20 KV.

SCANNING ELECTRON MICROSCOPY OF THE OAT KERNEL

The oat inflorescence is a loose open panicle, from the main axis of which arise branches. Each branch terminates in a pedicellate spikelet. The spikelet of the oat plant consists of the glumes and florets which form the seed when mature. In the common oat, the spikelet may contain up to four florets (kernels), but most varieties product two florets, main and secondary (5).

The lemma and palea are leaf-like parts, but at maturity they do not have characteristics of a foliage leaf. The mature lemma is a lanceolate structure which encloses the caryopsis and part of the palea. The palea is located on the floral axis above the lemma with its back to the rachilla. The rachilla has nodes and internodes. It gives rise to leaf-like structures (the lemmas) and to shoots (the floral branches) (2). The caryopsis is enclosed completely by the lemma and the palea.

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The oat caryopsis has a thin, tight pericarp originating from a superior ovary. Inside the pericarp, the caryopsis contains the endosperm and the embryo. The endosperm constitutes the largest part of the caryopsis. It is made up of cells of the aleurone layer and cells of the starchy endosperm. The caryopsis of oats, as in other cereals, is furrowed (has a crease) on the side opposite to the embryo (2).

Details of the ventral view of an oat kernel are shown in Fig. 1, a and b. The observations were made on a secondary floret with attached infertile third floret. The rachilla segment on the secondary floret is shown in Fig. 1a; it consists mainly of fundamental long cells with straight and deeply furrowed walls. The cells in the adjacent lemma are similar to those of the floret attachment segment. Well-differentiated cells and trichomes on the surface of an infertile third floret are shown in Fig. 1b. Trichomes are unicellular appendages found on all parts of oat plants.

An oblique view of a damaged trichome on the lemma surface is shown in Fig. 2. Appearance of the basal part of the lemma and palea (ventral view) is shown in Fig. 3a. Both in the palea and the lemma, one can see straight cells arranged end-to-end in rows that extend the length of the structure covered. The lemma has trichomes and a barbed appearance at the edges that are inrolled over the palea. In the central part of the palea (Fig. 3b), epidermal cells and trichomes are shown. The apical part of the palea (not shown here) contained straight cells and numerous trichomes.

When the lemma was removed and its interior surface was scanned by electron microscopy, the appearance shown in Fig. 4 was observed. The appearance of the interior surface of the lemma was completely different from the one in the interior of the palea over the crease (Fig. 5a). The longitudinal and cross ridges in the inside of the palea are covered by long (up to 30 μ) and fine (about 1 μ in diam.) hairs. The palea seems to be the site of microorganisms in oats. Oat diseases are a major factor in oat production in North America. The losses from oat diseases are generally higher than those from other small grains because most of the crop is grown in warm and humid regions which are normally favorable to disease development (6). In addition to regular parasitic fungi of the growing plant, several saprophytes occur on the oat seed. Several strands that could be mycelia were found on the outer surface of the palea (Fig. 3, a and b). Fungal mycelium on the interior surface of the palea of a seemingly healthy seed is shown in Fig. 5b; a plaque with microbial growth (probably a slime-producing bacterial colony) can be seen against the background of the hair-covered ridges in Fig. 5c. The area between the palea and the crease seems to create a favorable microenvironment for growth of microorganisms and to harbor them in the mature and dried grain. Presence of fungi in the crease area, beneath the palea, is also indicated in Fig. 6, which shows a conidium and conidiophores.

The oat cultivar used in this study (Orbit) is quite hairy, as can be seen from the dorsal and ventral view of the groat (dehulled kernel) (Fig. 7, a and b).

A transverse section through the crease area (Fig. 8a) shows the relatively large hairs, cord-like pericarp layers, aleurone layer, and starchy endosperm. The aleurone cells in the area adjacent to the crease area are almost elliptical in shape and covered by a cell wall with many fine protrusions (Fig. 8b). There were two lines of aleurone cells in the distal side of the caryopsis; the cells in that area were almost hexagonal or rectangular (Fig. 8c). Aleurone cells in a transverse section at the germ end (not shown here) were generally elliptical in shape and somewhat larger than the aleurone cells in the transverse section through the center of the kernel shown in Fig. 8c (with larger diameters of about 40 and 30 μ, respectively). Aleurone grains in the exposed parts of the aleurone cell can be seen in Fig. 8c; their diameter was about 2 μ. The diameter of aleurone grains in the section at the germ end was up to 3 μ. The fine structure of the wall covering the aleurone cells in oat is shown in Fig. 8d. This structure is different from the one observed in barley aleurone cells; the cell wall in the latter has a fine, wrinkled appearance (7). The appearance of the center of the endosperm (Fig. 8e) indicates, as in other cereal grains, a protein matrix in which are embedded starch granules.

Our observations regarding the size of aleurone cells and structure of aleurone cell wall in barley and oats were limited to examination of samples from one cultivar of the two cereals. Details of the aleurone cell wall in cereal grains and in buckwheat are also being investigated.

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