

Scanning Electron Microscopy of the Buckwheat Kernel¹

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ABSTRACT

The detailed structures of the pericarp, spermoderm, aleurone layer, and starchy endosperm of the buckwheat achene were studied by scanning electron microscopy. The presence of fungi on the surface of the spermoderm is illustrated. Similarities between the structure of buckwheat and of cereal grains are discussed.

Buckwheat (*Fagopyrum esculentum* Mönch), although the fruit of a dicotyledonous plant, is classed in agriculture and commerce with the cereals. Structurally and chemically the endosperm resembles the cereals in that it has a nonstarchy aleurone layer and a starchy endosperm, but the structures of other parts and external appearance of common buckwheat and cereals are dissimilar (1). Some general features of buckwheat kernel structure were described by Winton and Winton (1), Moeller and Griebel (2), and Bawtree and Gordon (3). Several recent publications concerned the use of scanning electron microscopy in studies of wheat, flour, and dough (4); barley (5); malted barley (6); and oats (7). The present study concerns details (some of which could not be determined by previously available techniques) of the pericarp, spermoderm, and endosperm; and illustrates the site of microorganisms in common buckwheat.

MATERIALS AND METHODS

The whole grain used was that of 'Pennquad' buckwheat, C.I. 16, Pa 84, an autotetraploid variety registered by Marshall (8). Pennquad, a naturally cross-pollinated variety, is the first tetraploid cultivar released for production in the U.S. Predominant seed color is gray with black mottling.

We examined the outer (including calyx) and inner surfaces of the pericarp (hull), the spermoderm, and the longitudinal and transverse sections of the kernel. The samples were mounted on circular (9 mm. diam.) specimen holders with an adhesive, and coated with a 200 to 300 Å gold layer. The specimens were examined in a Cambridge Stereoscan electron microscope at 20 KV.

¹Cooperative investigations between the Plant Science Research Division, Agricultural Research Service, and Forest Service, U.S. Department of Agriculture; and the Agricultural Experiment Station, University of Wisconsin, Madison.

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SCANNING ELECTRON MICROSCOPY OF THE BUCKWHEAT KERNEL

Common buckwheat has a sharply three-angled or three-keeled pointed dry fruit (achene), with a relatively smooth hull (pericarp), and often part of the calyx attached at the base of the hull. The fruit in most varieties is 4 to 6 mm. long; and in the Japanese type, 6 to 9 mm. long. Seeds of Pennquad used in this study were about 7 mm. long.

A micrograph of the fine structure of a segment of the calyx attached to the hull is shown in Fig. 1. The outer walls of the cells of the calyx are elevated to form papillae covered with wavy striations. In addition, several isodiametric stone cells can be seen. Examination of the surface of the hull (pericarp) (Fig. 2) shows elongated spiral-reticulated cells of the epicarp. These cells are arranged longitudinally at the angle and have a barb-like appearance on the sides of the hull. A general view of the inside (at the calyx attachment end) of the hull is shown in Fig. 3a. In this view, one can see the cross-section through the hull, several fiber layers, a section of the inner pericarp, and the conspicuous central section at the attachment end. The latter and the fiber layers are shown at higher magnification in Fig. 3b and 3c, respectively. In the exposed fiber layers (Fig. 3c) there seems to be indicated fungal growth. A cross-section through the hull (pericarp) at the angle is shown in Fig. 4. Examination of the oblique view of the cross-section shows the outer surface, the epicarp, several cells of thick-walled fiber layer, the elongated parenchyma cells of the pigment layer, the large longitudinally elongated cells of the endocarp, and the inside view of the hull. The longitudinally elongated wavy-walled cells of the outer spermoderm surface, apparently with some attached sections of the pericarp fiber layer, are shown in Fig. 5a. A higher magnification of a section of the outer epiderm of the spermoderm is shown in Fig. 5b. This layer is found to harbor conidia and hyphae, which is not surprising considering its large surface, fine texture, and probably high moisture-retention capacity.

A cross-section through the achene (without hulls) shows at low magnification (Fig. 6) the spermoderm; the embryo with its two cotyledons, folded to form a double curve; and the starchy endosperm. The cotyledon cells are much smaller than the cells in the starchy endosperm.

A cross-section through the spermoderm, the aleurone layer, and the subaleurone starchy endosperm is shown in Fig. 7. The section through the spermoderm shows the outer epiderm of longitudinally elongated wavy cells, the spongy parenchyma, and the inner epiderm. The starch granules in the endosperm are round or polygonal and fill the endosperm cells. The structure of the aleurone layer (including the aleurone cell wall and aleurone grains) and subaleurone endosperm is shown in Fig. 8, a and b. The surface of the endosperm cell wall enclosing the starch granules can be seen in Fig. 8a. The aleurone grains are embedded in a matrix; the grains are much smaller than the starch granules. Fig. 8b shows the outer and inner surfaces of the walls of two adjacent aleurone cells. The multi-layered aleurone cell wall is apparently finely textured on the inside and has a relatively smooth outside surface. The previous sites of the small aleurone grains contrast clearly with the large starch granules. The starch granules in the center of the endosperm (Fig. 9a) fill the contents of cells surrounded by relatively thin cell walls. Higher magnifications of the center of the endosperm (Fig. 9b) indicate that the starch granules are not free but surrounded by a matrix, presumably proteinaceous, which strengthens structural unity of the cell contents.

Studies by scanning electron microscopy confirm chemical analyses and examination by light microscopy, which indicated that composition and gross structure of the dehulled buckwheat resembles that of naked cereal grains. Similarly, the site of fungal growth in buckwheat, as in oats (7), is between the hull and surface of dehulled grain. On the other hand, the structure of the hulls; the site, shape, and size of the germ in the kernel; and details of the structure of the starchy endosperm in buckwheat and cereals are dissimilar.

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[Received June 16, 1971. Accepted September 1, 1971]