NOTE

The Effect of Commercial Processing on Some Chemical and Physical Properties of Oat Groats[1]

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ABSTRACT

Oat groats with protein contents of 16.2, 16.4, and 20.0% (N × 6.25 dry basis) from the oat genotypes Ogle, IL75-5860, and X4020-4-1, respectively, were sampled at various steps in commercial processing. The samples were: original cleaned groats, groats after drying at 121° C, and flakes produced by steaming at 100° C and rolling. Each sample was tested for gross composition, electrophoretic pattern, and cell-structure modification. Larger differences in gross composition were found among varieties than within samples at various stages of processing. Electrophoretic patterns of the avenin fractions, obtained by polyacrylamide gel electrophoresis, were identical for each sample of a given variety but different for each variety. Endosperm changes were noted after processing, especially heating, by scanning electron microscopy. It was concluded that commercial processing does not affect the avenin electrophoretic pattern even though small differences in gross composition (protein, ash, oil, and carbohydrates) and changes in microscopic appearance were found.

The major use of oats is as animal feed; up to 95% of the oats produced in the United States is used in this way. The remaining 5% is used in human consumption and thus constitutes both food and industrial usage. All oats utilized as human food are commercially processed. The effect of each processing step on the gross composition of the groats, on the possible protein damage as assessed by avenin electrophoregrams, and on cell structures as noted by scanning electron microscopy were studied.

MATERIALS AND METHODS

Chemicals and Reagents

Acrylamide, *N,N'*-methylene-bis-acrylamide, ascorbic acid, Coomassie brilliant blue R-250, methyl green, and trichloroacetic acid were from Sigma Chemical Company, St. Louis, MO; lactic acid (USP grade) and ferrous sulfate heptahydrate (AR grade) were from Mallinckrodt Chemicals, St. Louis, MO. Hydrogen peroxide (3% practical grade) was purchased in small plastic bottles from a local pharmacy. Water was purified by passage, in series, through a membrane filter, a charcoal filter, and two mixed-bed ion-exchange filters. Aluminum lactate was from K & K Laboratories, Plainview, NY.

Oat Samples

Duplicate samples of three oat genotypes, the Illinois cultivar Ogle, Wisconsin selection X4020-4-1, and Illinois selection IL75-5860, each sampled at various stages of processing, were obtained from Marvin Lenz of Quaker Oats Company and Robert Forsberg, University of Wisconsin. Seeds of the three genotypes, chosen to represent a range in protein and oil contents and to examine commercial and experimental types were produced in 1983 at Madison, Wisconsin.

Avenin Extracts for Electrophoresis

Oat samples were ground and extracted as described previously (Lookhart 1985).

Polyacrylamide Gel Electrophoresis (PAGE)

A Hoefer SE600 (18 cm × 16 cm × 3 mm) vertical slab gel electrophoresis apparatus was used with acrylamide concentration (7.5%), temperature (20° C), electrophoresis voltage (500 V), and time (2 hr) chosen to optimize separation and minimize time (Lookhart 1985, Tkachuk and Mellish 1980). The gel recipe was a combination of those reported by Lookhart (1985) and Khan et al (1984); 100 ml of gel solution (1 gel) required the following chemicals, 0.25 g of aluminum lactate, 0.024 g of ascorbic acid, 0.38 g of bis-acrylamide, 7.50 g of acrylamide, 0.2 mg of ferrous sulfate heptahydrate, lactic acid to pH 3.1, water to make 100 ml, and 100 μl of 3% hydrogen peroxide.

Commercial Processing

Each oat selection was segregated from harvest through processing. Samples of each genotype were taken after each of three stages of processing—dehulling to give "original groats," drying to yield "dried groats," and steaming and rolling to produce "oat flakes." Photographs of the oat cultivar, Ogle, and the three processing samples are shown in Figure 1.

Analytical Procedures

Moisture, protein, and ash contents were determined by AACC methods 44-15A, 46-11, and 08-01, respectively (AACC 1976). Crude fat (oil) was extracted with a Soxhlet using petroleum ether, and carbohydrates were determined by difference.

Scanning Electron Microscopy (SEM)

Four samples of each genotype at each stage of processing were split longitudinally and in cross sections (at the upper, middle, and bottom part) with dull razor blades and mounted on specimen holders (stubs) that were spread with colloidal graphite adhesive. The specimens were evaporatively thin coated with a series of elements: carbon, aluminum, carbon, and gold-palladium alloy (60/40). The coated samples were viewed on an ETEC autoscan at 10 kV, and photographs were taken with Polaroid PN 55 film after several locations on a given specimen showed consistent structures.

RESULTS AND DISCUSSION

The general procedure used in commercial processing of oats and pictures of the oat cultivar Ogle at each stage of processing are shown in Figure 1. Physical modification to the particles is indicated by the relative size and shape of each particle. Several broken and otherwise modified kernels are seen in the original groats, and even more modified kernels are seen in the dried groat fraction. The browning of the oat flakes is probably caused by the Maillard reaction and from heating.

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Samples of all three genotypes at each stage of processing were analyzed for gross composition (Table I). The results in Table I are the averages of duplicate analyses and agree with those previously reported by Salisbury and Wichser (1971). The protein contents were 16.3, 16.9, and 20.8% (N × 6.25, dry basis) for Ogle, IL75-5860, and X4020-4-1, respectively. The experimental sample X4020-4-1 had the highest protein and ash values but lower oil and carbohydrate values than the other two entries. The highest oil content was found for IL75-5860, whereas it had intermediate to low protein, ash, and carbohydrate values. Ogle had the highest carbohydrate content, lowest protein and ash, but intermediate oil levels. The moisture level was highest in the flakes (as expected after steaming) and lowest after drying. The protein ash, oil, and carbohydrate values were similar for each fraction.

PAGE patterns of the avenin extracts of the three fractions from each genotype are shown in Figure 2. Prolamin patterns of Ogle, IL75-5860, and X4020-4-1 are noted as A, B, and C, respectively. The fractions from original groats, dried groats, and flakes are noted by subscripts 1, 2, and 3, respectively. Duplicate samples gave identical patterns (not shown). The electrophoregram of each genotype was unique, as was reported by Lookhart (1985) using a different PAGE procedure on other varieties.

The electrophoretic patterns of the subsets 1, 2, and 3 for each genotype A, B, or C were identical, i.e., processing did not affect the electrophoretic patterns. SEM micrographs were taken at several positions on each of several kernels of each genotype and at each stage of processing. SEM photographs typical of each processing step are shown in Figure 3 for the selection IL75-5860. It shows the result of each processing step at the cellular level. The SEM micrograph of the original groat (Fig. 3A) shows rounded compound starch granules (S) with diameters of 3–15 μm, but individual granula are not seen because the granules were not fractured (Bechtel and Pomeranz 1981). The protein bodies (P) are small (diameter 0.5–2.0 μm) and randomly distributed, and the cell wall (W) appears intact. In the micrograph of the dried groat fraction (Fig. 3B), some starch granules were fractured into individual granula; however, the other components appear similar to those mentioned in the micrograph of the original groat. The micrograph of the oat flakes (Fig. 3C) shows changes not found in other fractions. The cell wall (W) is fragmented and separated from other cell components, the starch granules (S) are more fragmented into individual granula than before, fewer protein bodies (P) are visible, and a complete lack of organization (highly disrupted structure) is seen.

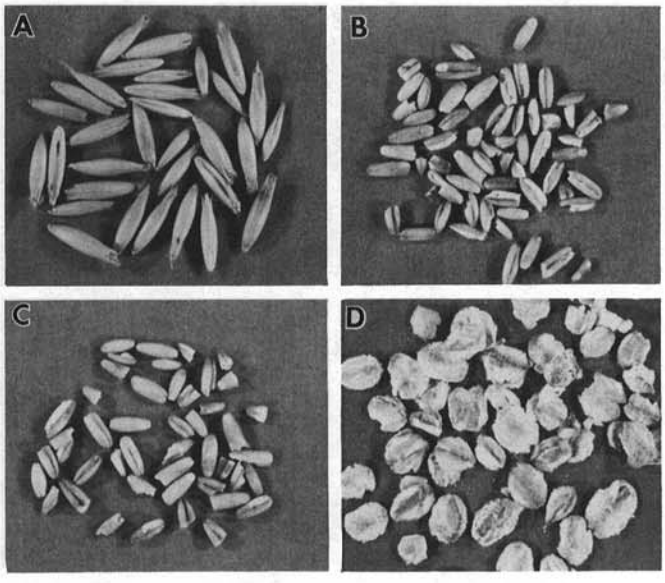

Fig. 1. Photographs of the typical processing stages of the cultivar Ogle: **A,** raw oats; **B,** dehulled and aspirated, original groats; **C,** groats, dried at 121° C; and **D,** oat flakes, steamed at 100° C and rolled.

The results of these studies show that commercial processing does affect endosperm structure, even at the first drying step and much more after steaming and rolling, but that the avenins are not affected in any way that changes their electrophoretic pattern. Commercial processing does not preclude identification of the genotype from which oat flakes were made. Since the avenin PAGE pattern was conserved, inter- and intra-avenin bands must be stable. The gross composition data are in agreement with these findings in that the protein, moisture, ash, and carbohydrate levels were similar for a given selection at each stage of processing.

TABLE I
Gross Composition of Oat Samples

Variety and Product	% Composition				
	Moisture[a]	Protein[b]	Ash[b]	Oil[b]	Carbohydrate[c]
Ogle					
Original groats	9.6	16.2	2.2	6.2	75.4
Dried groats	8.7	16.3	2.2	6.3	75.2
Flakes	12.8	16.3	2.2	6.4	75.1
IL75-5860					
Original groats	9.4	16.5	2.3	8.1	73.1
Dried groats	8.8	16.9	2.2	8.3	72.6
Flakes	13.2	16.0	2.2	7.2	74.6
X4020-4-1					
Original groats	9.2	19.1	2.4	4.8	73.7
Dried groats	8.6	20.8	3.0	5.2	71.0
Flakes	12.3	19.7	2.4	5.1	72.8

[a] Moisture as received.
[b] Dry basis; protein determined as N × 6.25.
[c] Carbohydrates by difference, dry basis.

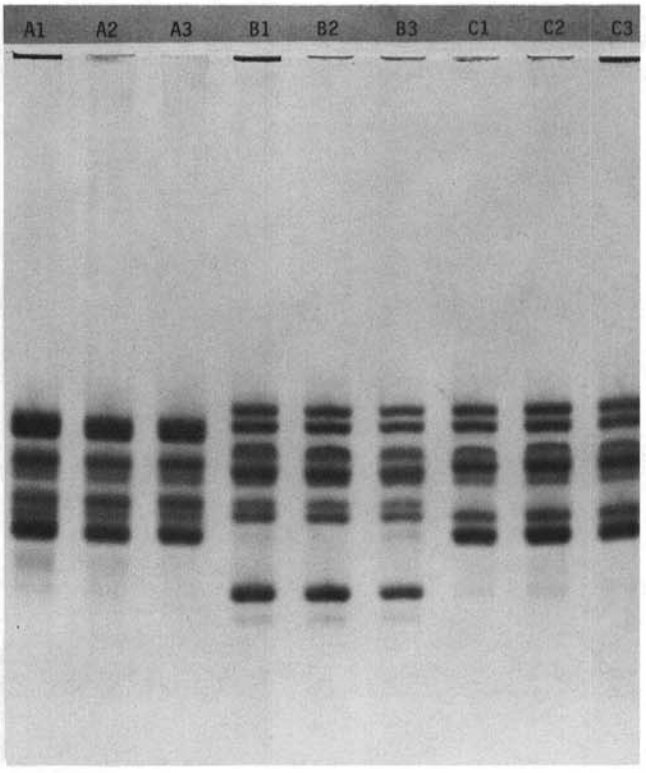

Fig. 2. Polyacrylamide gel electrophoresis patterns of avenins extracted from oat genotypes Ogle (**A**), IL75-5860 (**B**), and X4020-4-1 (**C**), each sampled at different stages of commercial processing; original groats (**1**), dried groats (**2**), and oat flakes (**3**).

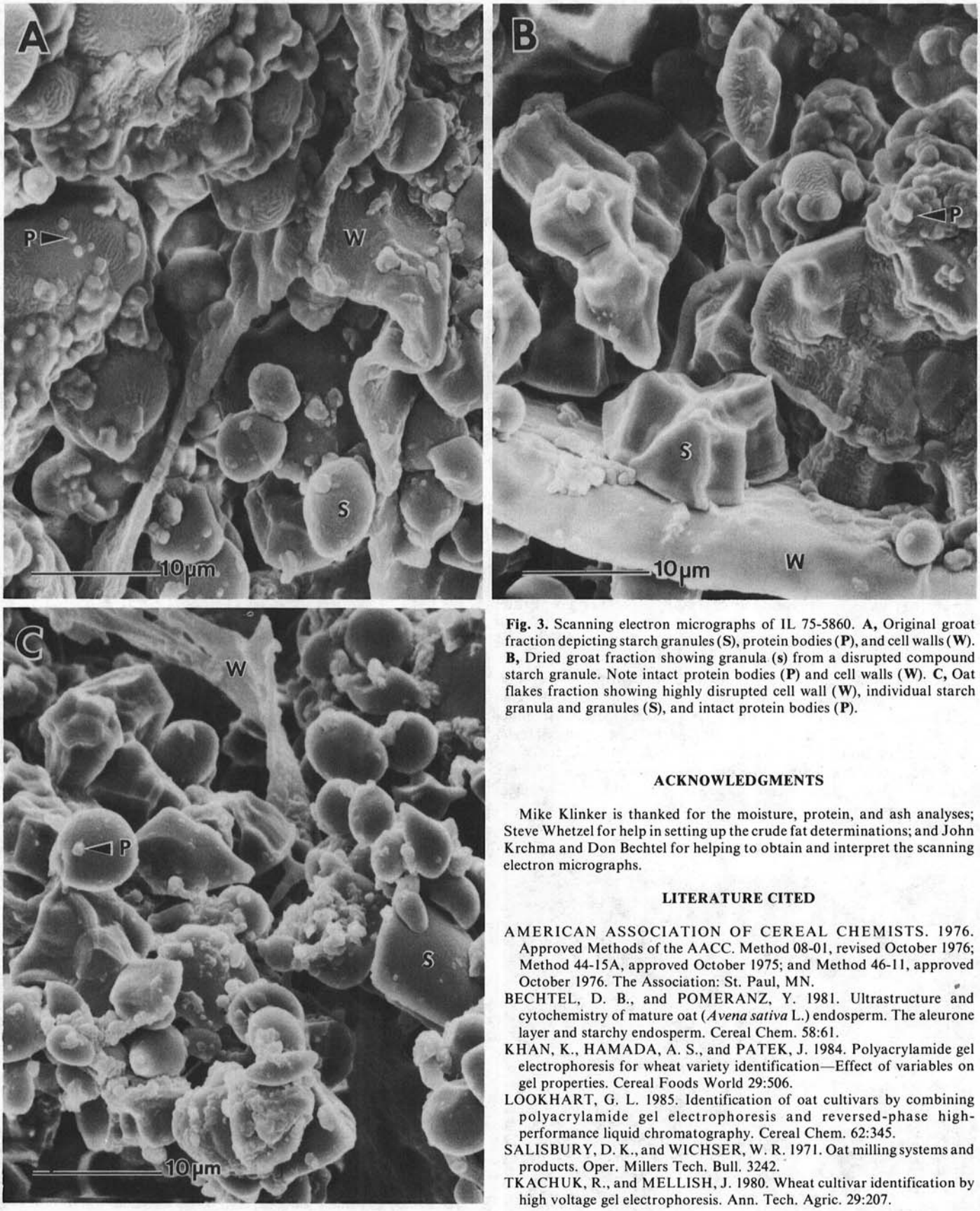

Fig. 3. Scanning electron micrographs of IL 75-5860. **A,** Original groat fraction depicting starch granules (**S**), protein bodies (**P**), and cell walls (**W**). **B,** Dried groat fraction showing granula (**s**) from a disrupted compound starch granule. Note intact protein bodies (**P**) and cell walls (**W**). **C,** Oat flakes fraction showing highly disrupted cell wall (**W**), individual starch granula and granules (**S**), and intact protein bodies (**P**).

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