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

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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.

MATERIALS AND METHODS

Chemicals and Reagents

Polyacrylamide, 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.

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 autocan 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.
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 Wicher (1971). The protein contents were 16.3, 16.9, and 20.8% (N x 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 avenins 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 electrophoretogram of each genotype was unique, as was reported by Lookhart (1985) using a different PAGE procedure on other varieties.

The electrophoretic patterns of the subgroups 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 (Becchi 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. 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.

### Table I

<table>
<thead>
<tr>
<th>Variety and Product</th>
<th>Moisture*</th>
<th>Protein*</th>
<th>Ash*</th>
<th>Oil*</th>
<th>Carbohydrate*</th>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td>6.2</td>
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<td>6.3</td>
<td>75.2</td>
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<td>Flakes</td>
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<td>2.2</td>
<td>6.4</td>
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<td>IL75-5860</td>
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<td>8.1</td>
<td>73.1</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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<td>19.0</td>
<td>2.4</td>
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<td>72.8</td>
</tr>
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</table>

* Moisture as received.
* Dry basis; protein determined as N x 6.25.
* Carbohydrates by difference, dry basis.

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**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.

**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 H. 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).

ACKNOWLEDGMENTS

Mike Klinker is thanked for the moisture, protein, and ash analyses; Steve Whetzel for help in setting up the crude fat determinations; and John Krchma and Don Bechtel for helping to obtain and interpret the scanning electron micrographs.

LITERATURE CITED


[Received December 5, 1985. Revision received February 14, 1986. Accepted February 19, 1986.]