A NOTE ON THE CHARACTERIZATION OF CRYOMILLED WHEAT FLOUR BY SCANNING ELECTRON MICROSCOPY[1]

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Research on low-temperature milling or cryomilling of grains and other agricultural products was initiated by two of the authors (Fan and Kobayashi), to learn if it is possible to develop: 1) a special-purpose milling or food-production process capable of accelerating the extraction and transformation of major ingredients of foodstuffs such as starch and protein, or capable of decelerating thermal deactivation of trace nutrients such as vitamins; and 2) a general-purpose, high-capacity milling process. Freezing tends to induce brittleness in materials such as wheat grains and other agricultural products; brittleness in turn makes the products susceptible to fracture. Also, large-scale but hitherto unexploited attainment of "coldness" is much commoner than generally believed. Examples of available large-scale "coldness" are: evaporation of liquefied nitrogen, liquefied air, and liquefied propane; and sublimation of Dry Ice in many industrial processes.

A key to that long-range process development is to characterize the products from the process. This study constitutes a small but essential part of such an effort.

MATERIALS AND METHODS

Kansas hard winter wheat harvested in 1974 was used. Cryomilled flour samples were prepared first by precooling the wheat (11.4% moisture, 1.73% ash, and 12.7% protein) to −20° C in a deep freezer; the wheat was then passed through a turbo-type grinder (Nippon Sanso, K. K.) operated at a temperature range between −30° and −50° C and a rotor speed range between 3000 and 5000 rpm.

The same wheat sample was also test-milled through a Buhler pneumatic laboratory mill. The particle sizes of the bran and shorts obtained were further reduced by passing them through a mini-impact mill (Hosokawa Iron Work, AP-B type, operated at 11,000 rpm), 2 and 1 times, respectively, at room temperature. The ground brans and shorts were blended back to the Buhler-test-milled flour to use as a control.

Flour samples were mounted on aluminum stubs, coated with gold-palladium alloy, viewed, and photographed in an ETEC autoscan scanning electron microscope (SEM) at an accelerating voltage of 20 kV.

RESULTS AND DISCUSSION

Observations under SEM revealed that particle sizes of the cryomilled flour obtained at a temperature of −50° C and a milling speed of 3000 rpm (Fig. 1) were

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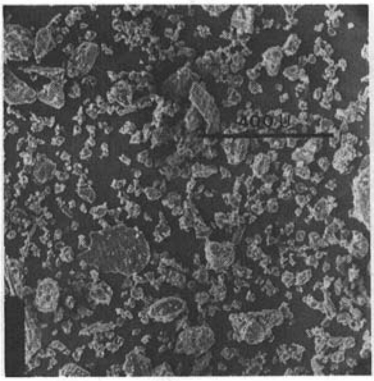

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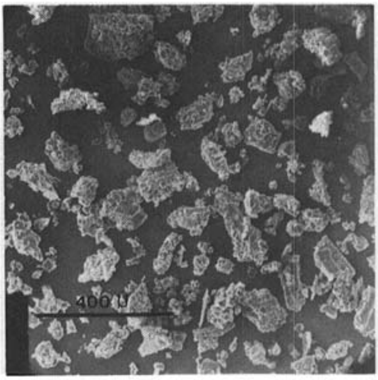

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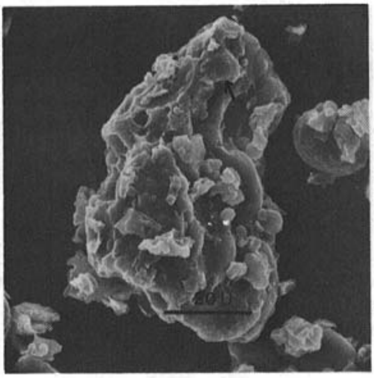

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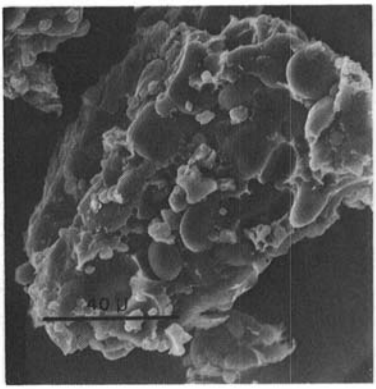

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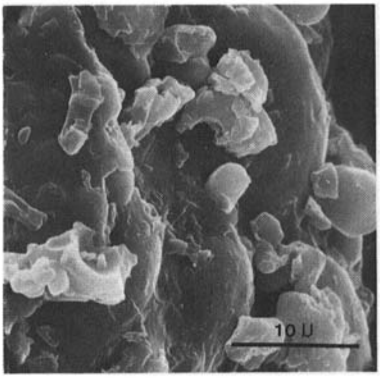

Fig. 1. SEM of the hard winter wheat flour milled at −50° C and 3000 rpm. Fig. 2 SEM of the Buhler-test milled hard winter wheat flour. Fig. 3. SEM of the hard winter wheat flour milled at −50° C and 3000 rpm. Arrow depicts fractured starch. Fig. 4. SEM of the Buhler-test-milled hard winter wheat flour. Fig. 5. SEM of the hard winter wheat flour milled at −50° C and 3000 rpm showing the starch fracture pattern.

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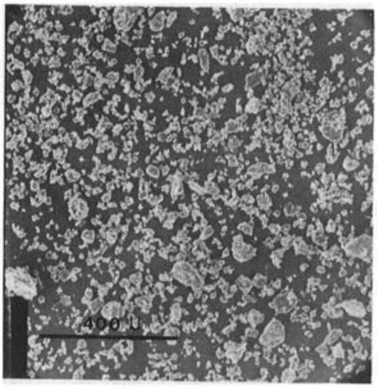

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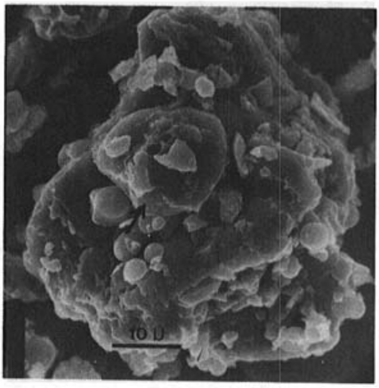

Fig. 6. SEM of the hard winter wheat flour produced by immersing the sample into liquid nitrogen, and by milling at −80°C and 5000 rpm. Fig. 7. SEM of the hard winter wheat flour prepared by the same method as that of Fig. 6. Arrow depicts fractured starch.

substantially smaller than those of the Buhler-test-milled control flour (Fig. 2). A close observation of the cryomilled flour particles revealed that, although their size had been greatly reduced, the integrity of the protein-starch matrix essentially remained intact, as shown in Fig. 3.

A major concern in flour particle-size reduction is the degree of starch damage. For baking, there exists a critical level to which flour starch could be damaged. Damaged starch is known to affect dough rheology and gas retention ability (1); on the other hand, if wheat is milled to produce substrates for fermentation, a high degree of starch damage might be desirable, because damaged starch is more susceptible to enzyme attack than undamaged starch. Figures 3 and 4 indicate that the small flour particles obtained from cryomilling contained more damaged starch than did the large particles of the control; hence, they might be suitable as substrates for fermentation.

The higher degree of starch damage observed in cryomilled than in noncryomilled flour may be related to its fracture pattern. In their study of soft and hard wheat structures, Hoseney and Seib (2) obtained micrographs of roller-milled flour that exhibited smooth fracture across starch granules. The chipping and crumbling of starch observed in the cryomilled flour (Fig. 5) were very different from those fractures observed by them.

Figures 6 and 7 are micrographs of the wheat flour sample produced by immersing the sample into liquid nitrogen and subsequently milling it at −80°C and 5000 rpm. Comparing Figs. 6 and 7 with Figs. 1 and 3 tends to support the expectation that a smaller particle size and a somewhat higher degree of starch damage might result from a higher milling speed and a lower temperature.

CONCLUSION

Results of this study suggest that cryomilling yields a unique fracture pattern and some degree of starch damage to wheat grains. Therefore, this technique appears to be suitable as a special-purpose milling technique in which a higher degree of starch damage is desirable.

Acknowledgments

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