A NOTE ON THE EFFECT OF STEEPING TIME ON WET-MILLING HIGH-AMYLOSE CORN CONTAINING 57-PERCENT-AMYLOSE STARCH[1]

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A recent paper by the authors reported that high-amylose corn exhibited a considerably greater volume increase during steeping than did ordinary corn (2). Kernels of high-amylose corn with starch containing 57% amylose increased 128% over their original dry volume, as compared with a 63% increase in volume during steeping of ordinary corn. In a commercial run on the same high-amylose corn, it was observed that swelling took place in a relatively short period of time. It was thought that steeping might be completed at this time, i.e., when the high-amylose corn kernels swelled to the same degree as the ordinary corn. This consideration prompted a short study on a laboratory scale to determine the effect of steeping time on the processing of high-amylose corn with starch containing 57% amylose.

Fifteen hundred-gram batches of corn were steeped in distilled water containing 0.25% sulfur dioxide at 125°F. (52°C.) for the required period of time. At the completion of steeping, the water was drained and the grain was ground in a Quaker City[2] drug mill. Germs were recovered by flotation, and the remaining fibrous material was again ground in the drug mill. To remove coarse fibers, the resulting slurry was screened on a 0.039-in. perforated copper sieve. It was then rescreened on a 200-mesh stainless-steel sieve to remove fine fibers. The germ and fiber fractions were washed to remove starch. The final slurry, the mill starch, was tabled twice to separate the starch from the gluten.

Protein (N × 6.25) in the various fractions was determined by an improved Kjeldahl method for nitrate-free samples (1). Starch content was determined polarimetrically by the procedure of Earle and Milner (4). Fat analysis was carried out according to the official method of analysis of the AOAC (3). Moisture was determined by drying the samples for 4 hours at 110°C. under a vacuum of 28 in. of mercury.

The chemical composition (on a moisture-free basis) of the corn used was:

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[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

	%
Protein	13.9
Crude fat	7.1
Starch	60.9
Solubles	8.6

TABLE I

RECOVERY AND ANALYTICAL DATA FROM THE WET-MILLING OF HIGH-AMYLOSE CORN

FRACTION AND ANALYSIS MADE	STEEPING TIME, HOURS			
	16	24	36	48
Steepwater				
Yield[a] of solids, % MFB[b]	2.3	2.8	3.2	3.6
Protein content, % MFB	22.8	26.8	27.6	31.0
Steeped corn				
Average final moisture, %	51	51	51	52
Volume increase, %	126	124	131	128
Germ				
Yield, % MFB	7.6	7.3	7.6	6.5
Crude fat content, % MFB	49.4	48.7	46.3	56.0
Recovery of total oil, %	51.0	50.0	49.8	51.0
Coarse fiber				
Yield, % MFB	12.1	9.3	9.8	12.6
Protein content, % MFB	11.8	11.1	10.9	10.4
Starch content, % MFB	14.9	11.2	12.9	12.4
Fine fiber				
Yield, % MFB	5.9	7.0	7.7	4.9
Protein content, % MFB	23.7	21.2	18.9	21.1
Starch content, % MFB	29.1	24.5	25.6	30.1
Starch				
Yield, % MFB	41.0	41.5	42.0	43.5
Recovery, % of total starch	67.3	68.2	69.0	71.4
Protein content, % MFB	0.7	0.7	0.8	0.7
Gluten				
Yield, % MFB	16.7	19.1	16.6	15.5
Protein content, % MFB	33.0	30.6	25.6	33.1
Starch content, % MFB	56.4	55.6	56.0	52.3
Squeegee starch[c]				
Yield, % MFB	5.4	3.3	6.3	4.9
Protein content, % MFB	12.3	7.9	15.6	5.0
Starch content, % MFB	82.6	88.2	71.5	94.4
Process waters				
Yield of solids, % MFB	7.1	6.7	6.5	6.9
Protein content, % MFB	34.6	36.3	30.0	44.5

[a] Yield based on original weight of dry corn.
[b] Moisture-free basis.
[c] Squeegee starch is result of second tabling.

The corn was steeped for 16, 24, 36, and 48 hours and then processed under the described conditions. The recovery and analytical data are given in Table I.

Several differences were noted during the processing of the high-amylose corn steeped for the four time periods. The amount of solubles removed from the corn in 16 hours was about 36% less than that removed during the full steeping period of 48 hours; there was a

2.3% yield of solids at 16 hours, as compared to 3.6% at 48 hours. Similarly, the protein content of the steepwater solids was considerably less when the corn was steeped only 16 hours; 22.8% compared to 31% when the steeping time was 48 hours.

Water absorption by the corn during steeping was the same for all tests, and increase in volume of the corn after steeping was also the same for the four different steeping times.

Germ separation was slightly better when the corn was steeped for 48 hours. The recovered germ was freer of fiber and had a higher oil content, 56%, as compared to about 49% for the 16-hour steep. This increase is probably due to the more complete removal of solubles in the 48-hour steeping. The recovery of total oil was about the same, but less germ was needed to yield the oil when the 48-hour steep was used. No particular difficulties were encountered during separation of fibers from the mill starch.

The yield of starch from corn that was steeped for 48 hours was materially higher than that from corn steeped for shorter periods; i.e., 43.5%, as compared to 41.0, 41.5, and 42.0%, respectively, for 16, 24, and 36 hours. With the protein content of the recovered starch about the same in all experiments, this increase would be important to the wet-miller. There were no significant differences observed in processing gluten, squeegee starch, and process-water fractions. Of note is the protein content of the process-water solids, which was about 10% higher for the 48-hour run than it was in the 16-hour test.

This study indicates that this high-amylose corn is not completely steeped after 16 hours, even though it has absorbed its optimum moisture and has experienced a considerable increase in volume. A 48-hour steeping period is required to obtain complete removal of solubles and a maximum yield of starch. However, shorter steeping could be used in certain cases where, for economic reasons, the small loss in solubles and starch could be taken in lieu of increasing steeping capacity of existing facilities. Also, the utilization of countercurrent steeping as carried out by the corn refining industry should permit a shorter steeping time, but this operation should be shown on an industrial scale when sufficient high-amylose corn is available.

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