Chemical Dehulling of Dent Corn[1]

C. W. BLESSIN, W. L. DEATHERAGE, and G. E. INGLETT, Northern Regional Research Laboratory, USDA, Peoria, Illinois

ABSTRACT

A process has been developed that rapidly dissolves the pericarp (hull or bran) of dent corn with alkali and leaves the endosperm, aleurone layer, and germ intact. Various times (2, 4, and 6 min.), temperatures (140°, 160°, and 180°F.), and concentrations (10, 15, and 20% w./w.) were investigated with aqueous solutions of sodium hydroxide to determine its effectiveness as a dehulling agent. Three dent corns (Bear C-14, Bear X-800, and a commercial sample of U.S. No. 2 yellow) were used in this study. In general, a 15% solution of sodium hydroxide at 160°F. essentially dissolved the pericarp in 3 to 4 min. when agitation was adequate. Residual alkali was neutralized with acetic acid. Average yield of the dehulled corn from this treatment was 93%. Microscopic observation showed that the major portion of the aleurone layer was not removed under these conditions. Alkali dehulling had little measurable effect on ash, ether extract, or protein content. Fiber and total niacin levels were reduced to 50% of their original value.

A number of procedures have been proposed for dehulling or peeling cereal grains, including corn, with various chemicals. Pomeranz (1) reviewed treatment of

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grains with sulfate ions, cellulose derivatives, gums, surface-active agents, fat solvents, and strong acid and alkalis. Morgan et al. (2,3) obtained yields of approximately 85 to 90% when wheat was dehulled with 25% sodium hydroxide at 180°F. for 3 min. However, Subba Rao et al. (4) reported a 35% loss in weight when corn was boiled in 10% sodium hydroxide for a period of 4 min. The data indicate that a considerable quantity of the germ and endosperm was removed by the alkali. In contrast, our procedure, when used with proper time, temperature, and alkali conditions, rapidly dissolves the pericarp and leaves the endosperm, aleurone layer, and germ intact. The dehulled product is similar to ordinary corn in appearance, taste, and hardness.

MATERIALS AND METHODS

Materials

Three yellow dent corn samples were used in this investigation. Bear C-14 and Bear X-800 were grown in the vicinity of Decatur, Ill. These two samples of corn were dried at air temperatures not exceeding 140°F. The third sample, of unknown origin and identity, came from a local elevator and was graded No. 2 yellow. Drying and handling conditions used with this commercial sample are not known.

Methods

Various combinations of alkali concentrations (10, 15, and 20%, w./w., aqueous solutions of sodium hydroxide), times (2, 3, 4, and 6 min.), and temperatures (140°, 160°, and 180°F.) were investigated in this work.

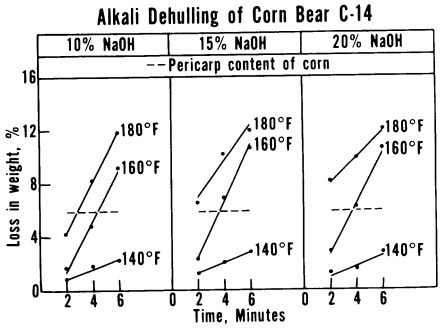
Exploratory studies were conducted with 25-g. samples of sound whole kernels tempered with water at 140°F. for 3 to 4 min. The corn was drained, treated with 50 ml. of aqueous alkali solution for the indicated times and temperatures, and washed immediately with 140°F. water to prevent further action of the alkali. Residual alkali was neutralized by submerging each sample in 50 ml. of 5% glacial acetic acid (v./v.) for 5 min. at 140°F. After rinsing with 140°F. water, the product was drained and air-dried. The corn was stirred continuously during the alkali-treating, neutralizing, and rinsing operations.

Larger samples were prepared similarly. A 1,000-g. sample was tempered at 140°F. for 5 min., drained, and heated with an alkali solution under various conditions. The dehulled corn was drained and washed six to eight times with 140°F. water. Residual alkali in the drained and washed product was neutralized with 2,000 ml. of 5% glacial acetic acid at 140°F. during a 5-min. period. The neutralized product was washed four to six times with 140°F. water. The sample was drained and dried at 113°F. in a rotating dryer to approximately 12% moisture.

The extent of removal or retention of the pericarp and aleurone layer was determined by microscopic examination of kernels stained for 1 to 3 min. with a solution of iodine and potassium iodide. Total niacin, ash, fiber, ether extract, and protein were determined by standard AOAC methods.

RESULTS AND DISCUSSION

Effects of temperature, concentration, and contact time of the various alkali solutions on the amount of material removed from the corn are shown in Figs. 1, 2, and 3. Pericarp content of Bear C-14, Bear X-800, and No. 2 yellow determined by



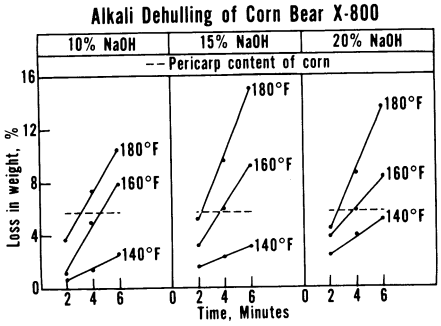


Fig. 1 (left). Effect of time, temperature, and alkali concentration on dehulling of Bear C-14 corn.

Fig. 2 (right). Effect of time, temperature, and alkali concentration on dehulling of Bear X-800 corn.

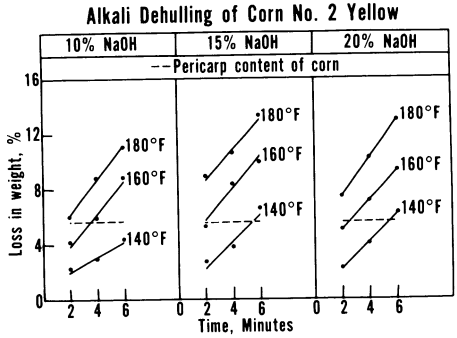


Fig. 3. Effect of time, temperature, and alkali concentration on dehulling of No. 2 yellow corn.

hand-dissection was 5.9, 5.7, and 5.6%, respectively. A loss in weight equivalent to the amount of pericarp in the sample (indicated by the dashed line in the figures) was used as a preliminary guide to select the most satisfactory conditions for dehulling. Alkali dehulling was temperature-dependent. When temperatures were increased from 140° to 160°F., and then to 180°F., larger quantities of material were removed at any specific time or alkali concentration. The slope of the 140°F. line was usually less than that of either the 160° or 180°F. line. This effect was more pronounced with Bear C-14 than with the other two corns. A temperature of 140°F. was not suitable, under the conditions studied, for any of the three corn samples, since the amount of material removed from the kernels was usually less than the weight represented by the pericarp. Apparently a certain temperature was necessary for rapid wetting or penetration of the pericarp. An increase in alkali concentration from 10 to 15% usually was beneficial. However, an increase in concentration from 15 to 20% was not advantageous. On the basis of data obtained with these three corns, the most suitable temperature and alkali concentration for the removal of the pericarp appeared to be 160°F. and 15%, respectively. An

TABLE I. ALKALI DEHULLING OF CORN: COMPARISON OF SAMPLE SIZE

Corn Sample	Time	Loss in Weight[a]		Corn Sample	Time	Loss in Weight[a]	
		Sample, 25 g.	Sample, 1,000 g.			Sample, 25 g.	Sample, 1,000 g.
	min.	%	%		min.	%	%
Bear C-14	2	2.6	5.0	No. 2 Yellow	2	5.7	4.4
	4	6.7	8.1		3	6.9	6.3
	6	10.9	11.3		4	8.1	8.1
					6	10.4	11.9
Bear X-800	2	3.1	3.5				
	4	6.1	7.5				
	6	9.1	11.6				

[a]With 15% NaOH at 160°F.

increase in time, regardless of temperature or alkali concentration, resulted in removal of larger quantities of material.

Larger samples (1,000 g.) were prepared at various time intervals with a 15% sodium hydroxide solution at 160°F. Data obtained with 1,000- and 25-g. samples prepared under the same conditions are compared in Table I. Slightly higher values for some of the 1,000-g. samples are probably due to losses of fines or broken material in the rotary dryer.

Visual inspection of the samples indicated that removal of the pericarp with alkali is essentially due to a solution or dissolving action rather than loosening and then removing by mechanical action. Removal of a portion of the pericarp from the kernel is more noticeable with varieties, such as Bear X-800, which contain a highly pigmented pericarp. Examination under a microscope of alkali-treated whole kernels stained with iodine and potassium iodide provided a means for estimating more quantitatively the degree of removal of pericarp and aleurone layer. Under the conditions of this test the pericarp either does not stain or stains brown; the aleurone layer, yellow; and the endosperm, blue.

Some differences in behavior with respect to alkali dehulling were noted for the three corns (Table II). Treatment of Bear C-14 for 2 min. with 15% NaOH at 160°F. was not effective in removing the pericarp, since 80% of the kernels retained one-half or more of the original quantity of pericarp. Of course, none of the aleurone layer was removed by this treatment. During an intermediate time period, 4 min., the pericarp was almost completely removed, and yet the dehulled sample retained approximately 100% of the aleurone layer. A 6-min. treatment removed both pericarp and aleurone layer.

Data obtained with Bear X-800 and No. 2 yellow were not so clear-cut as with Bear C-14. Treatment of Bear X-800 for 2 min. removed some of the pericarp but none of the aleurone layer; whereas with No. 2 yellow this same treatment removed appreciable quantities of both the pericarp and aleurone layer. A 6-min. treatment removed most of the pericarp and aleurone layer from the kernels of both samples. Of the time intervals examined, 4 min. was selected for Bear X-800 and 3 min. for No. 2 yellow because these time periods removed most of the pericarp and left

TABLE II. REMOVAL OF PERICARP AND ALEURONE LAYER FROM CORN

Corn Sample[a]	Time	Quantity of Pericarp and Aleurone Layer Remaining after Alkali Treatment									
		Less Than One-Fourth		One-Fourth		One-Half		Three-Fourths		More Than Three-Fourths	
		P[b]	A[b]	P	A	P	A	P	A	P	A
	min.										
Bear C-14	2	10[c]		10		10		15		55	100
	4	90		5		5					100
	6	100	95		5						
Bear X-800	2	15		5		10		55		15	100
	4	70	55	25	25	5	15		5		
	6	100	100								
No. 2 yellow	2	55	20	25	20	10	15	5	5	5	40
	3	95	25	5	35		5		25		10
	4	100	60		30		5		5		
	6	100	75		20		5				

[a]15% NaOH at 160°F.

[b]P, pericarp; A, aleurone layer.

[c]Percentage of total kernels with specified quantity of pericarp and aleurone layer remaining after alkali treatment.

appreciable quantities of the aleurone layer with the endosperm. An average yield of 93% of dehulled material was obtained under these conditions.

Data on the effect of alkali dehulling on composition were obtained with No. 2 yellow corn processed for 2, 3, 4, and 6 min. with 15% alkali at 160°F. (Table III). As previously discussed, a 3-min. processing was considered most satisfactory for this corn. Processing under these conditions had little measurable effect on ash, ether extract, or protein content. Fiber content was reduced from 2.3% in the unprocessed corn to approximately 1% in the 3-min. sample. Further processing did not reduce fiber content. Another effect of alkali dehulling is a reduction in total niacin content. Niacin values reported in Table III represent total niacin (free plus bound), since the AOAC method used for this determination involves hydrolysis.

TABLE III. COMPOSITION OF ALKALI-DEHULLED CORN[a]
(Moisture-free basis)

Time min.	Total Niacin γ/g.	Ash %	Fiber %	Ether Extract %	Protein %
Unprocessed	27.6	1.2	2.3	4.1	9.3
2	14.2	1.3	1.4	3.6	9.7
3	11.4	1.4	1.1	4.1	9.3
4	8.1	1.3	1.0	3.7	9.4
6	4.9	1.3	1.1	3.4	9.1

[a]No. 2 yellow, 15% NaOH, 160°F.

Processing of this particular sample of corn for 3 min. reduced total niacin level to approximately 50% (11.4 γ per g.) of its former value (27.6 γ per g.).

Two areas of research require further investigation. Stress cracks in the endosperm were evident in many of the dry alkali-dehulled kernels. Some of the stress cracks existed in the unprocessed corn, especially the commercial No. 2 yellow. Future studies on alkali dehulling will examine the effect of tempering, washing, and drying temperatures on stress-crack formation. The procedure described here does not remove the tip cap or the highly pigmented hilar layer. The response of alkali-dehulled corn to wet- and dry-milling and the distribution of the tip cap and hilar layer in dry-milled fractions are now under investigation.

Acknowledgment

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