Effect of Alkali Dehulling on Composition and Wet-Milling Characteristics of Sorghum Grain[1]

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ABSTRACT

Three sorghum grains (RS-626, TE-77, and a commercial sample of U.S. No. 2 yellow) were selected to determine the effectiveness of aqueous solutions of sodium hydroxide (NaOH) as dehulling agents. Various times (2, 4, 6, and 8 min.); temperatures (140°, 160°, and 180°F.); and concentrations (15, 20, and 25% w./w.) were investigated. A 20% solution of NaOH at 160°F. essentially removed the pericarp in 4 to 8 min. and left the endosperm and germ intact. The treated grain was washed, neutralized with acetic acid, and washed again. Microscopic inspection of stained kernels showed that the major portion of the aleurone layer was not removed with this treatment. Under these conditions, average yield of dehulled sorghum grain was 92%. Ash, ether extract, and protein levels were not significantly affected by alkali dehulling. Fiber contents of the dehulled products were approximately 50% of the level of the whole grain. When dehulled grain was wet-milled, there was a loss of 5 to 8 percentage points in starch recovery. However, protein content of the starch was about the same as in starch recovered from whole grain. Color of starch from dehulled grain appeared whiter. More and cleaner germ with higher oil content was recovered from dehulled grain. From an overall processing standpoint, 6 min. was an optimum dehulling time with 20% NaOH at 160°F.

Varieties of sorghum grain differ greatly in color, ranging from white, to red, to dark brown, depending on the type of phenolic pigments in the pericarp (1). In addition, colorless pigment precursors termed leucoanthocyanins or anthocyanogens are located in the pericarp of certain varieties (2,3). Anthocyanogens are converted into colored substances in acid solutions. During wet-milling, water-soluble pigments and pigment precursors may be absorbed by starch (4). Since some pigments are not removed by washing, bleaching is often necessary to produce a satisfactory white starch. Removal of undesirable pigments before wet-milling should therefore improve starch quality. In this paper we describe some effects of alkali dehulling on the composition and wet-milling characteristics of sorghum grain.

MATERIALS AND METHODS

Materials

Three sorghum-grain samples were selected. RS-626 and TE-77 were grown under comparable conditions in the same field at the Texas Agricultural Experiment Station, South Plains Research and Extension Center, at Lubbock. These two samples were dried at air temperatures not exceeding 140°F. The third sample, of unknown origin and identity, came from the Amarillo Grain Exchange and was

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graded No. 2 yellow. Drying and handling conditions for this commercial sample are not known.

Methods

Various combinations were investigated of time (2, 4, 6, and 8 min.); temperature (140°, 160°, and 180°F.); and alkali concentration (15, 20, and 25% w./w. aqueous solutions of sodium hydroxide (NaOH)). Exploratory 25-g. samples and larger 1,000-g. samples were dehulled by treating the grain with alkali. The dehulled grain was then washed with water, neutralized with acetic acid, and washed again. Details of the procedure were given previously (5). The extent of removal or retention of the pericarp and aleurone layers was determined microscopically. The kernels were stained for from 1 to 3 min. with a dilute solution of iodine and potassium iodide. The stained kernels were examined with an American Optical binocular dissecting microscope with 10X oculars and 3X objectives. Under the conditions of this test, the pericarp either does not stain or stains brown; the aleurone layer, yellow; and the endosperm, blue. Ash, fiber, ether extract, and protein were determined by standard AOAC methods (6).

Dehulled grain was processed by the laboratory wet-milling procedure described by Anderson (7) to recover starch, oil, and feed products.

RESULTS AND DISCUSSION

The amounts of material removed from the three sorghum samples under various times, temperatures, and alkali concentrations are plotted in Figs. 1, 2, and 3. Respective pericarp contents (by hand dissection) of RS-626, TE-77, and No. 2 yellow were 7.5, 7.8, and 7.8%. Preliminary conditions for dehulling were selected by using as a guide a loss in weight equivalent to the amount of pericarp in the sorghum grain (indicated by the dashed line in the figures).

Alkali dehulling was both time and temperature dependent. An increase in time or temperature, regardless of alkali concentration, resulted in the removal of larger quantities of material. Under the conditions studied in this preliminary examination, dehulling of RS-626 and TE-77 at 140° and 160°F. removed less material from the kernels than the weight represented by the pericarp. However, these temperatures were suitable for dehulling No. 2 yellow. The 180°F. temperature was suitable for dehulling RS-626 and TE-77, but removed material from No. 2 yellow in excess of the weight represented by the pericarp. A temperature of 160°F. appeared most suitable for all three samples. An increase in alkali concentration did not appear to affect the results significantly.

Larger samples (1,000 g.) were dehulled at various time intervals with a 20% NaOH solution at 160°F. In general, data obtained with 25- and 1,000-g. samples dehulled under the same conditions agree fairly well. With the 1,000-g. samples, an 8-min. dehulling time was necessary with RS-626 and TE-77 to remove material equivalent to the weight of the pericarp.

Removal of a portion of the pericarp from the kernel was readily apparent by visual inspection, since the pericarp is highly pigmented compared to the rest of the kernel. More quantitative data on the degree of removal of pericarp and aleurone were acquired by inspecting stained kernels under the microscope. Under the conditions of this test, the best dehulling times appear to be 8 min. for RS-626 and

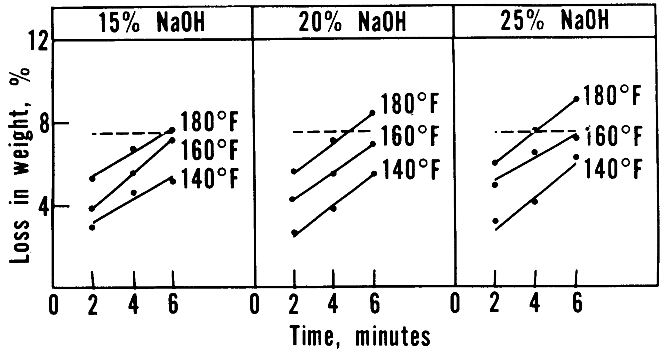

Fig. 1. Alkali dehulling of RS-626 sorghum grain.

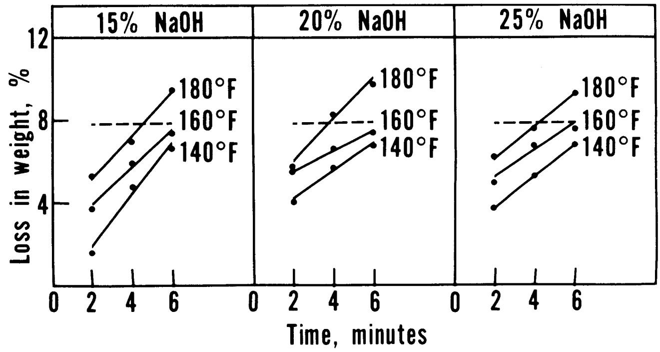

Fig. 2. Alkali dehulling of TE-77 sorghum grain.

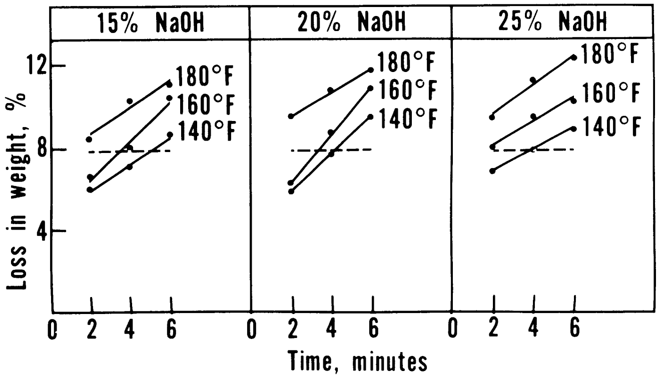

Fig. 3. Alkali dehulling of No. 2 yellow sorghum grain.

TE-77 and 4 min. for No. 2 yellow. During these time periods the pericarp was almost completely removed, whereas the dehulled sample retained the major portion of the aleurone layer. An average yield of 92% of dehulled material resulted at optimum dehulling times.

The same samples were examined to determine the effect of alkali dehulling on composition. Dehulling under these conditions of time, temperature, and alkali concentration had little measurable effect on ash, ether extract, or protein content. At the optimum dehulling conditions described above, fiber content was reduced approximately 40% with RS-626, 60% with TE-77, and 30% with No. 2 yellow (Table I).

TABLE I. FIBER CONTENT OF ALKALI-DEHULLED SORGHUM GRAINS

	Fiber		
Time[a] min.	RS-626 %	TE-77 %	No. 2 Yellow %
Control	2.1	2.8	2.0
2	1.4	1.6	1.6
4	1.6	1.5	1.4
6	1.2	1.5	1.5
8	1.2	1.0	...

[a]20% NaOH at 160°F.

TABLE II. COMPARISON OF STARCH AND GERM FRACTIONS RECOVERED FROM WHOLE- AND ALKALI-DEHULLED NO. 2 YELLOW SORGHUM GRAIN (moisture-free basis)

	Whole	Dehulled		
Fraction	Grain %	2 min. %	4 min. %	6 min. %
Starch				
Recovery[a]	81	73	74	76
Yield	63	57	58	60
Protein	0.38	0.45	0.45	0.46
Germ				
Oil in germ	33.8	50.3	51.9	50.5
Oil recovery[b]	45	65	65	58

[a]Based on starch present in whole grain.

[b]Based on oil present in whole grain.

The effect of alkali dehulling on wet-milling characteristics was examined only with No. 2 yellow and its alkali-dehulled products. Table II compares yields and product characteristics of the starch and germ fractions from milled, dehulled grain with those from whole grain. There was a loss in starch recovery as a result of dehulling, the loss ranging from 5 to 8 percentage points. Color of the starch from the dehulled grain appeared to be whiter than starch from whole grain. This improvement might be expected, as the pigmented layer was essentially removed by the alkali treatment. Protein content of the starch remained about the same for all tests. Even though quantities of fiber were less from dehulled samples, starch was more difficult to wash from these fractions than from the same whole-grain fractions. This difficulty resulted in starch loss. More efficient mechanical mixing and separation in commercial milling might overcome this problem. The process waters recovered from milling of the dehulled samples contained considerable free solids, most of which was starch. Loss of starch was also mentioned by Freeman and Watson (4) in their study on water peeling of grain sorghum.

Both the recovery of germ and its oil content were considerably improved as a result of alkali dehulling. Germ recovered from the dehulled grain was quite free of hull and very clean. Recovery of oil from the dehulled-grain samples was 13 to 20 percentage points higher than recovery of oil from milled whole grain. Oil content of germ from the dehulled samples was about 50% higher when compared to germ from whole grain.

Improved starch color and higher oil recovery are the major benefits resulting from wet-milling alkali-dehulled sorghum grain. Lower starch recovery may offset these benefits. From an overall processing standpoint, an optimum period of dehulling would be 6 min.

Acknowledgments

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