Corn Dry-Milling: Pretempering Low-Moisture Corn[1]

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ABSTRACT

As determined by Beall degermination tests, the dry-milling characteristics of naturally dried yellow dent hybrid corn (about 14% moisture and under) were improved by pretempering. A pretemper step to increase the moisture content of the corn made the conventional temper more effective, largely through a reduction in number of stress cracks formed during subsequent tempering. Pretemper times of 3 to 91 hr. and pretemper moisture levels of 14 to 20% were tried. All tempering was at room temperature. Pretempering to a moisture level of 15–17% was optimal, and a pretemper time of about 20 hr. was preferred. However, a pretemper time of 8–10 hr. gave good results, and the yield of flaking grits was increased moderately with only a 3- to 4-hr. pretemper. Pretempered corn produced more flaking grits, better degermination, and a higher yield of total grits than corn having only the conventional temper. A pretemper plus a second temper also proved quite satisfactory. When screens with small perforations (14/64-in.) were used, the degerminator throughput was reduced by 30% or more on pretempered corn. With large perforations (18/64-in.) the reduction was slight, and product yields and oil contents also changed less. Pretempering was moderately effective on the artificially dried corn used.

Use of a pretemper in tempering naturally dried low-moisture corn was shown previously to improve the degermination of such corn in the dry-milling process (1). Further tests have now been made to determine the optimal moisture level and rest time in the pretemper step. The merit of adding a pretemper to improve the response of artificially dried corn to degermination was also investigated.

MATERIALS AND METHODS

Corn

Several lots of yellow dent hybrid corn were used. Most of the work was done with one lot, No. 33, about 13 to 19 months after it had been harvested. This corn had been grown on a Peoria area farm in 1962. For fertilization, 400–475 lb. per acre of ammonium sulfate was plowed under and 165 lb. per acre of mixed fertilizer (65 lb. of potash and 100 lb. of ammonium sulfate) was applied when the seed was planted. The corn was field- and crib-dried and shelled at a moisture content of about 14%. Another lot of corn, No. 42, presumably from the 1965 crop and not artificially dried, was used about 12 months after harvest for some additional tests on the effect of pretemper time. No other information was available on history of this corn.

Three lots of artificially dried corn were used. One, No. 32, was similar in general characteristics to No. 33. These two were of the same variety and crop year and were grown on the same farm. Lot 32 was

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TABLE I
CORN CHARACTERISTICS

CORN LOT NO.	CROP YEAR	VARIETY	CHEMICAL ANALYSIS, D.B.				WT. PER 1,000 K.	SIEVE ANALYSIS[a]				HARDNESS CLASSIFICATION	GERMINATION	ARTIFICIALLY DRIED
			Oil	Protein	Ash, 600°C.	Crude Fiber		On 24/64-in.	On 21/64-in.	On 20/64-in.	On 17/64-in.			
			%	%	%	%	g.	%	%	%	%		%	
32	1962	P.A.G. 444	4.8	9.2	1.4	1.8	.....	7	56	70	97	Soft	10	Yes
33	1962	P.A.G. 444	4.7	9.9	1.5	1.9	.....	5	46	61	99	Average	64	No
42	1965	?	4.3	9.9	1.4	2.0	346	9	54	68	97	Average	40	No
225R	1964	Pfister SX-29	4.7	8.5	1.3	2.6	318	1	28	46	93	Average	1	Yes
230	1964	Pfister SX-29	4.7	8.5	1.3	2.6	316	1	27	45	93	Average	8	Yes

[a] Sieves had round-hole perforations.

TABLE II
SUMMARY OF TEMPERING CONDITIONS

VARIABLE STUDIED	PRETEMPER CONDITIONS		FIRST-TEMPER CONDITIONS		SECOND-TEMPER CONDITIONS		CORN LOT AND INITIAL MOISTURE CONTENT	EXPERIMENTAL RESULTS RECORDED IN TABLE NO.
	Moisture Content	Time	Moisture Content	Time	Moisture Content	Time		
	%	*hr.*	%	*hr.*	%	*min.*	%	
A. Pretemper moisture level:								
Series 1	14.5–18.5	17	21	2±	3[a]	20±	No. 33; 12.7–13.1	III
Series 2	15.0–20.4	40–42	none	none	3–4	30±	No. 33; 12.4–13.4	IV
B. Pretemper time:								
Series 1	15.4	3–91	21	2±	3[a]	20±	No. 33; 12.6–12.9	V
Series 2	15.2	4–88	21	2±	3[a]	20±	No. 42; 12.2–12.7	VI
C. Pretempering artificially dried corn	15.5±	10 or 17	21	2½ ±	none	none	Nos. 32, 225R, 230; 11.7–12.0	VII

[a] Approximate.

dried from 18.0 to 14.3% moisture content in a commercial-size batch dryer with 166°–148°F. air temperature (burner on 14 sec., off 3 sec.) during a 40-min. heating cycle followed by a 20-min. cooling cycle. Lots 225R and 230 were dried from approximately 25 to 15% moisture content by the Dryeration process (2). Lot 225R was dried in two stages with an air temperature of 290°F. For No. 230, the air temperature was 290°F for the first heating stage and 190°F. for the second.

Each lot of corn was cleaned in a grain cleaner to remove foreign material and both undersized and very large kernels. Samples from three of the lots tested U. S. Grade No. 1. Lot 42 graded No. 2 and lot 225R was Sample Grade, both being downgraded because of the percentage of damaged kernels. Additional data on each lot are given in Table I.

Processing Equipment

A 16-bu.-capacity, rotating, double-cone grain blender fitted with spray nozzles was used for mixing corn with water and for holding the wetted corn for specified rest periods in the pretemper[2] and first-temper steps. Second-temper water was added as a spray in two screw conveyors that transferred the grain to the degerminator supply hopper. The corn was milled in a No. 0 Beall degerminator fitted with a "blunt" studded rotor driven by a 15-h.p. motor at 840 r.p.m. and three screens having 14/64-in. round-hole perforations (r.h.p.). For one series of tests on pretemper time, screens with 18/64-in. r.h.p. were used.

Experimental Conditions and Procedures

Pretemper moisture levels of 14–20% and pretemper times of 3–91 hr. were tried. When a first-temper step was used, the corn was brought to a moisture content of 21% and held for 2 to 3 hr. For the second-temper step, about 3% moisture was added and the corn was held for about 20 min. All tempering was conducted at room temperature.

Specific combinations of tempering conditions used for the various groups of tests are outlined in Table II.

For the degermination step, the Beall rotor was operated at 840 r.p.m. in a 50% closed position. The motor input approximated 13.2 kw. or 17.7 h.p. for all tests except one pair made on artificially dried corn at 8.8 kw. Screens having 14/64-in. r.h.p. were used for all tests except in one series on effect of pretemper time when the screens had 18/64-in. r.h.p. The tail gate (a V-notched slide) (3) was adjusted to give approximately 2% of recycle stock based on gross, air-dried product. This level was set for all tests, except those on artificially dried corn when a 5% recycle was preferred since no second temper was used.

The combined degerminator product streams (throughs and tailings) were sampled, air-dried, and fractionated by a laboratory procedure em-

[2] Strictly speaking, a pretemper is the first temper, because moisture is being added for the first time. However, pretempering is the term used by industrial operators because in mill operation pretempering is usually done before the corn is washed. Pretempering is used infrequently.

In this paper, a long holding period (3–91 hr.) was used for the pretemper, an intermediate period (2–2½ hr.) for the first temper, and about 20 min. for the second temper. When all three of these tempers were used, they were employed in the order named. Also, the combination consisting of the first and second tempers is referred to later in this paper as a "conventional temper."

ploying screening, aspiration, and flotation. Grits of various sizes, plus degerminator fines, germ, and hull fractions were recovered quantitatively by this procedure. The various fractions were analyzed for their oil contents, usually by the Butt extraction method with petroleum ether. Additional details of the pilot-plant installation, fractionation procedure, and analytical methods have been described earlier (4–6).

RESULTS AND DISCUSSION

Effect of Pretemper Moisture Level

For corn given both a first and second temper before degermination, Table III gives degerminator throughput plus product yields and characteristics as the pretemper moisture level was varied from 14.5 to 18.5%. For all pretemper levels tried, the throughput at constant power input decreased

TABLE III

EFFECT OF PRETEMPER MOISTURE LEVEL WHEN FIRST AND SECOND TEMPERS WERE USED

ITEM	MOISTURE ADDED FOR PRETEMPER					
	0%	1.8%	2.8%	3.8%	4.8%	5.8%
M.c. of pretempered corn, %	12.7	14.5	15.5	16.5	17.5	18.5
Degerminator throughput, bu./hr.[a]	42	24	23	25	26	26
Yields, % n.p.[b]						
—3½+25 Grits	63	67	65	67	66	66
—3½+4 Grits	2	5	7	6	4	5
—4+6 Grits	30	48	46	42	38	39
—6+8 Grits	23	10	8	14	18	16
—8+16 Grits	6	2	2	3	4	3
—16+25 Grits	2	1	1	2	2	1
—25+Pan fines	11	11	13	11	11	11
Germ fraction	20	16	16	16	18	17
Hull fraction	6	6	6	6	5	6
Oil contents, % d.b.						
—3½+25 Grits	0.8	0.5	0.5	0.5	0.5	0.5
—3½+4 Grits	1.1	0.3	0.5	0.4	0.6	0.4
—4+6 Grits	0.7	0.3	0.4	0.3	0.3	0.3
—6+8 Grits	0.7	0.5	0.6	0.7	0.6	0.6
—8+16 Grits	0.9	1.1	0.9	0.9	0.9	0.9
—16+25 Grits	1.8	1.9	1.9	2.2	2.2	2.1
—25+Pan fines	5.1	6.8	6.6	6.4	6.5	6.4
Germ fraction	17.0	21.1	20.1	20.2	19.8	20.1
Hull fraction	2.0	2.6	2.4	2.7	2.0	2.0
—4+6 Grits with attached hulls, %	<1	<1	<1	<1	3	<1
Recoverable oil, lb./net bu.[c]	1.3	1.4	1.4	1.4	1.4	1.4
Yields, lb./bu.						
—4+6 Grits	16.7	27.2	26.0	23.3	21.2	22.1
—3½+25 Grits	35.3	37.4	36.5	37.4	37.0	36.8
—25+Pan fines	6.2	6.4	7.1	5.9	6.2	6.2
—3½+25 Germ	11.1	8.7	9.2	9.2	9.8	9.5
—3½+25 Hull	3.4	3.5	3.2	3.5	3.0	3.5
No. of tests averaged	5	1	2	1	1	1

[a] Corrected to 15% moisture content (m.c.), 13.2 kw. motor input, 2% recycle level.

[b] Percent of net product; i.e., gross product less +3½-mesh recycle fraction.

[c] Calculated yield based on weight of germ fraction recovered by flotation and its moisture and oil content; and assuming oil cake contains 5% residual oil on dry basis.

TABLE IV

EFFECT OF PRETEMPER MOISTURE LEVEL WHEN SECOND TEMPER ONLY WAS USED

ITEM	MOISTURE ADDED FOR PRETEMPER				
	0[a]	2.6%	4.2%	5.5%	7.5%
M.c. of pretempered corn, %	12.7	15.0	16.6	18.8	20.4
M.c. of second-temper corn, %	23.4	18.5	19.6	22.3	24.7
Degerminator throughput, bu./hr.[b]	42	17	20	24	22
Yields, % n.p.					
—3½+25 Grits	63	66	65	66	65
—3½+4 Grits	2	4	4	5	3
—4+6 Grits	30	46	43	44	42
—6+8 Grits	23	12	14	14	17
—8+16 Grits	6	2	2	2	3
—16+25 Grits	2	1	1	1	1
—25+Pan fines	11	15	14	12	11
Germ fraction	20	14	16	17	18
Hull fraction	6	6	6	6	6
Oil contents, % d.b.					
—3½+25 Grits	0.8	0.5	0.5	0.5	0.5
—3½+4 Grits	1.1	0.3	0.3	0.4	0.4
—4+6 Grits	0.7	0.4	0.4	0.4	0.4
—6+8 Grits	0.7	0.7	0.5	0.6	0.6
—8+16 Grits	0.9	1.1	1.1	1.0	0.8
—16+25 Grits	1.8	3.0	2.8	2.2	2.0
—25+Pan fines	5.1	8.2	7.3	6.7	5.2
Germ fraction	17.0	20.1	19.4	20.0	19.5
Hull fraction	2.0	3.6	3.6	2.4	2.0
—4+6 Grits with attached hulls, %	<1	<1	2	<1	1
Recoverable oil, lb./net bu.	1.3	1.2	1.3	1.4	1.4
Yields, lb./bu.					
—4+6 Grits	16.7	25.9	24.1	24.4	23.4
—3½+25 Grits	35.3	36.7	36.4	36.7	36.5
—25+Pan fines	6.2	8.2	7.6	6.7	6.2
—3½+25 Germ	11.1	8.0	8.9	9.5	9.9
—3½+25 Hull	3.4	3.1	3.1	3.1	3.4
No. of tests averaged	5	1	1	1	1

[a] Comparative series made with first and second temper. Same data as column 1, Table III.
[b] Corrected to 15% moisture content (m.c.), 13.2 kw. motor input, 2% recycle level.

about 40%—from 42 to about 25 bu./hr. Yield of –3½+25 (mesh) grits increased 3 percentage points, from 63 to an average of 66%, and their oil content decreased from 0.8 to 0.5% when a pretemper was used. Within this particle size range, oil content of the larger grits (i.e., –3½+4, –4+6, and –6+8) fell and that for the –16+25 grits rose. The increase in yield and reduction in oil content for the –3½+4 and –4+6 grits were particularly significant. Pretempering also (a) increased the oil content of the –25+pan fines, (b) lowered the yield and increased the oil content of the germ fraction, and (c) improved the yield of recoverable oil.

The only differences noted as the pretemper level was varied were in yields of the –4+6 and –6+8 grits. They followed the usual pattern of one increasing at the expense of the other. Best yield of –4+6 grits came at the two lower pretemper levels.

For the series made with a pretemper (to moisture levels of 15.0 to 20.4%) followed by only a second temper, the pretemper again proved effective. Pretempering decreased degerminator throughput by some 40 to 60%, the least reduction being at the higher pretemper levels, i.e., 18.8 and 20.4% (Table IV). As the pretemper level was increased in successive steps starting at 15.0%, the following changes also occurred progressively: (a) Yields of the −4+6 and −6+8 grits varied inversely, but the degree of change was appreciably less than for the series made with both a first and second temper; (b) yields of −25+pan fines decreased and that of the germ fraction increased, the sum of the two remaining fairly constant, 29 to 30%; and (c) oil contents of −16+25 grits, −25+pan fines, and hull fraction decreased.

For these tests, a maximum or near maximum amount of moisture, based on the corn's ability to retain surface moisture, was added in the second-temper step. The degree of hull removal was quite good for all tests. Even with the corn pretempered to only 15.0%, the second temper proved adequate for a good polish.

In the tests described so far, when the first and second tempers were used, a pretemper level of 14.5 or 15.5% proved entirely satisfactory. Corn will pick up 2 to 4% moisture in the washing step and thus moisture addition at this point would be sufficient for a pretemper when corn with 12–13% moisture is being milled. Holding the washed corn would be one way of incorporating a pretemper step into the milling process.

When only a pretemper and a second temper were used, choice of the pretemper level depended in part upon the weight given to such factors as yield of −3½+6 grits and of oil, degerminator throughput, and dryer capacity. Unless maximum oil yield was required, a pretemper of 15.0 to 16.6% appeared adequate, according to data given in Table IV; yield of large grits was maximum. In addition, the drying load was smaller because total moisture content of the tempered corn was 18–20% rather than 24%.

In one test made with the corn pretempered to 16.6% and neither a first nor second temper, the results were, with one major exception, much like those for 16.6% pretempered corn given a second temper; however, hull removal was poor. Hull yield dropped to 2%; attached hull count rose sharply to 98%; and yield of −3½+25 grits increased to 69% because of the additional adhering hull. Oil content of −3½+25 grits was slightly higher, 0.6%, and calculated yield of recoverable oil remained unchanged at 1.3 lb./net bu. If good hull removal in the degermination step is not of prime importance, use of only a pretemper would be satisfactory.

There was evidence of microbial activity occurring at the 18.8 and 20.4% pretemper levels during the 40- to 42-hr. holding time, because the degerminator streams had a slight "sour" smell. A lower pretemper level and a shorter holding time will minimize the microbial activity and will also be quite adequate to improve the milling characteristics of the corn.

Effect of Pretemper Time

As pretemper time was extended from 3 to 91 hr. for corn pretempered to 15.5%, followed by first and second tempers, changes occurred in de-

TABLE V

EFFECT OF PRETEMPER TIME (14/64-IN. DEGERMINATOR SCREENS)

ITEM	PRETEMPER TIME					
	0[a]	3 Hours	9 Hours	18 Hours	43 Hours	91 Hours
Degerminator throughput, bu./hr.[b]	42	37	30	23	23	24
Yields, % n.p.						
—3½+25 Grits	63	65	66	65	64	66
—3½+4 Grits	2	4	6	7	7	6
—4+6 Grits	30	40	43	46	45	47
—6+8 Grits	23	16	12	8	8	9
—8+16 Grits	6	3	3	2	3	3
—16+25 Grits	2	2	2	1	2	2
—25+Pan fines	11	11	12	13	13	13
Germ fraction	20	19	17	17	17	16
Hull fraction	6	5	6	6	6	6
Oil contents, % d.b.						
—3½+25 Grits	0.8	0.7	0.6	0.5	0.5	0.4
—3½+4 Grits	1.1	1.1	0.8	0.5	0.4	0.5
—4+6 Grits	0.7	0.7	0.4	0.4	0.4	0.3
—6+8 Grits	0.7	0.6	0.6	0.6	0.7	0.5
—8+16 Grits	0.9	1.0	1.0	0.9	0.9	0.8
—16+25 Grits	1.8	1.5	1.8	1.9	1.7	1.8
—25+Pan fines	5.1	5.9	6.6	6.6	6.6	6.5
Germ fraction	17.0	18.6	19.7	20.1	19.3	22.0
Hull fraction	2.0	2.3	1.9	2.4	2.5	2.0
—4+6 Grits with attached hulls, %	<1	1	<1	<1	<1	<1
Recoverable oil, lb./net bu.	1.3	1.4	1.3	1.4	1.3	1.4
Yields, lb./bu.						
—4+6 Grits	16.7	22.7	23.9	26.0	25.3	26.1
—3½+25 Grits	35.3	36.6	36.7	36.5	36.0	37.0
—25+Pan fines	6.2	6.0	6.8	7.1	7.1	7.0
—3½+25 Germ	11.1	10.5	9.3	9.2	9.5	8.7
—3½+25 Hull	3.4	2.9	3.2	3.2	3.4	3.3
No. of tests averaged	5	1	1	2	1	1

[a] Comparative series made with first and second temper. Same data as column 1, Table III.
[b] Corrected to 15% moisture content (m.c.), 13.2 kw. motor input, 2% recycle level.

germinator throughput and in yields and oil contents of the various fractions. Rather large changes were noted during the first 10 hr., but only minor changes after 20 hr. (Table V). For the test made with a 9-hr. pretemper, the degerminator throughput was reduced by about 30%, yield of –4+6 grits increased by more than 40%, and their oil content dropped from 0.7 to 0.4%. Yield of –6+8 grits fell off about 50% and their oil content was lowered from 0.7 to 0.6%. For this series, pretemper time had a definite influence on oil content of the –3½+25 grits. Without a pretemper, the oil content was 0.8%. It fell off progressively with increased pretemper times, reaching 0.5% in about 18 hr. or less.

Yields and oil contents of the –25+pan fines and the germ fractions changed slightly with pretemper time. Most of the change occurred during the first 10 hr., but only oil content of the –25+pan fines increased significantly. Yield of recoverable oil and oil content of the hull fraction were

not affected by pretemper time. The attached hull count was acceptable in this test series.

Several tests were made with the same tail-gate setting as used on corn not given a pretemper. With this larger tail-gate opening, the recycle level rose to 7–9% and the gross degerminator remained fairly constant for the series. However, after a 9-hr. pretemper, the corrected throughput fell off approximately 30%, as it did with the smaller tail-gate openings, and remained at this level (27–31 bu. per hr.) when the pretemper time was extended to 91 hr. Yields of the various grits, germ, and hull fractions approximated those recorded in the series with the variable tail-gate opening. With the larger tail-gate opening, however, both degermination and hull removal suffered. Oil content of the –3½+25 grits was higher, ranging between 0.6 and 0.7%. Oil content of the –4+6 grits was slightly higher, 0.6%, and did not change over the 9- to 91-hr. pretemper. Because less abrasion occurred within the degerminator, the attached hull count was higher, 2 to 3.5%, and yield of the germ fraction decreased. In spite of less germ being recovered, the calculated yield of recoverable oil was significantly higher for the 43- and 91-hr. pretempers than for corn having only the conventional temper.

The tests with a variable tail-gate opening were repeated to learn if extending the pretemper time to 80–90 hr. does, in fact, lower oil content of the grits, particularly the –4+6 fraction. Two changes were made for this series; namely, another lot of corn was milled and the degerminator screens had 18/64-in. rather than 14/64-in. r.h.p. In this series a pretemper gave only a small reduction in degerminator throughput and a small increase in yield of –3½+16 grits; neither change was significant (Table VI). Yields of –3½ + 4 and –4 + 6 grits again increased appreciably and yield of –6+8 grits definitely fell off, but they were not influenced by the variation in pretemper time. As observed previously with a pretemper, oil contents were lower for the mixture of –3½ + 16 grits and for the intermediate fractions; i.e., –3½+4, –4+6, and –6+8 grits, whereas oil value for the –8+16 grits rose. Most of the change again occurred in the first 10 hr.; however, the 88-hr. values were no lower than those for the 18-hr. pretemper.

Changes in yield and oil content of the –16+pan fines, hull, and germ fractions were not sufficient to be meaningful. Pretemper time did not have a significant effect on attached hull count, and in spite of a second temper being used, the count rose to unacceptable levels. With the 14/64-in. r.h.p. used in the earlier series, the yield of throughs stock ranged between 50 and 70% and averaged about 60% of the combined throughs and tailings stock. The average climbed to 81% for the 18/64-in. r.h.p. series and, with the consequent reduction in attrition, the attached hull count climbed considerably because grits were not abraded sufficiently.

Use of a pretemper had a pronounced effect on development of stress cracks in the tempered corn. Without a pretemper, stress cracks appeared in approximately three-fourths of the kernels. With a pretemper of 10 hr. or more, the level dropped to about one-fourth. Conditions that lead to

TABLE VI

EFFECT OF PRETEMPER TIME (18/64-IN. DEGERMINATOR SCREENS)[a]

ITEM	PRETEMPER TIME				
	0	4 Hours	10 Hours	18 Hours	88 Hours
Degerminator throughput, bu./hr.[b]	42	41	39	40	41
Kernels without stress cracks, %[c]	27	57	70	76	76
Yields, % n.p.					
—3½+16 Grits	57	59	59	59	60
—3½+4 Grits	3	5	6	7	7
—4+6 Grits	32	40	39	39	39
—6+8 Grits	17	10	10	10	10
—8+16 Grits	6	4	4	4	4
—16+Pan fines	17	18	17	18	18
Germ fraction	19	18	18	16	16
Hull fraction	7	6	6	7	6
Oil contents, % d.b.[d]					
—3½+16 Grits	1.0	0.7	0.8	0.7	0.7
—3½+4 Grits	1.2	0.7	0.8	0.7	0.7
—4+6 Grits	1.1	0.6	0.7	0.6	0.6
—6+8 Grits	0.9	0.6	0.8	0.8	0.8
—8+16 Grits	0.9	1.0	1.0	1.0	1.1
—16+Pan fines	4.2	5.2	5.2	5.4	5.5
Germ fraction	16.0	16.6	17.3	18.3	18.7
Hull fraction	1.7	2.0	1.5	2.2	2.1
—4+6 Grits with attached hulls, %	6	11	10	11	6
Recoverable oil, lb./net bu.	1.2	1.2	1.2	1.1	1.2
Yields, lb./bu.					
—4+6 Grits	17.7	22.2	21.7	21.7	21.8
—3½+16 Grits	32.0	32.8	32.8	33.2	33.6
—16+Pan fines	9.3	9.8	9.6	10.2	10.2
—3½+16 Germ	10.9	10.1	10.3	8.8	8.7
—3½+16 Hull	3.8	3.3	3.3	3.8	3.5
No. of tests averaged	1	1	1	1	1

[a] Lot 42 corn used.
[b] Corrected to 15% moisture content (m.c.), 13.2 kw. motor input, 2% recycle level.
[c] Tempered corn to degerminator. Before tempering, 92% of kernels were free of stress cracks.
[d] Oil content for germ determined by Butt extraction; all others by gas-liquid chromatography method (see ref. 7).

formation of stress cracks in tempered corn and the effect of stress cracks upon yield of large grits, their oil content, and degerminator throughput have been reported previously (8).

Pretempering Artificially Dried Corn

Pretempering such corn was beneficial, but not to the degree noted for naturally dried corn. Use of a pretemper lowered degerminator throughput approximately 15% (14/64-in. r.h.p. were again used); yield of –4+6 grits was increased appreciably, from 18 to 26%; and their oil content lowered from 0.6 to 0.5%—an insignificant difference (Table VII). Again, pretempering lowered the oil content of the larger grits and increased it for the smaller grits and the –25+pan fines. There was no effect on oil content or yield of –3½+25 grits. Attached hull count for –4+6 grits was

TABLE VII

EFFECT OF PRETEMPERING ARTIFICIALLY DRIED CORN

PRETEMPER USED	YES	NO	PRETEMPER USED	YES	NO
Degerminator throughput, bu./hr.[a]	24	28	Oil contents, % d.b. (cont.)		
Kernels without stress cracks, %[b]	45	36	—3½+25 Grits (cont.)		
Yields, % n.p.			—6+8 Grits	0.6	0.6
—3½+25 Grits	63	62	—8+16 Grits	0.9	0.8
—3½+4 Grits	2	1	—16+25 Grits	2.4	2.0
—4+6 Grits	26	18	—25+Pan fines	4.6	3.5
—6+8 Grits	23	28	Germ fraction	20.6	19.9
—8+16 Grits	9	12	Hull fraction	2.3	1.8
—16+25 Grits	3	3	—4+6 Grits with attached hulls, %	36	16
—25+Pan fines	14	14			
Germ fraction	15	16	Recoverable oil, lb./net bu.	1.3	1.3
Hull fraction	8	8	Yields, lb./bu.		
Oil contents, % d.b.			—4+6 Grits	14.4	9.8
—3½+25 Grits	0.7	0.7	—3½+25 Grits	35.2	34.8
—3½+4 Grits	0.5	0.8	—25+Pan fines	7.9	8.0
—4+6 Grits	0.5	0.6	—3½+25 Germ	8.4	8.8
			—3½+25 Hull	4.5	4.4
			No. of tests averaged	3	3

[a] Corrected to 15% moisture content (m.c.), 5% recycle level. Also adjusted for comparable motor inputs.

[b] Stress crack count made only on two lots of corn dried by Dryeration method.

high because of the second temper being omitted and because of the smaller amount of water added in the first-temper step.

CONCLUSIONS

Dry-milling characteristics of low-moisture corn (about 14% and under), as determined by milling in a Beall degerminator, were improved by use of a pretemper ahead of the conventional temper. A pretempering step increased the moisture content of corn and made the conventional temper more effective, largely because the corn then developed fewer stress cracks during subsequent tempering. For the pretemper step, a moisture level of 15–17% was optimal and a pretemper time of approximately 20 hr. preferred, but many of the benefits were achieved in an 8- to 10-hr. pretemper. Effectiveness of the pretemper was influenced also by diameter of the perforations in degerminator screens. With perforations of 18/64-in., moderate benefits were obtained with only a slight reduction in degerminator throughput. With perforations of 14/64-in., a greater change in product yields and oil contents occurred but at the expense of a 30% or more reduction in throughput.

Use of a pretemper followed by a second temper proved quite satisfactory and would be more practical than use of a pretemper, first-temper, and second-temper combination. The milling response of artificially dried corn was improved by pretempering, but to a lesser degree than for naturally dried corn.

Pretempering proved most beneficial in increasing the yield of –3½+4 and –4+6 grits and decreasing their oil content. With pretemper times of

only 3–4 hr., the yield of these grits sometimes was increased proportionately more than their oil content was reduced.

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