VACUUM-TEMPERING CORN FOR DRY-MILLING[1]

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ABSTRACT

Insufficient tempering capacity in commercial plants frequently hinders dry-milling of corn. The possibility of improved tempering by use of a vacuum was investigated. Laboratory studies showed that 14%-moisture corn, immersed in water and subjected first to 5- to 25-in. Hg vacuum and then to atmospheric pressure for 1 to 5 minutes, increased to 20% moisture compared to 16% for the control sample.

Three pilot-plant runs using a Beall degerminator on 13%-moisture corn, vacuum-tempered to 21% (3% of which was surface moisture) (1 minute at 5-in. vacuum and 9 minutes at atmospheric pressure under water, then 10 minutes' drainage and rest time) were compared with one on corn given a conventional temper for 1 hour. With the 20-minute vacuum-tempered corn, throughput, hull, and oil recovery were reduced, −4+6 grits of lower fat content and fewer attached hulls were obtained in increased yield along with fewer −6+8 grits.

The corn dry miller, when pressed for production, will often shorten the tempering time to increase plant throughout. This procedure causes the corn to fall short of the optimum moisture distribution required to give the largest amount of quality finished goods.

This paper discusses the technique of rapid vacuum-tempering (3) and the milling characteristics of corn so treated. A comparison is made with corn tempered for 1 hour under atmospheric pressure to the same moisture level as the 20-minute-tempered corn subjected to vacuum for 1 minute. A survey of the literature on conditioning wheat for milling includes a description of a similar "outer layer process" wherein the grain is subjected to a vacuum, treated with water, etc., and concurrently returned to normal air pressure (1).

Materials and Methods

Materials. Yellow dent, grade 2, air-dried corn of the 1959 crop, having an initial moisture of 14.1%, was used for laboratory studies. The same corn, air-dried to 12.9–13.1%, was used for the pilot-plant runs.

Processing Methods and Equipment. In the laboratory investigation, 50-g. samples of corn contained in 8-oz. widemouth bottles and

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covered with water were subjected to vacuum in the range of 0–25 in. Hg for 0–4 minutes and then to atmospheric pressure for 0.1–5 minutes. The samples were then towel-dried to remove surface moisture.

For each of the three pilot-plant vacuum tests, 100 lb. of corn were covered with water at approximately 75°F. (23.9°C.) while contained in a 55-gal. steel drum fitted with an airtight lid, subjected to 5-in. Hg vacuum for 1 minute, allowed to soak for 5 minutes, transferred, and degerminated. The total temper time was about 20 minutes. For the one conventional temper test, 280 lb. of corn were elevated into a batch mixer and blended for 5 minutes; then an "as-received" Universal moisture test was taken. Sufficient water was added, during tumbling of the mixer, to obtain a final moisture level of 21%; the corn was tempered for 1 hour and degerminated.

The pilot-plant degermination installation (using a size No. 0 Beall degerminator) has been described by Brekke *et al.* (2).

In the current investigation, the degerminator was equipped with three 16/64-in. round-hole perforated screens, the cone was set at 50% open, and the "blunt" stud rotor was operated at 697 r.p.m. with a motor loaded to 10 h.p.

Corn, after either vacuum or conventional tempering, was placed in the supply hopper and fed at a controlled rate to the degerminator. The tails and throughs product streams were collected in tared containers for a period of 3 minutes.

Analytical Methods—Product Evaluation. For all samples, Brabender moisture determinations were made. Ease of hull and germ removal, as well as brittleness of endosperm, was evaluated visually by hand peeling and breaking.

The pilot-plant samples consisted of 250–700 g. each of the throughs and tails streams (obtained by splitting the total machine throughput on a Boerner sample divider), and samples were subjected to screening, aspiration, and flotation treatments for particle sizing, hull removal, and germ separation following the procedure outlined by Brekke *et al.* (2).

Results and Discussion

The laboratory results of vacuum-tempering, listed in Table I, show that there is no advantage to treating corn at a vacuum greater than 5 in. Hg because the variation in moisture absorption was consistent within 1% for vacuum in the 5- to 25-in. range. Likewise, the time under vacuum (in the 0.5- to 4-minute range) and the time at atmospheric pressure (in the 1- to 5-minute range) did not appreciably

TABLE I
EFFECT OF VARIOUS VACUUM-TIME LEVELS ON CHARACTERISTICS AND MOISTURE ABSORPTION OF CORN[a]
(Laboratory study)

VACUUM	TIME IN WATER		MOISTURE LEVEL	CORN CHARACTERISTICS[b]		
	Vac.	Atmos.		Hull	Germ	Endosperm
in. Hg	*minutes*	*minutes*	%			
	Corn as received		14.1	T	H	B
0	0	5	16.0	T	H	B
5	0.1	0.25	16.1	L	H	B
5	0.5	5	19.4	L	S	S
5[c]	0.5	5	15.2	L	H	B
15	4	1	19.0	L	S	S
15	4	3	20.3	L	S	S
15	4	5	20.0	L	S	S
25	4	1	18.9	L	S	S
25	4	3	19.1	L	S	S
25	4	5	19.3	L	S	S

[a] Typical data from a series of four tests.
[b] T = tight; H = hard; S = soft; L = loose; B = brittle.
[c] Sample oven-dried at 180°F. (82°C.) for 3 hours to 8.1% moisture before treatment.

affect moisture absorption, hull looseness, germ softness, or endosperm brittleness. After 0.1 minute under 5 in. vacuum, plus 0.25 minute at atmospheric pressure, the hull was softened, but the elapsed time was too short for the water to soften the germ or endosperm. Either corn of low initial moisture or corn that has been severely dried (8.1% initial moisture sample) is capable of picking up approximately 7% moisture in one treatment, but neither is still at a sufficiently high level to cause germ or endosperm softening.

Yields of the various-sized grits, germ, and hull fractions for the pilot-plant runs, shown in Table II, were comparable for treated vs.

TABLE II
COMPARATIVE YIELDS OF HULL, GERM, AND GRIT FRACTIONS — PILOT-PLANT RUNS[a]

PARTICLE SIZE[b]	GRIT[c]		GERM[c]		HULL[c]	
	Vacuum	Non-vacuum	Vacuum	Non-vacuum	Vacuum	Non-vacuum
+ 3½	1.5	0.6	0	0	0	0
− 3½+4	6.9	7.8	0	0	0	0
− 4+6	49.9	40.6	1.5	2.8	0.18	0.18
− 6+8	7.5	15.5	4.9	5.2	1.31	2.15
− 8+16	4.1	4.7	1.3	1.2	1.40	1.74
−16+25	3.5	3.0	0.7	0.5	0.79	1.18
−25+50	7.6	5.9	0	0	0	0
−50+Pan	7.7	6.0	0	0	0	0
Total	88.7	84.1	8.4	9.7	3.7	5.3

[a] Values given are averages from three vacuum tests and one nonvacuum test.
[b] Particles pass through and are retained on U.S. sieves as indicated.
[c] As percent of feedstock.

untreated corn, except that the −4+6 grit fraction was approximately 9% higher and the −6+8 fraction 8% lower for vacuum-treated corn and that its recovered germ and hull were 1.3 and 1.6% lower, respectively.

Products from the pilot-plant run showed improved hull release, less attached germ, less oil in the −4+6 grit fraction, and lower potential oil recovery for vacuum-treated corn compared to corn tempered in the conventional manner (Table III).

TABLE III
PHYSICAL CHARACTERISTICS OF VACUUM-TEMPERED VS. NONVACUUM-TREATED CORN — PILOT-PLANT RUN[a]
(Percent of sample)

	VACUUM-TEMPERED	NONVACUUM-TREATED
−4+6 Grits		
Attached hull	1.8	3.2
Attached germ	3.6	8.6
Checked grits	73	75
Oil content (% m.f.b.)	0.26	0.40
−6+8 Grits		
Oil content (% m.f.b.)	0.58	0.60
Germ		
Potential oil recovery (lb./bu. corn)	0.85	1.02

[a] Values given are averages from three vacuum tests and one nonvacuum test.

Degerminator throughput was reduced from 13 bu. per hour to 10 bu. per hour by use of vacuum-tempering. Towel-dried pilot-plant samples of vacuum-tempered corn had a moisture content of 18% compared to 21% for corn from which surface moisture had not been removed.

The primary mode of entry of water into corn is through the tip cap by capillary action into an area under the hull and surrounding the germ and then by diffusion through the seed coat membrane into the germ and endosperm (4). A vacuum exhausts trapped air from these areas and creates a differential pressure. Upon release of the vacuum, water absorption is rapid. These voids apparently remain even under conditions of severe initial drying.

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