Dry-Milling of Corn Attacked by Southern Leaf Blight[1]

O. L. BREKKE, A. J. PEPLINSKI, E. L. GRIFFIN, Jr., and J. J. ELLIS, Northern Regional Research Laboratory, Peoria, Illinois 61604

ABSTRACT

Southern corn leaf blight (caused by *Helminthosporium maydis* Nisik. et Miyake, Race T) did appreciable damage to the 1970 corn crop in the U.S. In addition to the reduction in crop yield, the damaged yellow dent hybrids tested usually were low in test weight and had excessive amounts of small, damaged, or moldy kernels. White corn lots had many of these same characteristics but to a lesser degree. Cleaning losses ran higher for blighted samples, and our cleaning procedure removed only some of the moldy kernels. No operating problems were encountered in laboratory-scale dry-milling tests. As test weight of the corn decreased, yield of the prime-product mix also decreased. Recoverable-oil yield varied with oil content of the corn. The prime products had acceptable fat contents but often had more dark specks and floury endosperm than products from unblighted corn. Presence of *H. maydis* usually was low in the prime products. No statistically significant differences in odor or flavor scores were noted between grits prepared from blighted corn and those from unblighted corn.

Race T of the fungus *Helminthosporium maydis*, the cause of Southern corn leaf blight (SCLB), made a widespread and sometimes severe attack on much of the corn grown in the U.S. during 1970, most noticeably in the region east of the Mississippi River. Concern arose about the dry-milling response of corn subjected to such attack. Experimental work was undertaken at the Northern Laboratory to determine dry-milling characteristics of yellow and white corn that had been damaged to varying degrees by the blight.

MATERIALS AND METHODS

Corn

Samples of severely damaged yellow corn were collected from farmers and local elevators around Peoria and Champaign, Ill., during the fall and early winter months. The yields of blighted corn were greatly reduced, generally, to about one-half of the preceding (1969) crop. The corn samples were harvested at 18 to 30% moisture content (m.c.) and each lot was dried to 14% or less, with one dried to 9%. Drying air temperatures varied from 70° to about 180°F. or above.

Experimental Equipment, Conditions, and Procedures

The grain was mechanically dry-cleaned in a simple milling separator and a multilouver aspirator. A 28- or 26/64-in. round-hole-perforated (r.h.p.) sieve in the milling separator removed pieces of cob and other oversized material, including some kernels that later were recovered by handpicking and added to the dry-cleaned corn. For one lot where blight had severely weakened the cob, kernels still attached to some pieces of cob were recovered by hand shelling. A 14/64-in.

---

[1] Presented at the 56th Annual Meeting, Dallas, October 1971. Contribution from the Northern Regional Research Laboratory, Peoria, Ill. 61604. This is a laboratory of the Northern Marketing and Nutrition Research Division, Agricultural Research Service, U.S. Department of Agriculture. The mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

r.h.p. sieve in the separator removed small kernels, corn chips, and other undersized matter. The milling separator took out some of the beeswing and other lightweight materials, and the aspirator removed more. Each lot of corn was blended and sampled after the dry-cleaning step.

For each degermer run, 15 to 25 lb. of corn was pretempered, if necessary, by daily 2% additions of water until the m.c. was 14%. Next, the corn was washed in either a small Miag combined washer, stoner, and whizzer, or in an experimental water-flotation column (1).

Feed rates to the column were: corn, 2.3 to 2.9 cwt. per hr.; water, 15 to 18 lb. per lb. corn. A basket centrifuge, operated for 1 min. from a standing start and developing a maximum centrifugal force of 145 X g, served to dewater corn discharged from the flotation column. Conditions for the washer-whizzer operation were: corn feed-rate at 9 to 13 cwt. per hr.; water flow-rate at 1.2 to 1.6 lb. per lb. corn.Even though the water-recycle valve was open, the results are typical of those obtained with clean water because the washing time was so short.

Fifteen-pound quantities of the washed corn were moistened to about 21% m.c. for 1.75 hr. for a first temper, then to 24% for a dehulling temper 15 min. before the degerming step. All tempering was at room temperature (28 ±5°C.). Next, the tempered corn was processed in an experimental horizontal drum degermer, operated at 1,650 r.p.m. at a net motor load of about 0.4 h.p. All corn had to pass through the 20/64-in. r.h.p. screen surrounding the rotor. Other details of this degermer's construction and operation have been published previously (2). Degermer stock was dried to 17 ±1% moisture in a forced-circulation tray dryer operated at 82°C. air temperature, and then milled into grits, meal, and other fractions by a roller-milling and grading system based upon the flow shown in Fig. 1.

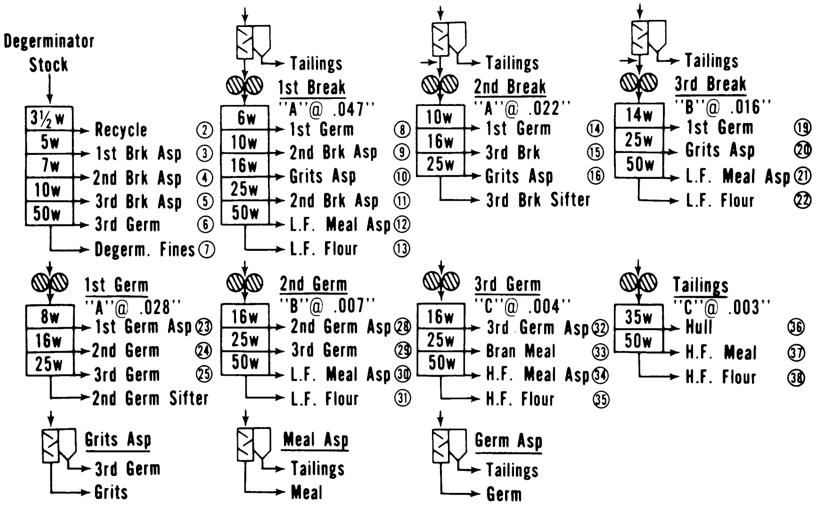

Fig. 1. Roller-milling and grading flowsheet. Degermer stock from yellow and white corn infected with *H. maydis* was milled into grits, meal, and other products in this manner. Brk = break; Asp = aspirator; L. F. Meal = low-fat meal; H. F. Meal = high-fat meal; w = wire mesh, e.g. number of wire meshes per lineal inch of sieve surface.

The rolls and grading equipment consisted of three pairs of corrugated rolls measuring 6 X 6 in., a Bates laboratory aspirator, and a box sifter holding three 12 X 12-in. sieves clothed with woven-wire fabric meeting U.S. Standard Sieve Series specifications. The rolls had modified Dawson corrugations and operated dull to dull. Other details for the roller mills are given below:

Mill	*A*	*B*	*C*
Corrugations per in.	10	16	24
Spiral, in. per ft.	0.25	0.5	0
Differential	1.5:1	1.5:1	2.0:1
Usage	1st break 2nd break 1st germ	3rd break 2nd germ	3rd germ Tailings

Four-pound samples of degermer stock were roller milled and the products air-dried 1 or 2 days before calculation of yields. The following products were recovered:

Product	*Mill Streams*[a] *Used*	*Particle-Size Range*
Grits, 1st break	10	–10 + 16 Mesh
Grits, 2nd and 3rd break	16,20	–16 + 25 Mesh
Low-fat meal	12,21,30	–25 + 50 Mesh
Low-fat flour	13,22,31	–50 Mesh + pan
Prime-product mix was a blend of the above products.		
High-fat meal	34,37	–25 + 50 Mesh
High-fat flour	35,38	–50 Mesh + pan
Germ fraction	23,28,32	+16 Mesh
Bran meal	33	–16 + 25 Mesh
Hull fraction	36	+35 Mesh
Degermer fines	7	–50 Mesh + pan
Recycle stock	2	+3.5 Mesh

---

[a] See Fig. 1.

AACC procedures were followed for protein, crude fiber, ash, starch, fat-acidity value, free fatty acid (FFA) content, and oil composition (3). Moisture in whole-kernel corn samples was based on loss of weight after heating 200-g. samples for 72 hr. in a forced-draft oven at 103°C. Other moisture determinations were on 10-g. samples heated for 30 min. in a Brabender oven at 130°C. Fat content of germ fractions and whole grain was measured by the Butt extraction procedure with a pentane-hexane solvent mixture. Other fractions were analyzed for fat content by a gas-liquid chromatographic method (4) which gives values some 15 to 20% higher than those of the Butt method on fractions containing about 2% fat or less. Kernel-hardness classification was based upon the "floaters" test described by Wichser (5).

For the extent of infection by *H. maydis*, 100, 200, or 500 of the best, undamaged kernels were surface-sterilized in a 1% sodium hypochlorite solution, washed, and five kernels per plate were placed on yeast-extract agar containing tetracycline to prevent bacterial growth. After 4 to 5 days' incubation at 28°C., the kernels were examined and the number recorded for each infecting mold or as mold-free. Kernels that initiated germination during the incubation were considered viable.

Grading tests on the grain (10 to 15% m.c.) including broken corn and foreign material (BCFM) and damaged-kernels-total (DKT) contents followed the USDA standard procedures (6). Moldy-kernel content of the corn, expressed as weight percent, was made by visual inspection of individual kernels in approximately 200-g. samples. Broken kernels were counted in the +12/64-in. fraction.

Grits (a mixture from the second- and third-break stages) prepared in the pilot plant from blighted-corn samples (both yellow and white) were tested for their odor and flavor by a 12- to 15-member panel. Each sample of blighted grits was compared with grits prepared from blight-free corn of the same class. In addition, grits from the blighted lots were also compared with commercially prepared quick-cooking enriched yellow grits or unenriched, commercial white grits.

Other details of the equipment, procedures, and analytical methods have been described previously (7,8,9).

RESULTS AND DISCUSSION

Physical Characteristics and Chemical Composition

Data for selected physical and microbiological analyses made on various lots of the dry, clean corn are given in Table I, and data for the proximate chemical compositions are presented in Table II.

The more heavily infected corn usually had the highest content of moldy kernels and the lowest kernel weight. Seven of the blighted yellow lots had soft kernels, while the eighth had hard kernels. Kernel weight correlated roughly with test weight. Values for the blighted white corn ran much closer to their control than did values for the yellow corn. Based upon these physical characteristics, the white lots as a group were better for dry-milling than the yellow lots tested. Some of the latter, however, had much lower test weights and higher damage levels than the white-corn samples. Also, most white-corn hybrids are selected and grown specifically for the dry-milling industry, whereas a high percentage of the yellow corn is used for animal feed for which hybrids with small or soft kernels are acceptable.

In hand-sieved fractions of two yellow-corn samples tested, percentage of moldy kernels increased as kernel size decreased. Such a distribution appears reasonable because the tip kernels on a damaged ear often had the highest proportion of mold, and butt kernels the least. Also, the moldy kernels may not have grown to full size. For a given sample, the moldy-kernel content was always lower when expressed as weight percent than as number percent.

Percentage of viable kernels in the two classes of corn varied from 6 to 98%, depending both upon the level of infection by *H. maydis* and other molds and upon conditions used in drying the corn. A high degree of *H. maydis* infection did not necessarily reduce ability of the kernels to initiate germination. A low viability value and a high percentage of "sound," mold-free kernels was indicative of drying conditions that adversely affected the viability of both molds and embryo.

TABLE I. PHYSICAL AND MICROBIOLOGICAL ANALYSES OF BLIGHTED CORN[a]

Lot No.	U.S. Grade	H. maydis-Infected Kernels[b] %	Viable Kernels[b] %	"Mold-Free" Kernels[b] %	Moldy Kernels %	Damaged Kernels Total %	Kernel Size[c] %	Kernel Weight g./100 K.	Test Weight lb./bu.	Hardness Classification[d]
					Yellow Corn					
71[e]	1	0	98	13	Tr	0.3	72	36	56.0	M
74	2	16	91	19	3	5.0	40	26	59.0	H
57	2	29	79	6	9	3.4	43	23	54.0	S
61X	3	21	88	6	6	3.8	34	21	53.5	S
62	3	26	87	1	9	5.0	36	18	52.0	S
58	4	3	14	84	8	2.8	22	22	50.0	S
68	4	42	73	1	11	9.5	47	18	51.5	S
79	4	43	81	...	18	13.4	23	18	51.6	S
77	Sample	24	92	0	11	20.5	4	15	45.5	S
					White Corn					
81[e]	1	0	23	...	1	1.9	76	31	56.0	H
73	2	2	6	69	1	0.7	61	31	54.5	S
72	2	3	31	68	5	3.0	67	28	55.5	M
76	2	22	75	...	9	4.7	62	26	56.5	M
75	4	27	89	2	15	8.0	49	24	56.5	M

[a] Air-dried (10 to 15% moisture content) and dry-(i.e., mechanically) cleaned.

[b] Based on sample of kernels selected as visually sound before testing.

[c] As percentage of corn retained on 21/64-in. r.h.p. sieve.

[d] H = hard, M = medium, and S = soft.

[e] Control lot.

TABLE II. CHEMICAL ANALYSES OF CORN[a]

Lot No.	H. maydis-Infected Kernels[b] %	Fat Acidity mg. KOH/100 g. Corn, d.b.	Fat % d.b.	Protein % d.b.	Ash % d.b.	Crude Fiber % d.b.	Starch % d.b.
			Yellow Corn				
71[c]	0	16	4.8	11.6	1.5	2.2	71.0
74	16	20	4.3	6.6	1.5	2.2	71.4
57	29	22	4.5	10.2	1.4	2.4	72.0
61X	21	34	4.6	9.7	1.5	2.5	71.8
62	26	35	3.8	11.1	1.7	2.7	70.6
58	3	20	3.8	9.1	1.4	2.7	73.3
68	42	48	3.8	11.2	1.6	2.6	71.2
79	43	44	3.7	10.8	1.5	2.9	72.0
77	24	47	3.0	6.6	1.5	2.6	69.8
			White Corn				
81[c]	0	26	4.5	10.7	1.2	2.0	74.3
73	2	24	4.3	8.9	1.2	1.9	74.3
72	3	33	4.6	10.1	1.4	2.1	72.3
76	22	41	4.2	6.8	1.4	2.3	72.4
75	27	53	4.1	6.2	1.5	2.3	71.2

[a] Dry-cleaned.

[b] Based on sample of kernels selected as visually sound before testing.

[c] Control lot.

Fat acidity values for the blighted lots usually ran above 22, a level which has been reported by Baker et al. (10) as the approximate upper limit for freshly harvested corn. Our values, determined from 1 to 8 months after the corn was harvested, ran considerably below the range of 112 to 284 that Baker et al. (11) found for samples graded as having 100% blue-eye mold, or the 224 to 272 range for samples with 100% cob-rot damage.

For the more heavily damaged yellow lots, fat content generally was below 4% and crude-fiber content increased slightly. No correlation of protein content with blight damage was observed. The variations in protein contents shown in Table II can result from use of different varieties and agronomic conditions. Chemical composition of the white corn followed the yellow-corn pattern except that fat values were above 4%.

While variations noted in the physical and chemical characteristics are attributed to the blight, these variations are less than those reported by Cavins et al.[2] for a set of hand-shelled corn samples covering a wider range of blight damage. Cavins' samples ranged from kernels that were very friable and either entirely black or dark gray as a result of the blight, to visually sound, yellow kernels. The samples were selected from both moldy and nonmoldy ears coming from the same field planted to a single variety.

A comment about the differences in DKT and moldy-kernel contents of the corn may be helpful to the reader. Both are subjective tests and depend upon the

---

[2] Unpublished work, J. F. Cavins, O. L. Brekke, E. L. Griffin, Jr., and G. E. Inglett, Northern Marketing and Nutrition Research Division, 1971.

analyst's judgment. Kernels showing any sign of mold in the opinion of the operator were included in our lots, whereas by U.S. grain standards damaged kernels include only those that are "materially damaged."

Losses in and Effectiveness of Cleaning Steps

The milling separator and aspirator reduced BCFM to 0.2 ±0.1% in all dry-cleaned grain. Dry-cleaning losses increased with BCFM content of corn fed to the cleaner. For blighted yellow corn, the losses varied between 1 and 4% as against under 1% for the control, which was exceptionally clean. For the white corn, the loss was less than 2% for the control; 2 to 3% for three of the blighted lots, and for the fourth lot, almost 9%. The latter had an excessive amount of broken corn. One-fifth to one-third of the losses consisted of oversized material, such as pieces of cob, while corn chips, small kernels, and weed seeds made up the undersized offal.

Wet-cleaning losses ranged from a trace to 19%, varied with both quality of the corn and type of washer used, and were related to DKT of the unwashed corn (Table III). Kernel hardness or density did not appear to be a factor in the amount of loss when grain was put through the washer-whizzer. With the flotation column, losses for lots having the more dense kernels were in general agreement with those for the washer-whizzer operation. However, losses were considerably more for corn having soft, less-dense kernels. When the loss exceeded 1%, offal from the flotation column usually contained more visually sound but lightweight kernels than did offal from the washer-whizzer.

Reduction in precentage of moldy or damaged kernels was erratic and generally ineffective in both the dry- and wet-cleaning steps. Moldy-kernel content was reduced somewhat with the flotation column on certain lots, usually where large amounts of offal were removed during the washing step, but very little or none on other lots, or with the washer-whizzer (Table III). After five tests, use of the flotation column was discontinued because compared with the washer-whizzer there was a greater loss of corn without effective removal of all moldy kernels, more water was absorbed by the corn, and much more water was required for the washing step. However, more kernels were broken in the washer-whizzer. This breakage possibly would have been appreciably less if m.c. of the corn had been 15 to 16% rather than 14% at the time of washing.

Dry-Milling Response

No processing problems or operating difficulties were encountered with the blighted corn in our tempering, degerming, or roller-milling and grading steps. However, our laboratory procedure for separation and recovery of germ from grits by the sink-float principle (6) proved ineffective because differences in density were insufficient for a good separation. Presumably, development of the kernel was arrested by the blight, and therefore the endosperm did not attain its normal density. Consequently, the germ fraction was contaminated with more grits than normal.

As test weight of corn decreased, yield of the prime-product mix (i.e., grits, low-fat meal, and low-fat flour) fell. The equation for regression of yield on test weight, as calculated by the method of least squares, is $Y = 1.23X - 9.86$, where Y is the prime-product yield and X is test weight. The standard deviation, s, is 2.56.

TABLE III. COMPARISON OF WASHER-WHIZZER AND FLOTATION COLUMN FOR WASHING CORN

Lot No.	*H. maydis*-Infected Kernels	Kernel Hardness	Moisture Pickup	Damaged Kernel Content	Loss as Offal	"Good" Corn in Offal	Moldy-Kernel Content		Broken-Kernel Content	
							To washer	From washer	To washer	From washer
	%		%	%	%	%	%	%	%	%
				Washer-Whizzer						
81	0	H	1.6	1.9	0.2	57	1	1	7	20
71	0	M	1.2	0.3	0.3	44	Tr	0	5	9
			1.5	0.3	0.4	16	Tr	0	5	9
72	3	M	1.8	3.0	0.7	28	5	3	9	18
76	22	M	1.7	4.7	1.0	17	9	11	5	10
73	2	S	1.3	0.7	0.5	41	1	1	7	16
57	29	S	2.4	3.4	2	...	9	...	7	...
			2.0	3.4	1	14	9	9	7	12
68	42	S	1.8	9.5	7	18	11	11	7	10
79	43	S	2.0	13.4	8	9	18	11	4	6
77	24	S	2.0	20.5	19	29	11	6	3	4
				Flotation Column-Centrifuge						
74	16	H	2.6	5.0	2	22	3	3	3	1
75	27	M	3.4	8.0	3	25	15	8	4	5
61X	21	S	3.9	3.8	6	29	5	2	5	7
62	26	S	5.0	5.0	9	43	9	3	8	11
68	42	S	4.3	9.5	18	45	11	5	7	7

The yield of individual products varied in the following manner as test weight decreased from 59.0 to 45.5 lb. per bu.:

a) 1st-break grits decreased from 15 to 3%.
b) 2nd- and 3rd-break grits fell from 37 to 28%.
c) Low-fat meal held at 9 to 11%.
d) Low-fat flour increased from 4 to 7%.
e) High-fat meal increased from 7 to 10%.
f) High-fat flour climbed from 1 to 5%.
g) Degermer fines increased from 2 to 5%.
h) Hull fraction rose from 4 to 9%.
i) Germ fraction usually fluctuated between 15 and 17%.
j) Bran meal held at 4 to 7%.

Calculated yield of recoverable oil correlated with oil content of the corn being milled. For lots containing more than 3.6% oil, and assuming the germ cake contains 5% oil, the regression equation is $Y = 0.63X - 0.12$, where Y is recoverable oil and X is available oil, both expressed as percent of the corn, dry basis (d.b.). Standard deviation is 0.15. Milling losses were disregarded so recoverable oil could be expressed as a percentage of the corn rather than a percentage of the recovered-product mix consisting of grits, meal, flour, degermer fines, hull, and germ fractions. In a typical commercial operation on sound corn, this loss would be approximately 4%.

Characteristics of Products

Fat Content. Fat content of the prime-product mix usually decreased as test weight decreased. Average values for selected intervals are given below:

Test Weight lb./bu.	*Fat Content % d.b.*
59.0	0.87
55.5–56.5	1.05
53.5–54.5	0.90
51.5–52.0	0.79
45.5–50.0	0.72

A similar trend was noted for kernel weight vs. fat content:

Kernel Weight g./100 K.	*Fat Content % d.b.*
28–37	1.03
24–26	0.98
22–23	0.87
15–18	0.78

For lots having soft kernels, a reversal of the normal pattern for fat content of the products sometimes occurred. With these lots the fat content decreased rather than increased in going from second- and third-break grits to low-fat meal to low-fat flour. Fat content of the degermer fines was lower than normal and ranged between

0.5 and 1.3% vs. 1.7 to 4.1% when the kernels were medium-hard or hard. Bran meal also decreased in fat content when soft-kernel corn was milled. Reversal of the normal pattern is similar to that observed in our dry-milling of *opaque-2*, a corn having soft kernels (2).

Dark-Speck Count. Within broad limits, dark specks appearing in the grits and meal and coming from the hilar layer of the kernel increased in number with a) increasing percentages of visually sound kernels infected with *H. maydis*, or of moldy kernels; and with b) decreasing test weight or kernel weight (Table IV).

Color. Color of the grits from blighted yellow corn was poorer than that of the control because of a greater incidence of white intermingled with the yellow, an indication that grits from blighted corn contained more floury and less horny endosperm than grits from our blight-free corn.

A similar visual examination did not reveal any discernible difference in amount of floury endosperm in the white-corn grits; but here any difference would be more difficult to detect.

Taste-Panel Evaluation. The panel expressed a small but statistically significant taste preference for three of the seven samples of yellow grits from blighted corn over the control grits. The panel never did show a significant preference for the unblighted grits. Flavor and odor scores did not correlate with either the extent of *H. maydis* contamination in the corn or the damaged-kernel content.

The panel had no significant preference for grits prepared either from the blighted white corns or the pilot-plant control.

Fungal Counts. Total fungal counts for eight of the 11 grit samples tested were below 200 per g.; and for the other three, between 500 and 800 per g. The latter three samples either were prepared about 2.5 months after the corn had been harvested or had been air-dried to moisture levels of 9 to 11% rather than the 5 to 8% level typical of the other samples. *H. maydis* counts were below 80 per g. for all samples.

Mixtures of low-fat meal and flour in a similar set of 11 samples had less-than-500 counts of total fungi per g. except for the white control that had a count of 880 per g. after being dried to 10% m.c. Levels of *H. maydis* were 50 or less per g. for nine of the samples, and below 300 for the remaining two.

Moisture level to which the products were dried apparently had more of an effect on the fungal count than did level of infection in the corn from which the products were prepared.

TABLE IV. CORRELATION OF DARK-SPECK COUNT WITH CORN CHARACTERISTICS

Dark-Speck Count[a]		H. maydis-Infected Kernels	Moldy-Kernel Content	Test Weight	Kernel Weight
Grits	Low-fat meal	%	%	lb./bu.	g./100 K.
1 (0–2)	4 (2–14)	0–16	Tr-3	56.0–59.0	26–37
4 (0–10)	15 (3–60)	3–29	1–15	50.0–56.5	18–31
8 (3–15)	17 (5–50)	>40	11–18	45.5–51.5	15–18

[a] Number of hilar-layer specks per 10 sq. in. of sample surface. First value is the average, and values in parentheses are the range.

TABLE V. COMPOSITION OF CRUDE OIL RECOVERED FROM BLIGHTED-CORN GERM

Lot No.	H. maydis-Infected Kernels %	Damaged Kernels %	Oil Composition Palmitic %	Stearic %	Oleic %	Linoleic %	Linolenic %	Calculated Iodine Value	Free Fatty Acid % as Oleic
					Yellow Corn				
Typical commercial oil[a]			11.5	2.2	26.6	58.7	0.8	124	1.1–2.7
71	0	0.3	11.9	2.5	30.6	54.3	0.7	122	3.6
77	24	20.5	12.6	1.7	28.7	56.0	1.0	124	13.7
79	43	13.4	13.2	2.0	23.3	60.5	1.0	128	16.0
					White Corn				
Typical commercial oil[a]			16.1	...	35.3	48.6	...	114	1.1–2.7
81	0	1.9	13.8	3.0	33.7	48.5	1.0	116	2.2
72	3	3.0	12.5	3.1	33.0	50.3	1.1	118	3.6
76	22	4.7	12.8	2.3	33.8	50.5	0.6	118	3.6

[a] Source: Reference 12.

Composition of Oil

Oil extracted from the germ had a fatty acid composition fairly typical of that reported for yellow and white corns (12) (Table V). On the basis of yellow corn, there is some indication that the proportions of linoleic acid increased and of oleic acid decreased as damaged-kernel content and damage attributed to the blight mounted. Actually, composition of the two blighted samples coincided most closely with that of an average commercial oil. Damaged-kernel content of the two blighted white-corn samples was considerably less than the yellow corns, and composition of the oil from both the blighted and unblighted white corns was relatively constant and in good agreement with values for a typical commercial oil.

Oil from the two damaged yellow-corn samples had FFA contents of 14 to 16%, as against 3.6% for the control. Among the white-corn samples analyzed, the control had 2.2% FFA, and the moderate to heavily blight-damaged samples, 3.6%. Beadle et al. (12) reported FFA values typically ranging from 1.1 to 2.7% for oil recovered by wet-milling plants either in the U.S. or abroad.

SUMMARY AND CONCLUSIONS

As blight damage to the corn increased, decreases were noted in kernel size, weight, hardness, and test weight; and also the percentage of moldy kernels rose. Fat content tended to be low, whereas fat-acidity values and crude-fiber contents increased moderately. Dry- and wet-cleaning losses for the blighted corn were higher than normal, and our cleaning procedures removed some but not all moldy kernels.

As test weight of the corn fell off, yield and fat content of the prime-product mix declined and the dark-speck count increased. For equal test weights, the two classes of corn (yellow and white) had similar dry-milling responses. Blighted yellow grits had a less intense yellow color and they probably had less horny endosperm. Presence of *H. maydis* usually was low in prime products. Grits from the blighted corn compared favorably in flavor and odor scores with the control prepared in the pilot plant from blight-free corn. Recoverable oil yields varied with oil content of the corn being milled. The oil had a high FFA content when damaged-kernel content of the corn was high.

Dry millers normally select corn that grades U.S. No. 2 or better in all grading factors except m.c. Because of their selection process, the grain they mill would be comparable to the better-quality lots we tested.

Acknowledgments

We are indebted to Paul Brooks and Lloyd Burbridge for help with the milling studies; to Lynn Black, Frank Alaksiewicz, Jack Glover, Dean Uhl, and Patricia Schulz for chemical analyses; to Kathleen Warner for taste-panel tests; to W. F. Kwolek for statistical analyses of some taste-panel data; to E. B. Lancaster for computer calculations; and to M. L. Smith and L. J. Weih for assistance in the microbial assays. The Peoria office of the Grain Division CMS, USDA, conducted grading tests on the corn. Several lots of the corn were supplied through arrangements made by the American Corn Millers' Federation.

Literature Cited

1. WEINECKE, L. A., and MONTGOMERY, R. A. Separation of some sized and aspirated corn degerminator fractions by water flotation. Northwest. Miller 276(7): 14 (1969).

2. BREKKE, O. L., GRIFFIN, E. L., Jr., and BROOKS, P. Dry-milling of *opaque-2* (high lysine) corn. Cereal Chem. 48: 499 (1971).
3. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. AACC Approved methods (7th ed., rev.). The Association: St. Paul, Minn. (1971).
4. BLACK, L. T., SPYRES, G. G., and BREKKE, O. L. Determination of oil contents of dry-milled corn fractions by gas-liquid chromatography. Cereal Chem. 44: 152 (1967).
5. WICHSER, W. R. The world of corn processing. Amer. Miller Process. 89(4): 29 (1961).
6. U.S. DEPARTMENT OF AGRICULTURE. Official grain standards of the United States, Revised. Feb. 1970.
7. BREKKE, O. L., WEINECKE, L. A., WOHLRABE, F. C., and GRIFFIN, E. L., Jr. Tempering and degermination for corn dry-milling: A research project for industry. Amer. Miller Process. 89(9): 14; 89(10): 19 (1961).
8. BREKKE, O. L. Corn dry-milling: Effect of temper time and moisture level on degerminator performance. Cereal Chem. 42: 288 (1965).
9. BREKKE, O. L. Dry-milling artificially dried corn; roller-milling of degerminator stock at various moistures. Cereal Sci. Today 15: 37 (1970).
10. BAKER, DORIS, NEUSTADT, M. H., and ZELENY, L. Application of the fat-acidity test as an index of grain deterioration. Cereal Chem. 34: 226 (1957).
11. BAKER, DORIS, NEUSTADT, M. H., and ZELENY, L. Relationships between fat acidity values and types of damage in grain. Cereal Chem. 36: 308 (1959).
12. BEADLE, J. B., JUST, D. E., MORGAN, R. E., and REINERS, R. A. Composition of corn oil. J. Amer. Oil Chem. Soc. 42: 90 (1965).

[Received November 2, 1971. Accepted February 14, 1972]