Microbial Reduction in Stored and Dry-Milled Corn Infected with Southern Corn Leaf Blight[1]

C. VOJNOVICH, R. A. ANDERSON, and J. J. ELLIS, Northern Regional Research Laboratory, Peoria, Illinois 61604

ABSTRACT

Much of the 1970 corn crop was damaged by *Helminthosporium maydis*, the fungus causing southern corn leaf blight. For many uses of corn, particularly in dry-milling, low bacterial and fungal counts are essential. High microbial populations, including *H. maydis*, can be materially reduced or eliminated by certain treatments applied to corn before milling. Blight-infected corn with an initial microbial count of 1,700,000 bacteria and 110,000 fungi per g. was treated by dipping in a hot solution of a sanitizing agent, by indirect steaming, and by direct steaming. Any of the three treatments reduced the microbial count of dry-milled fractions to about 5,000 per g. or lower. Storage of blight-infected corn at moderate temperatures destroyed *H. maydis* and reduced the total microbial count to levels low enough to meet all microbiological specifications set for food products.

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Southern corn leaf blight, caused by *Helminthosporium maydis* Nisik.et Miyake (1), was prevalent throughout the Corn Belt in 1970. Much field corn infected by the organism varied widely in apparent damage. Other microflora either accompanied or followed the fungus and greatly increased the total microbial population of the infected grain. For corn dry-milled products to be acceptable for convenience-food uses, a microbial count below 5,000 per g. is desirable (2). Earlier we showed that the microbial population of unblighted corn can be reduced by various treatments of the whole grain (3). We now report on the destruction of infective fungi and bacteria by various treatments of whole blighted corn.

MATERIALS AND METHODS

Three lots of corn grown in Central Illinois and heavily damaged by southern corn leaf blight infection were collected and examined for microbial populations. Corn, designated as lot ED-57, was harvested at 28% moisture content and artificially dried on the farm to 11% moisture. This corn came from a highly infected field, and nine out of ten ears inspected had rot at ear tips. The number of kernels with visible molds was 9.3%. The total microbial count for the corn was 1,700,000 bacteria and 110,000 fungi (molds and yeasts) per g.

A second lot, ED-58, was harvested at 30.5% moisture content and dried on the farm more intensely with 180°F. air temperature to 11.6% moisture. This corn had heavy blight infection on the plants with some signs of rotting on the ear tips, and the number of kernels with visible molds was 4.4%. The microbial count of this sample was 1,300,000 bacteria and 3,200 fungi per g. Lots ED-57 and ED-58 were cleaned in a Pioneer fanning mill and then passed through a Kice aspirator before being stored at 34°F. to minimize any changes in microbial populations.

A third lot, ED-69, was hand picked as ear corn, hand shelled, and aspirated. A count on this hand-picked sample showed that 37% of the kernels had some mold. Total microbial count was 8,400,000 bacteria and 910,000 fungi per g.

From each lot of blight-infected corn, 500 undamaged kernels were surface-sterilized for 1 min. with 1% sodium hypochlorite solution, placed on a yeast extract-tetracycline medium, and incubated at 28°C. so that fungal identification and mold counts could be made (Table I). Among the six fungi that predominated, *Helminthosporium* and *Fusarium* represented the highest counts on ED-57 and ED-69 corn kernels. Lot ED-58 had only a few *Helminthosporium* colonies, and its overall mold population was low. These conditions probably resulted from the high drying temperature of the original corn. Furthermore, only a few lot ED-58 kernels germinated on agar plates, compared to those from the other two lots higher in total fungi.

Analytical Methods

Total number of aerobic bacteria and fungi in the samples was estimated by the method described by Hesseltine and Graves (4). Samples for analysis were ground to pass a 20-mesh screen. Eleven grams of flour or ground sample was suspended in 99 ml. of sterile 0.1% peptone water. From this primary dilution (1:10), appropriate decimal dilutions were prepared and pour plates inoculated in duplicate. Colonies on the plates were counted after incubation for 3 days, at 32°C. for bacteria and 28°C. for fungi. The crude-fat content for corn and corn dry-milled fractions was determined by AACC Method 30-25 (5).

TABLE I. FUNGI COUNTS ON SURFACE-STERILIZED WHOLE KERNELS OF BLIGHT-INFECTED CORN, 1970 CROP

Fungus	Corn Lot No.		
	ED-57	ED-58	ED-69
Helminthosporium	144[a]	13	102
Fusarium	123	30	336
Trichoderma	122	3	5
Nigrospora	1	10	71
Alternaria	30	5	6
Penicillium	4	2	1
Others	21	4	6
Total	445	67	527
Kernels germinated	396	78	473

[a]Number of kernels infected with this mold in a 500-kernel sample.

Experimental Methods

Blight-infected whole corn was treated before proceeding with tempering, degerming, and roller-milling. We treated the corn by immersion in a hot solution of a sanitizing agent, by heating indirectly with steam, by heating directly with steam, or by storage. These treatments had been found to be particularly effective in reducing fungi when applied to normal dent corn (2).

In the first treatment, corn was immersed for 1 min. in a solution containing 1 g. per liter of a sanitizing agent (Diversol BX) at 180°F., centrifuged to remove surface moisture, tempered with chlorinated water, and then milled. The principal active ingredient of Diversol BX is sodium hypochlorite combined with sodium phosphate to maintain an alkaline medium.

For indirect heating, corn was pretempered to 14.0% moisture and heated in a drum rotated in steam at atmospheric pressure (212°F.) for 20 min. The heated corn, which had a final temperature of 190°F., was quenched in chlorinated water, and centrifuged to remove surface moisture before tempering and milling.

Corn was directly steamed by passing it through an enclosed screw auger into which steam at atmospheric pressure was admitted. Feed rate was adjusted to give 30 or 60 sec. of steaming. The heated corn was discharged from the auger at 172° and 178°F., respectively, and then processed like indirectly heated corn.

Water containing 250 p.p.m. of chlorine was used first to quench the treated corn and later to temper the treated corn. Adding chlorine to water ordinarily prevents recontamination of treated corn. After each treatment, the corn was given a first temper with chlorinated water for 3 hr. to 21% moisture to toughen the germ, then a second temper for 1/4 hr. to 24% moisture to facilitate dehulling, and finally processed in a low-speed Raymond laboratory hammer mill equipped with a special screen for obtaining degerminator stock. The degerminator stock was dried at 180°F. for 20 min. to reduce moisture to 16%, and then sized to remove degerminator fines. Laboratory-scale roller milling was then carried out by a modification of Wichser's procedure (6).

For storage, lot ED-57 corn was conditioned by tempering for 2 hr. to a moisture content of 12%, and then placed in quart jars at 26°, 37°, and 45°C. The initial microbial count after conditioning was 2,400,000 bacteria and 1,600,000 fungi per g.

RESULTS AND DISCUSSION

Dry-Milled Products

The yields and crude-fat contents of dry-milled fractions produced from blight-infected corn and a normal dent corn are given in Table II. Dry-milling characteristics varied appreciably among the blighted corns, as well as yield of the milled fractions. Only feed fractions from the blighted corn always showed increased yields, probably from additional endosperm being thrown into the feed. This addition is possibly due to changes in endosperm character because of the blight. The changes in yield caused a change in the distribution of crude fat in the fractions. All dry-milled products showed lower values of crude fat.

Bacterial and fungal counts of dry-milled fractions from blight-infected corn before and after treatment are given in Table III. The lowest microbial counts occurred in the grits fraction and the highest in the feed from untreated blighted corn. Meal and flour fractions were intermediate between grits and feed. Fungal counts were lowest in fractions dry-milled from ED-58 corn, and this level is thought to be due to high temperatures reached during artificial drying. The highest bacterial counts were found in fractions from lot ED-69 corn. Because of the rather high fungal counts in ED-57 and ED-69, these two lots were used in all subsequent corn-treatment studies.

Dipping Corn in A Solution of Sanitizing Agent

Dipping blighted ED-57 corn in a hot solution containing 0.1% Diversol BX was a simple method for reducing microbial counts of corn dry-milled fractions. This sanitizing agent was effective in earlier dipping treatments of corn (2). The microbial count was readily reduced to 5,000 per g. in the feed fraction and to 1,500 per g. or lower in the flour, grits, and meal (Table III). The counts in these products were low enough to meet the microbial requirements for most food purposes. In dry-milling where corn is cleaned by washing, the hot dip method, limited to treating whole grain only, can be easily incorporated into the regular procedure.

Indirect Heating of Corn

Heating blight-infected ED-57 corn with indirect steam at atmospheric pressure was another very effective method for reducing microbial populations. Data in Table III show that microbial counts of dry-milled fractions from heat-treated corn

TABLE II. YIELDS AND FAT CONTENTS OF DRY-MILLED FRACTIONS PRODUCED FROM NORMAL AND BLIGHT-INFECTED CORN (14% MOISTURE BASIS)

			Blight-Infected Corn					
	Normal Corn		Lot ED-57		Lot ED-58		Lot ED-69	
Fraction	Yield %	Crude fat %	Yield %	Crude fat %	Yield %	Crude fat %	Yield %	Crude fat %
Whole corn	...	3.2	...	3.9	...	3.4	...	3.0
Grits	27.6	1.0	25.8	0.6	20.6	0.4	20.0	0.6
Meal	20.0	1.9	22.4	0.8	17.1	0.7	14.2	0.7
Flour + degerminator fines	23.6	0.9	15.7	0.8	21.4	0.7	23.9	0.6
Germ + feed	28.8	8.8	36.1	8.8	40.9	7.2	41.9	6.3

TABLE III. MICROBIAL COUNTS OF DRY-MILLED FRACTIONS PRODUCED FROM UNTREATED AND TREATED BLIGHT-INFECTED CORNS

Corn Sample	Grits		Meal		Flour + Degerminator Fines		Germ + Feed	
	Bacteria/g.	Fungi/g.	Bacteria/g.	Fungi/g.	Bacteria/g.	Fungi/g.	Bacteria/g.	Fungi/g.
Untreated								
ED-57	4,800	1,700	60,000	200,000	49,000	150,000	110,000	320,000
ED-58	24,000	45	71,000	410	43,000	600	260,000	16,000
ED-69	8,000	1,300	460,000	160,000	850,000	79,000	2,800,000	330,000
Treated								
ED-57								
Immersed in 0.1% Diversol BX 1 min. at 180° F.	370	15	120	120	1,500	860	5,000	250
Indirect steam, 20 min. at 212° F.	90	10	150	35	550	230	230	45
Direct steam, 30 sec. at 212° F.	1,600	0	5,200	200	12,000	2,600	14,000	1,500
60 sec. at 212° F.	15	0	120	5	2,600	330	1,500	320
ED-69								
Direct steam 60 sec. at 212° F.	40	10	240	160	1,300	300	3,900	470

were reduced to less than 600 per g. Indirect heating destroys microorganisms in either whole corn, dry-milled fractions, or a fraction that might become recontaminated. Microbial count can be brought to any desired level for any portion of the mill's output that must meet rigid microbiological specifications before formulation into food products. Also, materials can be treated at controlled moisture levels in a fairly wide range of temperature for various periods of time.

Steaming Corn

Samples from the two different lots of more heavily blight-infected corn were exposed to direct steam at atmospheric pressure for both 30 or 60 sec. Results of these treatments are shown in Table III. The 60-sec. treatment reduced microbial counts substantially in all dry-milled fractions produced from both ED-57 corn and the highly contaminated ED-69 corn. Direct steam for 30 sec. yielded products with higher microbial counts than the 60-sec. treatment. However, microbial counts in prime products appear to be low enough to be suitable for most food purposes.

Dilution cultures of dry-milled products showed *Fusarium* present in large and variable numbers in all fractions from untreated corn (Table IV). *Penicillium* appeared in smaller numbers, but not in grits. Small quantities of *Trichoderma* were also present. In three of the dry-milled fractions from 30-sec. steam-treated corn, *Fusarium* was the only microorganism found. Again, no colonies appeared in the grits.

H. maydis was not observed in fractions dry-milled from either untreated or treated blight-infected corn (ED-57) that originally had a high count of the organism. The absence of *H. maydis* probably was due to that part of the milling procedure in which the degerminated corn at 24% moisture was dried to 16% at 180°F. (20 min.) before roller milling. Apparently, *Helminthosporium*, sensitive to these conditions, was destroyed. This possibility appears to be substantiated by an *H. maydis* count in lot ED-58 corn, which was artifically dried at 180°F. air. While the moisture content of the corn was being reduced to the required level, *Helminthosporium* was also decreased to low levels or was completely destroyed.

If *H. maydis* is the only concern of the dry-miller, then drying the degerminator stock at 180°F. for 20 min. would be a practical way of controlling the fungus. Since this method can readily be made part of the milling procedure, no major changes in the present milling practice would be required. If by chance a fraction becomes recontaminated, *H. maydis* could be easily destroyed by the same drying method, thus averting any possibility of developing unfavorable effects on the quality of the material.

TABLE IV. FUNGI ON DRY-MILLED FRACTIONS FROM UNTREATED AND STEAM TREATED ED-57 BLIGHTED CORN

Dry-Milled Fraction	Untreated			Steam, 30 sec.		
	Fusarium No./g.	Penicillium No./g.	Trichoderma No./g.	Fusarium No./g.	Penicillium No./g.	Trichoderma No./g.
Grits	5,200	None	Present	None	None	None
Meal	260,000	120	Present	210	None	None
Flour + degerminator fines	280,000	1,800	Present	110	None	None
Feed + germ	36,000	140	Present	320	None	None

Storage of Blight-Infected Corn

Earlier work showed that the microbial population of commercial corn break flour dropped during storage at 12% moisture (2). Similar results were obtained for blight-infected lot ED-57 stored at moderate temperatures (Fig. 1). Bacterial count reduced to 850 per g. after storage at 45°C. for 4 weeks, and to 500 per g. at 37°C. for 15 weeks. Storage for 20 weeks at 26°C. reduced bacterial count to 19,000 per g. Fungi were practically nonexistent after storage for 2 weeks at 45°C. and 15 weeks at 37°C. After 20 weeks' storage at 26°C., the fungal count was reduced to 11,000 per g., and no trace of *H. maydis* was found.

Storage at moderate temperatures appears to be feasible for processing blight-infected corn to reduce microbial populations to less than 5,000 per g. Storage has advantages over other treatments because no chemicals are used, no food regulations are involved, no apparent damage is incurred by the grain, and microbial counts in dry-milled fractions are reduced to low levels. Compared to other methods, the only disadvantage is the longer storage time required to reduce microbial populations.

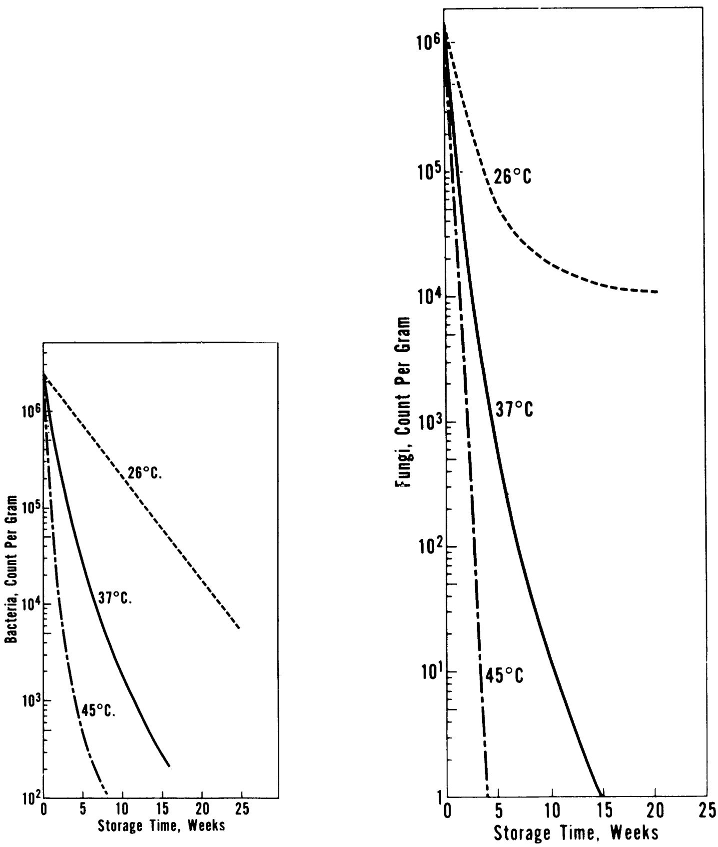

Fig. 1. Effect of heated storage on bacterial count (left) and fungal count (right) in blight-infected corn containing 12% moisture.

SUMMARY

H. maydis was quite prevalent in the large microbial populations found in blight-infected corn before milling. In dry-milled fractions from blight-infected corn, the total microbial count was very high in the feed, intermediate for the meal and flour, and low for the grits. Nevertheless, *H. maydis* was not observed in dry-milled fractions prepared from untreated blight-infected corn. Apparently, conditions used for drying the degerminator stock at 180°F. before proceeding with milling destroyed the organism.

Treatment of blight-infected corn before dry-milling with a hot solution of sanitizing agent, indirect steam heating, or direct steam heating, readily destroys *H. maydis* and reduces the overall microbial count to desirable levels in most fractions.

Storage of blight-infected corn at moderate temperatures reduced microbial count to levels low enough to meet all microbiological specifications set for food products.

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