NOTE ON A SIMPLE 100-g DOUGH MOLDER[1]

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An inexpensive, reliable molder is needed for doughs made from 100 g flour. For several years we have used a simple, sled-like, hand-powered device for molding doughs from 10 g flour (1). Simplicity and the relatively low cost of that molder warranted the development of a similar one for doughs made from 100 g flour.

MATERIALS AND METHODS

Molder Construction

Sides of the molder (Figs. 1 and 2) were constructed of wood, the curling and pressure plates from Plexiglas, and the runner from 1/4 in. × 3.5 in. × 7-ft plywood. Both ends of the curling device were free to rise as the dough passed. A 500-g weight, rather than a spring, applied pressure to the dough at the back end of the curling plate.

Corrugations of the curling plate gripped and kept the dough perpendicular to the line of travel. The plywood strip was the base for the curling action and corresponded to the drum of a conventional molder. The second piece of fixed Plexiglas corresponded to the pressure plate of the Thompson molder. Figure 3 is a scale drawing.

Punching and Molding Procedures

Sheeting rolls from the National Mfg. Co. (Lincoln, Nebr.) were narrowed to 2.5 in., the width of the head rolls on the Thompson molder, by mounting a hinged side plate on top of the existing one on the sheeting rolls. The raised position of the side plate and a roll spacing of 5/16 in. were used for the premolding punch. The down position and a roll spacing of 3/16 in. assimilated the head rolls of the Thompson molder.

Thus, the dough (after 3 hr fermentation) was punched at 5/16 in. with the side plate raised, and again at 3/16 in. with the side plate lowered, followed immediately by placing the ribbon of dough on the plywood strip ahead of the molder. Then, the end closest to the molder was straightened, turned up and back onto the ribbon (Figs. 1 and 2), and the sled-like molder was pushed along the plywood strip over the dough. Time of molding was about 3 sec.

First and second punches, after 105 and 155 min fermentation, were made with a roll spacing of 3/16 in. and with the side plate raised.

Baking Method

Mixing time, water absorption, and potassium bromate (0 to 40 ppm) were optimum, and the formula included 100 g flour, 6.0 g sugar, 1.5 g salt, 3.0 g shortening, 2.0 g yeast, 4.0 g nonfat dry milk, and 0.25 g malt flour containing

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Mention of specific instruments or trade names is made for identification purposes only and does not imply any endorsement by the U.S. Government.

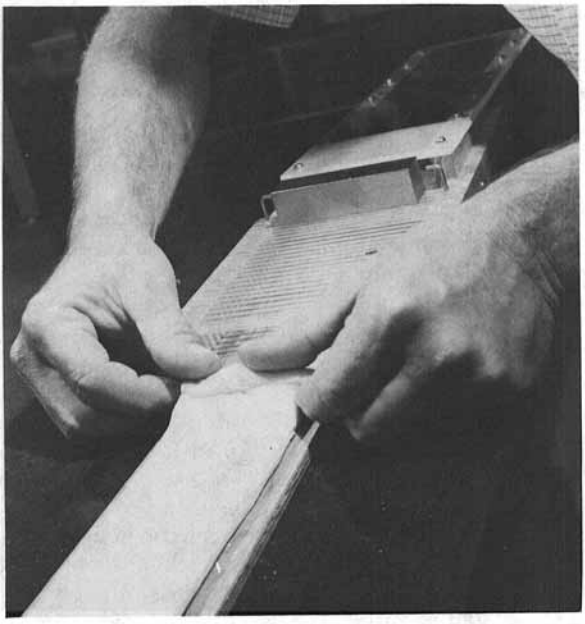

Fig. 1. Preparing sheeted dough for molding by the new, hand-operated molder.

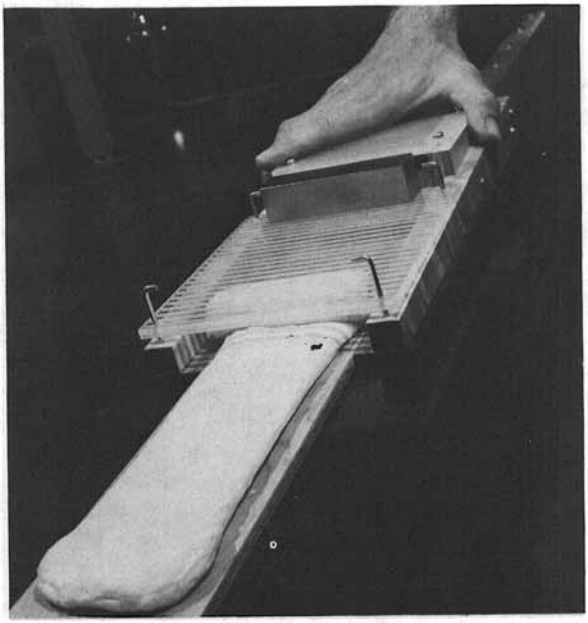

Fig. 2. Pushing the new 100-g dough molder along plywood runner to perform curling and other molding techniques.

about 50 D.U. (20°C)/g. Doughs were fermented 3 hr and proofed 55 min at 30°C. Additional details are given by Finney and Barmore (2–4). Loaf volumes were averages of at least three replications.

Flours

Doughs from 29 straight-grade flours, which varied in loaf volume potential from very poor to good, were processed by the Thompson and by the new molder. The flours included Regional Baking Standard (RBS), nine research standards, and 19 experiment station composites, each consisting of 31 equally weighted varieties. Protein contents varied from 8.7 to 16.7%, and mixing requirements from 1 to 8-3/4 min.

RESULTS AND DISCUSSION

Some of the features of the new molder duplicated and others improved the action of the Thompson machine molder. For instance, the 4.5-in. wide curling section on both molders rolled the dough into a cylindrical shape before it reached the pressure plate. A weight at the back end of the curling plate of the new molder permitted a variable distance between the plate and the runner. The fixed distance on the Thompson molder gave bucky doughs harsher treatment than the new molder. The weighted curling plate assimilated the spring-loaded curling plate of the machine molder.

Initiating curling of the dough by hand afforded the operator the opportunity to obtain a cylinder of dough of uniform diameter. If both ends of the curled dough were not equal in diameter, one end tended to roll faster than the other, and at an angle other than perpendicular to the line of travel. The Plexiglas curling plate and pressure plate allowed the operator to observe the entire operation.

The correlation coefficient was $r = 0.99$ and the slope of the regression line was $b = 0.98$ for loaf volumes of doughs processed by the new (N) molder *vs.* the machine (M) molder (Fig. 4). The regression equation was $Y = 0.9822X + 15.56$.

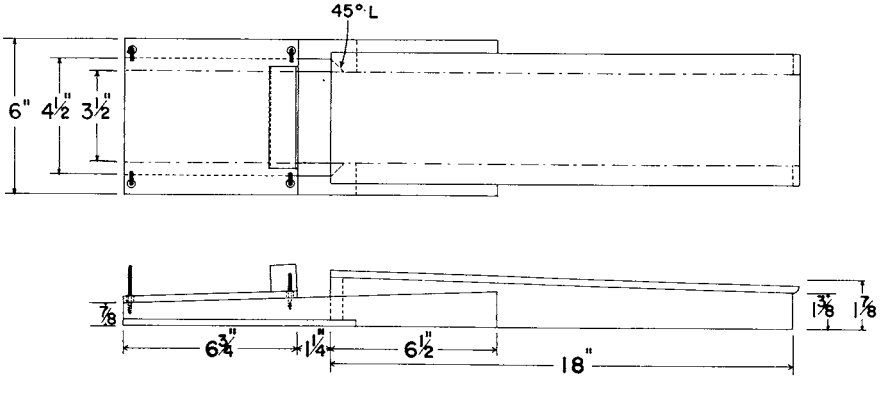

Fig. 3. Scale drawing that gives critical dimensions of the new 100-g dough molder. Plywood runner is not shown.

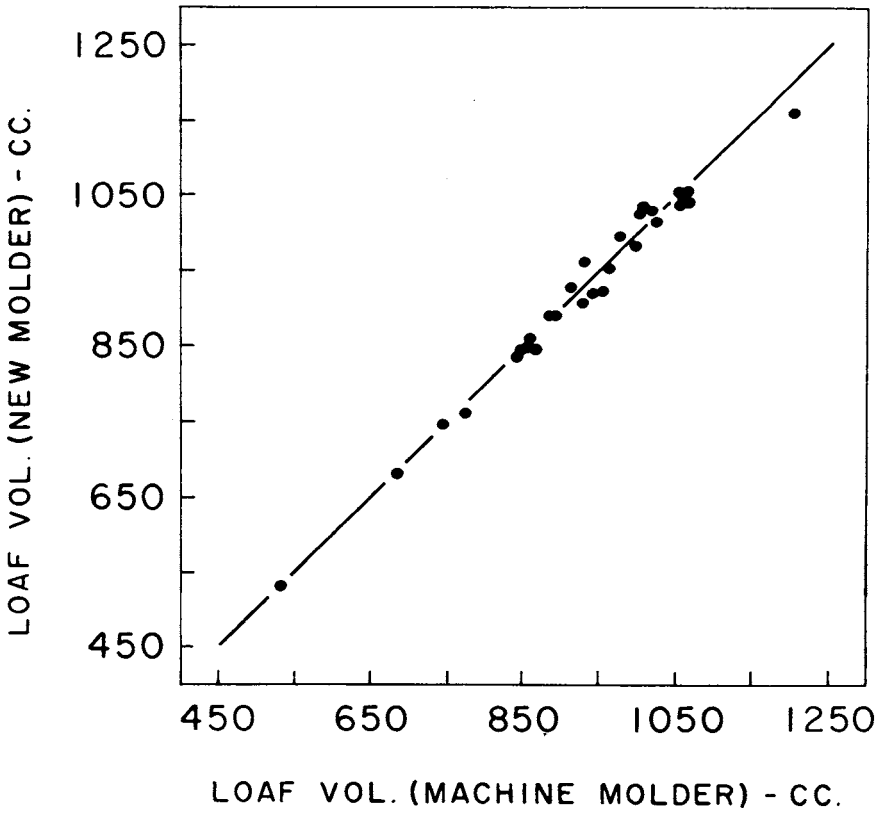

Fig. 4. Loaf volumes of doughs processed by the new *vs.* the Thompson machine molder.

The mean volumes were $\overline{M} = 928.55$ and $\overline{N} = 927.62$. External and internal loaf characteristics were essentially the same for both molders (data not given). The standard error of estimate for loaf volume by the new hand-operated molder was 17.3 cc, a value compatible with the difference (25 cc) required for significance ($P = 0.05$) between two variety means.

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AFLATOXIN OCCURRENCE IN 1973 CORN AT HARVEST. III. AFLATOXIN DISTRIBUTION IN CONTAMINATED, INSECT-DAMAGED CORN[1]

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ABSTRACT

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The distribution of aflatoxin was studied in samples of insect-damaged, aflatoxin-contaminated corn freshly harvested in 1973 in northeastern South Carolina. Corn in samples from six lots was separated into fractions based on the bright greenish-yellow fluorescence (associated with aflatoxin) and rice weevil and other damage. Fractions containing outwardly sound kernels from the six samples had 67–87% of the total weights. Four had no detectable aflatoxin; two had 9 and 13% of the total aflatoxin B_1 in their respective total samples. Kernels and pieces with obvious fluorescence and fluorescence under the seed coat represented only 0.1–0.4% of the total weights of each of the six samples, but comprised 35–90% of the B_1. At least 75% of the fluorescing kernels and pieces had obvious insect damage. In the five samples containing 24–47 ppb aflatoxin B_1, fractions with insect damage without BGY fluorescence and broken corn-foreign material accounted for 2–8% of the weight and 61–91% of the toxin. Fractions from these samples without insect damage made up 92–98% of the weight and 9–39% of the B_1. The sample with 209 ppb aflatoxin B_1 had the following distribution of weight and B_1: Fractions without visible insect damage—72% weight, 16% B_1; and fractions with insect damage—28% weight, 84% B_1. A few highly contaminated kernels accounted for appreciable amounts or most of the aflatoxin in the lots of corn studied.

Surveys (1–3) indicate a significant occurrence of aflatoxin in corn grown in various regions of the country. FDA actions involving corn have caused concern in the industry (4,5). The first surveys were made on southern corn moving in commercial channels (1) and on white corn that had been stored for a year (2). There could be no evidence as to when the corn in these surveys was invaded by *Aspergillus flavus* and when the mold produced the toxin. It is known that aflatoxin can be formed in storage under proper moisture and temperature conditions (6), and its formation can be prevented by keeping moisture low. A survey of freshly harvested 1973 corn in southeastern United States indicated that toxin formation took place prior to harvest (3). Studies in 1971, 1972, and 1973 (7) conducted in essentially all of the corn-producing areas of the United States also indicated aflatoxin could be formed in the field.

Although an association has been postulated between insect damage and *A. flavus* infection of corn and subsequent aflatoxin formation, a definite cause-effect relationship has not been established. Insects that have been implicated with *A. flavus* invasion are rice weevils, corn earworms, corn borers, stinkbugs, and mites. Taubenhaus (8) first reported that *A. niger* and *A. flavus* infection of field corn was frequently associated with corn earworm damage. The incidence of *A. flavus* on kernels from ears damaged by earworms, borers, mites, and

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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.

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stinkbugs was found to be significantly higher (5.1–7.2%) than on those from undamaged ears (2.5%) (9). There has been some evidence that aflatoxin contamination might be related to earworm damage (10). In a 1973 study on aflatoxin contamination in the field, insect damage was observed on 90% of the samples that had the bright greenish-yellow (BGY) fluorescence associated with the presence of *A. flavus* and possible aflatoxin in corn (7). All aflatoxin-contaminated samples of freshly harvested South Carolina corn found by Lillehoj *et al.* (11) came from fields with preharvest ears damaged by insects. However, in a sample of corn from one field, no correlation was found between per cent damage on an ear basis and aflatoxin occurrence. A more extensive study by Hesseltine *et al.* (12) on corn samples from the same study indicated a relation between rice weevil (*Sitophilus oryzae* L.) damage and *A. flavus* infection. Of 85 rice weevils collected from this corn, 78 were carrying *A. flavus* spores.

We have now inspected individual kernels from six lots of the 1973 freshly harvested South Carolina yellow corn to find whether insect damage on a particular kernel or group of kernels could be associated with aflatoxin contamination. The six lots were selected because they contained aflatoxin.

MATERIALS AND METHODS

Collection and Fractionation of Corn Samples

Samples (3.9–4.4 kg) of freshly harvested yellow corn were collected with probes from trucks or combines in fields in northeastern South Carolina (3). As soon as possible after collection (average time, 3 hr), samples were placed in a horizontal air flow, mechanical convection oven for drying. They were dried for 3 hr at 90°C to eliminate further growth of the mold and formation of aflatoxin.

Six samples of freshly harvested yellow corn were selected because they contained the BGY fluorescent kernels and pieces associated with the presence of *A. flavus* and possible aflatoxin. Each sample was shaken on a grain-grading, 12/64 round-hole sieve (13) to remove broken corn-foreign material (BCFM), which was then weighed and analyzed. The kernels remaining from the six lots were separated by hand into fractions based on the BGY fluorescence and insect and other damage. The fractions were (a) surface-fluorescing kernels and pieces, (b) kernels with fluorescence visible under the seed coat, (c) insect-damaged kernels without BGY fluorescence, (d) damaged, cracked, or discolored kernels, and (e) outwardly sound kernels. Insect damage was that typical of the rice weevil small round holes visible under 3× magnification and larger exit holes. The small dots or holes were tested with an inoculating needle to ascertain whether they were typical of those caused by female weevils chewing a cavity in the kernel in which to lay eggs. If a cavity were found, the kernel was regarded as being insect damaged. The eggs hatch and the rice weevils feed internally, eventually emerging through exit tunnels. The exit tunnels result in obvious round holes. Other insect damage could not be recognized as such.

Analytical Methods

The BCFM and insect-damaged fractions were ground and simultaneously extracted in a Waring Blendor for analysis by the method recommended for corn (14). Each corn sample was mixed with water, diatomaceous earth, and

chloroform in the Waring Blendor for 5 min before filtering. Because some of the fractions of insect-damaged kernels and of damaged, cracked, or discolored kernels and outwardly sound kernels were large, they were ground in a Raymond hammer mill to pass a No. 20 sieve and blended in a Hobart planetary mixer. Of each blended, ground fraction, 50 g was analyzed by the approved method for corn (14). The detection limit is 1–3 ppb aflatoxin. The presence of aflatoxin B_1 was confirmed by formation of water adducts (15). Confirmatory tests were run on representative samples.

Kernels and pieces with surface BGY fluorescence and with BGY fluorescence under the seed coat were assayed individually by crushing with pliers, weighing, and steeping for 48 hr in chloroform (2 to 3 ml) plus a drop of water (16). A second extraction removed all of the toxin that could be recovered in this manner. Pieces of corn too small to analyze individually were combined and extracted for assay. The level of toxin in all of the BGY fluorescent material was calculated from results obtained on individual kernels and pieces and on the combined pieces.

RESULTS AND DISCUSSION

Analyses of individual BGY kernels and pieces revealed that 83 of 86 particles with surface fluorescence had detectable aflatoxin B_1 (Table I). The limit of detection in a 0.25-g kernel or piece is 20–40 ppb. Extensive insect damage was noted in the BGY fluorescing kernels and pieces. Of 86 kernels analyzed, 65 had definite evidence of insect damage—the holes and cavities typical of rice weevil activity. Exit holes of the rice weevil were found in 49 (75%) of the insect-damaged kernels. Of the remaining 21 pieces and kernels, 18 were either so moldy or so broken that insect damage would not be obvious. Weevils were observed in 15 pieces and kernels. All but 2 of the 28 kernels and pieces containing >10,000 ppb aflatoxin B_1 had obvious insect damage. One of the 2 kernels had a large crack, and the other was so moldy that evidence of insect damage could have been destroyed.

Of the 69 kernels containing BGY fluorescence visible under the seed coat, 63 had detectable aflatoxin B_1 (Table I). Of the 69 kernels, 53 (77%) had holes and large cavities caused by rice weevils. Of the insect-damaged kernels, 28 (55%) had rice weevil exit holes. Fewer kernels with BGY fluorescence under the seed coat had exit holes than did kernels with obvious external fluorescence. Twelve of the remaining 16 kernels were so moldy or cracked that insect damage could not be identified. Eight weevils were found. Only one of 19 kernels containing >10,000 ppb B_1 did not have visible insect damage, but it was cracked and moldy.

Levels of aflatoxin B_1 in each of the different fractions separated from the six lots of corn varied greatly—from 9260 to 27,500 ppb in the BGY fluorescent material, and from nondetectable to 42 ppb in outwardly sound kernels. "Fluorescent material" includes kernels and pieces with surface BGY fluorescence and kernels with fluorescence under the seed coat. The BGY fractions combined had the highest levels of B_1. Insect-damaged kernels without BGY fluorescence and BCFM fractions had an average of 187 and 300 ppb B_1, respectively. The fractions with damage typical of rice weevil activity had high levels of B_1. The BCFM fractions which may have come from insect-damaged kernels also had high concentrations of B_1. Outwardly sound kernel fractions

TABLE I
Numbers of Corn Kernels and Pieces with Surface BGY[a] Fluorescence and Kernels with Fluorescence under the Seed Coat, by Aflatoxin B_1 Contamination Level and by Lots of Corn (3.9–4.4-kg Samples, *ca.* 16,000 Kernels) from which Kernels and Pieces were Separated

Levels Aflatoxin B_1 (ppb)	BGY Fluorescing Kernels and Pieces[b]						Kernels with BGY Fluorescence Visible under Seed Coat					
	Corn Sample and Contamination Level											
	A (24 ppb B_1)	B (24 ppb B_1)	C (25 ppb B_1)	D (38 ppb B_1)	E (47 ppb B_1)	F (209 ppb B_1)	A (24 ppb B_1)	B (24 ppb B_1)	C (25 ppb B_1)	D (38 ppb B_1)	E (47 ppb B_1)	F (209 ppb B_1)
0		1[c]	1		1						1	5
>0–100	9	4		1	1	6	2	1		3	4	4
101–1000	4	2	1	1		9	2			3	4	10
1001–5000	2	2	4	3	2	1					2	2
5001–10,000				1		1		1	2	1		3
>10,000		5	3	3	6	6	2	2		3	2	10
	Individual Levels in Kernels Containing >10,000 ppb B_1											
Average range	38,200	59,100	88,900	24,400	26,500	30,800	35,300	55,700		123,000	57,600	146,000
Low	10,300	10,300	17,000	23,400	13,500	11,700	32,900	37,700		25,200	42,100	17,700
High	77,100	148,000	171,000	26,300	65,100	64,000	37,700	73,700		314,000	73,000	793,000

[a]Bright greenish yellow (BGY) fluorescence under 365 nm ultraviolet light.
[b]Pieces that were too small to analyze individually are not included in this table.
[c]No aflatoxin detected; detection limit 0.25 g kernel 20–40 ppb.

from four of the six lots did not have detectable aflatoxin. The outwardly sound kernels from one lot had 4 ppb B_1. Outwardly sound kernels from the lot of corn containing 209 ppb aflatoxin B_1 had 42 ppb B_1.

The five samples of corn with levels of aflatoxin B_1 from 24 to 47 ppb had 1 to 6% by weight of kernels with rice weevil damage and no BGY fluorescence (Table II). The number of individual damaged kernels was not determined, but if one assumes the average weight of the individual insect-damaged kernels to be equal to the average weight of kernels in the total sample, the per cent of insect-damaged kernels by weight would approximate the per cent kernel damage by count. A 3-year study of rice weevil damage to corn in Louisiana, reported in 1958, revealed that the average kernel damage was 10% at harvest (17). In 1964, the overall infestation of rice weevils in eastern South Carolina was less than 20% of the ears with under 5% kernel damage at harvest (18), for a total of less than 1% kernel damage. The lower kernel damage was explained by the use of hybrids resistant to rice weevils. The sample containing 209 ppb aflatoxin B_1 had 28% by weight of kernels with damage typical of rice weevils.

The distribution of aflatoxin B_1 in the fractions separated from each lot of corn indicates a relation between toxin contamination and damage typical of rice weevil damage (Table II). Fractions of fluorescent material, including surface BGY fluorescence and fluorescence under the seed coat, accounted for only 0.1–0.4% of the weight in the six lots of corn but had 35–90% of the aflatoxin B_1. The fluorescent material as described before was damaged extensively by rice weevils. The BCFM material containing B_1 probably came from shattered insect- and mold-damaged kernels. Fractions with insect damage from the six lots of corn (including BGY fluorescent material and BCFM) accounted for 2–29% of the weight and 61–91% of aflatoxin B_1 in the lots. Although insect damage was not observed in the discolored, damaged, and cracked kernels, the nature of these would tend to obscure all but the most obvious damage (exit holes). Discolored, damaged, and cracked kernel fractions had 5–21% of the weight and 3–39% of

TABLE II
Aflatoxin B_1 in Each Fraction from Six Corn Samples (% of Total Sample)

Total Aflatoxin B_1 in Sample	BCFM[a]		Fluorescent[b] Material		Insect-Damaged Kernels[c]		Damaged, Cracked, and Discolored Kernels		Outwardly Sound Kernels	
ppb	wt %	B_1 %	wt %	B_1 %	wt %	B_1 %	wt %	B_1 %	wt %	B_1 %
24	0.2	0.1	0.5	90	1.4	1.3	18	9	80	0
24	0.7	1.0	0.1	69	5.0	3.1	21	26	73	0
25	2.0	9.0	<0.1	41	6.0	10.0	18	39	74	0
38	2.0	8.0	0.1	54	2.0	14.0	13	16	82	9
47	2.0	24.0	0.2	35	1.0	15.0	12	25	85	0
209	0.5	3.0	0.3	54	28.0	27.0	5	3	67	13

[a]Broken corn-foreign material.
[b]Bright greenish-yellow (BGY) fluorescence under 365 nm ultraviolet light including BGY fluorescence under seed coat.
[c]Round cavities and small holes indicating cavities (visible under 3× magnification) typical of rice weevil damage. There was no BGY fluorescence in these kernels.

the B_1. Fractions of outwardly sound kernels from four lots of corn did not have detectable aflatoxin, although they accounted for 74–85% of the weight. The lot with 38 ppb B_1 had 9% of the B_1 and 82% of the weight in the fraction of outwardly sound kernels. The outwardly sound kernels from the most contaminated lot (209 ppb B_1) accounted for 67% of the weight and 13% of the B_1.

This study indicates an association between rice weevil damage and aflatoxin contamination. Corn grown in the South is nearly all infested to some degree with rice weevils (19). The variation in aflatoxin levels between fields in the Southeast from which these samples were taken was found to be significant (3). Independent studies of rice weevil infestation have shown a definite variation between fields in percentage of weevil-damaged kernels (19). The *A. flavus* inoculum for producing aflatoxin may be carried by the rice weevil coming from stored corn. Most of the rice weevils isolated by Hesseltine *et al.* (12) had *A. flavus* spores. It is known that at least one generation of rice weevils develops in southern corn fields between the change from 65% grain moisture to approximately 25% (20).

If the rice weevil is an important vector in the formation of aflatoxin in field corn, several methods of toxin prevention are possible. Corn hybrids with rice-weevil resistance have been developed (18). The development of resistant hybrids has caused the overall infestation of rice weevils in southeastern United States to decrease from 65% of the ears with 20 to 30% kernel damage to less than 25% of the ears with under 5% damage at harvest. Application of the insecticide endrin has been found to decrease infestation by rice weevils (21). Crops (other than corn) that are more resistant to rice weevils could be grown in areas in the South that have had problems with aflatoxin contamination.

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