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Reactions of the Rice Weevil[1] to Newly Developed Wheat Products[2]

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ABSTRACT

Studies were conducted with 5 promising wheat products developed by the Western Utilization Research and Development Division, USDA, to evaluate attractiveness or resistance to *Sitophilus oryzae* (L.). The weevils were attracted consistently to pearled wheats of both light and heavy abrasion and were able to develop heavy populations therein. Parboiled WURLD wheats neutralized with either acetic or benzoic acid were not attractive to rice weevils. However, small numbers of progeny were produced in both materials. Progeny emergence was several days later in these than in the pearled wheats. More progeny was produced in scarified WURLD wheat than in the acid-neutralized products, but the number of progeny was still much lower than in the pearled wheats. Rice weevils were attracted to the Gaines wheat control about the same as to the pearled wheats, and progeny production was about the same in these materials. The bulgur and flour controls were the least attractive of all test materials to the rice weevil. However, the progeny production from the bulgur was similar to that from the acetic-acid-neutralized WURLD wheat.

Western Utilization Research and Development Division of USDA in Albany, Calif., in the continuing search for new uses of wheat, has developed several promising wheat products. Making available these additional nutritious products that could be processed into ready-to-eat foods would expand the market for wheat. However, knowledge of the relative resistance or attractiveness of these products to stored-product insects is necessary to plan effectively and to develop their export market potential. This paper reports results of tests conducted to determine the degree of attractiveness or resistance of these wheat products to the rice weevil, *Sitophilus oryzae* (L.).

MATERIALS AND METHODS.—*Test Products*.—The newly developed products were 2 pearled wheats and 3 WURLD[4] wheats developed from Gaines wheat. Bulgur, wheat, and white flour prepared from Gaines wheat were used as comparison controls. Table 1 gives a description of all materials and their moisture content prior to testing. The 2 pearled wheats were somewhat soft and covered with a light coating of flour with traces of bran still on the kernels. The WURLD wheats were similar to bulgur but were much lighter in color as a result of the chemical peeling of the bran. The kernels also appeared larger than bulgur kernels with some being markedly expanded and flattened. The scarified WURLD wheat was a light color but was more the texture of whole bulgur than were the other WURLD wheats. The WURLD wheats were developed to satisfy the demand of those who prefer a whiter product, more like rice. The process of their preparation was described by Morgan et al. (1964). The bulgur comparison control was obtained from a Kansas source and was prepared from hard red winter wheat. The bulgur had much of the bran removed and the endosperm was more shiny and translucent than the endosperm of the unprocessed wheat kernel; otherwise it was similar to raw wheat.

Test Insects.—The rice weevils were from a strain regularly maintained at the laboratory and were selected because the rice weevil is one of the most destructive insects infesting stored whole grain.

Distribution Studies (*Free-Choice Tests*).—Rice weevil distribution among the wheat samples was studied in 2 types of test chambers. Weevil cultures and tests were maintained in a rearing room at 26.7 ± 2°C and ca. 70% RH.

One type of chamber was a 62 × 62 × 15-cm frame (Fig. 1). Forty samples, 5 each of the 8 materials, were placed in separate 48 × 48 × 18-mm open plastic boxes. Each set of 40 samples was placed randomly in an exposure chamber. After the small boxes were arranged, 800 insects (unsexed) were released in the center of the chamber. A sheet of 6-mil plastic was drawn tightly over the top of each of the 5 chambers. At the end of 7 days, the chambers were opened, and the plastic boxes were quickly capped to contain their infestation. All insects free in each chamber and in each plastic box were removed, and the numbers were recorded. The test materials were retained in a rearing room for progeny development.

The other type of distribution test chamber was glass-covered and measured 38½ × 21½ × 4-cm deep (Fig. 2). Four samples of each of the test materials except the pearled wheat of light abrasion and the white flour, were exposed to the insects in a thin layer in boxes measuring 48 × 48 × 18 mm deep. The pearled wheat of light abrasion was omitted so that only one pearled wheat sample would be present for selection by the rice weevils. The flour was omitted because the rice weevil

Table 1.—Moisture content of wheat products; determinations made by the oven method.

Test materials	% moisture content
Experimental products:	
WURLD wheat; parboiled, lye-peeled, acetic acid neutralized	10.55
WURLD wheat; parboiled, lye-peeled, benzoic acid neutralized	10.21
WURLD wheat; scarified	11.95
Pearled wheat; light abrasion to remove outer bran layers, 88% recovery	10.75
Pearled wheat; heavy abrasion to remove the majority of the bran, 73% recovery	9.80
Check or control materials:	
Gaines variety wheat; whole and untreated	9.92
White flour; prepared from Gaines variety wheat	9.43
Bulgur; cracked and unsized	12.82

[1] Coleoptera: Curculionidae.
[2] Received Aug. 24, 1972.
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[4] So named to indicate origin of its development.

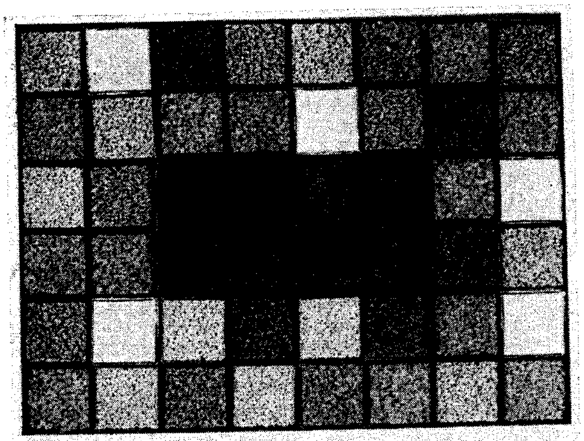

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FIG. 1.—Large chamber (62 × 62 × 15 cm) used to expose stored-product insects to wheat products.

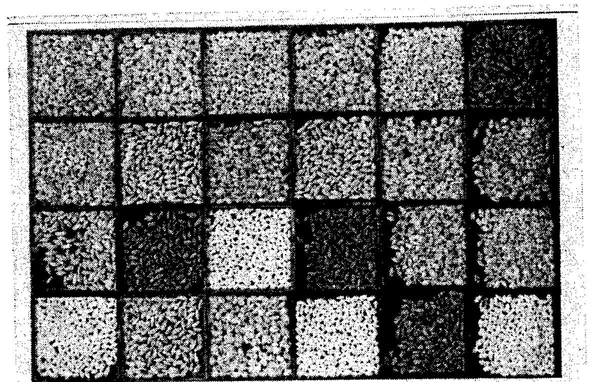

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FIG. 2.—Small glass-covered exposure chamber (38½ × 21½ × 4 cm) used to expose stored-product insects to wheat products.

cannot develop in it. In each chamber, 240 insects were released. The 5 chambers were then covered with the glass plates to allow inspection without disturbing the insects or the materials. At the end of each 24-hr period, for 6 days, the number of insects in each sample was estimated. At the end of 7 days, each chamber was opened, the boxes with their test materials were capped to contain their infestations, and all free insects in the chamber were counted. Insects in each of the boxed samples were then removed and counted, and the boxed material was retained in the rearing room for progeny development.

No-Choice Tests.—Fifty (unsexed) weevils were caged on samples of each of the materials for a 7-day ovipositional period. At the end of the period, weevils were removed, and the grain samples were retained in the rearing room for progeny development.

Direct Comparison Studies.—From the data of the distribution tests, pairings of the more susceptible and less susceptible materials were made for preference studies. A modification of the testing apparatus described by Laudani and Swank (1954) was used. In each test, six 118-ml samples of each of 2 products were exposed for 24 hr to a dispersal of 500 insects.

RESULTS.—*Distribution Studies* (*Free-Choice Tests*).—The pearled wheats were more susceptible to the rice weevil than were the 3 WURLD wheats (Table 2). In the large chamber, pearled wheat of light abrasion attracted 25% of the total insects, and pearled wheat of heavy abrasion attracted 19% of the total insects. Progeny increases were between 9 and 10 times these numbers. In comparison, the numbers of insects attracted to the acetic-acid-neutralized, the benzoic-acid-neutralized, and the scarified WURLD wheats were 9.8, 6.9, and 10.8% of the total insects, respectively. Progeny from the scarified WURLD wheat was ca. 10

Table 2.—Rice weevil attracted to wheat products and subsequent progeny development from each product.

Materials	Large chamber				Small chamber			
	Distribution[a]		Progeny[b]		Distribution[a]		Progeny[b]	
	%	Means[d] (no.)	%	Means[d] (no.)	%	Means[d] (no.)	%	Means[d] (no.)
Experimental:								
WURLD wheat; parboiled, lye-peeled, acetic acid neutralized	9.8	74.8[c]	3.8	263.6[e]	10.3	10.0[b]	6.2	48.0[b]
WURLD wheat; parboiled, lye-peeled, benzoic acid neutralized	6.9	53.0[d]	1.9	129.0[f]	11.1	10.4[b]	4.1	31.6[b]
WURLD wheat; scarified	10.8	83.0[c]	14.0	971.4[c]	20.0	19.4[a]	20.9	161.4[a]
Pearled wheat; light abrasion, 88% recovery[c]	25.0	191.2[a]	27.4	1896.6[a]	—	—	—	—
Pearled wheat; heavy abrasion, 73% recovery	19.0	145.6[b]	24.8	1718.4[b]	25.6	24.8[a]	34.9	270.0[a]
Checks:								
Gaines variety wheat; whole	23.3	178.4[a]	24.2	1677.6[b]	24.3	23.6[a]	32.8	253.8[a]
White flour; prepared from Gaines variety wheat[c]	1.1	8.4[f]	0	0[g]	—	—	—	—
Bulgur; cracked and unsized	4.1	31.2[e]	3.9	266.8[d]	9.1	8.8[b]	1.2	9.0[c]

[a] % original 800 insects found in each material at end of 7 days.
[b] % total progeny produced.
[c] Small-chamber test not used.
[d] Means followed by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test (Duncan 1955).

times its invasion rate (4857 insects), whereas progenies from the acetic-acid-neutralized and the benzoic-acid-neutralized WURLD wheats were ca. 3½ and 2½ times (1318 and 645 insects) their respective invasion rates. The Gaines wheat control was almost equal to pearled wheat of heavy abrasion in attractiveness to rice weevils, but it was more attractive than cracked bulgur or white flour. The trend of susceptibility of materials in the small glass-covered chambers was similar. Daily distribution counts made in these chambers indicated that rice weevils distributed themselves throughout the materials on the 1st day and maintained the same distribution throughout the observation period. The daily position readings were very similar to the final distribution positions determined at the 7-day removal examination. In both types of chambers, the emergence of progeny from the WURLD wheats neutralized by acetic acid and benzoic acid started several days later than did the progeny emergence from the other materials.

No-Choice Tests.—When insects were caged on samples of the materials, the efficiency of progeny production from each type (Table 3) was very similar to that found in the free-choice tests. The pearled wheats of light and heavy abrasion produced the greatest number of progeny, 6717 and 6465 insects, respectively. They were followed in order by the scarified (4560 insects), acetic-acid-neutralized (3813 insects), and the benzoic-acid-neutralized (2818 insects) WURLD wheats. In comparison, the Gaines wheat and bulgur checks produced progeny numbers of 6099 and 5489, respectively.

Direct Comparison Tests.—In direct-comparison studies, the findings of the distribution studies were confirmed. The most attractive material, pearled wheat of light abrasion, when matched against the next 3 most attractive materials, attracted about the same number of insects in each match (Table 4). It attracted 58.5, 62.3, and 61.6% of the insects when compared with pearled wheat of heavy abrasion, Gaines wheat, and scarified WURLD wheat, respectively. The benzoic-acid-neutralized WURLD wheat was less attractive to the rice weevil (40.1% response) than was acetic-acid-neutralized WURLD wheat (59.9% response). Matching the least attractive wheat product, benzoic-acid-neutralized WURLD wheat, against pearled wheat of light abrasion, emphasized the attraction of pearled wheat. The pearled wheat attracted 85.3% of the test insects.

Table 3.—Progeny from wheat products on which rice weevil adults had been caged for a 7-day ovipositional period; 5 replications of each material with 50 unsexed insects per each replicate.

Materials	No. progeny	Mean[a] (no.)
Experimental:		
WURLD wheat; parboiled, lye-peeled, acetic acid neutralized	3813	762.2
WURLD wheat; parboiled, lye-peeled, benzoic acid neutralized	2818	563.4
WURLD wheat; scarified	4560	912.2
Pearled wheat; light abrasion, 88% recovery	6717	1343.4 a
Pearled wheat; heavy abrasion, 73% recovery	6465	1293.0 a
Checks:		
Gaines variety wheat; whole	6099	1219.8
Bulgur; cracked and unsized	5489	1098.8

[a] Means followed by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test (Duncan 1955).

Table 4.—Preference of rice weevils when exposed to only 2 materials; 4 replicates of 500 insects each for each pairing test.

Materials	% response	Total insecst responding
Pearled wheat; light abrasion, 88% recovery vs.	62.3	1242
Gaines variety wheat	37.7	753
Pearled wheat; light abrasion, 88% recovery vs.	58.5	1160
pearled wheat; heavy abrasion, 73% recovery	41.5	823
Pearled wheat; light abrasion, 88% recovery vs.	61.6	1100
WURLD wheat; scarified	38.4	685
Pearled wheat; light abrasion, 88% recovery vs.	85.3	1543
WURLD wheat; parboiled, lye-peeled, benzoic acid neutralized	14.7	266
WURLD wheat; parboiled, lye-peeled, benzoic acid neutralized vs.	40.1	802
WURLD wheat; parboiled, lye-peeled, acetic acid neutralized	59.9	1198

CONCLUSIONS.—Results of all tests indicated that the experimental materials most consistently attractive to the rice weevil were the pearled wheats. The greatest numbers of progeny also were produced in the pearled wheats.

The parboiled, lye-peeled, WURLD wheats neutralized by either acetic or benzoic acid, were not highly attractive to the rice weevil. Although rice weevil progeny were produced in these materials, they were not produced in great numbers. The low-level attractancy, the delay in the start of progeny emergence compared with emergence in other test materials, and the low level of progeny production, suggest that the nature of the materials affected the ability of the female rice weevil to deposit eggs, or, in instances where successful egg deposition did occur, the ability of the larvae to complete development. It appears that these 2 wheat products, (acetic- and benzoic-acid-neutralized) have considerable resistance to rice weevil attack, a necessary condition in areas where wheat products are an important part of the national diet.

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