SHORT COMMUNICATION

Effects of red versus white wheat bran on rate of growth and feeding of some stored-product beetles

Noel D. G. White, Colin J. Demianyk, and Paul G. Fields

Cereal Research Centre, Agriculture & Agri-Food Canada, 195 Dafoe Road, Winnipeg, Manitoba, Canada R3T 2M9 (e-mail: nwhite@em.agr.ca). *Contribution no. 1751, received 29 July 1999, accepted 4 January 2000.*

White, N. D. G., Demianyk, C. J. and Fields, P. G. 2000. **Effects of red versus white wheat bran on rate of growth and feeding of some stored-product beetles.** Can J. Plant Sci. **80**: 661–663. The red pigment in the seed coat of hard red spring wheat is produced by phenolics. Most of the wheats grown in western Canada are hard red spring varieties; however cultivars with a whiter seed coat are being developed for their better milling and baking attributes. Because phenolics serve to protect some plants against insect attack, we compared the susceptibility of white and red spring wheat to attack by stored-product insects. *Tenebrio molitor* (Tenebrionidae) larvae reared on red wheat bran gained less weight than larvae reared on white wheat bran but this insect has a long developmental period and does not attack sound grain. *Tribolium castaneum* (Tenebrionidae) pupal weights were not affected by the type of wheat milled products on which the larvae fed. A feeding bioassay showed that red bran did not act as an antifeedant for *T. molitor, T. castaneum*, or *Sitophilus oryzae* (Curculionidae). However, it acted as a feeding stimulant for *Rhyzopertha dominica* (Bostrichidae), which is related to wood-boring insects. It is unlikely that white wheat in storage would be more prone to insect damage than red wheat.

Key words: Bran, colour, wheat, phenolics, stored-product insects

White, N. D. G., Demianyk, C. J. et Fields, P. G. 2000. **Influence comparative du son rouge et du son blanc du blé sur le rythme de croissance de certains coléoptères des céréales entreposées et sur les dégâts qu'ils causent.** Can. J. Plant Sci. **80**: 661–663. Le pigment rouge du tégument séminal du blé de printemps roux vitreux est dû à la présence de substances phénoliques. Or la plupart des cultivars de blé utilisés dans l'ouest du Canada sont de ce type. On s'intéresse, cependant, de plus en plus à l'obtention de cultivars à tégument séminal blanc en raison de leurs meilleures propriétés meunières et boulangères. Comme les substances phénoliques leur servent de protection contre les attaques des insectes présents dans certaines espèces végétales, nous avons comparé la sensibilité de blés de printemps à grain blanc et à grain roux aux déprédations des insectes des céréales stockées. Des larves de *Tenebrio molitor* (Tenebrionidés) élevées sur son de blé rouge prenaient moins de poids que celles élevées sur son blanc, mais il faut préciser que cet insecte possède une longue période de différenciation et qu'il n'attaque pas normalement le grain en bon état. Le poids des pupes de *Tribolium castaneum* (Tenebrionidés) était sensiblement le même quel que soit le type de blé des produits de meunerie dont elles se nourrissaient. Une analyse biologique a permis de constater que le son rouge n'agissait pas comme substance antiappétante envers *T. molitor, T. castaneum* ou *Sitophilus oryzae* (Curculionidés). Il avait, toutefois, un effet appétant pour *Rhyzopertha dominica* (Bostrichidés) lequel est apparenté aux insectes xylophages. Il est peu vraisemblable que le blé blanc en stockage soit plus vulnérable aux attaques des insectes que le blé roux.

Mots clés: Son, couleur, blé, substances phénoliques, insectes des céréales stockées

The main pigments in seed coats of hard red spring wheat are phenolics, including an insoluble tannin phlobaphene (Hoseney and Faubion 1992), which is associated with a delay in pre-harvest seed sprouting. The pigment in the bran is produced by two to three genes (Quinby and Martin 1954; Hare 1992). Some phenolics inhibit metabolism when ingested by insects and produce abnormal growth and development (Reese 1979). Some examples include cowpea, which is resistant to *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) (Oigiangbe and Onigbinde 1996) and sorghum, which is resistant to *Sitophilus oryzae* (L.) (Curculionidae) (Ramputh et al. 1999).

The rate of development and pupal weight of insects feeding on bran of red versus white wheat has not been studied. Hard white spring wheats are being developed in Canada for breadmaking. White cultivars have already been produced in many winter wheat lines and in the hard Canadian Prairie Spring (CPS) class of wheat; they are the basis of the Australian wheat production system (Bushuk 1982). Our aim was to determine if the bran of white wheat had a more positive effect on rate of development or food assimilation in stored-product beetles compared with red wheat bran.

Two beetle species that are known to develop and multiply on wheat bran are the yellow mealworm, *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) and the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) (Sinha and Watters 1985).

To assay the effects of white and red bran on development of these beetles, 25 kg each of CPS Biggar (red) and CPS Vista (white) wheat were milled into bran, shorts (a mixture of small pieces of bran and fibrous material), and flour with a Buhler roller mill. Rate of growth was determined on larvae of *T. molitor* and pupae of *T. castaneum* by

Abbreviations: **CPS**, Canadian Prairie Spring

Table 1. *Tenebrio molitor* larval weights (mg, mean ± SEM), when fed only white or red wheat bran at 30°C, 70% RH

		Bran		
Time (d)	Assessment	White	Red	*F*
45	Wet weight	13 ± 1*a*	10 ± 1*a*	2.72 NS
100	Wet weight	88 ± 3*a*	69 ± 4*b*	12.51***
180	Wet weight	211 ± 6*a*	175 ± 8*b*	11.9 ***
180	Dry weight	105 ± 3*a*	86 ± 4*b*	12.1 ***

a, b Means in a row followed by the same letter are not significantly different, at $P \leq 0.05$, based on $n = 25$ Student-Newman-Keuls test with 1,48 df.
***Significant at $P \leq 0.001$; NS, not significant.

weighing before and after oven drying at 70 ± 1°C for 48 h (Campbell and Sinha 1978). Analysis of variance and Student-Newman-Keuls test for means comparisons was used to analyse the data (Sigma Stat 1994).

Tenebrio molitor

Adults of *T. molitor* were placed on commercial enriched wheat flour for 1 to 2 d in petri dishes (16 cm diam. × 4 cm high) at 30°C, and eggs were then collected by sieving through 250 µm aperture screens. White or red bran (0.5 g) were then placed into glass vials (20.6 mm inner diam. × 70 mm high). An individual egg was placed into each vial, which was then covered with a filter paper held in place by a screened, snap-on plastic top and incubated at 30°C and 70% RH. Developing larvae (25 replicates per treatment) were assessed for weight at 45, 100, and 180 d feeding only on white or red bran.

Tenebrio molitor larvae weighed significantly more after feeding on white bran than on red bran for 100 and 180 d (Table 1). One *T. molitor* on the white bran was an adult by 180 d and many were over 2.5 cm long with head capsules 3.5 ± 0.1 mm wide demonstrating that larvae were near or in their last instar (Sinha and Watters 1985). These results indicated that a red seed coat, and the phenolic compounds associated with it, could be a factor in reducing weight gain in this species.

Tribolium castaneum

Eggs of *T. castaneum* were collected in a similar manner and added individually to glass vials containing 0.5 g of one fraction of white or red: bran, shorts, flour, or commercial, enriched wheat flour. The vials (20 per treatment) were incubated at 30 ± 1°C, and 70 ± 2% RH for 21 d and then pupae were collected and weighed on a microbalance.

The age at pupation of *T. castaneum* (20 ± 1 d) and pupal dry weights (843 ± 13 µg, mean ± SEM), were not significantly different regardless of the treatment (seed colour or milled fraction). There were no differences in pupal dry weights among white and red treatments (Table 2).

Feeding Deterence

To determine if differences in weight gain were due to reduced feeding, bioassays (Xie et al. 1996) were conducted on *T. molitor, T. castaneum*, and two seed borers, the rice weevil *S. oryzae* and the lesser grain borer *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae). The bioassays had five replicates with five food disks and 25 adults per replicate, except for *T. molitor*, which had five mid-instar larvae (based on head capsule width) per replicate. Three types of disks were made from unenriched wheat flour without bran, white bran or red bran (the brans were ground to a fine powder in a coffee grinder). After 3 d at 30 ± 1°C and 75 ± 5% RH, the insects were removed and the disks were reweighed.

The feeding bioassays with four beetle species indicated that the tannin is not acting as an antifeedant because bran type did not affect feeding (data not shown). An exception was slight feeding stimulation by red bran on *R. dominica*, a member of a wood-boring family.

These results indicate that phenols in the red seed coat could reduce weight gain for species like *T. monitor* with longer larval stages and larger adult dry weights, 180 d versus 21 d for *T. castaneum* development (Sinha and Watters 1985) and 90 mg (dry weight) versus 1.0 mg (dry weight) for these species, respectively. The larger insects consume much more bran.

Hence, the differences in growth of *T. molitor* may be due to reduced assimilation of food. Based on the response of *T. castaneum*, a typical stored-product beetle in size and developmental time, phenols such as those present in red wheats would not affect most stored-product beetles. Therefore, it is unlikely that white wheat in storage would be more prone to insect damage than red wheat.

We thank Tannis Mayert for technical assistance.

Bushuk, W. 1982. Wheat around the world. Pages 473–530 *in* Grains and oilseeds, handling, marketing, processing. Canadian International Grains Institute, Winnipeg, MB.
Campbell, A. and Sinha, R. N. 1978. Bioenergetics of granivorous beetles, *Cryptolestes ferrugineus* and *Rhyzopertha dominica* (Coleoptera: Cucujidae and Bostrichidae). Can. J. Zool. **56**: 624–633.

Table 2. *Tribolium castaneum* pupal weights (µg) 21 d after egg deposition at 30°C, 70% RH after feeding on various fractions of white or red bran wheat

	Flour		Bran		Shorts		Whole wheat flour	
	White	Red	White	Red	White	Red	White	Red
Wet weights	1877 ± 78	1851 ± 46	1944 ± 119	1956 ± 61	1967 ± 112	1964 ± 96	2123 ± 56	1973 ± 118
Dry weights	828 ± 43*a*	861 ± 14*a*	851 ± 50*a*	848 ± 20*a*	836 ± 55*a*	825 ± 43*a*	944 ± 69*a*	765 ± 56*a*

a Means followed by the same letter are not significantly different, ANOVA: fraction, $F = 0.06$, $P = 0.97$; bran colour, $F = 1.3$, $P = 0.25$; $n = 12$-19. Student-Newman-Keuls test for means comparison.

Hare, R. A. 1992. Anatomical location of inheritance of variegated red seed coat color in hexaploid wheat. Crop Sci. **32**: 115–117.

Hoseney, R. C. and Faubion, J. M. 1992. Physical properties of cereal grains. Pages 1–35 *in* D. B. Sauer, ed. Storage of cereal grains and their products. American Association of Cereal Chemists, St. Paul, MN.

Oigiangbe, N. O. and Onigbinde, A. O. 1996. The association between some physico-chemical characteristics and susceptibility of cowpea (*Vigna unguiculata* (L.) Walp) to *Callosobruchus maculatus* (F.). J. Stored Prod. Res. **32**: 7–11.

Quinby, J. R. and Martin, J. H. 1954. Sorghum improvement. Adv. Agron. **6**: 305–359.

Ramputh, A., Teshome, A., Bergvinson, D. J., Nozzolillo, C. and Arnason, J. T. 1999. Soluble phenolic content as an indicator of sorghum grain resistance to *Sitophilus oryzae* (Coleoptera: Curculionidae). J. Stored Prod. Res. **35**: 57–64.

Reese, J. C. 1979. Interactions of allelochemicals with nutrients in herbivore food. Pages 309–330 *in* G. A. Rosenthal and D. H. Janzen, eds. Herbivores: Their interaction with secondary plant metabolites. Academic Press, Inc., New York, NY.

Sigma Stat. 1994. User's manual. Jandel Scientific. San Rafael, CA. 741 pp.

Sinha, R. N. and Watters, F. L. 1985. Insect pests of flour mills, grain elevators, and feed mills and their control. Agriculture Canada, Supply and Services Canada, Ottawa, ON. Publication 1776, 290 pp.

Xie, Y. S., Bodnaryk, R. and Fields, P. G. 1996. A rapid and simple flour disk bioassay for testing natural substances active against stored-product insects. Can. Entomol. **128**: 865–875.