# DEVELOPMENT, RELATIVE RETENTION, AND PRODUCTIVITY OF RED FLOUR BEETLE ON RESISTANT STARCHES

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The development, relative retention, and fecundity of the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), on six different types of starches, flour, and flour plus yeast was investigated in the laboratory. The resistant starches used included: Amioca (waxy cornstarch, 98% amylopectin), Fibersym RW (70% total dietary fiber), Hylon VII (corn starch 70% amylose), Melojel (normal corn starch), Midsol 50 (wheat starch, 25% amylase), and potato starch (12-20% amylase). The particle size distribution of the six starches and flour was characterized. The viability of *T. castaneum* eggs was checked initially by placing 100 eggs in 9-cm diameter glass Petri dishes. The dishes with eggs were placed in the growth chamber at 28ºC and 65% RH. There were 10 dishes. Dishes were examined daily and the number of eggs that hatched out of 100 were counted and expressed as a percentage

**Protocols for measuring development**

About 5 g of each starch, flour, flour plus yeast (5% by wt) were taken individually in 30-ml plastic condiment cups. Eggs of T. castaneum were collected by placing 50 adults in flour sifted through a U.S. Standard Sieve No. 60. After 3 days the flour was sifted through the same sieve to retain eggs on top of the sieve. Into each cup, 50 eggs were added. Al l cups were placed in a growth chamber at 28ºC and 65% RH. Every 3 days three cups were removed and the length of 10 larvae were measured for 30 days (10 measurements over time). The head capsule widths of larvae in the cups were also measured. Larval weight was measured on a Mettler® balance by pooling all larvae in the three cups. Data were also collected on number of larvae surviving over time in the cups, and independent cups were examined over time.

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## Protocols for evaluating adult retention on starches

Circular arenas measuring 30 cm in diameter and 8 cm in height were constructed out of cardboard to study the relative retention of *T. castaneum* on resistant starches and flour. In each arena, one starch (2.5 g) and flour (2.5 g) were offered to adults in these dual-choice tests. The location of starch and flour was decided based on a coin toss. Exactly 50 unsexed adults of *T. castaneum* were released in the center of the arena. Arenas were then covered with a lid and kept at room conditions in the laboratory. Temperature and humidity of the room were measured using HOBO® data loggers. Four separate areas were used for four observation times: 36 h, 48 h, 60 h, and 72 h, and these experiments were replicated three times with each of the starches. The number of *T. castaneum* adults that were retained in starches or flour at the specified observation times were counted by sifting the starches or flour.

## Protocols for evaluating fecundity

Male and female pupae of *T. castaneum* were identified and placed in 9-cm glass Petri dishes at 28ºC and 65% RH until they reached the adult stage. After adults emerged, one male and one female were paired and placed on 2.5 g of a starch in individual 30-ml plastic condiment cups. The control treatment consisted of flour infested with a pair of adults. Every three days the adults were gently separated from the starches or flour and moved to new cups containing fresh 2.5 g of starches or flour. This experiment was replicated 10 times. The number of eggs laid in starches and flour were counted for up to two weeks. The eggs laid in two weeks in starches versus the flour were compared statistically using Ryan-Einot-Garbriel multiple comparison test at $\alpha = 0.05$.

## Results and conclusions

Results from the developmental studies showed that the larval length and head capsule width of *T. castaneum* reared on starches were smaller when compared with larvae reared on flour and flour plus yeast (Figure 1). The development was faster on flour plus yeast when compared with flour alone. Weight gain of larvae reared on resistant starches was also

appreciably less than those reared on flour or flour plus yeast. Larval mortality was high on all starches compared with flour and flour plus yeast. On Fibersym RW and potato starch mortality increased from 22.0% on day 9, to 100% on day 15, and from 37% on day 9, to 100% on day 21, respectively. These results suggest that resistant starches hindered *T. castaneum* development. The particle size of starches used in this research was between 15 µm to 58 µm, compared to 133 µm for flour. This indicates particle size was not a limiting factor for *T. castaneum* to digest the starch. The obstruction was either the lack of proteins and lipids in pure starches or the resistance of starches to enzymatic hydrolysis or both. Adults of *T. castaneum* did not show any preference of flour over starches in the arena tests. This indicated that the relative retention of adults in starch and flour was similar at all observation times. Interestingly, the number of eggs laid on starches during the two weeks varied from 0.1±0.1 per female to 2.6±0.5 per female, while it was 97.3±6.9 per female on flour and 108.7±5.7 per female on flour plus yeast diet. These results suggest that starches may have potential in managing the development and reproduction of *T. castaneum*—a pest that is common and severe in food-processing facilities.

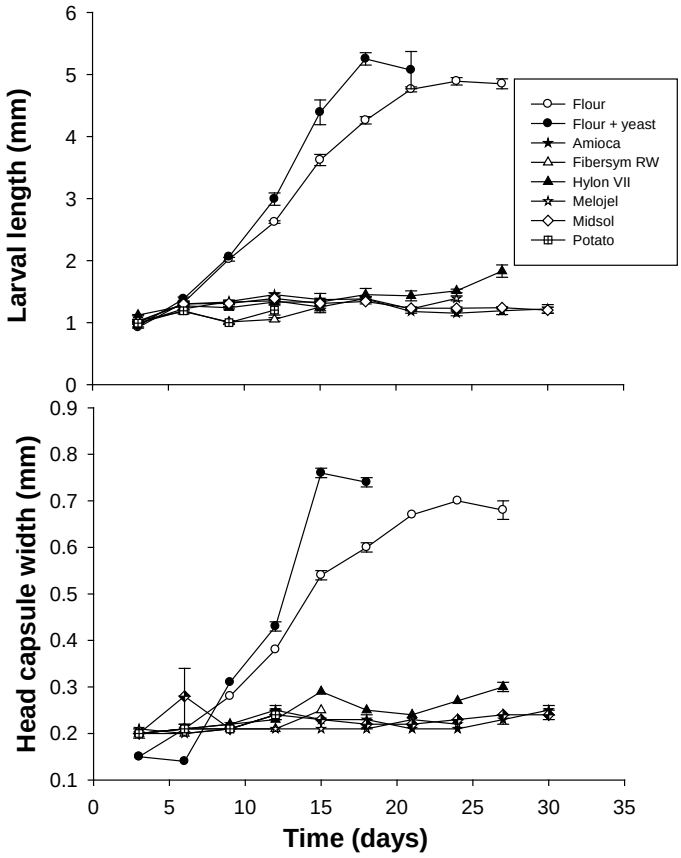


Figure 1. Development of *T. castaneum* larvae on starches and flour.