Keeping Insects Out of Flour

KSU tests ability of meshes to exclude flour beetle larvae

Red and confused flour beetles are common grain storage pests that prefer the fine particulates of milled grain, such as wheat flour. They can be present throughout the mill flow. These pests are most dreaded by millers, and mill fumigations and heat treatments are directed to manage these pests.

Pest Management

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To complement external insecticide inputs—such as crack/crevice treatments, fogging, fumigation, or heat treatment—practices such as sanitation and exclusion tactics are used to manage flour beetles.

Exclusion tactics are designed to prevent insects from entering a facility or entering the product stream. Preventing entry to the mill is accomplished by closing doors and windows and using plastic strips or air curtains. Preventing entry to the product stream is accomplished by use of sieves with specific mesh sizes to prevent insect eggs, larvae, and adults from ending up in the milled product.

However, very little research has been done in this area, because in my opinion, there are sieves of different sizes used throughout the mill flow, and the primary purpose is for particle size reduction, with the secondary purpose being for insect exclusion.

Figure 1: *PVC cylinders used in laboratory tests.*

Mesh Sieve Experiment

In 2006, my graduate students conducted laboratory experiments looking at the ability of sieves of 150 and 180 micrometer mesh size to exclude young larvae (larvae that hatch from eggs) under static and dynamic (moving) conditions.

In this article, I report findings on how the experiments were done and what we observed. Some of these findings can be extrapolated to sieves of different mesh sizes currently used in the milling process.

Insects used in tests were obtained from colonies established by the Stored Product Entomology Research and Education Laboratory in the Department of Grain Science and Industry, Kansas State University, Manhattan.

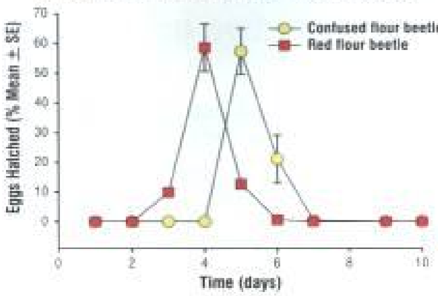
The species included in the tests were red flour beetle and confused flour beetle. Both of these species are commonly associated with flour mills worldwide.

Sieves were glued between two equal halves of PVC cylinders of 4 cm internal diameter, so that the total height of the PVC cylinder was 10 cm (see **Figure 1**).

Eight PVC cylinders were fitted with a 150-micrometer sieve and eight with a 180-micrometer sieve.

Four sieves of each mesh size were designated for red flour beetles and four for confused flour beetles. Exactly 60 eggs of each species laid within 24 hours of pairing were added to separate rings above the sieve of each ring.

Figure 2. Viability of flour beetle eggs



Each sieve had a plastic Petri dish at the bottom to collect larvae that passed through the mesh. To minimize contamination and escapes, a Petri dish was placed on top of each ring. Cylinders were placed on a tray and incubated at 27 degrees C and 56.7 ± 4.6% relative humidity.

The hatchability of eggs of red and confused flour beetles is shown in **Figure 2** above. Petri dishes were checked daily from egg hatch to count the number of larvae that were able to fall through

> "In the laboratory, we were interested in the ability of sieves of 150- and 180-micrometer mesh size to exclude young larvae (larvae that hatch from eggs) under static and dynamic (moving) conditions."

the sieve (see **Figure 3** on page 40).

Larvae that passed through the mesh were killed and saved in ethyl alcohol to measure the body length and width of the head capsule.

In addition to the exclusion tests with PVC cylinders, we used the same sieves in sieve frames and tried lateral and centrifugal motions to simulate real-world conditions to determine if the newly-hatched larvae were able to fall through the sieve openings. The 150 to 180 micrometer sieves were stapled to wooden frames.

One hundred newly-hatched larvae of red or confused flour beetles were added to 20 g of whole-wheat flour.

An additional 80 g of flour was added on top of the larvae. The jar was sealed and shaken gently to distribute the larvae among the flour evenly.

To agitate the flour/larvae mixture laterally, we utilized a strand-size shaker (Seedburo Equipment Co., Chicago, IL) set at 100 counts (68 rotations per minute).

Once the sieve and collection trays were secure, the jar of flour/larvae was poured onto the sieve. The shaker ran for 4.4-minute intervals (three sets of 100 counts).

At the end of the first interval, we collected the sample that passed through the mesh into the collection tray and put it in the incubator for later analysis.

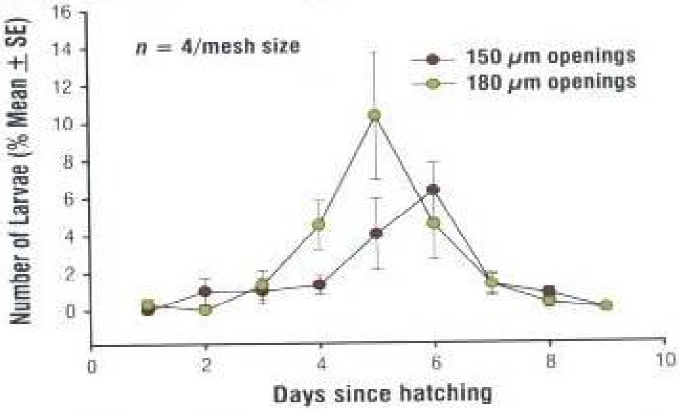
We repeated the process with what remained on top of the sieve three more times, for a cumulative total of 17.6 minutes, with samples collected every 4.4 minutes. This process was replicated two times.

Each 4.4-minute increment sample was analyzed for larvae under a microscope.

In addition, we searched for the larvae in the flour that did not ►

Figure 3: Newly-hatched larva squeezing through the 150 micrometer mesh.

Figure 4. Number of red flour beetle larvae that passed through the two mesh sizes



pass through the mesh within 17.6 minutes, to assess recovery (loss of larvae).

To test centrifugal motion, 60 newly-hatched larvae were added to 5 g of whole-wheat flour. The jar was sealed and shaken gently.

Due to the amount of time necessary to analyze large samples of flour, the number of larvae and amount of flour were reduced from the amount used in the lateral motion trial. Using a laboratory box sifter (Great Western Mfg., Leavenworth, KS) set at 263 rotations per minute, the flour plus larvae were sifted centrifugally.

The sieve drawer was loaded with the appropriate sieve with a collection tray below it. The jar contents were poured into the shaker, and the lid was sealed shut. Agitation took place for 2.5 minutes.

Once the run was finished, we collected the sample that passed through the mesh into the collection tray and analyzed it for larvae the same day under a microscope.

In addition, we searched for the larvae in the flour that did not pass through the mesh. This process was repeated three times.

Results

Newly-hatched flour beetle larvae are able to pass through both sizes of mesh (**Figures 4 and 5**). ►

After 14 days of incubation, 24.5% of red flour beetle eggs hatched and passed through the 150 micrometer sieve.

Of the confused flour beetle eggs, 14% hatched and passed through the 150-micrometer sieve.

On the 180 micrometer sieve, 35% of red flour beetle eggs hatched and passed through the mesh, while 38.7% of confused flour beetle eggs hatched and passed through it.

The highest number of larvae that passed through the mesh was consistently on the fifth day, because this was related to when most larvae hatched.

The mean body length of larvae ranged from 0.08 to 0.13 mm, regardless of the amount of time that passed since hatching, the species, or the mesh size. The head capsule width ranged from 0.01 to 0.02 mm (data not shown).

Red flour beetle and confused flour beetle larvae were unable to pass through both sizes of mesh, regardless of the type of agitation or 2.5 minutes of centrifugal agitation, regardless of mesh size or species.

Conclusions

Red flour beetles were passed through both mesh sizes successfully.

More larvae were able to pass through 180 micron size sieve than 150 micron size sieve.

More confused flour beetle larvae were able to pass throug[illegible]0 mesh than red flour beetle, yet there was no difference between species for the 150 mesh.

This is probably due to a higher survival rate of eggs and larvae.

The recovery rate was not 100% for either motion test.

When agitated laterally, only 405 to 70% of red flour beetle larvae were recovered; 405 to 90% of red flour beetle larvae were recovered.

The lateral agitation test was not run with the confused flour beetle larvae. These numbers imply that some larvae could not be recovered.

Due to the small size of the larvae and the nature of flour, it is likely that some larvae were stuck between the grooves of the sieve frame.

The complete lack of any larvae in any of the samples that passed through the mesh indicates that the unrecovered larvae could not pass through the mesh.

These results confirm that the 150- and 180-micrometer sieves will allow newly-hatched larvae of red and confused flour beetles to pass through them under static, but not under dynamic conditions.

Additional studies are needed to examine the role of sieves in mills for excluding various life stages of insect species.

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Figure 5. Number of confused flour beetle larvae that passed through two mesh sizes