Penetration of Packaging Films

film materials used for food packaging tested for resistance to some common stored-product insects

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Laminated film package showing penetration by the cadelle.

A nontransparent laminated film containing aluminum foil proved relatively resistant to insect penetration—but not insect proof—in tests of film materials used for packaging dried fruits, nuts, candies, cereals, grains, meats, cheese, and other food products.

In two series of tests, 14 different packaging films were used with 11 species of common stored-product insects: the cadelle, confused flour beetle, dermestid beetle, drugstore beetle, German cockroach, granary weevil, Indianmeal moth, lesser grain borer, Mediterranean flour moth, rice weevil, and sawtoothed grain beetle.

In one series of tests, the packaging films were made up into bags 3″ by 5″ in size, then filled with walnut meats and sealed according to standard commercial practices. Two or three bags of each film type were placed in a 50-pound-capacity lard can on top of approximately 3″ of the culture media, in which the various insect species were reared. A 4½″ hole in the lard-can lid was covered with a fine mesh wire screen. The film bags were examined for insect penetration at weekly intervals. The tests were usually terminated at the end of eight weeks but some were continued for 11 weeks. At the termination of a test, a new series of cultures was started and the entire test was repeated.

Packages were considered to be penetrated only if the insect actually chewed through the film. If insects obtained access into the package through a small tear or through a poor seal, the package was discarded.

Packaging films used in these experiments were of five groups or types, as follows:

1. Cellophane:
   - *a*, 300 MST, 0.0009″ thick
   - *b*, 450 MST, 0.0014″ thick
   - *c*, 600 MST, 0.0016″ thick
2. Polyethylene film:
   - *a*, 0.0015″ thick
   - *b*, 0.002″ thick
   - *c*, 0.004″ thick
3. Saran film:
   - *a*, 0.0015″ thick
   - *b*, 0.002″ thick
4. Pliofilm, 0.0014″ thick
5. Laminated film:

a, Tritect, 0.0029″ thick—two layers of 300 MST cellophane, with a wax film between.

b, K-202, 0.0014″ thick—450 MST cellophane, with saran coating 0.00005″ thick on each side.

c, Saran—0.0015″ thick—plus pliofilm—0.0012″ thick.

d, Polyethylene—0.001″ thick—plus aluminum foil—0.001″ thick.

e, Pliofilm—0.0008″ thick—plus aluminum foil—0.001″ thick—plus acetate—0.001″ thick.

In the laminated film packages, the thermoplastic materials, such as cellophane, polyethylene, and pliofilm, are generally on the inside in order to heat-seal the closures.

In the second series of tests, two small plastic cups with screw-type plastic lids were used. A hole 2″ in diameter was cut in the lid of each cup. A small amount of food was placed in one cup and 50 adult insects of the species being tested were placed in the other cup. A small piece of film was then placed over the lid of the first cup, and the second cup was inverted against the film. The two cups, with the film between, were held tightly together by three spring-type clips. The 50 insects in the top cup walked around on the film and either chewed through the film to reach the food or eventually died of starvation. The films were checked daily for insect penetration. In general, the length of time the insects lived in the absence of food determined the duration of the tests, which in most cases was approximately a week, but a few species survived longer than two weeks.

More than 70% of the cellophane packages used in the lard-can series of tests were penetrated by one or more stages of 10 species of insects tested, regardless of the thickness of the film under test.

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PENETRATION

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The saw-toothed grain beetle was the only insect of those tested that did not penetrate any of the cellophane packages. The granary weevil, dermestid beetle, cadelle, and lesser grain borer penetrated all the cellophane packages exposed to these insects; and the drugstore beetle, confused flour beetle, and German cockroach penetrated more than 80% of the cellophane packages exposed to these insects.

Resistance of the polyethylene films to insect penetration increased with increase in thickness of the film. In these tests, the saw-toothed grain beetle and dermestid beetle were the only two insects that did not penetrate any of the polyethylene packages. The lesser grain borer and cadelle were the only species that penetrated the 0.004″-thick polyethylene packages. The 0.0015″-thick polyethylene package appeared to be more resistant to insect penetration than the 0.0016″-thick cellophane.

There was very little difference in insect penetration of the 0.0015″-thick and the 0.002″-thick saran packaging films. The German cockroach, Mediterranean flour moth, and saw-toothed grain beetle did not penetrate any of the saran packages, but all the saran packages exposed to the lesser grain borer and cadelle were penetrated.

Packages made of pliofilm were similar to those of saran in their ability to resist penetration by the insects tested. The German cockroach, saw-toothed grain beetle, and confused flour beetle did not penetrate any of the pliofilm packages, whereas the lesser grain borer and the cadelle penetrated all the pliofilm packages.

Of all the packaging material tested, the nontransparent aluminum foil laminations of either polyethylene or pliofilm appeared to be the ones most resistant to insect penetration. The cadelle penetrated all packages of laminated film consisting of polyethylene—0.001″ thick, plus aluminum foil 0.001″ thick—while the dermestid beetle penetrated only a single package of this lamination. None of the packages of laminated film consisting of pliofilm—0.0008″ thick, plus aluminum foil, 0.001″ thick, plus acetate, 0.001″ thick—were penetrated by the insects tested.

Cup-test apparatus in operation.

The variation in penetration time was great, a given insect species varying as much as six to seven weeks in time required to penetrate the same material in the same culture.

The saw-toothed grain beetle, a common stored-product insect, penetrated only 1.8% of the packages exposed to it, while the lesser grain borer penetrated 82.4%, and the cadelle 75.0% of the packages. The lesser grain borer penetrated some or all the packages of all materials except the aluminum-foil laminations. This insect also required less average time to penetrate the packages than did any of the other species tested. Those insects commonly found in warehouses, grocery stores, and households, such as the Indian-meal moth, Mediterranean flour moth, confused flour beetle, and drugstore beetle penetrated from 25% to 44% of the packages consisting mostly of the cellophane and 0.0015″-thick polyethylene films.

Results of the cup test corroborated those of the lard-can or package tests, although there are some differences, probably because only adult insects were used in the cup tests, whereas adults and larvae or nymphs were used in the package tests.

Of the transparent laminated films tested, that consisting of saran 0.0015″ thick and pliofilm 0.0012″ thick was the one most resistant to insect penetration.

Cellophane films, single and laminated, were readily penetrated by most insects tested.

The resistance of polyethylene film to insect penetration varied directly with film thickness.

Of the insects tested, the lesser grain borer and the cadelle appeared to be the best penetrators of packaging films; the saw-toothed grain beetle appeared to be the one least able to penetrate the materials tested.

The ability of some insect species to penetrate packaging materials depended upon the stage of the insect—adult, larvae, or nymph—because, for example, the adults of the Indian-meal moth do not have chewing mouth parts, so it is the larvae that do the penetrating.

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Cellophane packages of walnut meats showing penetration by larvae of the Indian-meal moth.