THE USE OF CHEMICALS IN PROCESSING AND PACKAGING OF STORED PRODUCTS TO PREVENT INFESTATION

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ABSTRACT: Judiciously applied insecticides and repellents have been shown to provide, excellent protection from infestation by stored-product insects. Such chemical treatments should have little impact on the environment, are relatively nonhazardous when properly used, and protect the stored products after the costs of growing, of processing, and of distribution have been incurred. Spot treatments with liquid fumigants and crack and crevice surface treatments are available to eliminate existing infestations in processing areas and equipment. When added to flour or CSM (a high protein processed cereal), tricalcium phosphate (a food additive) will prevent the occurrence of large insect populations; DDT, Gardona(R), and chlordane on rubberized horsehair packing prevent attack by black carpet beetles. The liquid fumigants ethyl formate and methyl formate are used on raisins and currants. Malathion-treated paper raisin trays are used to prevent field infestation of natural raisins. Insect-resistant packages prevent infestation from packing plant to consumer. Pyrethrins synergized with piperonyl butoxide are approved for use on multiwall paper or cotton shipping sacks and on polyethylene-cellophane laminate for dried prune pouches. Promising potential new treatments include synthetic pyrethroids, anti-feeding compounds, silica gel, and carbaryl. Insecticide barriers in packages may be required to prevent migration of the insecticide into the commodity.

This report is concerned with chemicals used in food processing areas and in or on food packages to protect various commodities from contamination by stored-product insects. The treatment of storage areas for either bulk or packaged food by fumigants, residual treatments, or space treatments is excluded. Furthermore, most of this information is based on present practices and regulations in use in the United States; though many of these practices would be acceptable in most parts of the world.

Pesticides used in processing and packaging food and other infestible items such as feed, seed, and fiber must be applied in very restricted areas using closely controlled procedures. Therefore, these procedures can provide a very favorable cost-benefit ratio in terms of their impact on the environment, as is apparent when one compares these procedures with those used to control such insects as mosquitoes, field-crop insects, and forest insects. Nevertheless, the spatial and temporal proximity of the chemicals to products that are destined for human consumption makes this use of pesticides relatively hazardous because accidental contamination could result in unacceptable residues. These factors must be weighed against the benefits of protecting the commodity from infestation when a commodity has incurred the full cost of growing, harvesting, shipping, storing, and processing. To this we must then add the costs of packing, shipping, storing, and distributing the packaged commodities. It becomes obvious that to achieve the desired protection without objectionable residues, chemicals must be used judiciously, at minimum dosages, and with all available expertise.

USE OF CHEMICALS IN PROCESSING: In Food Packing Plants - Spot treatments with fumigants and localized "crack and crevice" treatments are used in food packing and processing facilities. Space treatments that involve dispensing a mist spray, fog, or vapor throughout the area are generally less favored because of the increased chances of contamination of food, packages, or processing equipment. However, pyrethrins synergized with piperonyl butoxide is approved for space treatments in food processing plants in the United States [1] provided that all food is removed or covered prior to treatments.

Spot treatments, usually with liquid fumigants, are used to periodically fumigate food-processing equipment where contamination and safety hazards can be kept to a minimum. Up to a 24-hour exposure period is required; therefore, this type of treatment is usually applied when the plant is not in operation and is empty of people. Recommended fumigants have included combinations of acrylonitrile+carbon tetrachloride; ethylene dibromide+ethylene dichloride+carbon tetrachloride; ethylene dichloride+carbon tetrachloride; ethylene dibromide+methyl bromide; and chloropicrin alone [2]. In the United States, carbon disulfide, carbon tetrachloride, ethylene dibromide, ethylene dichloride, and methyl bromide may be used to fumigate grain-mill machinery. However, because ethylene dibromide has been implicated in reduced fertility in chickens [3] and bulls [4], this and other similar fumigants must be used with extreme care.

Localized "crack and crevice" treatments have been approved in the United States. Insecticides are applied in small quantities into areas where insects may hide or enter the building such as expansion joints and between equipment and floors. The following insecticides were provisionally approved for this use: borax, boric,acid, carbaryl, chlordane, chlorpyrifos, dichlorvos, trichlorfon, diazinon, fenthion, malathion, propoxur, N-octylbicycloheptenedicarboximide, (MGK 264, also identified as N-(2-ethyl hexyl)-5-morbornene-2,3-dicarboximide), piperonyl butoxide, pyrethrins, ronnel, and silica gel. Final approval is granted upon submission of satisfactory evidence that unacceptable residues do not occur [5].

In Processed Commodities - The use of insecticidal or repellent chemicals in processed commodities is necessarily severely restricted because of the potential health hazards involved. Consequently, chemicals are used only when the treatment results in very low residues, in the case of foods, or on nonfood commodities where the presence of residues presents no hazards to health.

Tricalcium phosphate, a mineral food additive and flour conditioner, has been shown to reduce the survival of insects in flour [6]. In a large-scale shipping and storage test, tricalcium phosphate prevented the occurrence of large insect populations in both flour and CSM, a high-protein corn cereal blend [7].

Ethyl formate and methyl formate have been used to fumigate dried beans and cowpeas. Procedures and equipment were developed to apply small quantities of the liquid fumigant directly into packages just before the packages were closed and sealed [8]. This procedure is no longer used in the United States; however, both ethyl formate and methyl formate are registered for use as fumigants for packaged raisins and currants [9].

USE OF CHEMICALS ON PACKAGING: Although malathion-treated raisin trays are not packages in the strictest sense, they are used as containers while the grapes dry in the sun [10]. The paper trays are treated with 100 mg. of malathion per square foot to prevent in-field infestation by numerous insect species, principally *Drosophila* spp., *Carpophilus* spp., *Oryzaephilus* spp., *Cadra figuliella* (Gregson), and *Plodia interpunctella* (Hubner). The raisins remain on the treated paper trays for about 3 weeks, during which time infestation by insects is prevented by the malathion treatment. The raisins absorb some malathion but notenough to exceed the 12 p.p.m. that is allowed on processed ready-to-eat raisins.

Packages that are chemically treated and adequately constructed to resist insect infestations are becoming increasingly important in today's world of food shortages, rising costs to consumers, increasingly stringent sanitation regulations, and consumer rejection of infested foods. Even though the food processor may follow all necessary procedures to avoid insect contamination of his product, he may have little control over conditions encountered after the product leaves his plant. Packaged foods may be exposed to insect infestation in railcards or trucks, during central warehouse storage, on ships, in outlying warehouses, and in retail outlets. Insect-resistant packages can protect foods from infestation in all of these shipping and storage situations.

There are two important prerequisities for the manufacture of insect-resistant packages. First, the package must be constructed so as to prevent the entrance of insects through seams, closures, the weave of fabric, or any other opening through which the insect can crawl or oviposit [11,12]. Second, because some insects can bore through almost any flexible packaging material in use today [13,14,15], the package must be chemically treated to prevent these insects from boring into the package.

The use of chemicals on food packages can result in contamination of the product. Insecticides or repellents used on packages can migrate from the treated surface through the package walls and into the commodity [16,17]. This migration can be reduced or prevented by the use of barrier plies positioned between the insecticide-treated ply and the packaged commodity. Highland et al. [17] found that 4 plies of kraft paper prevented the occurrence of unacceptable levels of piperonyl butoxide in cornmeal, flour, rice, and beans stored in treated bags. Saran-coated paper and greaseproof paper [18,19] were also found to be effective barriers to the migration of piperonyl butoxide. Highland et al. [20] also found that the copolymer ethylene vinyl acetate in a coating that contained synergized pyrethrins reduced the movement of piperonyl butoxide into the packaged food.

Insecticides such as malathion, DDT, dieldrin, trichlorphon, dichlorvos [21], lindane, and aldrin [22] have been evaluated to develop insect-resistant treatments for food and feed packages. Many of the attempts met with only limited success because of the failure of researchers to utilize insect-tight constructions. Also it was found that the chemicals migrated from the treated package into the contents, producing residues that in many cases were unacceptable.

In the United States [23,24] and in England much of the early work on insect-resistant packaging was done with the so called safe insecticides and synergists--methoxychlor, pyrethrins, allethrin, piperonyl butoxide, sulfoxide, and similar materials. More recently other compounds have been tested successfully on a laboratory scale. These include synthetic pyrethroids [25], an experimental antifeeding compound [26], an inert silica gel [27], and carbaryl [28,29].

In the United States only pyrethrins synergized with piperonyl butoxide is registered for use as an insect-resistant package treatment. The insecticide combination must not exceed 6 mg. of pyrethrins and 60 mg. of piperonyl butoxide per square foot on the outer surface of multiwall paper on 5.5 mg. of pyrethrins and 55 mg. of piperonyl butoxide per square foot on the outer surface of cotton bags. All bags must contain at least 50 pounds of dry cereal products. The cotton bags must have an inner waxed paper liner, and the product must contain no more than 4 percent fat [30].

Official approval has been obtained for the use of a treated cellophane-polyethylene film laminate to protect dried prunes from infestation [31]. The pyrethrins and piperonyl butoxide are applied in the laminating adhesive at the rate of 10 and 50 mg. per square foot, respectively. These heat-sealed, treated packages must contain at least 2 pounds of prunes.

Recently Highland (unpublished data) found that paper-foil-polyolefin laminated pouches treated with synergized pyrethrins protected cocoa powder from infestation by *Trogoderma variabilr* Bsllion and by mixed populations of other common stored-product insects. Foil-wrapped meat cubes have been protected from infestations of *Ptinus tectus*, Boieldiew (=*Ptinus ocellus* Brown in U.S.), *Stegobium paniceum* (L.), *Dermestes lardarius* L., and *Tribolium confusum*

Jacquelin du Val, by packing them in synergized pyrethrins-treated cartons [32].

Mallis et al. [33] recommended a mixture of 1,5a,6,9,9a, 9b-hexahydro-4a(4H)-dibenzofurancarboxaldehyde (Repellent mixture R-11) and N-(2-ethylhexyl)-5-norbornene-2,3-dicarboximide (MGK 264) sprayed on corrugated shipping cases to prevent cockroaches from infesting beer cases. Because these shipping cases are not tightly sealed to prevent the entrance of cockroaches, prevention of infestation is entirely dependent upon the repellent activity of the chemicals.

The development of pesticides and pesticide formulations for use in processing and packaging is inherently slow and difficult. Legal limitations resulting from possible health hazards and effects on the environment are some of the contributing factors. Also, pesticide manufacturers and formulators often cannot profitably assume the task of developing pesticides for these uses because of relatively small potential sales volume. However, if we are to conserve food, reduce costs, and maintain or raise sanitation standards, it is essential that we have the proper tools at hand. Among these tools are pesticides for use in food processing and packaging.

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