

Literature

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10 - Physical control of stored product insects

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Abstract

Given the declining number of chemical agents for pest control, non-chemical methods gain importance in stored product Integrated Pest Management. Physical methods play an important role not only in pest control, but also in pest prevention (e.g. product cooling, drying, insect-proof storage and packaging) and pest monitoring (e.g. measurement of temperature, product density, movement or bioacoustics). In pest control, heat disinfestation has become an established method for empty structures. A difficulty is that insulators such as large amounts of flour, dust or bag stacks with products need to be removed prior to treatment. Freezing at temperatures of minus 18°C is a method to disinfest high-value products without the risk of deteriorating product quality. However, energy costs may be the limiting factor. For fine and powdery goods such as flour, sieving and milling is the only choice because just mechanical methods can lead to effective pest control in this substrate. In future, processing steps leading to pest control (e.g. heating, milling, extrusion) should be combined with pest exclusion, ventilation and temperature management in order to keep product quality high and pest control efforts at a minimum.

Key words: control, heat, cold, impact, sieving

Introduction

In the last decades, chemical means of pest control in bulk products have been the most important methods of pest control. However, the development of resistance is a threat to phosphine fumigation in grain. Recently, dichlorvos (DDVP) used in insecticidal fogs and evaporation strips was banned by the European Union due to the wish to reduce residue levels on treated products. Furthermore, new concerns on fluoride residues prompted the European Union to reduce the tolerated maximum residue levels in nuts, grain and grain products and dried fruits which reduced the availability of sulfuryl fluoride in stored product protection mainly to structural treatments. Because stored product protection is a rather small market for pesticides with stiff requirements regarding workers safety and residue levels, a significant increase in chemicals available for this purpose seems not probable in the near future. The lack of chemical means of pest control increases the need to prevent and detect pests and renders non-chemical methods of pest control more attractive.

Physical methods to prevent or detect infestation: Physical methods are important means to prevent, detect and control stored product pest within the concept of Integrated Pest Management (IPM) and Integrated Stored Product Protection (see fig. 1). If one thinks of staple food such as grains or pulses, cleaning, drying, and cooling are physical processes essential to keep a durable product in good quality during prolonged storage periods (Vincent et al. 2002). The drying process could be utilized to control pest arthropods that may have found their way into the grains provided that a uniform temperature above some 55°C is achieved for 60 min or 60°C for about one minute. Cooling to temperatures below 13°C prevents insect development and is thus another method to provide safe storage conditions (Fields 1992). This method is used for grain storage not only by organic farmers and its importance may increase due to the loss of dichlorvos emitting strips for stored product moth control in 2007.

Insect-proof or hermetic storage structures or enclosures prevent the immigration of pests and thus could reduce efforts for pest control provided the stored goods are free of living insects at the time of reception. Insect-proof packaging is the only means of pest prevention on the way from processing to consumption, and e.g. some chocolate bar producers have improved the quality of their packages in recent years changing from a wrap with aluminium foil and paper to a gas-tightly sealed plastic film. A recent test of different packaging films to the attack by various stored product insects was published by Riudavets et al. (2007).

For pest monitoring and detection, thermometers are used widely in commercial bulk grain storages to detect heat produced by metabolic activity. Further physical parameters that could be used for pest detection are product moisture content, and movement. In rice grains, optic systems using the NIR spectra are used to remove discoloured

kernels from the bulk with the darkening of kernels corresponding to fungal infestation and increased levels of mycotoxins. In some cases, bioacoustics are utilised to detect feeding larvae hidden in grain or adults moving in dry and hard bulk goods (Welp and Reichmuth 1994, Hagstrum et al. 1996).

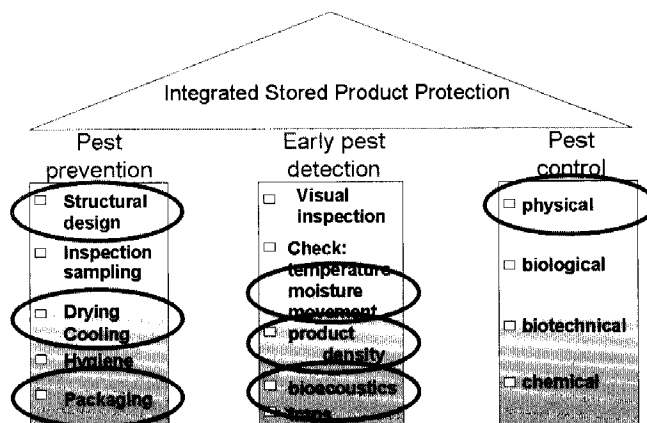


Fig. 1 Physical methods to prevent detect and control stored product pests within the frame of Integrated Stored Product Protection

Physical methods are also applicable for the control of pests. Generally, extreme temperatures and mechanical methods are used for pest control at present. A vacuum can be applied to products packed into a flexible structure in order to remove oxygen from the inter-granular space. Especially at higher product temperatures this can lead to fast and reliable pest control as reported from cocoa storage (Finkelman et al. 2003). On the other hand CO₂ can be applied in pressure chambers at high pressures of up to 35 bar in order to achieve rapid control of stored product insects in exposure times of a few hours. Of the almost 7000 t of inert gases used in 2006 for stored product protection in Germany (BVL, see table 1) the majority probably was carbon dioxide used at high pressure for the treatment of products such as herbs, teas, medical drugs, spices, dried fruits, nuts and breakfast cereals.

Heat for structural treatment: Another method that has gained importance in industrialised countries in recent years is the heat treatment of empty structures (Beckett et al. 2007). The high temperatures needed for pest control can be achieved by burning oil or gas and fanning the heated air into a building from outside through air ducts. Another method is the recirculation of air within a building and heating with mobile electrical heaters (Hofmeir 2000). High temperatures above some 50°C need to be achieved in all parts of a building and a thorough vertical and horizontal air circulation during the treatment is essential for the even distribution of temperatures. Insulation material such as corrugated cardboard or large amounts of grain, dust or flour need to be removed prior to a heat treatment because insects would find a safe refuge from where to re-infest a structure after the treatment (Adler 2006). Heat was also tested successfully by the tobacco industry for the disinfection of cigarette producing machines (unpublished data).

A combination of heat and controlled atmospheres is tested for the large scale treatment of tobacco in the countries of origin and for the treatment of medical herbs and spices in Germany as an alternative to carbon dioxide at high pressure or phosphine fumigation.

Cold for product treatment: Some companies apply freezing temperatures to disinfest raw products such as spices, teas, medical herbs, and dried fruits prior to processing. While in some cases cold chambers at constantly minus 20°C are used and products are spread out in trays for a treatment of some 24 h, one company in Germany has run a cooling chamber using liquid air or nitrogen that can provide chamber temperatures of minus 80°C for a more rapid disinfection in the core of a bigbag. In both cases a temperature of minus 18°C is aimed for in order to achieve complete control. Recent laboratory studies with eggs, larvae, pupae and adult *Plodia interpunctella* and larvae and beetles of *Stegobium paniceum* showed that 60 min exposure time was needed for complete control in 5ml of wheat bran. Eggs appeared to be most tolerant which corresponds to the results by Carrillo and Canon (2005) who studied various strains of *P. interpunctella*. At minus 14°C first results seem to indicate that at least 240 min are needed for a similar level of control. Not all of the tested eggs of *S. paniceum* were controlled at this exposure time. A preliminary experiment at minus 10°C showed that up to 480 min did not lead to complete control in *S. paniceum* while all moth stages could be controlled at the longest exposure time tested.

Sieving and milling for pest control in fine powders and flour: Flour mills have a special problem due to the fact that flour and large amounts of dust or powder cannot be disinfested without movement. Powders due to their fine structure are perfect insulators to render extreme temperatures, gases, contact insecticides and other means of pest control ineffective provided the product volume exceeds some 20L. Only mechanical techniques such as sieving may be used for pest control. Sieving has the advantage of separating the contaminant or insect from the flour while milling can be used to destroy living insects prior to packaging. In a number of mills rotary mills (e.g. Bühler Entoleter) are used for this purpose (Plarre and Reichmuth 2000).

Advantages and disadvantages of physical methods for pest control: The methods described here are usually at least as rapid as chemical methods. All of them imply simple laws of physics that render the development of resistance in pests highly improbable. All the methods mentioned do not alter the quality of the treated product and can be regarded as rather safe in terms of workers safety. Physical control methods do not require authorization and leave no residues. A disadvantage of some methods could be the energy input required that could render e.g. freezing too costly for bulk goods such as grain as long as other methods are more feasible.

Conclusion

In general, physical methods are established and widely used methods in stored product IPM. While they may not be feasible in all cases, the loss of chemical compounds may lead to a revival or increased utilisation of physical methods. Improvements in the structural design of bakeries, pasta factories and other processing plants could help to prevent re-infestation after processing steps leading to pest control such as extrusion, drying or milling. Heat treatments could gain importance for the residue-free treatment of machinery or structures

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