

## Factors affecting quality

The maintenance of quality of food or feed commodities depends upon the same principles and practices whether the quantities be small, perhaps a few tonnes, or whether national food reserves are to be considered. The suggestions and recommendations described will focus on quantities that might be stored by small to medium traders or millers, lots of up to 100 tonnes, but will be applicable whatever quantities are held.

The following factors will influence actions that might be necessary to take.

- The **type of material** being stored, whether it is cereal, pulse or oilseed; entire grain or milled products;
- The **end use** of the commodity, whether it be for animal feed or food for human consumption; commodities for local or national consumption or for export;
- The **duration of storage**, i.e. transit, medium- or long-term;
- The **climatic conditions** to which the commodity was exposed before receipt; what conditions are likely to occur whilst commodities are held in storage;
- What **pest management practices** have been put into place before receipt; the cost benefit of pest control; what pest control materials and equipment are available; what training in pest management have staff received; what pest control services are locally available and their cost.

The **type of commodity** will determine which insect pests are likely to be present. Whole cereal grains, such as maize, wheat, rice and sorghum will be at risk particularly from weevils, including *Sitophilus zeamais* and *S. oryzae*, the maize and rice weevil respectively, and in Africa and South America from the larger grain borer, *Prostephanus truncatus*. Small grains will also

be at risk from the lesser grain borer, *Rhyzopertha dominica*. Flour beetles such as *Tribolium castaneum*, the red flour beetle, infest flour and grain products and are generally not associated with entire grain unless it has sustained physical damage and is cracked or split. Moths, including *Cadra cautella* and *Plodia* and *Ephestia* species, also cause problems to milled grain and grain products. Figure 2 illustrates some of the major insect pests of stored grain and grain products found in the tropics and sub-tropics.

Pulses, beans, cowpea, gram, lentils etc. are attacked by a group of insects known as bruchids. Unlike the cereal pests, which do not discriminate between host type - the maize weevil will quite happily attack and develop on wheat - bruchids are quite specific in their host range. *Acanthoscelides obtectus*, the bean beetle, will only develop on the common bean and other members of the *Phaseolus* family. *Callosobruchus maculatus*, the cowpea weevil, will develop on cowpea and some grams but not on beans. Groundnuts in West Africa are at risk from *Carydon serratus*, the groundnut beetle but nowhere else in the world.

The varietal type will also influence quality maintenance. Some varieties are much more susceptible to insect pests than others. Many soft hybrid maize varieties are extremely susceptible to insects and could lose up to 25% of their weight in just a few months in store if they are not protected with insecticides. Other maize varieties, especially those that originate through lines grown traditionally by farmers may well be relatively resistant to insect pests and only lose 1-2% by weight in a six-month period in store. Furthermore, grain that is unthreshed, such as paddy rice and groundnut in shell, is much

**FIGURE 2** Some common tropical and sub-tropical storage insect pests of grain and grain products



*Acanthoscelides obtectus*  
bean beetle



*Callosobruchus maculatus*  
cowpea beetle



*Sitophilus sp.* weevils



*Trogoderma granarium*  
Khapra beetle, larva and adult



*Tribolium castaneum*  
red flour beetle



*Ephestia sp.*  
tropical warehouse moth

less susceptible to insects than threshed grain, white or brown rice and groundnut kernels or redskins.

Milled commodities do not keep as well as intact grain. Flours, which consist of relatively finely divided particles, are able to absorb water from the air much more readily than whole grains. They are then prone to infection by *Aspergillus* and *Penicillium* moulds, which are able to produce mycotoxins such as aflatoxin and ochratoxin. Furthermore, these finely divided flour particles are much more easily oxidised by oxygen in the air. This is particularly important in feed that has a high fat content, such as fish meal or cotton seed cake, as the fat is converted into free fatty acids producing rancid and noxious odours. Therefore, to avoid these problems it is important not to store finished flour and feed for long periods.

**The end use of** the commodity will also influence how it is managed in store. Commodities that are designated for animal feed are generally of inferior quality to that used for human food. This should not be the case as livestock thrives on good quality feed although it can tolerate feed of poorer quality. However, frequently this attitude leads to livestock being given poor if not toxic feed, which may then suffer the consequences of disease and perhaps death. It is not uncommon, for example, for mouldy grain to be down-graded for animal feed when it really ought to be discarded and destroyed; sometimes it is used in brewing. A classic example of animals suffering from inferior feed was demonstrated in the UK in the 1960s when thousands of turkeys died as a result of eating aflatoxin contaminated groundnut meal.

Commodities that are designated for export require a higher level of management than those to be sold internally. Importing countries and organisations, such as the European Union, lay down stringent restrictions on imported food commodities. For example, to export cereals to the EU the grain must have less than 2 µg/kg of

aflatoxin B<sub>1</sub>, less than 1 mg/kg of the insecticide deltamethrin and less than 0.03 mg/kg of the fungicide imazalil. Many countries will require imports to be accompanied by a phytosanitary certificate, which guarantees that the commodity is free of live insects, contains only a minimum of foreign matter and has chemical residues below specified limits. If these conditions are not adhered to the consignment may be rejected or the exporters may be forced to fumigate the consignment at their own expense. It is essential, therefore, that commodities designated for export remain free from all contamination.

Grain that is only in transit, perhaps in store for up to a month or so, will not be subject to the same infestation pressure as grain to be kept for six months or more. **The duration of storage** will, therefore, influence the degradation of the commodity and what management practices will be needed to rectify any potential problems. The life cycle of insect pest species in the tropics and sub-tropics takes about a month. If the commodity is only to be stored for a short period and is uninfested or very lightly infested on intake, it would not be economic to undertake any pest control whilst it remains in transit. However, in six months this very light infestation could become severe. Then it will be necessary to undertake fumigation and/or spraying with contact insecticide to restrict the damage.

**Climate** will play a very important role in determining what happens to a commodity in store. In hot, humid conditions food commodities will deteriorate rapidly. Moulds require the relative humidity to be above 80% for optimum growth and for insects this is 70%. For both types of organisms, increases in temperature to 27-32°C will enable the maximum rate of reproduction to be achieved and so maximise the damage that they can inflict. Good storage conditions in high humidities are very difficult to achieve and to enable commodities to be kept for more than a month will require artificial aeration, ventilation systems or refrigeration, methods generally

unavailable or too expensive for small to medium trader enterprises in the developing world. Similarly, methods to reduce temperatures in stores are also difficult to put into practice. As a result, in the tropics it is not possible to keep grain or grain products for very long in one location, and the commodity must pass rapidly along the marketing chain so that the consumer has access to a good quality product.

In areas where the relative humidity is less than 70% problems created by moulds and insects are not as severe, although some species are adapted to these less optimal conditions. For example, the Khapra beetle, *Trogoderma granarium*, develops best at 35°C and is able to grow at a relative humidity as low as 2%. This beetle pest is particularly prevalent in the Middle East, Asia and Africa and is a proscribed, quarantinable pest where found outside its normal range. It goes into diapause in adverse conditions and so is extremely difficult to control with insecticides.

Generally, it is possible to store grain for longer periods in dryer conditions without fear of deterioration and it is possible for this period to be extended for as long as two years with appropriate management. Nevertheless, pests are still able to operate in dryer, cooler climates so that good management needs to be maintained.

At intake, grains will often be infested with insects or may even show signs of mould contamination. Mouldy grain may need to be dried in order to prevent the mould from spreading. If insects are present then the grain may not have been treated with insecticide, the effects of the treatment may have worn off over time, or the treatment was ineffective (it may have been badly applied; it may have been old and under strength; it may have been fake). If insects are absent it is essential to know whether the commodity has been treated before receipt so that duplication of treatment can be avoided. It may be that the consignment has not been treated but that previous good management has enabled it to be kept

free of pests. Even if this is the case it cannot be guaranteed that even with continued good management it will remain pest free without treatment.

It is therefore essential to apply the appropriate **pest management** initiatives to fit the circumstances. Disinfestation is best achieved by fumigation with phosphine gas. This treatment has the advantage of requiring very little application equipment but, to be effective and safe, knowledge of the correct procedures is essential. Thus trained personnel only should be allowed to conduct fumigation.

Treatments to protect grain against infestation can be achieved with liquid contact insecticides. However, these need to be applied to the grain with a sprayer and, once a sack has been filled, are difficult to apply without emptying the sack. Spray applications to sack surfaces are not recommended because insects can penetrate sack fabric very quickly and avoid picking up a lethal dose of the protectant. Because of the awkwardness of using liquid protectants the trader may choose, instead, to fumigate at regular intervals to keep the infestation pressure at negligible levels. This works where large quantities of grain or grain products are to be stored for long periods, but for short periods and with small quantities this may be uneconomic.

If the trader or miller does not have the expertise to carry out pest control operations, there are usually private sector companies available to fill this role. Using such expertise increases the cost of storage and may not guarantee that good practice is implemented. There are many charlatans involved in the pest control industry and it is not uncommon for them to underdose, use the wrong chemicals, apply the chemicals with inappropriate equipment or even not treat the grain at all. In southern Tanzania it has been known for a company to carry out a 'fumigation' by spraying only the outside surfaces of a stack of bags, and then the spray contained no insecticide but just water!

It has been common practice to spray the walls and floor of stores with contact insecticides to provide residual protection against insects. However, in most environments in the tropics and sub-tropics such treatments only persist for two weeks or so and would then have to be repeated. This would not be cost effective and such practices are no longer recommended. However, if the conventional insecticide is replaced with a diatomaceous earth (DE), the persistency of the treatment is much longer and much more effective. It is still very uncommon for DEs to be used

in this way as they are not widely available and they are not easy to apply.

Before applying pest control procedures the store owner must estimate the cost-benefit of the treatment. Decisions regarding treatment must take into account the equipment needed and the level of competence of the staff who would undertake the procedures. As a last resort, if external contractors are employed they must adhere rigidly to requirements and specifications established by the store or mill owner.

