Detection of Insect Infestation in Stored Food Commodities

Detection of insect infestation in food commodities and their storage premises is essential to ensure that;

1) The food offered is wholesome and acceptable for consumption.

2) For regulatory compliance.

3) For diagnosis of incipient infestation and to ascertain the success of the control measures using fumigants. Current methods detect whole insects or, insect fragments directly or, indirectly

Detection of hidden infestation;

For minimizing the stored grain losses, early detection of insects holds paramount importance. Different methods used to detect the storage grain insects

Careful observation is necessary when detecting samples. These observations are imperative, as there are not always larvae, pupa, or adults readily available for examination and identification. In the absence of physical specimens, like rice weevil, maize weevil, lesser grain borer, Angoumois grain moth, and bruchids that have latent or hidden infestations that cannot be detected by usual grain examining in the sieves unless other methods were used such as:

1-Staining method: This is the rapid method in which various dyes are used to stain the egg plugs in grains made by the weevils.

- **Acid Fuchsine**: The stain is prepared by mixing 0.5 g acid fuchsine in one litre of 5% aqueous glacial acetic acid. Samples of grains are prepared by soaking in warm water for 5 minutes and are immersed in the stain for 2-5 minutes. The excess stain is removed by washing in tap water. The egg plugs of the weevil are stained bright cherry red and feeding punctures including mechanical injuries are stained light pink.
- **Gentian violet**: Grain samples are immersed for 2 minutes in a solution containing 10 drops of 1% aqueous stock solution of gentian violet in 50 ml of 95% ethanol and the egg plugs are stained to purple color.
- **Berberine sulphate**: Grain samples are immersed in a 20 ppm solution of the aforementioned dye for one minute, rinsed, and examined under ultraviolet light. The egg plug stains show an intense greenish-yellow color.

2-Floating method:

This method involves using two solutions of different specific gravity, e.g. sodium silicate in water (Sp gravity 1.16) and methyl chloroform (Sp gravity 1.30) Sodium silicate remains on the top. The grains are immersed in the fluids and a three-layer separation occurs. The healthy kernels sink into the bottom, the infested one floats and the lightweight kernels including those infested by early stages of insects hang in the line of separation between the two solutions.

3-Gelatinization method:

when the grain is boiled for 10 minutes in a 10% solution of sodium hydroxide, the kernels become translucent, thereby, revealing the presence of internal infestation.

4-**Acoustical method**:

Acoustical detection methods use insect-feeding sounds to automatically monitor both internal and external grain-feeding insects. Insects hidden inside kernels of grain can be detected acoustically by amplification and filtering of their movement and feeding sounds.

The effective use of an acoustic method to detect insects in grain requires a quantitative understanding of several characteristics that affect sound production:

1-Physical factors: The physical factors include the intensity, duration, and spectral characteristics of the sound at the source, the distance to the receiver, the receiver's spectral sensitivity, and the background noise.

2-Biological factors: Biological factors include unfavorable environment, insect behavior, insect inactivity insect distribution, and detection.

disadvantages of acoustic methods are

1- It cannot detect dead insects in grain.

2- It cannot detect infestation by early larval stages of insects.

5-Electrical conductance Pearson,

A single kernel characterization system is commonly used to measure grain kernel weight, moisture content, diameter, and hardness. This system works on the principle of electrical conductance and compression force. The kernel acts as one resistor in a two-resistor and voltage-divider circuit of the single kernel characterization system.

Conductance is monitored by measuring the voltage across the kernel. A low voltage measurement corresponds to low kernel resistance, which is typical of high moisture-content kernels. If a live insect is present inside a kernel, there is likely to be a large downward slope in the conductance signal. Based on the signal characteristics of the system and by computing the range of voltage levels in the conductance signal, infested kernels are differentiated from sound kernels.

Disadvantages of this method:

1- Inspecting single-grain kernels is time-consuming.

2-Infested kernels with insect eggs and young larvae may be undetected because of the low moisture content.

3-This method cannot detect kernels with dead internal insects.

4-The insect detection rates by this method are very low when compared with the inspection by soft X-rays.

5-X-Ray radiographic method:

Soft X-ray is the only non-destructive, direct method that can detect insect infestations in grain kernels. Indicated that in the future an automated line-scan X-ray system could inspect 1 kg grain in about 15 min compared to 5–6 h using a Berlese funnel. A soft X-ray system consisting of a fluoroscope operated at 15 kV potential and 65 uA, produces real-time images. Single kernels were placed on plastic wrap on a platform between the X-ray tube and detection system and were scanned. Images formed on the detection screen were captured by a CCD black and white camera and digitized by a digital video creator. The digital images were processed to detect insect-infested kernels.

Advantages of soft X-ray;

1- Soft X-ray imaging is the only non-destructive, time-saving technique, and highly accurate
2- The soft X-ray technique can be effectively used to identify mechanical damage in grains destined for seed purposes.
3- detect both internal and external insects, able to detect both live and dead insects inside grain kernels.

Disadvantages of soft X-ray; Small larvae and weevil egg plugs are difficult to distinguish from denser portions of the grain by using the soft X-ray method.

6- Near-infrared reflectance (NIR) spectroscopy

The NIR technique provides information based on the reflectance properties of different substances present in a product. The NIR is based on the absorption of electromagnetic wavelengths in the range of 780–2500 nm. The concentrations of constituents such as water, protein, fat, and carbohydrates can be determined using classical absorption spectroscopy. The NIR system used to detect insects in kernels can scan 1000 kernels per second. compared a NIR system and the standard floatation method for detecting insect fragments in wheat flour. They determined that the standard floatation method is time-consuming (about 2 h/ sample) and expensive.

Advantages of (NIR)

1-Rapid method, no sample preparation

2-NIR spectroscopy has evolved as a fast, reliable, accurate, and economical technique available for the compositional analysis of grains.

3-This technique can be used for both qualitative and quantitative analysis.

4- detect external and internal insect infestation in wheat.

Disadvantages

1-The NIR method cannot detect low levels of infestations.

2-Cannot differentiate between live and dead insects.

3-The NIR imaging method is indirect and cannot detect larvae because of the movement of larvae in the cavity due to heat generated from the lighting which obscured the details of NIR images.

4-Sensitive to the moisture content in samples.

5- Calibration of equipment is complex and frequent

Techniques for the detection of light infestation:

1-Visual Inspection:

Detection of insect infestation in stored food grains can be done through visual inspection. The presence of eggs, adult insects, and infested grains can be seen by the naked eye without drawing grain samples or looking for residual infestation within the storage bags. Ministry of Agriculture, Fisheries and Food Inspector, developed some notations for the use of sack, storage, and sampling inspection.

Table-1
Characters for insect inspection in storage structures.

Character	Specification	Number of insects
C - Clear or none	No insects	Require protection from cross-infestation and regular inspection.
F - Few or light	Irregular occurrence of few numbers of insects. Absence of insects in sacks	< 20 insects per 90 kg sieved sample for a few notations (requires disinfestation in near future). 20–300 insects per 90 kg sieve sample for light notation.
MN - Moderate numbers	Regular occurrence and formation of small population of insects	50-300 insects per 90 kg sieved sample.
LN - Large numbers	Large number of insects creeping on the stack surface	300-1500 insects per 80 kg sieved sample.
VLN - Very large numbers	Intense occurrence of insects, audible and dead skins seen around the stalk	> 1500 insects per 90 kg sieved sample.

2-Agitation of bags: this is effective for low population densities of *Sitophilus* spp., which will often walk out of the sack after they have been sufficiently disturbed. A long stick may be drawn over surfaces of the vertical stack or they can be hit to activate a small number of moths which are therefore more readily observed.

3-The feel of grain in bulks: walking across the surface of bulk grain with bare feet may prove an excellent guide to its general condition. If it feels cool there is no need for immediate concern. However, if a hot spot exists, this is indicative of high dust content and moisture migration with a subsequent temperature rise.

4-Berlese funnel method

A Berlese funnel works on the principle that insects move away from heat. The Berlese funnels are 49– 79% efficient in recovering free-living adults of *Cryptolestes ferrugineus* (Stephens) in wheat samples. This method is often slow and inaccurate in detecting infestations. It takes 5–6 h to determine the presence of insects in 1 kg grain samples and during this time, the grain would have been loaded into bins or ships. The performance of a Berlese funnel depends on the insect stage, the size of the grain sample, and the moisture content of the grain. Furthermore, this method cannot be used for hidden infestation in grain kernels.

5-Visual lures

"Light" can be used for the detection, monitoring, and management of insects in stored food grains in warehouses, elevators, etc. by utilizing the responses of insects toward the light. It is a "clean" form of technology and uses three types of lights: incandescent, fluorescent, and ultraviolet. Insects are allured towards the lights of wavelength between 280 and 600 nm and some colored objects due to their explicit reflectance. Insect species, age, environmental conditions, sex, and intensity of light affect the responses of insects toward the light.

5-Use of traps: various traps have been designed to exploit the activities of many species of insects.

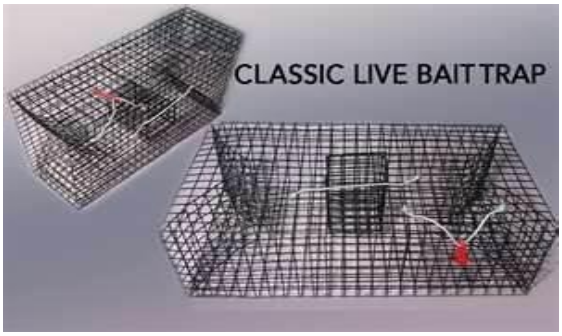
A-Crevice traps: Most pests that attack stored produce prefer to keep their body in contact with as much substrate as possible. Such insects will seek cracks and services rather than remain in the open. A trap that contains many attractive crevices will accumulate insects. Once insects enter they may be reluctant to leave even though they can. A simple crevice trap can be made from a piece of corrugated cardboard that is highly effective at detecting *Tribolium*, *Oryzaephilus*, and *Cryptolestes* within stored grains

B. Pitfall traps: Designed for monitoring insect pests in bulk grains. It can be used either at the surface of grain or can be buried up to 50cm deep under the surface. The dome is specially designed so that insects cannot walk in a direct line across the surface without falling into one of the trap holes. Thus, rely on the fact that many insects cannot climb out of vertically walled containers once they have fallen in them because the inside border is coated to prevent insects from climbing out.

Simple pitfall traps can be made from disposable plastic drinking cups. These can be buried into grains so the top is level with the grain surface. Grains can be prevented from entering the traps by covering the opening with mesh that still allows insects to pass through. The sides are slippery and cannot climb in or a small quantity of vegetable oil (e.g. cooking oil) may be placed on the bottom to trap insects that fall in like *Oryzaephilus* spp.

These traps allow early detection of pests, often before, or replacing visual detection, even with low levels of infestation. In providing information on the distribution and extent of pest problems they can also help to optimize or reduce the use of chemical treatments.

C- Bait traps: Certain foodstuffs are highly attractive to storage insects, especially those that contain volatile oils. Examples include dried fruit, ground nuts, and brown rice. A simple trap can be made from a mesh bag containing a mix of such materials. Insects attracted can simply be shaken out and examined.



D- Light traps: Many insects are attracted to lights like *Lasioderma serricone* in the tobacco industry while the Pyralid moths such as *Ephestia* and *Plodia* are not very attracted to light

E-Pheromone traps

Pheromones are chemical substances secreted by insects and used in traps to control insect populations. These are used for communication among insects. Traps of different materials, containing pheromones (sex and aggregation pheromones) are used on adhesive-coated surfaces or a funnel-shaped structure to catch the insects.

Synthetic versions of pheromones of many storage insects are commercially available as baits. Baits are packaged in a vial or membrane that permits the slow release of the volatile chemical over weeks or months. Pheromones are important to detect species that are almost impossible to detect by direct inspection. There are different types according to their function such as:

1. Alarm pheromone/ When a family member at risk will secrete a type of pheromone to alert individuals of the same species and thus avoid the danger source.
2. Marking pheromones/ Females of some cowpea beetles such as *Callosobruchus chinensis* will secrete a type of pheromones on

eggs thus preventing other species from depositing eggs on the same site.

3. Trial pheromone/ Some species secrete a certain type of pheromones when coming out from nests so can follow back the trace to the nest

4. Dispersal pheromone/ Some lepidopteran flour larvae such as *Ephestia Kuehniella* secrete a type of pheromones from special glands on food substrates during feeding and thus prevent other larvae going to the same source to reduce competition among larvae

5. Aggregation pheromone/ Males normally secrete a certain type of pheromone that announces the presence of plenty of food in a place thus allowing eating and mating.

6-Sex attractant pheromone/ Females of some species release a pheromone that attracts males for mating, many types of pheromones have been isolated from stored product pests and produced the synthetic form to control stored product pests

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Data collection

It is important to collect basic data about each specimen, useful data to collect includes:

1. Place of collection-e.g. town, location, name of farm
2. Nature of location-e.g. silo, shed, flour mill

3. Commodity from which specimen was collected, how collected, type of trap
4. Date of collection
5. Grain temperature, moisture content, time in store
6. Person who collected it – name, phone number, email address