

Storage Insect Pests of Makhana and Their Management Technology

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In Bihar, the farmers store makhana primarily to prevent spoilage, prolonged self life, stabilize market price and build inventory for export. Since Bihar State accounts for nearly 85-90 percent of India's makhana production, accordingly in proper storage is a crucial intervention to reduce post-harvest losses and maximize profits. However, insect pests of makhana is vulnerable to specific pests and causes of post-harvest loss and food safety, particularly when stored for long periods. The processed nut/popped makhana highly susceptible to moisture absorption and subsequent infestation. High infestation rate, sometimes reaching 20-30 percent in unsealed conditions. Several major beetles and moths that infest the nuts and popped makhana during storage and which as follows :

Categories of insect pests in stored Makhana

- **Primary insect pests** : These pests directly damage the stored makhana nuts, often boring into them.
- **Secondary insect pests** : These pests infest already damaged or broken makhana, thriving in high-humidity conditions.
- **Common insect pests** : The most common stored product beetles, moths and mealworms known to affect similar products are generally implicated in makhana storage damage.
- **Associated insect pests** : While the Singhara beetle is a field pests that attacks fruits, its damage can carry over into storage.

Major Stored Insect pests of Makhana

- **Rice Moth (*Corcyra cephalonica* Strain)** : The most common destructive pest. The caterpillars (larvae) web the makhana together and feed from inside and destroying the kernels.
- **Khapra Beetle (*Trogoderma granarium* Evert)** : The larvae are highly voracious and can survive in very dry conditions, severely boring into the popped nuts.
- **Red Flour Beetle (*Tribolium castaneum* Herbst)** : Primarily attacks already damaged or broken makhana nuts and processed products which ruining the marketability of the produce through foul odors and waste.
- **Saw-Toothed Grain Beetle (*Oryzaephilus surinamensis* Linn)** : A secondary pest that easily penetrates loose storage containers/bags. The pest feed on damaged makhana seeds.
- **Rice Weevil (*Sitophilus oryzae* Linn)** : A common primary pests that infest stored makhana and leading to powdery debris, especially if the store area is humid.
- **Angoumois Grain Moth (*Sitotroga cerealella* Oliver)** : A significant pest that larvae damage the stored makhana seeds.

- **Makhana Beetle (*Galerucella birmanica* Jacoby)** : The primary pest, that cause of damage in packet products.
- **Cigarette Beetle (*Lasioderma serricorne* Fab.) and Khapra Beetle (*Trogoderma granarium* Evrt)** : Both beetles damage stored dried products.
- **Other Potential Pests:** Moths and various beetle are mentioned as general store grain pests that can infest makhana nuts or popped makhana.

Major Identification Indicator

- Makhana has bugs that may be found inside the popped nut.
- Storage pests cause loss of weight, foul smell, and contamination of the makhana products.

Storage Infestation Symptoms

- **Sogginess and Rancidity:** Caused by moisture absorption.
- **Mold Growth :** Due to improper proper humidity storage conditions.
- **Insect Infestation :** Visible holes in kirnals, webbing and frass (Insect waste).
- **Fungal Contamination of Processed seeds:** After harvest, improperly stored makhana puffs can becomes infested by toxigenic fungi such as *Aspergillus flavus*, *Aspergillus ochraceus* and *Penicillium citrinum*. These species can produced harmful toxins (alfatoxins and ochratoxing), which are making unsafe for human consumption.

Prevention and Management Technologies

Makhana is susceptible to primary and secondary storage pests, especially during prolonged storage or in improper conditions. Therefore, to prevent catastrophic post-harvest losses, farmers and processors in Mithilanchal and Simanchal-Koshi regions of Bihar should be employed Integrated Storage Pest Management Technologies and which as follows :

- **Sanitation:** Empty storage containers should be cleaned thoroughly before storing the new produces to avoid infestation from previous batches.
- **Sun-drying :** Thoroughly drying the nut and popped makhana in the hot sunlight before storage to reduce moisture levels (less than 10°C), which inhibits insect growth.
- **Moisture Control:** Keeping storage areas dry is crucial, as moisture increases pest infestation risk. Drying makhana in the sun and storing in airtight containers to prevent moisture pickup.
- **Proper Drying:** Ensure popped makhana is sufficiently dried (Moisture controlled to roughly 10% to 12%) before bagging high moisture attracts insect.
- **Air-tight Storage:** Using airtight containers or polybags to prevent infestation by beetles/moths.
- **Packing Technologies:** Vacuum packing or modified atmospheric packaging (MAP) is recommended to prevent stored product from pest outbreak.
- **Natural Treatments / Botanical Repellents:** Use of plant extracts such as neem, long pepper and sweet flag in storage to acts as repellents and can help control the pest infestation.
- **Chemical Intervention / Fumigation:** Treatment with food-grade carbon dioxide (CO₂) in sealed silos is recommended for organic storage / products.
- **Oxygen Absorber:** Using oxygen absorber to remove moisture, increasing self life up to three times.
- **Hermetic Storage:** Stored dried makhana in airtight containers, Purdue Improved Crop Storage (PICS) bags, triple-layer plastic bags or vacuum packaging to prevent adult insects from laying eggs and to suffocate existing larvae.
- **Fumigation and Organic Control:** For bulk storage, fumigation using aluminium phosphide is a common practice, but not feasible for health. For organic market or domestic storage, the use of safe botanicals (like dried neem leaves is recommended).

- **U.V. Light Trapping:** U.V. traps effectively attract the adult lesser grain borer with peak attraction observed at 8:00 PM.
- **Physical Disinfestation:** Dipping gunny bags in boiling water and sun-drying them, kills lingering insect stages before storage.
- **Controlling Atmosphere:** Treating bulk makhana nuts with high concentration of carbon dioxide (CO₂) is an effective, natural way to disinfest commodities for organic market.
- **Temperature:** Cold-storing or freezing makhana nuts can kill any lingering microscopic eggs or larvae that might be hidden deep within the makhana nut crevices.
- **Airtight Storage:** Use heavy-duty, airtight containers/reusable pouches with oxygen absorbers to create an environment where insects can not survive.
 - **Storage Hygiene:** Clean godowns thoroughly before storage and disinfect storage containers by sun-drying or dipping bags in boiling water.

Conclusion

Makhana is a highly nutritive and lucrative crops, but its high perishability during storage which threats quality with profitability. Because it is consumed directly as a popped snack, and chemical pesticides are generally discouraged. Therefore, makhana storage pest management is an integrated approach centered on strict moisture control measure, hermetic storage and packaging as well as organic/botanical repellents. By adopting these measures, makhana producer and processors can significantly extend self life, preserve popping quality and meet the modern food safety standard.