ABSTRACT

Pulses (family Leguminosae) are the major source of protein (20-30 %) in the everyday Indian diet. Pulses are susceptible to insect infestation during storage, deteriorating their quality and quantity. *Callosobruchus maculatus* is very common and highly detrimental to pulses during storage. Different chemical pesticides in large-scale grain storage systems are currently employed to combat insect infestations; however, these pesticides have proven detrimental to human health and the environment. In the present study, research is carried out to develop a metallic bin and eucalyptus essential oil-based nanoemulsion to control *C. maculatus* during pulse (*Vigna mungo*) storage.

Initially, a field study was conducted in Nandgao (Uttar Pradesh, India) to understand the current grain storage system for storing pulses domestically. It was found that almost 75 % of farmers keep their legume grain in plastic bottles or jars. Jute and polyester bags are also being used. It was noted that the traditional storage methods/practices were insufficient to ensure complete protection during storage. The findings highlight the necessity of developing a new storage bin specially designed for pulse storage. The *C. maculatus* infestation has a negative impact on the nutritional value of stored pulses. Additionally, changes in the amino acid profile resulted in nutritional deficiencies in the infested pulses, rendering them unfit for human consumption.

The chemical composition of the chosen essential oils-*Mentha piperita, Eucalyptus globulus*, *Curcuma longa*, *Cymbopogon citratus,* and *Ocimum sanctum,* was confirmed by the results of the GC-MS data. The effectiveness of each essential oil against *C. maculatus* was evaluated using bioassays for repellent activity, contact toxicity, and fumigant toxicity. *Eucalyptus globulus* essential oil was the most effective repellent against *C. maculatus*, whereas *O. sanctum* was the least effective. Based on the results, *Eucalyptus globulus* was chosen to develop a formulation against *C. maculatus.* Several combinations (F1, F2, F3, F4, and F5) were tried and optimized to get a stable nanoemulsion. The spherical shape of the emulsion droplets was validated by TEM imaging, and the nanoscale homogenous composition was further confirmed by the small droplet size (17.16 nm) and low PDI (0.313) values. Its stability was confirmed after six months of storage, as there was no sign of crystallization, creaming, phase separation, or sedimentation. Testing at the laboratory level verified the nanoemulsion's potency against *C. maculatus.*

Finally, based on the findings, a new metallic bin capacity of 20 kg was designed for pulse storage to test the bio-efficacy of the nanoemulsion under simulated field settings (in artificial infestation conditions). It was found that the untreated bins had a higher population of insect pests and egg counts as compared to untreated storage bins. Both weight loss (less than 1 %) and grain damage (less than 1 %) were minimal in treated bins (T) due to the arrested growth of insects at earlier stages in the treated bins. Insect trap also effectively captures the insect, enhancing the effectiveness of the newly designed bin. Thus, an integrated system based on a newly designed storage bin and developed nanoformulation showed effective control of *C. maculatus* during the storage period of three months. It indicated its feasibility for field application.