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Nanoemulsion of eucalyptus oil: An alternative to synthetic pesticides against two major storage insects (*Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst)) of rice

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ABSTRACT

The residue of chemical pesticides used against storage insects may cause health hazards. Hence, alternative management of storage insects of rice is the need of the hour and eucalyptus oil (EO) is one of the safer alternatives. The study proposes to prepare EO nanoemulsions to improve its efficacy. Different combinations of EO, surfactant (Tween 80) and water, were homogenized at high speed to obtain nanoemulsion. Based on centrifugation, thermodynamic stability, heating and cooling, freezing and thawing experiments, two combinations, 1:2 and 1:2.5 (EO: Tween 80) of 6% EO concentration were optimum to formulate nanoemulsions. The droplet sizes of nanoemulsions were 4.04 nm and 2.27 nm and poly dispersity index (PDI) were 0.37 and 0.77 and zeta potential were 6.20 mV and 7.69 mV, respectively for these two combinations. Lethal concentration (LC_{50}) of 1:2 and 1:2.5 formulated nanoemulsion eucalyptus oil against *Sitophilus oryzae* were 0.56 and 0.45 μL/cm^2, respectively and against *Tribolium castaneum*, it was 1.11 and 0.89 μL/cm^2, respectively. Whereas, LC_{50} of eucalyptus oil was 0.795 and 4.178 μL/cm^2 against *Sitophilus oryzae, Tribolium castaneum*, respectively. The formulated nanoemulsions were superior over eucalyptus oil and it can be recommended as an innocuous alternative to harmful chemical pesticides against stored grain pests.

1. Introduction

For thousands of years, rice has been a staple food source for many parts of the world. Prolonged storage of rice is utmost important for future use and to maintain food security. Stored grain pests could cause 10% loss of harvest during storage (Shankar and Abrol, 2012). Scientific storage methods can reduce these losses up to 1–2% (Kumar and Kalita, 2017). Generally, chemical pesticides are applied to manage these stored pests. But, their continuous application may arise few problems like, insect resistance, environmental pollution and handling hazards (Yuan et al., 2014; Meyer-Baron et al., 2015). There are also unintended poisoning threats to humans because of their incorrect use (Jones et al., 2014). Besides these, rice for export must be free from pesticide residue. So, novel alternatives to chemical pesticides are needed to meet new regulatory norms and consumers demand of safe food. Botanicals mainly, essential oils are being favoured for their high vapour pressure and they have broad spectrum efficacy against large number of insect-pests (Tapondjou et al., 2005; Batish et al., 2008; Rajkumar et al., 2019).

Eucalyptus oil (EO) is effective against storage pests e.g. *Sitophilus oryzae*, *Tribolium castaneum*, *Rhyzopertha dominica*, *Sitophilus zeamais* etc. (Lee et al., 2004; Mossi et al., 2011). EO, especially *E. globulus*, is the most representative species in the international pharmacopeia (Bajaj, 1995). Pesticide property of EO is due to the presence of volatile compound “eucalyptol or 1,8-cineol”. The lethal dose (LD_{50}) of 1,8-cineole against *S. oryzae* adults were between 19.0–30.6 μL/L air and it was toxic to *T. castaneum* and *R. dominica* too (Lee et al., 2004). In another study, LD_{50}s of EO were 0.36 μL/cm^2 against *S. zeamais* and 0.48 μL/cm^2 against *T. confusum* (Tapondjou et al., 2005). Despite its efficacy, use of EO is limited due to lack of better formulation. As EO is insoluble in water, it can only be used as emulsion to disinfect soil and surfaces. Particle size and stability of the emulsion is most crucial for its efficacy. The emulsions are generally susceptible to creaming, flocculation and phase separation due to Oswald ripening (Simonazzi et al., 2018). This study was carried out to prepare nanoemulsion of EO based on high speed homogenization technique.

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