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Nanoemulsion of eucalyptus oil: an alternative to synthetic pesticides against storage pests

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Production losses caused from stored grain pests might be as high as 10% in rice. Chemical insecticides are currently important to manage these insects. Indiscriminate usage of synthetic pesticides contaminate food and pollute the environment. Pesticide alternatives are being sought worldwide to meet new regulatory rules and customer demand for safe food. Essential oils, in particular, are preferred because of their volatility, which makes them suitable for application grain storage against a wide range of insect pests. The use of eucalyptus oil (EO) against a variety of storage pests has been recorded, including *Sitophilus oryzae, Tribolium castaneum*, *Rhyzopertha dominica, Sitophilus zeamais,* etc. As EO is insoluble in water, it can be used as emulsion to disinfect soil and surfaces. The objective of this technology is to prepare an EO nanoemulsion, using a high-speed homogenization technique, that would be stable and effective against insect pests. Nanoemulsion is a translucent product with droplet sizes ranging from 0.1 to 200 nm and has sufficient chemical stability to prevent coalescence. The use of an emulsifier in a nanoemulsion system reduces interfacial tension at the oil-water interface. The high-energy emulsification methods involve the input of mechanical energy particularly high-pressure homogenization, high-shear blending and ultrasonication. This technology proposes to formulate eucalyptus oil nanoemulsions using a high-speed homogenizer and utilise them against two most devastating rice stored pests namely, *Sitophilus oryzae* and *Tribolium castaneum*.

Method of preparation

1. Materials

Eucalyptus oil (EO) and non-ionic surfactant (Tween 80) should be procured from recognised vendors.

2. Chemical constituents of eucalyptus oil

The chemical constituents of eucalyptus oil vary with the crop management practices, environmental conditions. Constituents are specific to genotypes. In our study, the major constituents of eucalyptus oil are Eucalyptol (64.80%), α-Pinene (11.17%), β-Pinene (8.19%), γ-Terpinene (5.91%), α-Phellandrene (3.88%), Terpinen-4-ol (0.72%), α-Terpineol (1.01%) and 4-Carene (0.51%). Few other minor components are Carvacrol, α-Terpinene, 1-Epi-alpha-gurjunene, Aromandendrene, Alloaromadendrene, α-Farnesene, γ-Gurjunene, γ-eudesmol and β-eudesmol.

3. Preparation of nanoemulsion

We could conclude that high speed homogenization at 15000 RPM for 10 minutes should be optimum for nanoemulsion preparation. Among all the oil and surfactant combinations, the mixtures EO:tween 80 at 1:2 and 1:2.5 are optimum. Maximum loading capacity of EO in this nanoemulsions is fixed as 6%.

4. Characterization of nanoemulsion

The nanoemulsion should be checked for thermal stability and particle size, PDI, ε-potential should be understood. In this technology, we are proposing two nanoemulsions having EO: Tween 80 (at 1:2 and 1:2.5 W / W) with 6% oil concentration. Their particle sizes are 4.04 nm and 2.27 nm, respectively.

5. Bioefficacy test

LC_{50} of bulk EO against *S oryzae* and *T castaneum* are 0.79 and 4.18 $\mu L / cm^2$ respectively. The nanoemulsions are 1.4 and 3.5 times effective against *Sitophilus oryzae* and *Tribolium castaneum* as compared with eucalyptus oil, respectively.

Brief description of the technology:

Chemical pesticides are in use to overcome losses incurred by storage insects. The residue of these pesticides may persist and can cause health hazards. Hence, alternative management of storage insects is the need of the hour. Eucalyptus oil (EO) has been preferred as safer alternative. Nanoemulsion of EO may give better results. Combinations of EO, surfactant (Tween 80) and water are homogenized at high speed to obtain nanoemulsion. Based on centrifugation, thermodynamic stability, heating and cooling, freezing and thawing experiments, we conclude combinations, 1:2 and 1:2.5 (EO: tween 80) of 6% EO concentration are optimum to prepare nanoemulsion. For these two combinations, the droplet sizes of nanoemulsions are of 4.04 nm and

2.27 nm with poly dispersity index (PDI) of 0.37 and 0.77, respectively. The zeta potential of these two emulsions are 6.20 mV and 7.69 mV, respectively. Lethal concentration (LC_{50}) of 1:2 and 1:2.5 formulated nanoemulsion eucalyptus oil against *Sitophilus oryzae* are 0.56 and 0.45 μL / cm^2, respectively and against *Tribolium castaneum*, these values are 1.11 and 0.89 μL / cm^2, respectively. The formulated nanoemulsions are superior over eucalyptus oil and have great potential to be used as alternative to harmful chemical pesticides against stored grain pests. Such an effective and eco-friendly benign formulation must be emphasized and utilized as natural insecticide and can be altered with hazardous chemical pesticides.

Salient features

- Eucalyptus oil nanoemulsions with 6% loading capacity
- Low droplet sizes (2.27 nm) improve its efficacy
- Effective (1.4 times) against *Sitophilus oryzae* as compared with eucalyptus oil
- Reduction of 3.5 times of eucalyptus oil to manage *Tribolium castaneum*
- Has potential to replace the chemical pesticides in stored grain pest management

Precautions

1. Source of EO is very important. Efficacy, stability may differ with the EO source.
2. EO based formulation storage could be an issue for longer period of time

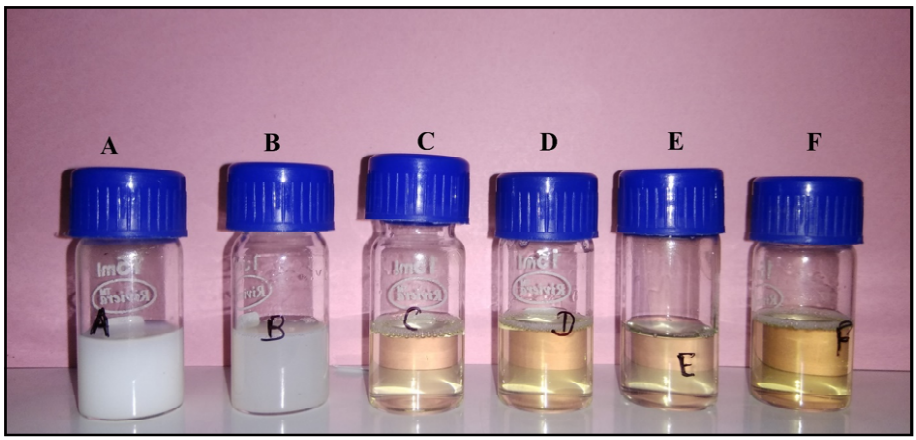

Fig. 1. Nanoemulsions prepared with different combinations of eucalyptus oil (EO) and surfactant

3. As the formulation contains water, precautions should be taken during direct application on the bags of grain
4. Degassing time needs to be standardised.

Country Context of Potential Industry

Reduction of chemical pesticides and utilization of non-chemical method is a priority in pest management. The limited choice of pesticides in stored grain pest management is a challenge. Besides, the bio-pesticide market is ever-expanding. The offered technology will fulfill all the needs of post-harvest pest management issues. State Government / Central government warehousing corporation like (FCI, CWC), private entrepreneurs / pesticide formulation manufactures can take up the technology

Upscaling

Nano-formulations can alter the dynamics of pesticide industry due to their higher efficacy and targeted action. Present study is a complete report of indigenous preparation of eucalyptus oil based nanoemulsion formulations and their efficacy. Unique, low-cost, environmental friendly nanoemulsions will have greater future.

FAQS

- ***Where from I will get the chemicals?***
  The chemicals should be procured from recognised vendors.
- ***Is the toxicity study undertaken?***
  No, we have not done yet.
- ***Is the technology covered under patent?***
  No, it is not covered under patent. A simple MOU is required for technology transfer.
- ***Is any field study undertaken?***
  No, we did laboratory experiment to understand the efficacy of the formulations.

N.B. - The technology is approved by the institute and uploaded in the Krishi Portal (201637145350944).

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