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Characterization and evaluation of formulations based on shrimp co-products for the protection of stored semolina

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INTRODUCTION & AIM

At the global level, cereals are the foundation of food security and occupy some 1.5 million ha in Tunisia. While long-term grain storage is essential, it promotes bio-aggressors that can cause up to 30 % losses. Conventional fumigation with synthetic insecticides carries health and environmental risks and drives resistance. Essential oils from bay laurel (*Laurus nobilis*) and thyme (*Thymus vulgaris*) offer a natural alternative, but their volatility and poor water solubility limit their effectiveness. Encapsulation of these oils in a chitin–chitosan powder matrix derived from shrimp shells improves their stability and persistence. This work focused on the evaluation of insecticidal activity by the fumigation of essential oils of *Laurus nobilis* and *Thymus vulgaris* and the formulations encapsulated in a powder matrix obtained from shrimp and chitosan against adult *Rhyzopertha dominica*.

METHOD

INSECTICIDAL ACTIVITY BY FUMIGATION OF ESSENTIAL OILS

The rearing of *R. dominica* for the bioassays was carried out at INRAT under controlled conditions (25 ± 1 °C, 45 % RH, 12 h light/12 h dark) on semolina or flour. The leaves of *Laurus nobilis* (Rafraf, Bizerte; February 2021) and *Thymus vulgaris(* Djebel Sidi Abderrahmane, Cap Bon; March 2021) were hydrodistilled (Clevenger apparatus) at INRAT and then analyzed by chromatography at INSAT.

Laurus nobilis

Thymus vulgaris

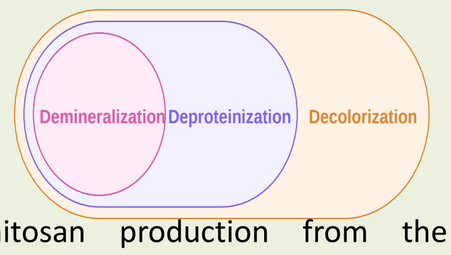
Gas chromatography–mass spectrometry (GC–MS) analytical system

Formulations incorporated into a powder matrix derived from shrimp shells and chitosan

FORMULATIONS INCORPORATED INTO A POWDER MATRIX

Shrimp by-products were stored at –20 °C, dried at 35 °C, and ground to 0.5–0.8 mm particles. The resulting powder was characterized for moisture, ash, total protein, total fat, sodium, and potassium content. For the formulations, EO was diluted in acetone, mixed with talc and shrimp powder, then held at 30 °C until complete evaporation of the acetone. A control powder without EO was prepared similarly. The flavored powders were stored in opaque bottles at 4 °C.

The efficacy of the EO is assessed by its median lethal concentrations. These LC_{50} values are calculated using Finney's (1971) probit analysis.



Chitosan production from the shells involved demineralization, deproteinization, and decoloration.

RESULTS & DISCUSSION

Chromatographic analyses identified 21 and 16 compounds, respectively, for *T. vulgaris* and *L. nobilis* Eos.

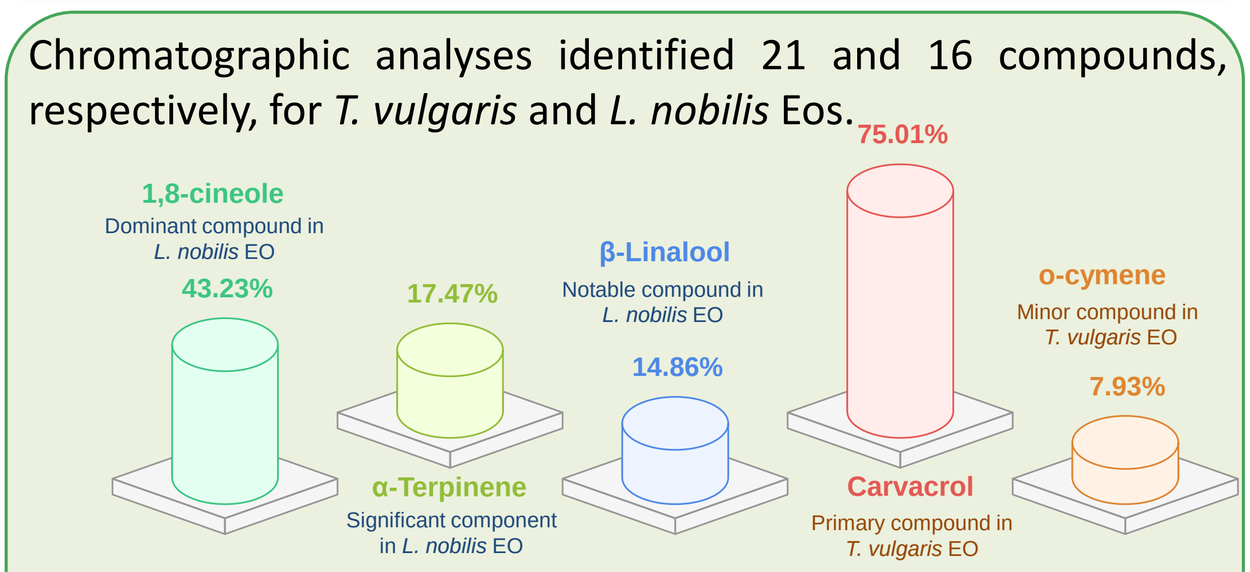


Figure 1. Major Compound in EO

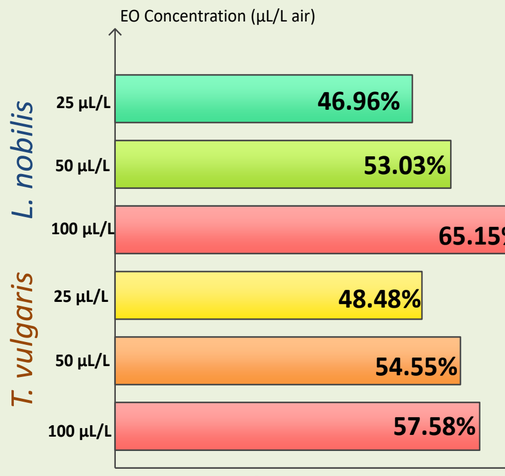
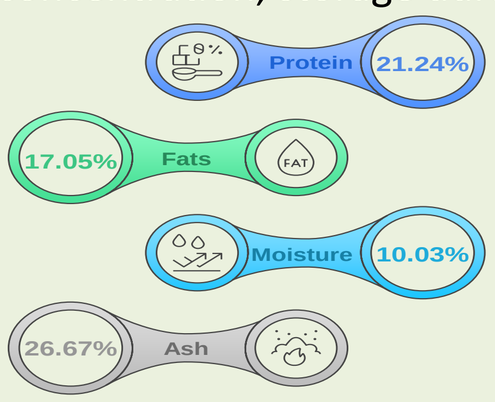


Figure 2. Fumigant toxicity of crude EO

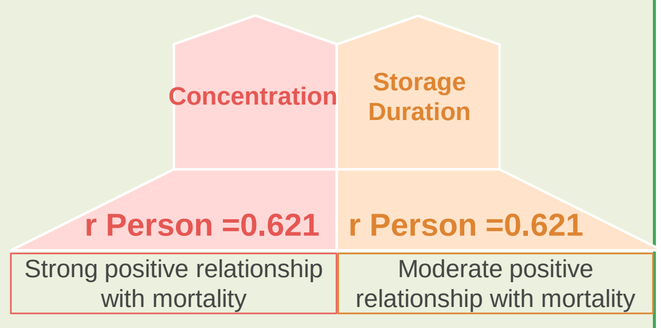
The mortality rate increased with concentration. After 20 days of exposure, *L. nobilis* essential oil at 25, 50 and 100 µL/L of air induced 46.96 %, 53.03 % and 65.15 % mortality, respectively, compared to 48.48 %, 54.55 % and 57.58 % for *T. vulgaris*. Thus, *L. nobilis* oil demonstrated a stronger insecticidal effect than *T. vulgaris.*

Statistical analyses revealed highly significant effects of concentration, storage duration and oil type.



The characterization of shrimp co-products revealed that the powder contains essential protein (21.24 %) and fats (17.05 %). In addition, these co-products exhibited 10.03 % of moisture content and 26.67 % of ash content.

The insecticidal activity of *L. nobilis* and *T. vulgaris* EO formulations encapsulated in shrimp powder increased during the storage period.



Formulation toxicity increased significantly : LC_{50} values dropped from 12.03 and 29.88 g/L air after 10 days to 3.65 and 7.78 g/L air after 30 days for *L. nobilis* and *T. vulgaris*, respectively. Moreover, the formulations also reduced larval emergence.

CONCLUSION / FUTURE WORK

The results of the present study highlighted the promising potential of the formulations prepared from the powder of shrimp co-products for the control of insect pests of stored food. Future research should optimize powder formulations and evaluate their safety and residue persistence.