Advancing Sustainable Pest Management in Rice Storage: Behavioural Insights, Infestation Detection, and Essential Oil Effects on *Sitophilus* spp.

TRACING RICE AND VALORIZING SIDE STREAMS ALONG MEDITERRANEAN BLOCKCHAIN

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

Instituto Nacional de Investigação Agrária e Veterinária, I.P.

Importance of Pest Management in Rice Storage

- Effective pest management is crucial to prevent infestations that compromise rice quality, leading to substantial losses and reduced market value.
- Key Focus: *Sitophilus* spp. (rice weevils) due to their significant impact on rice quality, reducing grain value through contamination and physical damage.
- Challenges with conventional insect management and the extensive use of chemical methods have led to resistance development within insect populations; and environmental and health concerns due to pesticide use.
- Environmentally friendly insect management techniques have been researched and published (2023) offering alternative strategies for sustainable rice storage.

Open Access Review

Advances in Environmentally Friendly Techniques and Circular Economy Approaches for Insect Infestation Management in Stored Rice Grains

by Inês Gonçalves de Sousa [1,2], Jorge Oliveira [3,4], António Mexia [2,5], Graça Barros [5], Carina Almeida [1], Carla Brazinha [6], Anna Vega [7] and Carla Brites [1,8,*]

Relevance of the Study

Preventing infestations from the field to industrial processing and retail.

Chemical solutions raise concerns about environmental impact and human health.

Insects reveal resistance mechanisms.

new alternatives and approaches

Main Objective

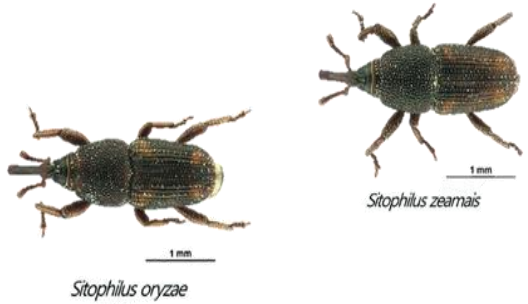
Test the effectiveness of physical and biological-based solutions to eradicate the use of synthetic chemicals and ensure the elimination of insect infestation in stored rice.

Key Research Tasks

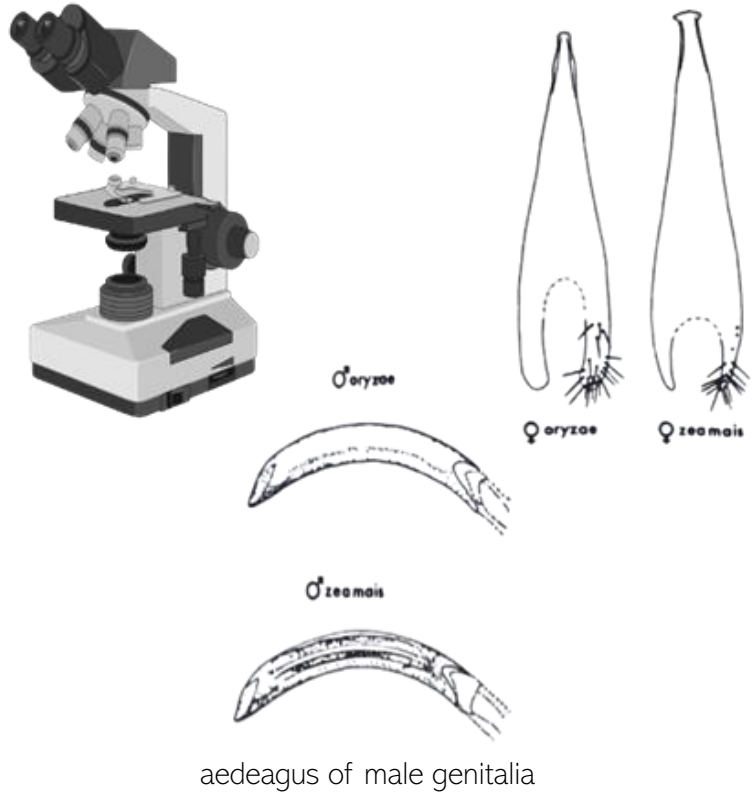
1. Reproduction of insect biomass - *Sitophilus oryzae* and *Sitophilus zeamais*.
2. Testing fast and accurate methods to detect hidden insect infestations in rice.
3. Evaluating the repellent activity of several volatile substances.
4. Testing the efficiency of physical and biological solutions to control infestations in rice.
5. Evaluating the effect of treatments on the physicochemical and organoleptic quality of rice.

Reproduction of Insect Biomass

Sitophilus oryzae and *Sitophilus zeamais*



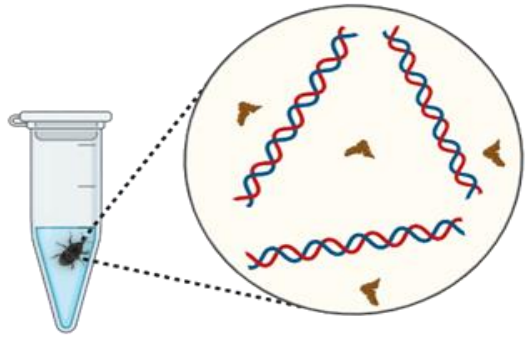
Total insects	Total larvae/pupae	Identified insects		
			male	female
~5000	~600	~460	~260	~200



Testing fast and accurate methods to detect hidden infestations in rice

Improved carbon dioxide production detection (portable sensor)

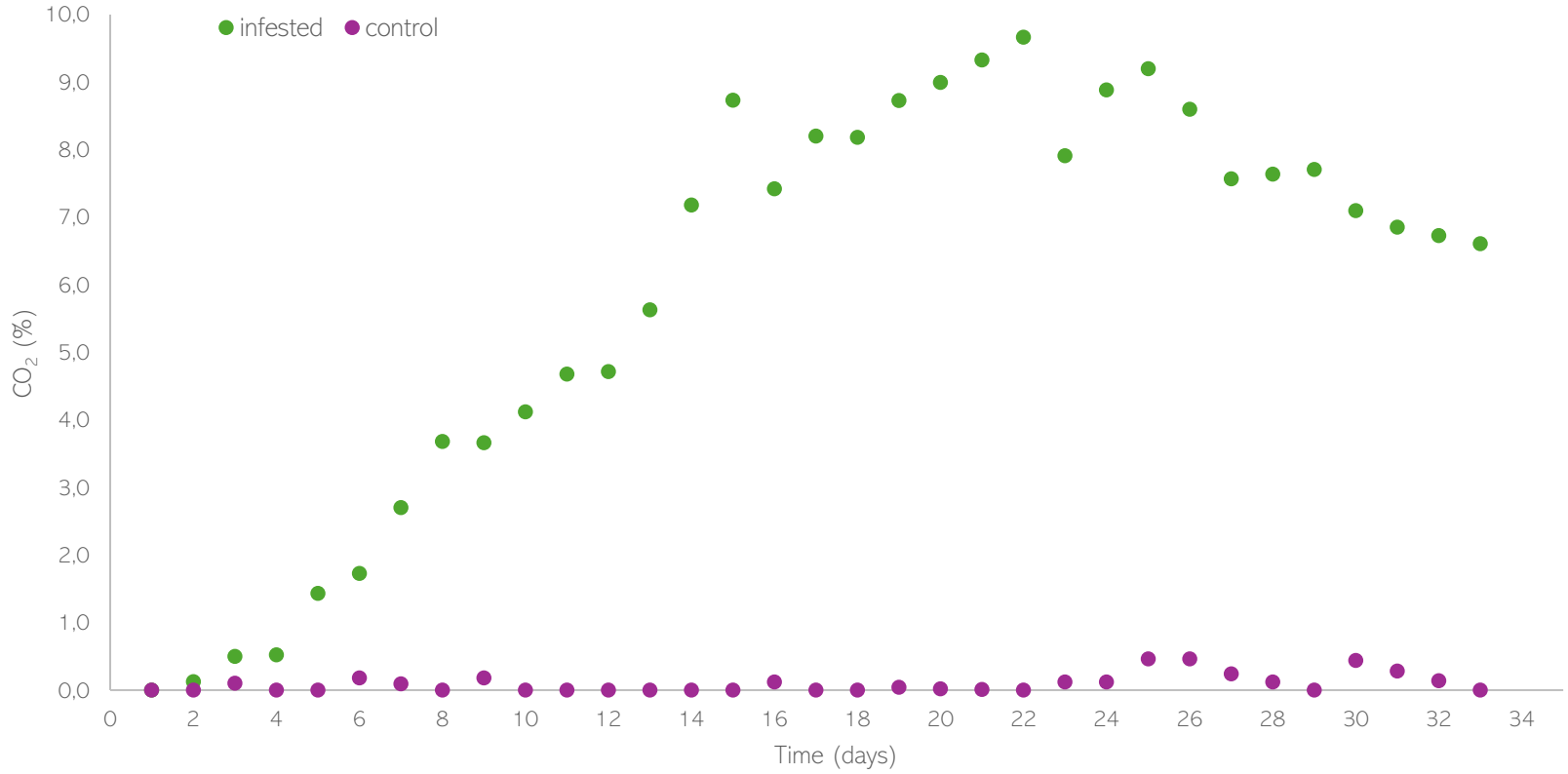
Quantitative real-time polymerase chain reaction (qRT-PCR)



Testing fast and accurate methods to detect hidden infestations in rice

Evolution of the carbon dioxide levels throughout the insect's life cycle.

The test ends when adult insects are detected.



Mean CO_2 values (%) throughout the life cycle of the insects, determined on previously infested rice samples.

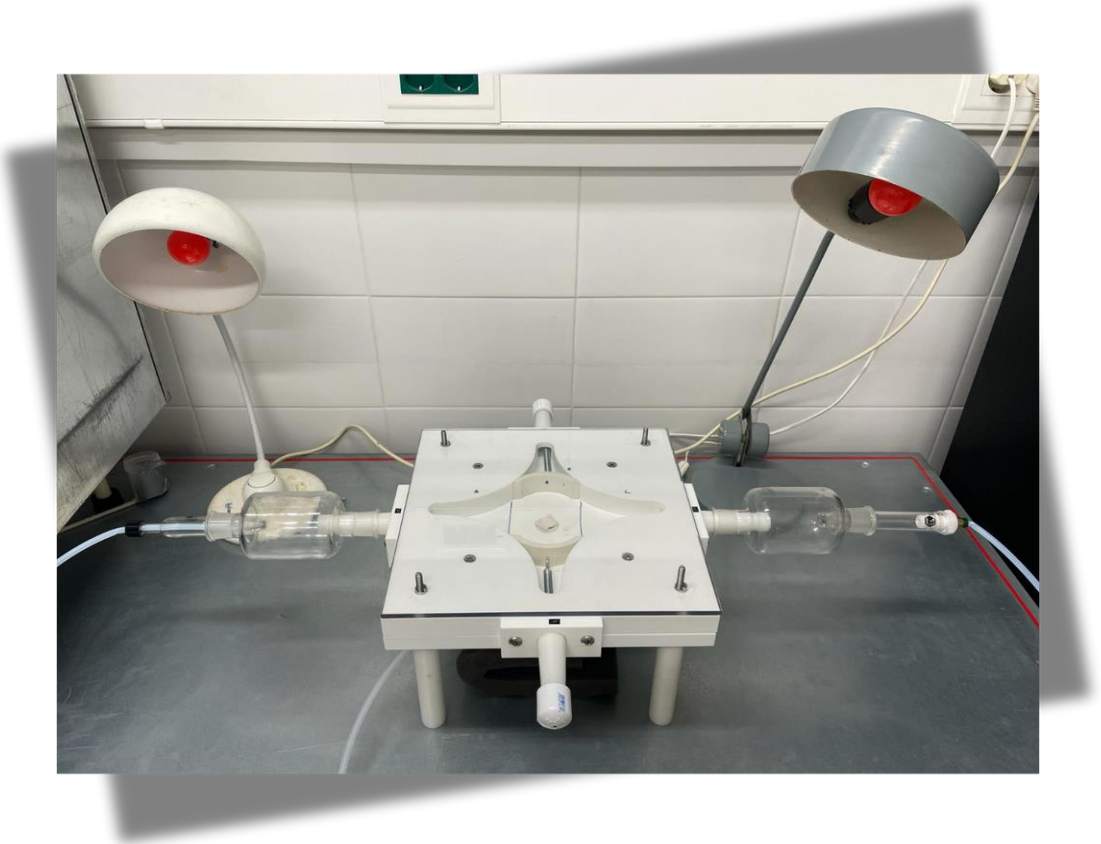
Testing fast and accurate methods to detect hidden infestations in rice

CO_2 (%)	qRT-PCR results
0,2	*S. zeamais* positive *S. oryzae* positive
0,5	*S. zeamais* positive *S. oryzae* positive
2	*S. zeamais* positive

Evaluating the repellent activity of compounds from essential oils

Understand the behaviour of *Sitophilus* towards substances with possible repellent activity.

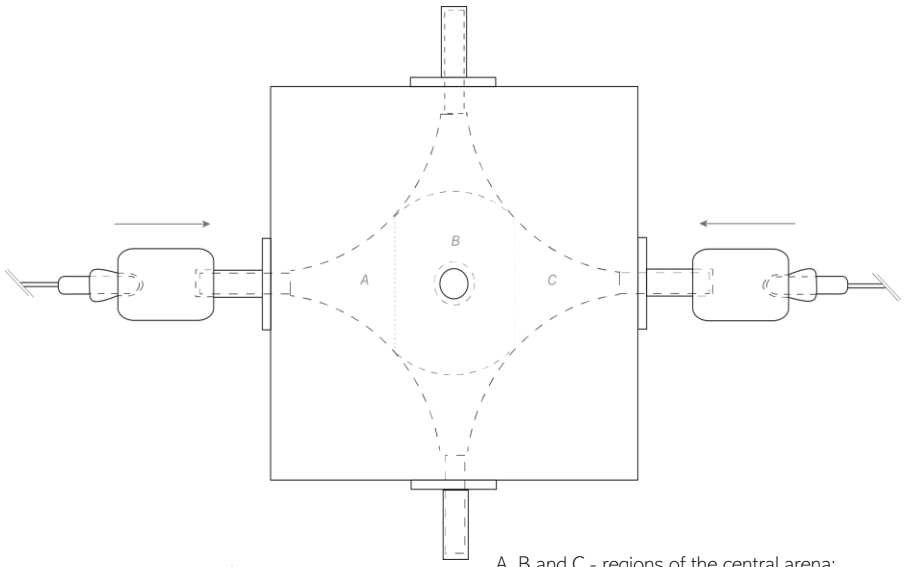
Eugenol
Eucalyptol
(S)-(-)-Limonene
L-menthol
Thymol



Evaluating the repellent activity of compounds from essential oils

Mean Time (min.)

source	near	central	far
Cotton Disc	not significantly different		
Rice Flour (200 mg)	***4,92±2,72^b***	2,95±1,89^a	1,71±1,76^a



A, B and C - regions of the central arena;
analysed whether the insects were near or far from the stimulus source

200, 100 and 50 µL

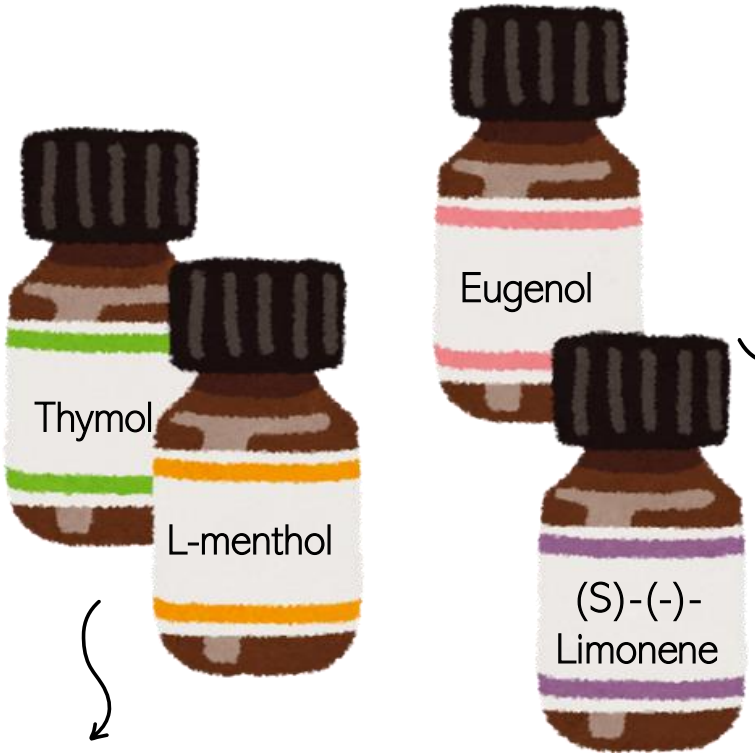
Mean Time (min.)

source	near	central	far
EC200	not significantly different		
EC100	2,98±1,33^a	***5,17±1,62^b***	1,85±1,71^a
EC50	3,08±1,57^a	***4,95±1,96^b***	1,97±1,42^a
L200	2,86±2,55^a	2,54±1,51^a	***4,60±2,86^b***
L100	not significantly different		
L50	2,78±2,19^a	2,74±1,05^a	***4,48±1,94^b***
EG200	not significantly different		
EG100	2,84±1,84^a	3,13±2,13^a	***4,03±2,16^b***
EG50	2,93±2,10^a	***5,19±2,37^b***	1,88±2,46^a

EC – Eucalyptol
L – (S)-(-)-Limonene
EG – Eugenol

Testing the application of compounds from essential oils in rice

Application of food-grade compounds from essential oils to prevent weevil infestations in stored rice.



0.1 mg and 0.2 mg/100g
(solid compounds)

10 µL and 20 µL/100 g
(liquid compounds)

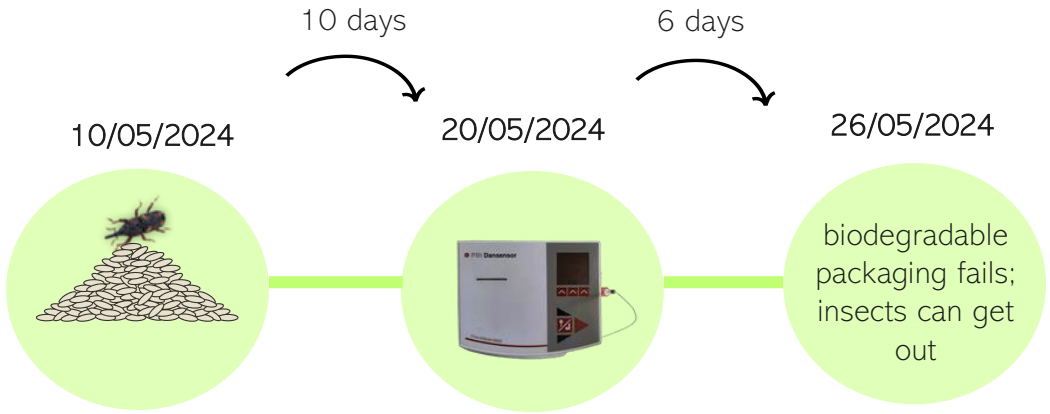
Testing the efficiency of ultraviolet light (UV-C) to control infestations in rice

3 g of infested rice treated with UV-C 280nm

UV-C 280nm directly in larvae

Ultraviolet equipment tested

Testing the use of biodegradable packaging



A – biodegradable packaging; Mater-Bi (EN 13432 standard)
B – traditional petrochemical plastic (BOPP with a 30 µm transparent layer and a 70 µm transparent PE layer)

Evaluating the effect of treatments on the physicochemical and organoleptic quality of rice

Analyses carried out to evaluate the effect of the selected treatments on the physicochemical quality characteristics of the rice.

Analysis	Method
basic chemical composition	Near Infrared Spectroscopy (NIR)
pasting properties gelatinization temperature	Rapid Viscoanalyser (RVA) AACC 61-02.01 AACC 61-04.01
colour	Colourimeter Minolta CR300
moisture	ISO 712:2009
amylose	ISO 6647-2:2020
resistance to extrusion	ISO 11747:2012

Conclusions and Future Directions

- Field-Based Prevention: Implement strategies to reduce weevil infestations originating from the field.
- Facility Hygiene and Temperature Control: Prioritize thorough cleaning and maintain optimal temperature control in storage facilities to reduce infestation risks, though complete prevention may be challenging.
- Advanced Sensor Technology: Modern sensors show promise for early detection and prediction of hidden infestations, supporting proactive pest management.

TRACE-RICE Project Innovations:

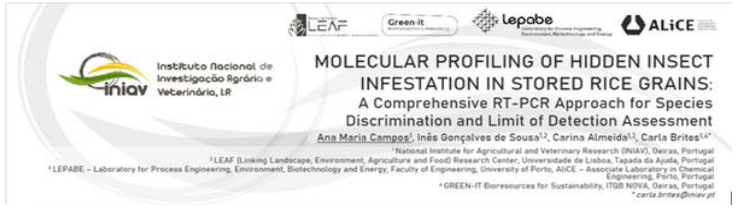
Trialled chemical-free solutions to prevent egg hatching and control infestations in stored rice.
Aimed to reduce reliance on conventional chemical treatments in the industry.

Promising Approaches for Validation:

Essential Oil Compounds: Impregnation of rice with Limonene, Eugenol, and Eucalyptol.
UV-C Application: Tested as an effective non-chemical control method.

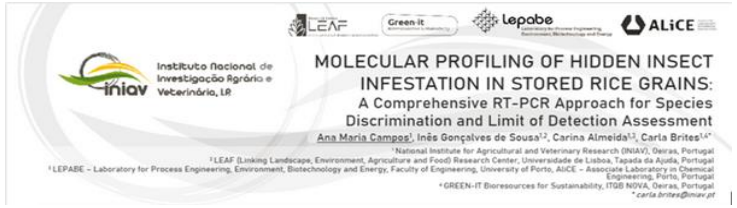
Publications

Posters

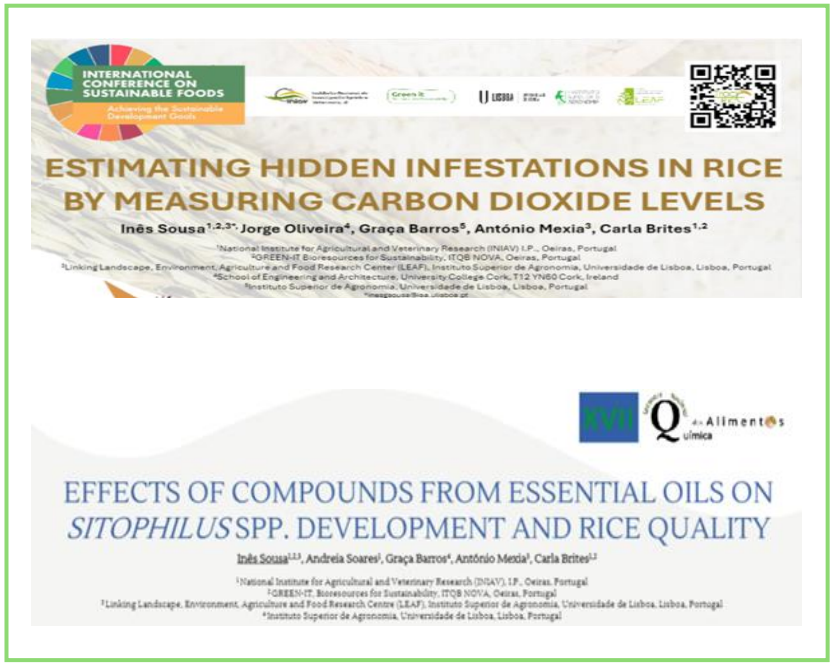


Oral Communications

Posters



Publications



Awards

Inês Sousa & Carla Brites

thank you!

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