IECAG 2024 Conference

The 4th International Electronic Conference on Agronomy

02–05 December 2024 | Online

MDPI

Brewing Sustainability: Transforming Coffee Waste into Powerful Crop Protectors - A Circular Economy Approach

Eva Sánchez-Hernández[1], Jorge Clérigo-De Santiago[1], Vicente González-García[2], Zacarías Clérigo-Pérez[3], Jesús Martín-Gil[1], Pablo Martín-Ramos[1]

[1] Dept. Agricultural and Forestry Engineering, ETSIIAA, University of Valladolid, Spain; [2] Dept. Agricultural, Forestry, and Environmental Systems, CITA-University of Zaragoza, Spain; [3] Dept. Materials Science and Metallurgical Engineering, ETSIIAA, University of Valladolid, Spain

INTRODUCTION & AIM

The coffee industry generates substantial waste, often discarded, creating environmental and economic challenges. However, these residues can be a valuable source of bioactive compounds with antimicrobial properties. This presents an opportunity for their use in crop protection, both pre- and post-harvest. Following **circular economy principles**, this study proposes the extraction and characterization of **bioactive products from coffee byproducts** and evaluates their antifungal activity against pathogens affecting coffee plants (***Fusarium xylarioides***) and stored coffee beans (***Aspergillus flavus, A. niger***, and ***Penicillium verrucosum***).

METHODOLOGY

The extraction of coffee byproducts (**husk, parchment, green bean + silver skin, and silver skin**) was conducted in an aqueous ammonia medium assisted through ultrasonication. The extracts were freeze-dried and characterized using gas chromatography-mass spectroscopy (**GC-MS**). Their **antimicrobial activity** was assessed through ***in vitro*** analyses, following the EUCAST guidelines. For **coffee plant protection assays**, the protocol established by González *et al.* (2020) was employed, whereas the protocol outlined by Sánchez-Hernández *et al.* (2023) was followed for **bean protection** experiments.

RESULTS & DISCUSSION

Extract characterization by GC-MS:

The main components of the by-product extracts are **caffeine**, **acetamide**, and ***n*-hexadecanoic acid**. **Methoxyphenyloxime** is a significant compound in peel and parchment extracts, while **quinic acid** is predominant in silver skin extracts. The high caffeine content in the freeze-dried extract of coffee beans (52%), in husk (23%), parchment (16%), and silver skin (18.5%) highlights the **efficiency** of the proposed **extraction method**.

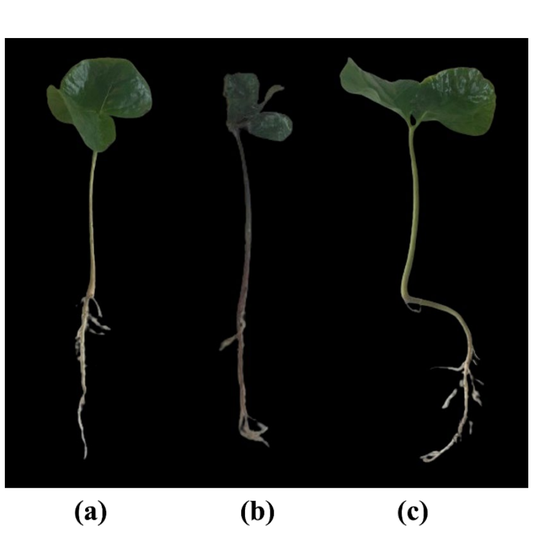
In vitro antifungal activity:

In vitro activity assays demonstrate **high antimicrobial activity** of the extracts, with minimum inhibitory concentrations in the range of 15.6–375, 31.2–1000, 62.5–1000, and 62.5–1500 µg/mL against *F. xylarioides*, *A. flavus*, *A. niger*, and *P. verrucosum*, respectively, depending on the residue used.

Coffee by-product	Minimum inhibitory concentration (µg/mL)			
	F. xylarioides	*A. flavus*	*A. niger*	*P. verrucosum*
Husk	375	1000	1000	1500
Parchment	250	750	750	1000
Green bean + silver skin	125	250	375	500
Silver skin	15,6	31,2	62,5	62,5

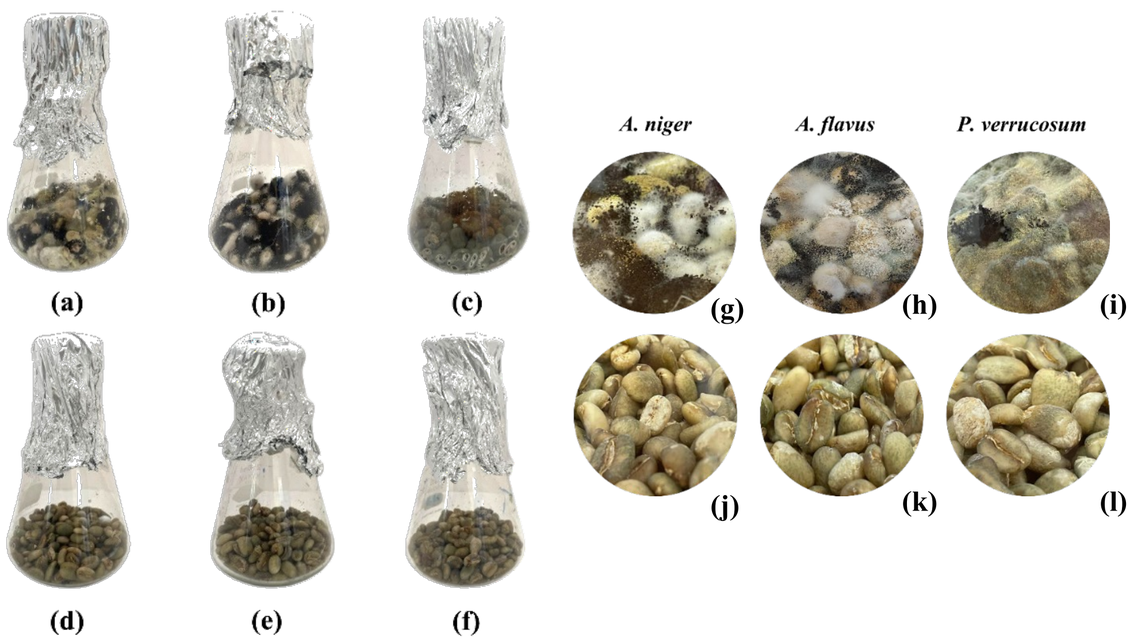
In planta and postharvest protection:

The extract with the highest activity, derived from **silver skin**, was tested for pre-harvest protection of coffee plants, demonstrating **complete inhibition of tracheomycosis caused by *F. xylarioides*** at a concentration of **62.5 µg/mL**. At the same concentration, the silver skin extract also demonstrated **complete post-harvest protection of coffee beans against *A. flavus*, *A. niger*, and *P. verrucosum***.



(a) (b) (c)

Symptoms of coffee tree tracheomycosis caused by *F. xylarioides* in *Coffee arabica* plants after 30 days of inoculation: **(a)** negative control; **(b)** positive control; **(c)** silver skin extract, the most active extract *in vitro*, conferred complete protection of coffee plants at 62.5 µg/mL.



Untreated coffee beans artificially inoculated with **(a)** *A. niger*, **(b)** *A. flavus*, and **(c)** *P. verrucosum*. Effect of the application of silver skin extract at a concentration of 62.5 µg/mL for each pathogen in coffee beans on the growth of **(d)** *A. niger*, **(e)** *A. flavus*, and **(f)** *P. verrucosum.* Detail of: **(g-i)** untreated coffee beans; **(j-l)** treated coffee beans.

CONCLUSION

These findings suggest that the **aqueous ammonia extracts** of **coffee byproducts** represent a promising **alternative to conventional synthetic phytosanitary products**, with the potential to improve the sustainability of the coffee industry.

REFERENCES

González, V. *et al.* (2020). First report of *Neocosmospora falciformis* causing wilt and root rot of muskmelon in Spain. Plant Disease, 104, 4, doi:10.1094/PDIS-09-19-2013-PDN.

Sánchez-Hernández, E. *et al.* (2023). Phytochemical profile and activity against *Fusarium* species of *Tamarix gallica* bark aqueous ammonia extract. Agronomy, 13, 496, doi:10.3390/agronomy13020496.

Eva Sánchez Hernández, PhD.
eva.sanchez.hernandez@uva.es