Foods 2026 Conference

The 7th International Electronic Conference on Foods

28–30 October 2026 | Online

Biotechnological development of active polymeric biostructures containing nanoencapsulated essential oils for antifungal protection of horticultural produce

Yésica Pallavicini [1], Luciana Biondi [1], Sara Diosdado-Ruipérez [1], Marta Sánchez [1] María Virginia Ozcariz-Fermoselle [1*]

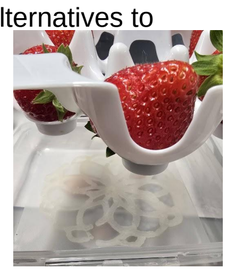
Affiliation [1] R&D department, Centro Tecnológico Agrario y Agroalimentario, Palencia 34004, Spain

*Corresponding author: mvozcariz@itagra.com

INTRODUCTION & AIM

The highly perishable nature of fruit and vegetable products, driven by their high susceptibility to fungal spoilage and pathogenic microorganisms, demands advanced biotechnological solutions to mitigate quality deterioration and postharvest economic losses.

This research focuses on developing fully sustainable, edible, and eco-friendly alternatives to synthetic fungicides through the design of bioactive polymers.

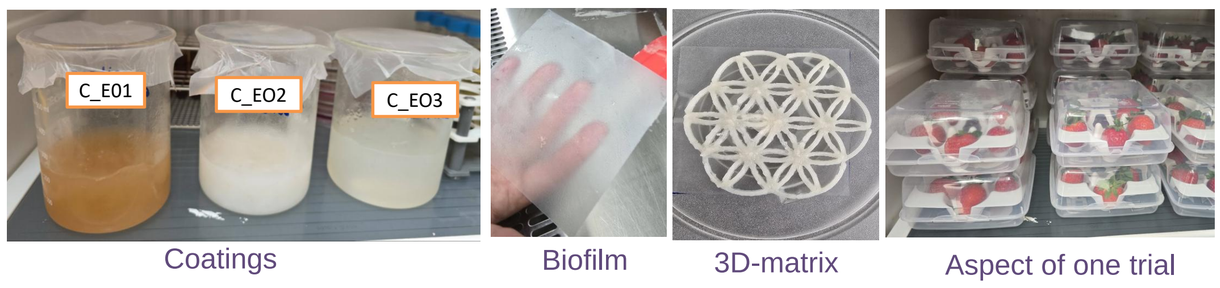


In this study, three polymeric biostructures were designed and developed:

- **Coatings**: Liquid formulations applied directly to the fruit surface
- **Biofilms**: Preformed biodegradable sheets that act through the vapor phase.
- **3D-printed matrices:** Custom-designed support structures that release active compounds through the vapor phase.

METHOD

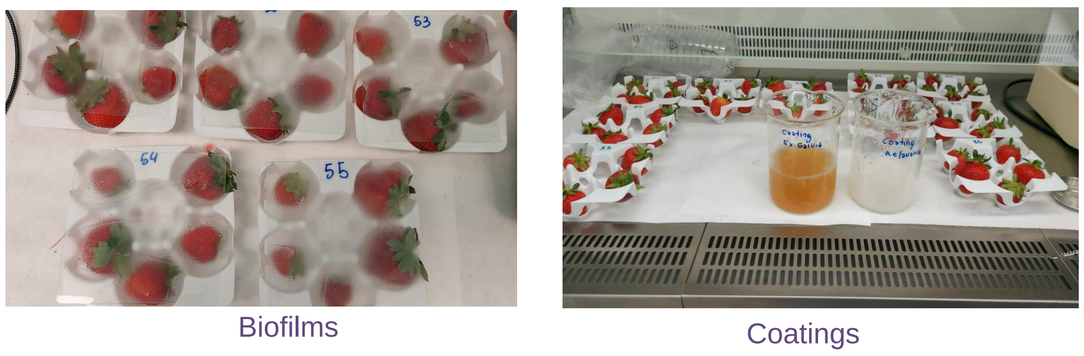
The biostructures were formulated using edible structural polymers, naturally derived plasticizers, and emulsifiers, and were functionalized with nanoencapsulated essential oils (EOs) acting as antimicrobial agents. These biotechnological systems provide sustained antifungal protection, either through direct contact or via vapor-phase dispersion (Fig.1).



Coatings | Biofilm | 3D-matrix | Aspect of one trial

Fig 1: Aspect of the 3 biostructures

To evaluate the potential of these biostructures to extend shelf life, strawberries (*Fragaria × ananassa*) were used as an “in vivo” study model due to their high vulnerability. The efficacy of the developed systems was assessed by monitoring fungal infection incidence alongside critical fruit quality parameters such as weight loss and firmness (Fig.2).



Biofilms | Coatings

3D-matrix impresión process | 3D-matrix

Fig 2: Application of the biostructures in experimental trials

RESULTS & DISCUSSION

Preliminary trials suggest that matrices enriched with EO nanoparticles reduce both disease incidence (number of rotten fruits; Fig 3a and severity (percentage of fruit affected by disease symptoms; Fig. 3b).

The most effective polymeric systems were coatings enriched with EO_1 and EO_2, showing negligible or no disease incidence and severity, followed by Biofilm_EO1. The plant extract coating showed disease incidence below 30% and low severity, while the 3D matrix exhibited moderate efficacy.

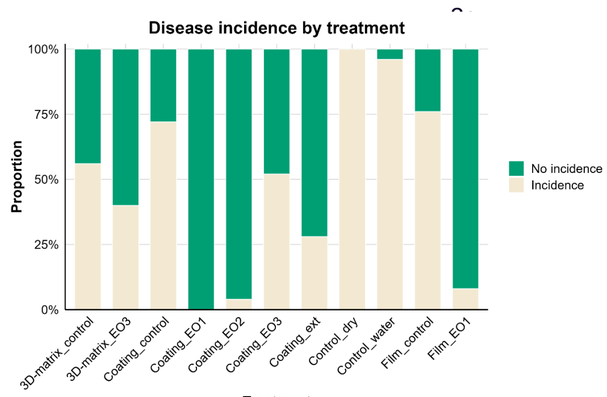


Fig. 3a. Number of infected fruits.

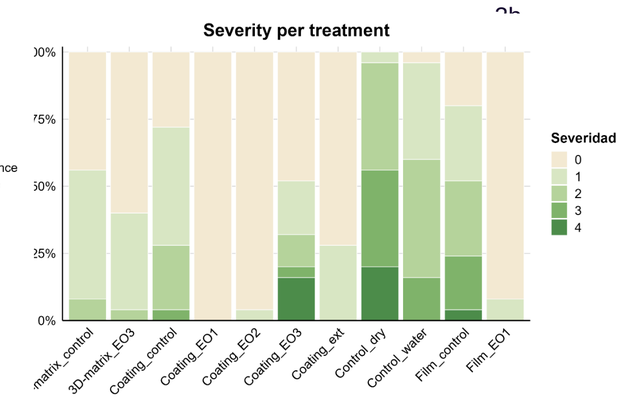


Fig. 3b. Severity of the symptoms

Weight loss and firmness are key indicators of fruit quality and deterioration. No significant differences in weight loss (Fig. 4a) or fruit firmness (Fig. 4b) were observed between the treatments and controls. These findings suggest that the biostructures did not adversely affect fruit tissue integrity or quality.

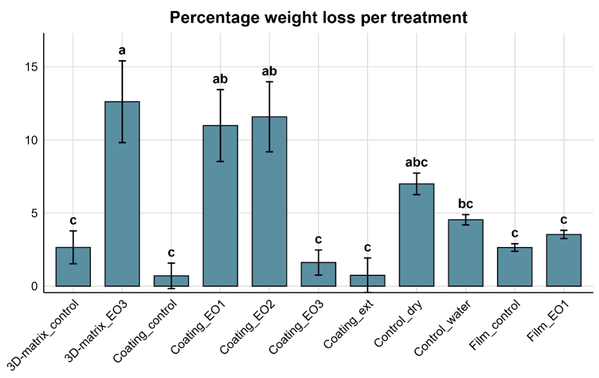


Fig. 4a. Percentage of weight loss by treatment.

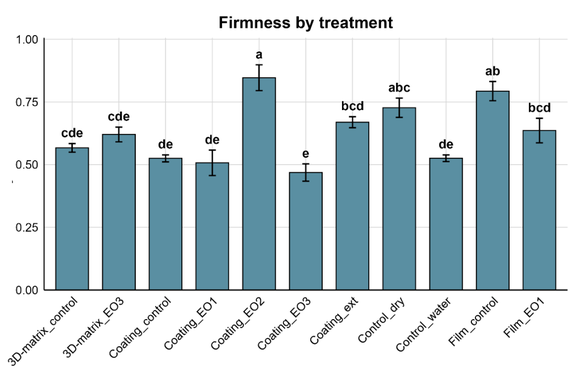


Fig. 3b. Firmness by treatment

CONCLUSION & FUTURE WORK

This research highlights the great potential of materials biotechnology and structural design in the creation of active packaging, offering a natural, safe, and effective strategy for the agri-food sector to address the challenge of food waste. Future research will focus on evaluating a broader range of essential oils incorporated into biostructures to assess their efficacy and potential applications.

ACKNOWLEDGEMENTS

This research was supported by the BIOTECFILMS project, funded by the Instituto para la Competitividad Empresarial de Castilla y León (ICECYL) under grant CCTT5/23/PA/0003, co-financed by the European Regional Development Fund (FEDER).

Project Website: https://itagra.com/proyectos/biotecfilms/