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Sustainable Production of Antimicrobial Peptides from Fruit Waste Using Genetically Modified Yeast for Pathogen Control

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INTRODUCTION & AIM

Sustainable practices in the chemical and cosmetic industries are essential to reduce environmental impacts and meet the growing demand for eco-friendly products. Through the valorization of by-products, it is possible to convert waste materials into innovative ingredients, thereby minimizing food waste generation [1].

Antimicrobial peptides (AMPs) are short oligomers with antimicrobial properties, representing a promising alternative to conventional preservatives. In this study, they were produced by a genetically modified *Saccharomyces cerevisiae* Ethanol Red *TDH1* strain with high potential for fermentative processes [2].

The aim of this study was to produce AMPs employing residual fruit peels as fermentation substrates. Their antimicrobial activity was evaluated against relevant food and cosmetic pathogens to assess their potential as natural preservatives in cosmetic formulations.

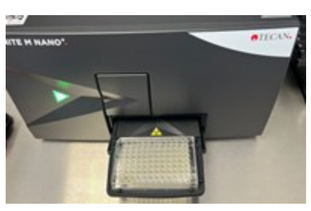
METHOD

1. Fruit peels were selected for their nutrient content and inhibitory compounds (Table 1), and the must was analyzed for fermentation suitability, with acid and enzymatic hydrolysis

Table 1. Initial composition of the fruits used in the fermented fruit must, indicating the concentration of sugars (g/L), phenolic compounds (mg/grams used) and fiber (g/L)

Fruit type	Sugars (g/L)	phenolic compounds	Fiber (g/L)
Banana	116.60	154.92 mg/400g	19.80
Apple	121.34	3502.76 mg/200g	21.83
Pineapple	102.96	1969.20 mg/400g	14.56
Mango	136.00	954.48 mg/400g	15.76

2. Fermentation with genetically modified *S. cerevisiae* Ethanol Red *TDH1* [2] was performed for 8 days in duplicate using fruit and synthetic musts.



3. Daily measurements included fermentable sugars and ethanol, determined with specific assay kits, and CFU/mL

4. A <10 kDa peptide fraction was obtained by ultrafiltration and tested against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans*. Fractions were inoculated at a standardized OD_{600}, and microbial growth was monitored over 24 hours.

RESULTS & DISCUSSION

Initial quantification of fermentable sugars revealed concentrations of 12.69 g/L glucose and 13.48 g/L fructose. Acid hydrolysis was applied to increase sugar availability, raising glucose levels to 29.16 g/L, whereas enzymatic hydrolysis did not significantly enhance fermentable sugar release, likely due to limited cellulase access to fruit peel polysaccharides.

During fermentation, *S. cerevisiae* showed higher growth in fruit must (4.68×10^8 CFU/mL) than in synthetic must (1.98×10^7 CFU/mL). However, *S. cerevisiae* in the synthetic must produce higher ethanol concentration (7.29 g/L) than in fruit must (5.55 g/L) , indicating lower fermentative efficiency in fruit must, likely due to inhibitory compounds such as polyphenols and flavonoids [1].

Both <10 kDa fractions exhibited antimicrobial activity. The synthetic must was more effective against *E. coli* and *P. aeruginosa* (data not shown), whereas the fruit must induce stronger growth inhibition in *S. aureus* and *C. albicans*. For the 50% fruit fraction, the minimum inhibitory concentration (MIC) was 1.46 mg/mL, as shown in Figure 2.

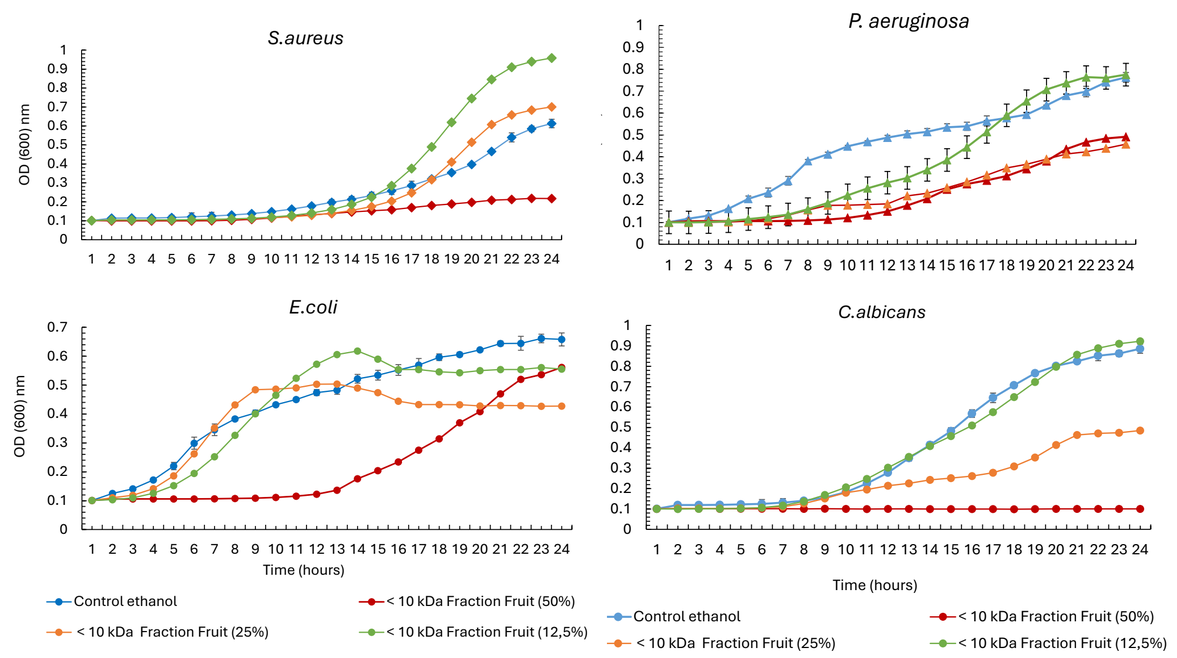


Figure 2. Minimum inhibitory concentration (MIC) of the 50% fruit fraction against *S. aureus, P. aeruginosa*, *E. coli* and *C. albicans*

CONCLUSION

This study demonstrated the biotechnological potential of fermented fruit must fractions as sources of natural antimicrobial compounds. Although the synthetic must exhibit a higher sugar-to-ethanol conversion rate (14 g/L vs <3 g/L), possibly due to the presence of yeast growth–inhibitory compounds such as polyphenols and flavonoids in the fruit peels, the overall approach remains promising for further development.

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