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Improving the flavor of fermented foods: Biotransformation of hydroxycinnamic acids into volatile aroma compounds by lactic acid bacteria from dairy products.

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ABSTRACT

Food flavor is impacted by the presence of 4-vinylphenols, volatile compounds with low-perception thresholds produced by decarboxylation of hydroxycinnamic acids (HCAs) ubiquitous in nature. In fermented foods like sourdough bread and pickled vegetables, the bacterial strains used for the fermentation process will determine the development of the desired sensory properties. Our goal was to screen the ability of lactic acid bacteria (LAB) strains isolated from dairy products (OSU-Parker Endowed Chair collection) to produce 4-vinylphenols. LAB with potential to produce phenolic acid decarboxylase (22 strains) were incubated with HCAs for 36 hrs at 32°C. Decarboxylation was monitored using a novel high-throughput spectrophotometric method based on hypsochromic shifts resulting from the conversion of HCAs into 4-vinylphenols. Spectrophotometric results were verified by uHPLC-DAD-ESI-MS analyses. *E. mundtii*, *L. plantarum* and *P. pentosaceus* were able to decarboxylate all *p*-coumaric, caffeic and ferulic acid. To our knowledge, this is the first report of *E. mundtii* decarboxylating capabilities. This work can help on LAB strain selection for the design of better fermentation starters for food applications, ultimately improving the characteristics of HCA-rich foods.

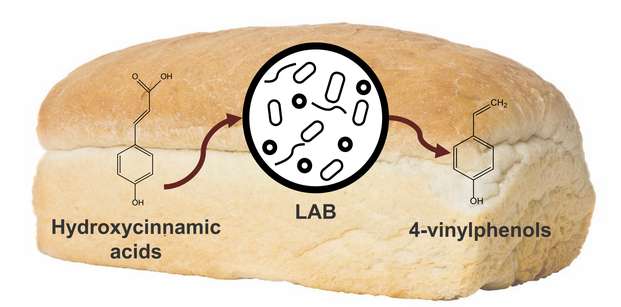
INTRODUCTION

HCAs are secondary metabolites in plants and fungi characterized by a C6-C3 structure. In high concentrations, HCAs exert an antibacterial effect over a wide range of gram-positive and gram-negative bacterium.

Studies have shown that some bacterial strains can decarboxylate HCAs as a mechanism for detoxification, eliminating the double bond in the side chain of the structure[1], responsible for their antimicrobial activity.

In products such as wine, HCA degradation by yeast results in the formation of 4VPs; which are responsible for imparting distinct phenolic off-flavors in the final product[2]. However, depending on the application, these compounds may be desirable as it is the case of sourdough bread, where presence of 4-vinylguaiacol was key for its characteristic aroma[3].

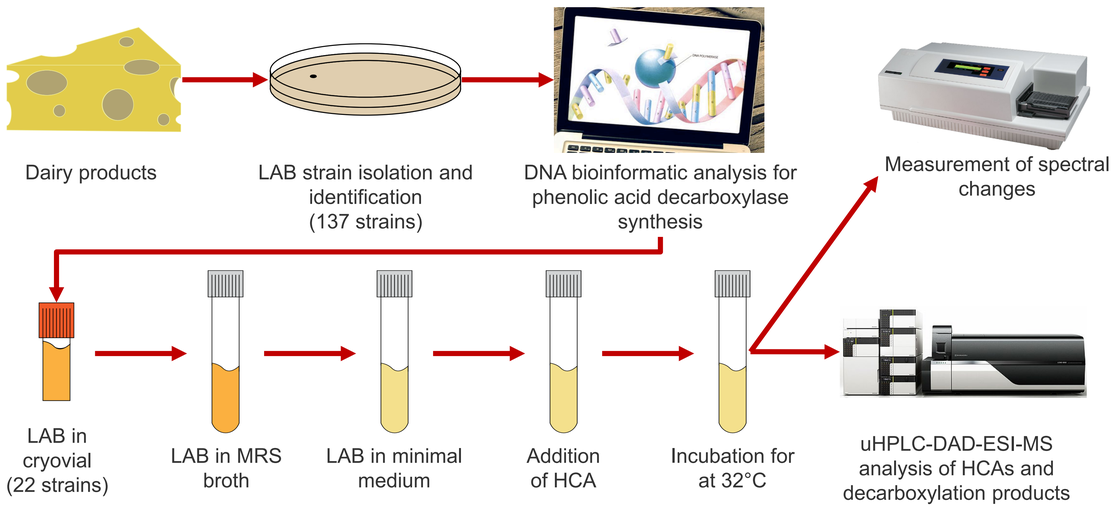
In addition, 4VPs can also react with other components in the food matrix such as anthocyanins, resulting in the formation of pyranoanthocyanins, compounds partially responsible for imparting color to aged red wines with an enhanced resistance to bleaching[4].



AIM

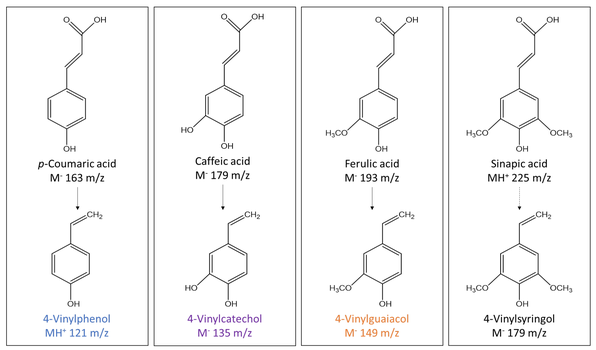
Our goal was to screen the ability of lactic acid bacteria isolated from dairy products to decarboxylate hydroxycinnamic acids resulting in the production of 4-vinylphenols.

MATERIALS AND METHODS



RESULTS

Figure 1: uHPLC-DAD-ESI-MS allowed us to monitor the presence and identity of initial hydroxycinnamic acids and their respective decarboxylated products after incubation for 36 hours at 32°C in the dark. Shown are HCA structures, their resulting 4-vinylphenols and representative chromatograms of samples incubated with *Lactobacillus plantarum* (OSU-PECh-BB).
λmax : maximum absorption in the 230-500 nm range.



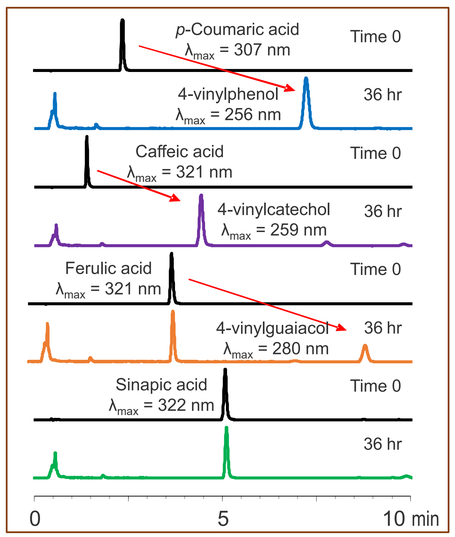


Figure 2: UV-Vis absorption spectra changed over time (6 hr at 32°C) due to decarboxylation of HCA. This change was faster for *p*-coumaric than caffeic acid when incubated with *Enterococcus mundtii* (OSU-PECh-39B), *Pediococcus pentosaceus* (OSU-PECh-27B), *Lactobacillus plantarum* (OSU-PECh-BB). *Lactobacillus casei* (OSU-PECh-C) was used as a negative control.

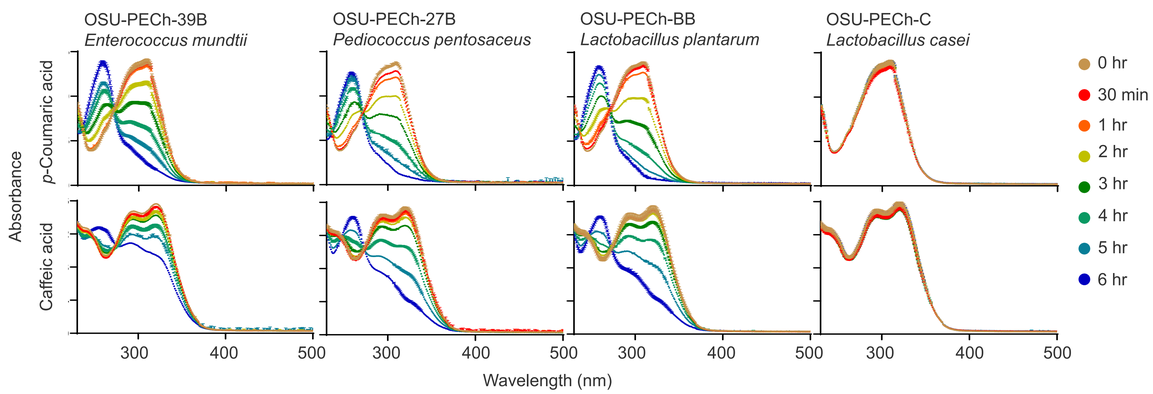


Table 1: Ability of lactic acid bacterial strains to degrade hydroxycinnamic acids (+). Results showed that **3 strains** decarboxylated all HCAs, **7 strains** decarboxylated both pCA and CA, **1 strain** decarboxylated only pCA and **1 strain** only CA. *E. coli* and *S. epidermidis* were used as Gram-negative and Gram-positive controls, respectively.

LAB strain	Accession code	pCA	CA	FA
Enterococcus mundtii	**OSU-PECh-39B**	**(+)**	**(+)**	**(+)**
Lactobacillus acidophilus	**OSU-PECh-LA5**	**(+)**	**(+)**	(-)
Lactobacillus helveticus	**OSU-PECh-LH1B**	**(+)**	(-)	(-)
	OSU-PECh-LH7	**(+)**	**(+)**	(-)
	OSU-PECh-LH4A	(-)	(-)	(-)
	OSU-PECh-LH15A	(-)	(-)	(-)
	OSU-PECh-LH19	(-)	**(+)**	(-)
	OSU-PECh-26	(-)	(-)	(-)
	OSU-PECh-60	(-)	(-)	(-)
	OSU-PECh-25	(-)	(-)	(-)
	OSU-PECh-57B	(-)	(-)	(-)
	OSU-PECh-40	(-)	(-)	(-)
	OSU-PECh-33	(-)	(-)	(-)
Lactobacillus plantarum	**OSU-PECh-LPA**	**(+)**	**(+)**	(-)
	OSU-PECh-LPBB	**(+)**	**(+)**	**(+)**
Lactobacillus pentosus	**OSU-PECh-LP6C**	**(+)**	**(+)**	(-)
Lactobacillus rhamnosus	OSU-PECh-24	(-)	(-)	(-)
Pediococcus acidilactici	**OSU-PECh-PA3A**	**(+)**	**(+)**	(-)
	OSU-PECh-PAL	(-)	(-)	(-)
Pediococcus pentosaceus	**OSU-PECh-PP13**	**(+)**	**(+)**	(-)
	OSU-PECh-6A	**(+)**	**(+)**	(-)
	OSU-PECh-27B	**(+)**	**(+)**	**(+)**
Escherichia coli	**BL21 (Invitrogen)**	**(+)**	**(+)**	(-)
Staphylococcus epidermidis	ATCC 1222	(-)	(-)	(-)

CONCLUSIONS AND SIGNIFICANCE

- *Enterococcus mundtii*, *Lactobacillus plantarum* and *Pediococcus pentosaceus* strains decarboxylated all *p*-coumaric, caffeic and ferulic acids producing their 4-vinylphenol derivatives.
- To our knowledge, this is the first study showing decarboxylating activity by the *E. mundtii* strain.
- Decarboxylation of *p*-coumaric acid was the fastest, followed by caffeic acid and lastly ferulic acid.

Significance: This work can help on LAB strain selection for the design of fermentation starters for food applications, ultimately improving the sensorial characteristics of fermented HCA-rich foods.

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