

Plant Polyphenol-Physical Field Marination Inhibits Advanced Glycation End Products and Heterocyclic Amines in Roast Steak

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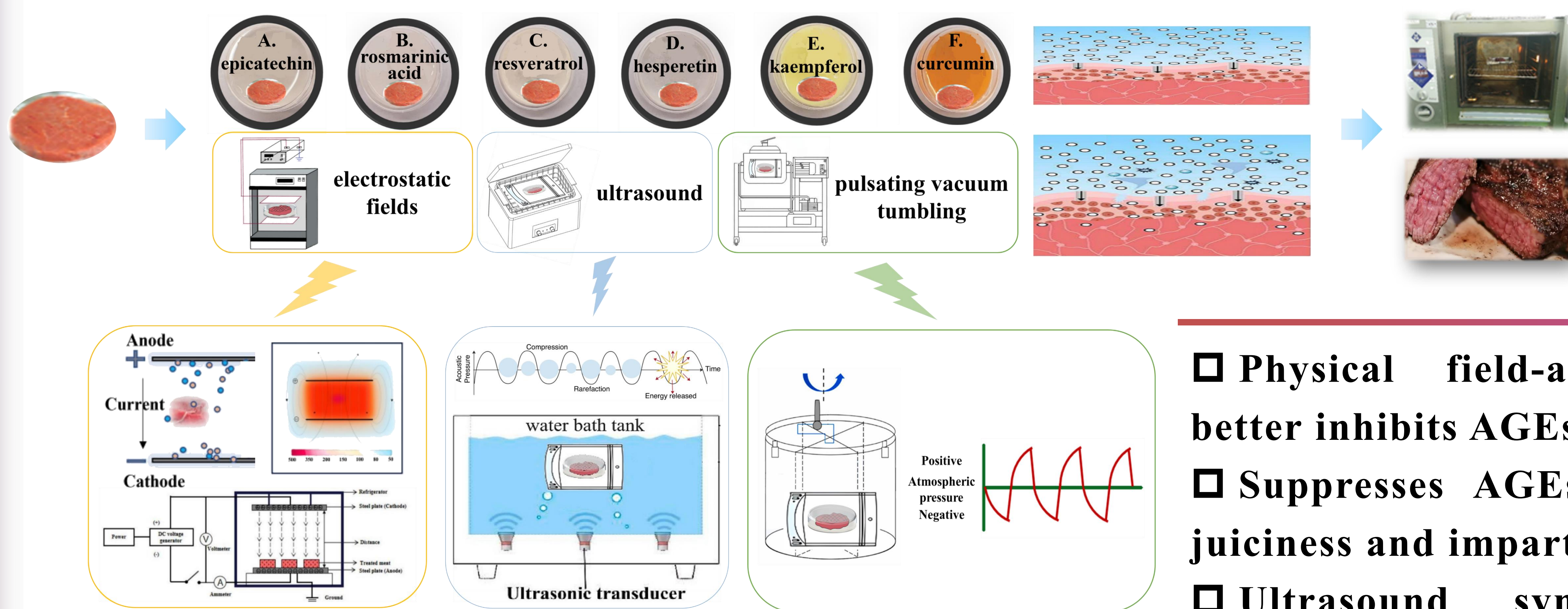
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INTRODUCTION

The simultaneous control of multiple harmful Maillard reaction products — particularly advanced glycation end products (AGEs) and heterocyclic amines (HAs) — in thermally processed meats remains challenging. While plant polyphenols show inhibitory potential, their efficacy in bulky matrices like steak is limited by poor permeation, and conventional approaches often fail to address multiple hazards concurrently. This study explores the novel combination of plant polyphenols with physical field technologies (ultrasound, electrostatic fields, and pulsating vacuum tumbling) to develop a synergistic strategy for the co-inhibition of AGEs and HAs.

MATERIALS & METHODS



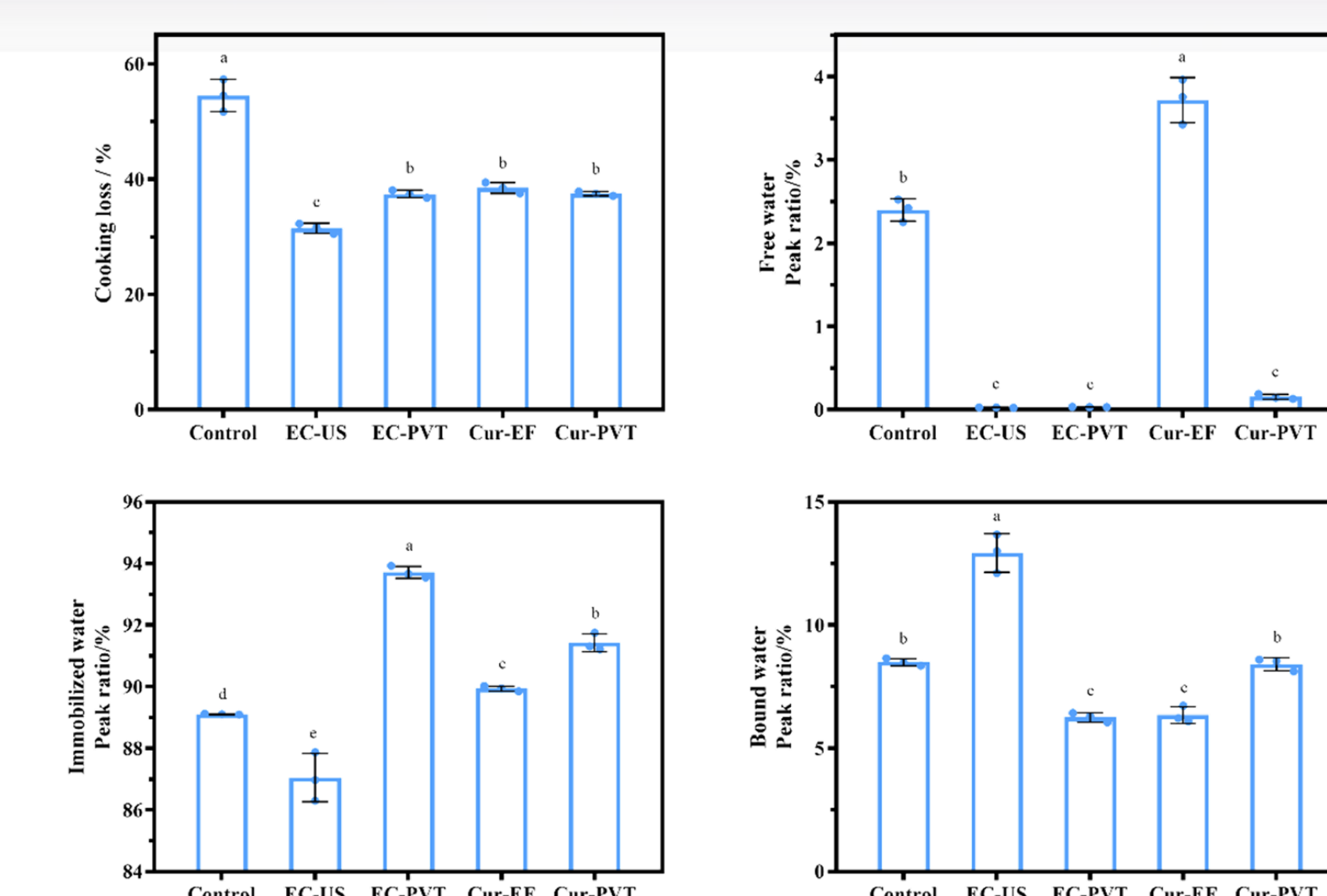
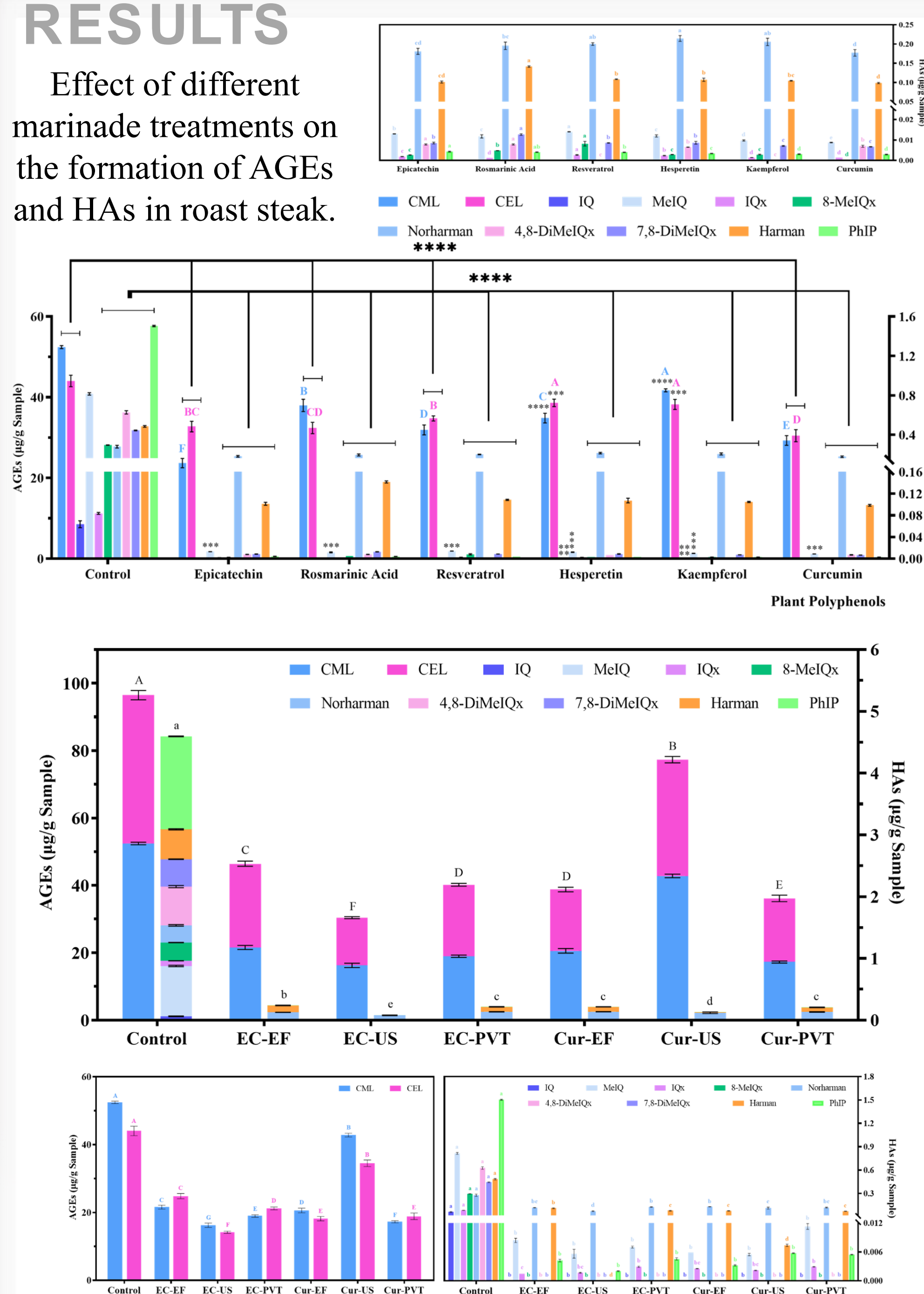
- Determination of AGEs and HAs
- Determination of the water-holding capacity (Cooking loss, Moisture mobility and distribution)
- Determination of the color
- Determination of the taste by electronic tongue
- Determination of the volatile flavor compounds
- Sensory evaluation of different marinated roast steak
- Statistical analysis

- Physical field-assisted polyphenol marination better inhibits AGEs and HAs formation.
- Suppresses AGEs/HAs by 69.8% while boosting juiciness and imparting unique flavor.
- Ultrasound synergizes epicatechin delivery, enabling industry-scale application.

HIGHLIGHTS

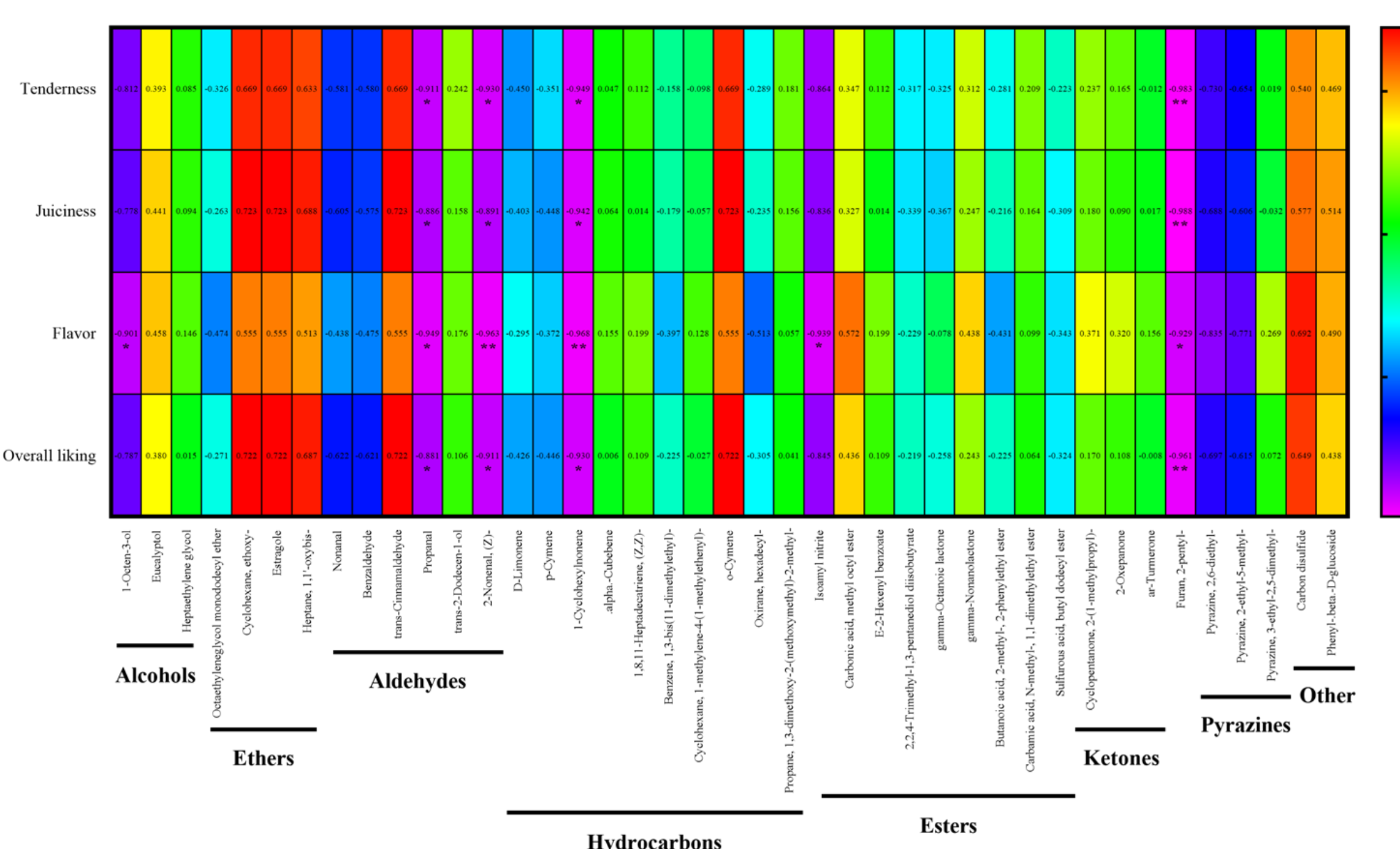
RESULTS

Effect of different marinade treatments on the formation of AGEs and HAs in roast steak.



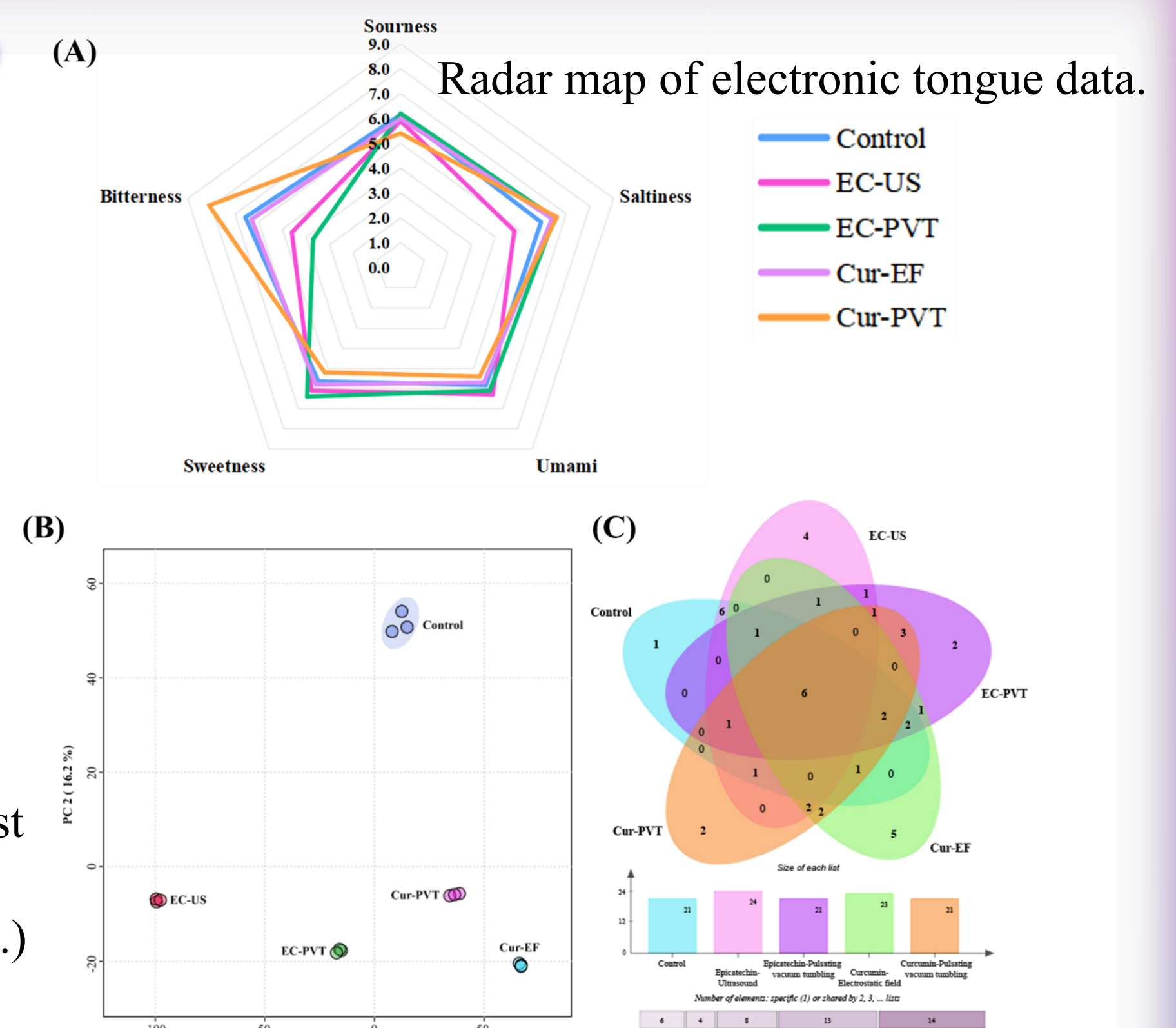
Effect of different marinade treatments on water-holding capacity in roast steak. (A): cooking loss; (B-D): water trimorphic percentage. (Different letters indicate significant differences among groups, $p < 0.05$.)

Correlation analysis of volatile compounds with consumer palatability scores. (*: Significant correlation; *: $p < 0.05$; **: $p < 0.01$.)

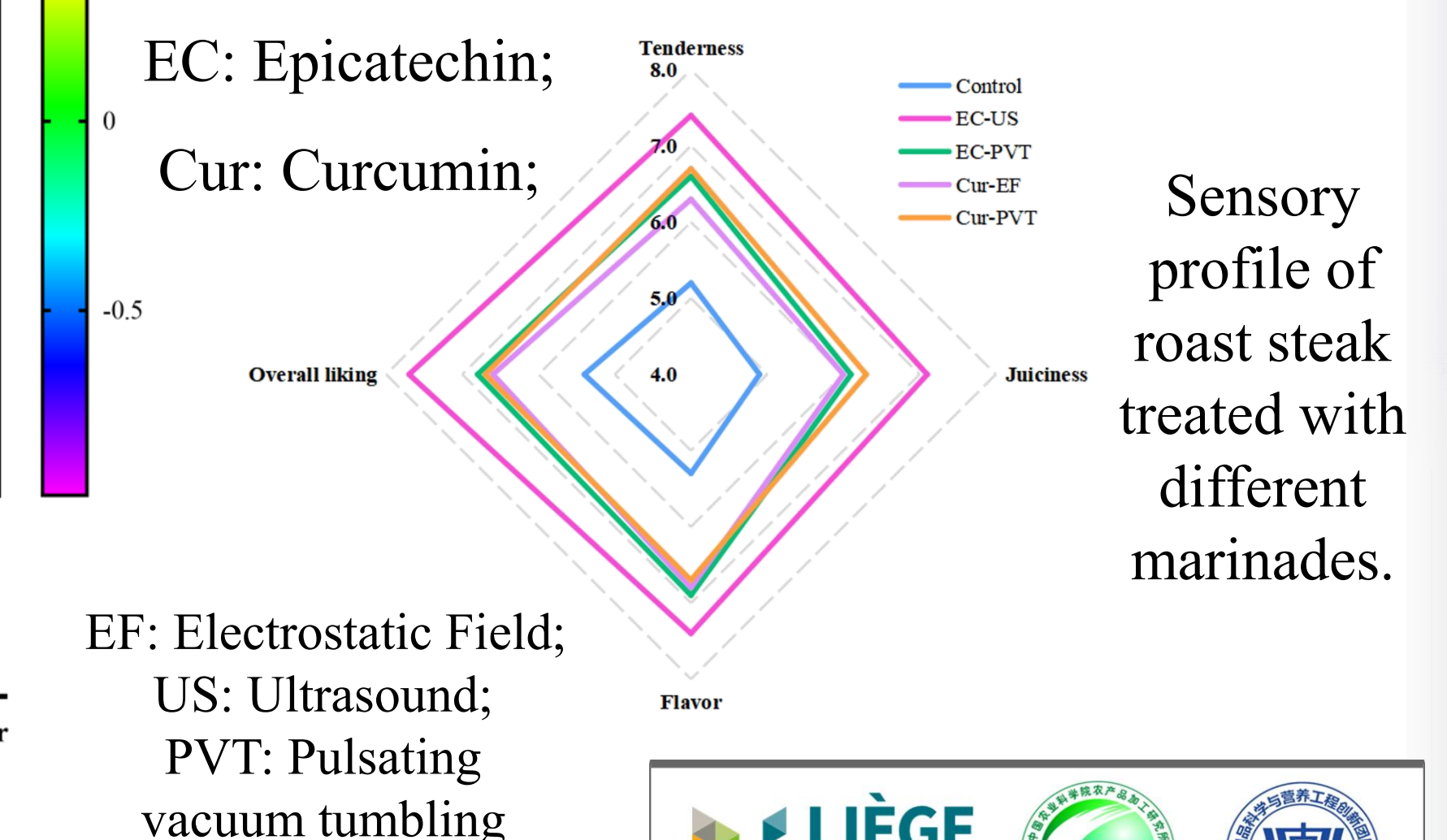


Quality

Effect of different marinade treatments on flavor profile in roast steak.



(B) The PCA analysis of volatile flavor compounds. (C) Distribution of volatile flavor compounds.



EF: Electrostatic Field; US: Ultrasound; PVT: Pulsating vacuum tumbling

The highest concentrations of **CML** and **PhIP** were found in the control group; **epicatechin** and **curcumin** served as the most potent inhibitors; efficacy was dictated by polyphenol chemical structure; and **physical-field** assisted marination provided a **superior** mitigation effect. **Safety**

Specific volatiles showed strong, contrasting links to consumer preference: detrimental aldehydes (e.g., 2-pentyl-furan) **negatively** correlated with palatability, whereas beneficial compounds (e.g., estragole, trans-cinnamaldehyde) were **positive** drivers, highlighting targets for flavor optimization.

