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Volatile Organic Compounds Profile of Spanish Chestnut (*Castanea*) Honey

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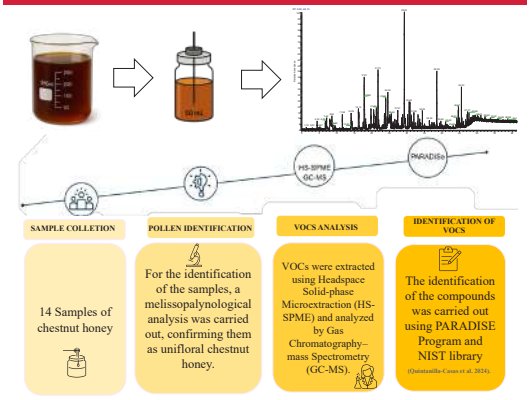
INTRODUCTION

Honey has long been regarded as the most important food product derived from honey bees. Spain is the fourth largest producer of honey in Europe and this product has a great economic impact on the primary sector in some regions.

Castanea is the taxon of interest to beekeepers, especially in inland areas from the north of the Iberian Peninsula. It produces unifloral chestnut honey of great value. This honey has very well-defined organoleptic characteristics, due to its high *Castanea* content (over 70%), with only differences due to its geographical origin and the accompanying flora. There is limited information in Spain regarding the volatile organic compounds (VOCs) that contribute to the characteristic aroma and quality of honeys.

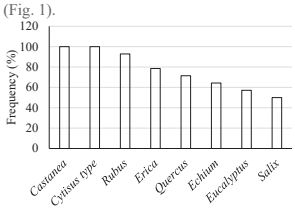
For this reason, the present study analyzed the volatile profiles of 14 chestnut honey samples from three regions of Spain, aiming to contribute to the typification and characterization of their quality attributes.

METHODOLOGY



RESULTS

POLLEN ANALYSIS revealed a clear dominance of *Castanea* pollen (mean 78.1%, range 68.5–94.9%, present in 100% of samples), confirming the unifloral character of chestnut honey. The most frequent accompanying pollen types were *Cytisus* type (3.8%, 100%) and *Rubus* (12.9%, 92.9% of samples) (Fig. 1).



- *Erica*, *Quercus*, *Echium*, *Eucalyptus*, and *Salix*, were presented in more than 50% of the samples.
- Their occurrence varied depending on the geographic origin of the honey.

Fig. 1. Most Frequent Pollen Types in Chestnut Honey

AS A RESULT, a total of 39 volatile compounds were successfully identified. The compounds fall into 8 chemical families:

1. Terpenoids (monoterpenes & oxygenated derivatives)
- Linalool oxide (fr.1)
- Hotrienol
- Thymol
- Carvacrol
- Borneol
- Safranal
- 2,5,5-Trimethylcyclohex-2-enone
- 2,6,6-Trimethyl-2-cyclohexene-1,4-dione

2. Alcohols
- Phenylethyl alcohol
- Benzyl alcohol
- 3-Cyclohexene-1-methanol, α,α,4-trimethyl-, (S)-
- Cinnamyl alcohol

3. Aldehydes
- Cinnamaldehyde, (*E*)-
- Benzaldehyde
- *p*-Anisaldehyde
- Benzeneacetaldehyde
- 1H-Indene-4-carboxaldehyde, 2,3-dihydro-

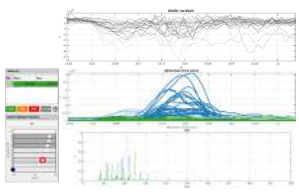
4. Phenols
- Phenol, 3,4,5-trimethyl-
- Phenol, 2,4-bis(1,1-dimethylethyl)-
- Phenol, 3-methyl-5-(1-methylethyl)-, methylcarbamate
- Eugenol
- 7-Methyl-1-naphthol

5. Acids and Esters
- Nonanoic acid
- Benzoic acid, ethyl ester
- Methyl salicylate

6. Furans and Lactones
- Furan, 3-phenyl-
- 2(3H)-Furanone, 5-butyldihydro-4-methyl-, *cis*-
- 2-Furanmethanol, 5-methyl-
- Benzofuran, 2-methyl-

7. Aromatic Hydrocarbons
- Benzene, pentamethyl-
- Benzene, 4-ethenyl-1,2-dimethyl-
- Naphthalene, 1,2-dihydro-1,1,6-trimethyl-
- 1-Naphthalenol, 1,2,3,4-tetrahydro-2,5,8-trimethyl-

8. Nitrogen-containing compounds
- 2'-Aminoacetophenone
- Benzyl nitrile
- 6-Cyanoquinoline



- PARADISe software applied interval deconvolution combined with FIT models, which allowed a more accurate separation of overlapping chromatographic peaks
- Each compound was assigned based on its mass spectral similarity, expressed as Match Quality, together with its RI, ensuring reliable identification.

Fig. 2. PARADISe software application

Chestnut honey was characterized by high relative concentrations of phenylethyl alcohol ($C_8H_{10}O$) and (*E*)-cinnamaldehyde (C_9H_8O) as its most abundant compounds. Other abundant compounds identified are presented in the Fig. 3).

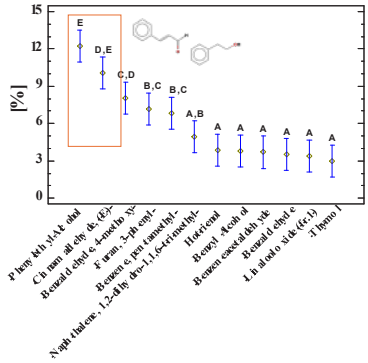


Fig. 3. Major Volatile Organic Compounds in Chestnut Honey: Mean Values with 95% Fisher LSD. Different letters denote statistically significant differences.

CONCLUSIONS:
- These compounds can be considered as key markers defining the volatile profile of unifloral chestnut honeys from Spain, supporting their typification and quality characterization.

PRACTICAL IMPLICATIONS FOR BEEKEEPERS:
- Highlights the high value of Spanish chestnut honey as one of the most appreciated unifloral honeys.Provides insights into its volatile composition, useful for product differentiation and market promotion.

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References. Quintanilla-Casas, B., Bro, R., Hinrich, J. L., & Davie-Martin, C. L. (2024). Tutorial on PARADISe: PARAFAC2-based Deconvolution and Identification System for processing GC–MS data.

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BACKGROUND: Honey has always been the most important food product obtained by man from bees. Spain is the fourth largest producer of honey in Europe and this product has a great economic impact on the primary sector in some regions. Castanea is the taxon of interest to beekeepers, especially in inland areas from the north of the Iberian Peninsula. It produces unifloral chestnut honey of great value. This honey has very well defined organoleptic characteristics, due to its high Castanea content (over 70%), with only differences due to its geographical origin and the accompanying flora.

PROBLEM DESCRIPTION: There is little information available in Spain on the composition of the volatile organic compounds (VOCs) responsible for these qualities.

METHODOLOGY: For this reason, this study defines the volatile profile of 14 chestnut honey samples using the Headspace Solid-Phase Microextraction (HS-SPME) technique coupled with gas chromatography-mass spectrometry.
RESULTS and CONCLUSION: The volatile profile of chestnut honey showed a total of 39 VOCs. These VOCs belonged to 11 chemical categories: aldehydes, alcohols, ketones, esters, furanones and furans, carboxylic acids, phenols, quinoline and derivatives, polycyclic aromatic compounds and naphthalenoids, sesquiterpenes and terpenes, and other aromatic compounds. The most abundant compounds in all the samples were the aromatic alcohol β-phenethyl alcohol and the aromatic aldehyde cinnamaldehyde, (E)-, with an average relative concentration of over 10% and a maximum of over 20%. The aromatic aldehyde, p -anisaldehyde, also demonstrated high values, reaching 30.3% in some samples. Other aromatic compouds were: furan, 3-phenyl-; benzene, pentamethyl-; naphthalene, 1,2-dihydro-1,1,6-trimethyl-; hotrienol; benzyl alcohol; linalool oxide (fr. 1), benzene acetaldehyde and benzaldehyde. These compounds could define the volatile profile of unifloral chestnut honeys from Spain.

PRACTICAL IMPLICATIONS FOR BEEKEEPERS: This study values one of the highest quality unifloral honeys produced by Spanish beekeeping and contributes to the understanding of its volatile profile.