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EDMUND MACH



DIFFA23

DIRECT INJECTION FOOD FLAVOUR ANALYTICS

BOOK OF ABSTRACTS

Fondazione Edmund Mach

San Michele all'Adige (TN), Italy

20 - 22 September 2023

1st International Symposium on
Direct Injection Food Flavour Analytics (DIFFA)

Edited by

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**Proceedings of the DIFFA23 - 1st International Symposium on Direct Injection
Food Flavour Analytics**

Fondazione Edmund Mach – San Michele All’Adige (TN) Italy

20-22 September 2023

This book collects the conference proceedings of the 1st International Symposium on Direct Injection Food Flavour Analytics, held at the Fondazione Edmund Mach from 20th to 22nd September 2023.



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FOREWORD

Volatile organic compounds (VOCs), particularly flavour compounds, represent an invaluable noninvasive metric to follow the multi-faceted journey of food, from the farm to the fork and beyond, such as relating to the human microbiome after consumption or in addressing reduction strategies for food waste. VOCs thereby serve as a direct and swift means of measurement and notably act as a main driver of the perceived quality of food.

Mass spectrometry (MS) is an established yet increasingly pivotal tool in food and beverage characterization with a broad range of applications. When coupled with gas chromatography (GC), it stands as the predominant analytical method for exploring many aspects of food, from safety to traceability and nutritional aspects, and equally facilitates control measures in quality and process monitoring.

Recent remarkable advancements in both technology and methodology have paved the way for highly sensitive, specific, rapid, robust, and validated MS-based techniques that have become indispensable in food science and technology research and application. A subgroup of these technologies has been devised over the past two decades in the form of analytical approaches that enable the analysis of VOCs through direct injection. These methods have gained attention for their rapid, highly sensitive and high-throughput analytical capabilities.

A leading technology in this area is proton transfer reaction-mass spectrometry (PTR-MS), which has driven many innovative applications for direct flavour/food analysis. Commencing 2003, the University of Innsbruck, Austria, has organized a biennial event dedicated specifically to PTR-MS and its applications, including a focused session on food science and technology.

The **1st International Symposium on Direct Injection Food Flavour Analytics (DIFFA23)** was conceived with the backdrop of the PTR-MS conference but with a different aim, namely to embrace a broader community beyond PTR-MS uses, encompassing similar direct injection mass spectrometry (DIMS) technologies, such as atmospheric pressure chemical ionization-mass spectrometry (APCI-MS) and selected ion flow tube-mass spectrometry (SIFT-MS), with a primary emphasis on flavor compounds. It was also not exclusive to MS-based analytical techniques, but welcomed the inclusion of complementary non-MS approaches, such as solid-state sensors, fast gas chromatographic direct approaches and ion mobility spectrometry (IMS), amongst others, to ensure a wider reach and broader engagement. The meeting was established to foster scientific discussions of common interest and facilitate scientific collaborations. This book of abstract highlights the details of the event and contains the contribution summaries of both the oral and poster presentations.

The conference featured one plenary and four keynote lectures delivered by distinguished guests, as well as numerous invited and contributed talks and 25 poster presentations, with 97 attendees from different EU states, the USA, the UK, Israel and New Zealand. The event provided valuable insights into direct injection food/flavour analytics, with reviews from pioneering scientists who played key roles in developing and advancing DIMS methods in its early days, such as Andy Taylor, Patrik Španěl and Jean-Luc Le-Quéré, showcasing both historical developments and recent advancements in analytical performance and novel applications. Topics discussed included nose-space analysis of composite foods, rapid and high-throughput phenotyping, fermentation monitoring, both as an

innovative technological tool and for investigating the human microbiota, advanced data analysis and data mining tools. These are just a few examples of the themes explored during the conference.

Numerous partners contributed to the success of the event: the sponsors, whose engaging presentations and financial support sustained the quality of the meeting and ensured that the conference fees were kept to a minimum, as well as various supporting institutions and patronages. Special thanks go to the Fondazione Edmund Mach (FEM) for its scientific contributions and for hosting the conference at the Research and Innovation Centre, as well as the Division of Mass Spectrometry of the Italian Chemistry Society (DSM-SCI) for their organizational support and creation and hosting of the conference website. The invaluable support from these companies and institutions are further acknowledged through inclusion of their logos on the back cover of this book.

The conference started a fruitful exchange of results, ideas and issues amongst scientists working with direct tools to monitor VOCs in food science and technology, with broad attendance from sensory and applications scientists from academia and industry.

We would like to thank all those who, through their participation and support, made this event possible, which exceeded our most ambitious expectations.

Thank you all, and we look forward to seeing you at the next edition.

On behalf of the Scientific Committee

Franco Biasioli, Jonathan Beauchamp, Pat Silcock

CONFERENCE PROGRAM

20th September 2023

12.30-14.00 Registration and welcome buffet

Conference opening

14.00-14.10	Welcome addresses Fulvio Magni - <i>Società Chimica Italiana-Divisione Spettrometria di Massa</i> Mario Pezzotti - <i>Fondazione Edmund Mach</i>
14.10-14.20	Why DIFFA23? Franco Biasioli - <i>Fondazione Edmund Mach</i>
14.20-15.05	Plenary lecture: <i>DI-MS – A game changer for flavour research?</i> Andy Taylor - <i>University of Nottingham</i>

Session 1 | Unlocking Flavour with DIMS

Chairs: Pat Silcock & Nina Cleve

15.05-15.35	Jonathan Beauchamp - Fraunhofer Institute for Process Engineering and Packaging IVV <i>The long and winding road: a flavoursome tale of PTR-MS</i>
15.35-15.55	Graham Eyres - <i>University of Otago</i> <i>What is Flavour and how can DIMS help untangle the puzzle?</i>
15.55-16.15	Andreas Mauracher - <i>IONICON</i> <i>Advantages of Next-Gen PTR-ToF instruments for food and flavour sciences</i>

16.15-17.00 Tea break and poster session

Session 2 | DIMS in Health and Wellbeing

Chairs: Donatella Caruso & Eirini Pegiou

17.00-17.20	Josep Rupert - <i>Wageningen University & Research</i> <i>Signalling volatile compounds in the human gut microbiota: new avenues offered by direct analytical methods.</i>
17.20-17.40	Chris Mayhew - <i>University of Innsbruck</i> <i>Real-Time Trace Analysis of Breath Volatiles using Proton Transfer Reaction Mass Spectrometry: implications for in-vivo flavour release measurements</i>
17.40-18.00	Enrico Davoli - <i>Istituto Mario Negri</i> <i>Direct analysis of sex-wellness products using a field deployable MS equipped with a Direct Sampling Atmospheric Pressure (DSAP) source</i>
18.00-18.20	Corrado Di Natale - <i>University of Rome Tor Vergata</i> <i>Direct injection mass spectrometry and gas sensors: a teacher-pupil relationship</i>
18.20-18.40	Luca Cappellin - <i>University of Padua</i> <i>Improved compound identification in direct VOC analysis using an EI&CI-TOFMS</i>
19.00	Welcome cocktail - cloister of the monastery and historical cellar

21st September 2023

Session 3 | Linking DIMS Data to Sensory Perception

Chairs: Graham Eyres & Iuliia Khomenko

9.00-9.30	Jean-Luc Le-Quéré - <i>INRAE-CSGA Dijon</i> <i>Twenty years of Direct Injection Mass Spectrometry for aroma research in Dijon</i>
9.30-9.50	Catrienus De Jong - <i>Wageningen University & Research</i> <i>Exploring new in vivo and in vitro methods to integrate sensory and instrumental analysis to get insight and improve the flavour of plant-based food products during oral processing and drinking</i>
9.50-10.10	Markus Stieger - <i>Wageningen University & Research</i> <i>In vivo aroma release and sensory perception of composite foods</i>
10.10-10.20	Michele Pedrotti - <i>Wageningen University & Research</i> <i>Characterization of plant-based milks by combining sensory analysis with headspace and nose-space direct injection mass spectrometry</i>
10.20-10.30	Karina Gonzalez-Estanol - <i>Wageningen University & Research</i> <i>In vivo analysis of nose-space concentration by direct injection mass spectrometry to study the effect of chewing rate on aroma release during food consumption</i>
10.30-10.40	Laura Hill - <i>University of Nottingham</i> <i>Understanding the relationship between lipids, capsaicin and aroma release in confectionery</i>

10.40-11.10 Coffee break and poster session

Session 4 | Flavour Complexity and Cooking

Chairs: Fulvio Magni & Caroline Perltier

- | | |
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<i>Development of fast-GC PTR-MS method for coffee VOCs analysis</i> |
| 11.30-11.45 | Nina Cleve - <i>Fraunhofer Institute for Process Engineering and Packaging IVV</i>
<i>Milk matters: Unraveling retronasal aroma release and perception of coffee by combining in vivo nosespace analytics with dynamic sensory methods</i> |
| 11.45-12.05 | Tomasz Majchrzak - <i>Gdansk University of Technology</i>
<i>What happens when food goes into oil during deep frying? Monitoring the first minutes of frying using PTR-MS</i> |
| 12.05-12.20 | Gregory Schmauch - <i>Rational F&E GmbH</i>
<i>Influence of product quantity, cooking parameter and flow tube pressure on the measurement with Sift-MS in a cooking oven</i> |
| 12.20-12.40 | Vaughan Langford - <i>Syft Technologies</i>
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12.40-14.00 Conference group photo and lunch

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| 14.15-14.30 | Matteo Tonezzer - <i>University of Cagliari</i>
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<i>Characterization of isoflavones and its metabolites in foods by direct probe ionization mass spectrometer (DPiMS) with high resolution detection</i> |
| 15.05-15.25 | Hansruedi Gygax - <i>GAS Dortmund</i>
<i>GC-IMS instruments and their use in food and flavour analysis</i> |

15.25-16.15 Tea break and poster session

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Chairs: Riccardo Flamini & Michele Pedrotti

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| 16.45-17.05 | Vittorio Capozzi - <i>Institute of Sciences of Food Production - National Research Council of Italy (CNR)</i>
<i>DIMS techniques and the study on microbial VOCs in food: flavour attributes, fermentation monitoring and emerging trends</i> |
| 17.05-17.20 | Eirini Pegiou - <i>Wageningen University & Research</i>
<i>Easy and fast detection of abnormal olive brine fermentation – A showcase of SPOTDETECT.</i> |
| 17.20-17.40 | Caroline Peltier - <i>INRAE</i>
<i>Automatic pretreatment and multiblock analysis of flavor release and sensory temporal data simultaneously collected in vivo</i> |
| 17.40-18.00 | Ana Rita Monforte - <i>AFB INTERNATIONAL</i>
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| 18.00-18.20 | Pietro Franceschi - <i>Fondazione Edmund Mach</i>
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| 18.20-18.35 | Mickael Le Behec - <i>Institute of Analytical Sciences and Physico-Chemistry for Environment and Materials (IPREM)</i>
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22nd September 2023

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10.00-10.15	Antonella Grosso - <i>University of Bolzano</i> <i>Monitoring autoxidation of vegetable oils by proton transfer reaction mass spectrometry</i>
10.15-10.30	Pedro Martinez Noguera - <i>University of Copenhagen</i> <i>Using PTR-ToF-MS to quantify microbial off-flavors geosmin and 2-methylisoborneol in water. Method development, performance assessment and comparison with established GC-MS methods</i>
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12.25-12.40	Alberto Roncone - <i>Fondazione Edmund Mach</i> <i>Validation of gas chromatographic methods for the botanical characterization and authentication of lavender essential oil by stable isotope analysis of its organic volatile compounds</i>
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P.24 Real time MS nose space monitoring allows to get insights into biological and behavioral factors affecting the inter-individual variability on flavor release

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Summary: This study used nose-space analysis (SIFT-MS) to examine the influence of biological factors (age, BMI, oral microbiota) and behavioral factors (food neophobia) on flavor release. Age and BMI were anticorrelated with release, whilst neophilics exhibited contrasting behavior likely due to reduced anxiety-related responses. Intriguing correlations with the oral microbiota were observed. *Keywords:* nose-space analysis; food neophobia; SIFT-MS.

1 Introduction

It is known that factors affecting flavor release during food consumption comprise a complex interplay between our biology and eating behaviors. However, evidence supporting the effect of both components on representative sample sizes and using an ecologically valid method are still lacking. In this vein, mounting evidence suggests that real time MS in-vivo monitoring of volatile organic compounds exhaled from the nose during food consumption, also called nose-space analysis, still remains the most direct and promising way to ecologically investigate the dynamics of flavor release and, therefore, it ought to be considered as the gold standard method when such studies are thought to be performed.

Hence, this contribution aims to get insights into the inter-individual variability on flavor release of a representative healthy population, monitored in real time, by taking into account both biological (age, BMI, gender, oral microbiota) and behavioral variables. To address this later issue, we choose Food Neophobia (FN), a widely studied behavioral trait underlying people not willing to try novel and/or unfamiliar foods [1].

2 Methods

Eighty-three subjects (57.8 % female; aged 22 to 68 yo) filled out the Italian validated version of the Food Neophobia Scale [1,2]. Later, they were asked to consume at least three replicates of a strawberry jelly candy, which was chosen as reference food to study aroma release. Simultaneously, nose-space analysis with Selected-Ion Flow-Tube Mass Spectrometry (SIFT-MS) was carried out by monitoring in real time the release of 7 key aroma compounds (5 esters, 2 alcohols) [3]. This analysis was performed in conjunction with a fixed chewing procedure supported by a video tool.

Lastly, participants were required to provide an unstimulated saliva sample before initiating the task. These samples were subsequently analyzed via 16s rRNA gene sequencing to obtain metataxonomic profiles of the oral microbiota [4].

3 Results

Overall, all the compounds monitored followed similar release kinetics across individuals. Flavour profiles information based on parameters commonly used to analyze time-intensity curves (i.e., AUC, I_{max}, I_{mean}, T_{lmax}, T_{end}, Slope) revealed a slightly negative effect of age and BMI on flavor release [3]. No gender effect was observed.

Moreover, individuals with lower FN tendencies showed a higher flavor release, probably due to a longer oral processing and lower anxiety-related physiological responses (such as breathing rate) (Fig. 1) [3].

Intriguingly, a panel of correlations between food neophobia, flavor release and the composition of the oral microbiota were observed, whose biological meaning has yet to be fully elucidated.

4 Conclusions

These results validate the effectiveness of real-time nose-space monitoring using mass spectrometry as a valuable tool for understanding the complexities of flavor release dynamics and investigating behaviors that impact food choices. Additionally, intriguing correlations between flavor release, food neophobia, and the oral microbiota have been observed, providing a foundation for further exploration into the fundamental aspects of flavor release and perception. As a final remark, we emphasize the importance of employing representative sample sizes and considering the multidimensional nature of flavor release when such research topics are of interest.