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From aroma chemistry via bioactives to toxicology—remembering the broad expertise of Michael Granvogl in food science

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On March 23, 2022, the field of food science lost a pioneering and impassioned scientist through the tragic and untimely passing of Prof. Michael Granvogl. Born on December 21, 1974 in Munich, Germany Michael's inquisitive nature led him to study food chemistry at the Technical University of Munich (TUM). After graduating in 1998, he remained at TUM to pursue a doctoral degree (conferred in 2007), then habilitation (2016), qualifying him as Associate Professor in Food Chemistry. In 2019, Michael Granvogl was appointed Full Professor at the Institute of Food Chemistry, University of Hohenheim, Germany where he managed a young and dynamic team of enthusiastic scientists in their pursuits to push the boundaries of food chemistry research in their specialized disciplines. Indeed, Michael was a renowned international subject-matter expert on multiple facets of food chemistry, foremost on aroma-active compounds and food-borne toxicants, with a deep knowledge of their formation and degradation mechanisms, and with skilled application of effective extraction procedures and comprehensive analytical techniques to explore and elucidate their nature. Beyond his teaching and research, Michael was a staunch and dedicated member of the Division of Agricultural and Food Chemistry (AGFD) of the American Chemical Society (ACS), taking active and prominent roles on the executive committee to promote the field and support the next generation of scientists. As a native of the city of Munich, it might be noted that his passion for science, evidenced in lecture theaters and laboratories, was mirrored in his private life through his enthused and loyal support of his native soccer team, FC Bayern Munich. That team must now move forward with the loss of one dedicated fan, but the field of food chemistry – in particular the sub-discipline food bioactives – must overcome the void previously filled with Michael Granvogl's stalwart presence and must cope with the absence of discoveries that will no longer materialize. There are many researchers in the field who lost a dedicated mentor, an esteemed colleague and a dear friend on that fateful day in spring 2022.

Michael Granvogl's collective research has left an indelible mark in the field of food chemistry, foremost in the areas of flavor and natural products. Many scientists throughout the world have been inspired by his contributions, from his identification of key aroma compounds in foods to his discernment of food-borne toxicants elicited through thermal processes. This special issue of *Journal of Food Bioactives* commemorates Michael's scientific achievements by showcasing latest research from his peers, with authorships by former students, colleagues and collaborators. The journal collection comprises two review articles and eight research papers, with contributions stemming from different parts of the world, from USA to Japan, China and Michael's native Germany, highlighting his resonance and global reach in the field. The different areas of research covered in these special issue articles reflect Michael's own focal topics, dominated by chemistry of aroma-active compounds and (bio)transformation of food constituents.

The review article by Koh and Wang examines the roles of types 1 and 2 taste receptors on obesity-induced inflammation, highlighting the that suppression of taste receptor or signaling molecules can potentiate inflammatory response, whereas progressive inflammation attenuates the expression of taste receptors *in vivo* (Koh and Wang, 2022). This suggests that taste receptors serve as a potential therapeutic target in tackling obesity. The second review paper by Bolster *et al.* offers a treatise on improving an impaired gut barrier function through the use of novel plant bioactives (Bolster et al., 2022). The paper outlines how the co-administration of *N*-trans caffeoyltyramine and *N*-trans feruloyltyramine, two naturally-occurring bioactive compounds in hemp hulls, elicits a physiologically relevant reversal of impaired gut barrier function during inflammation, with significant improvement in transepithelial electrical resistance and permeability.

Of the research papers published in this special issue, five cent-

er on flavor and the remaining three feature biotransformation or chemical reactions. Davila *et al.* present their research quantifying taste compounds in *Agaricus bisporus* mushroom powder with a view to its use as a starting material to develop protein concentrates and isolates (Davila et al., 2022). The powders contained all essential and sweet and bitter related amino acids, along with around 20 % protein, with the sugars being dominated by mannitol, followed by glucose and sucrose, oxalic, acetic and malic acid as the main acids, and five nucleotides and free amino acids associated with umami taste. In their work on identifying, quantifying and sensorially elucidating off-taste compounds in wheat bran, Duggan and colleagues identified two alkyl resorcinols to be major bitter compounds in this cereal, with other components being key contributors to off-taste, including saturated analogues, alkyl resorcinols, and fatty acids and their oxidation products (Duggan et al., 2022). Posing the question "Where has all the aroma gone?", Shanmugam and Loos explore constituent aroma compounds of fresh and dried *Melissa officinalis* and highlight the changes that occur during the drying process (Shanmugam and Loos, 2022). Although some compounds, such as neral, geranial and geraniol, were present in both fresh and dried leaves (eliciting a lemon-like smell), the drying process resulted in the generation of aldehydes, including (*Z*)-4-heptenal and (*E*,*Z*)-2,6-nonadienal, which shifted the aroma profile towards hay-like, straw-like and algae-like/fishy off-flavor impressions. The systematic analytical study on the formation of furanoic compounds in model systems with saccharides, amino acids, and fatty acids, published by Schöpf and colleagues – and a posthumous contribution by M. Granvogl – examines the precursors and formation pathways of furan and its derivatives with a view to predicting these processes in foods (Schöpf et al., 2022). The formation of different furan derivatives was attributed to distinct precursors, with furfuryl alcohol being highly formed from 1,4-linked disaccharides, whereas polyunsaturated fatty acids formed the highest amounts of 2-ethylfuran and 2-pentylfuran. Wrapping up the flavor-related research articles, the paper by Fang *et al.* focuses on sulfur compounds in Pinot noir wine in relation to aspects of horticulture (Fang et al., 2022). The authors demonstrated that the combination of irrigation and soil nitrogen supplement led to the highest amounts of hydrogen sulfide and methanethiol in the wines, whereas the presence of dimethyl sulfide, methionol, methyl thioacetate, ethyl thioacetate (EtSOAc) were mainly driven by vintage.

The research papers on chemical reactions and biotransformations cover three distinct topics. In the article by Miyauchi and co-workers, the metabolic fate of peptides in a rice protein hydrolysate was investigated in a rodent-based model (Miyauchi et al., 2022). The authors demonstrated that the pyroglutamyl peptides can enter enterocytes and reach the lumen through transportation via the blood, indicating the prospective use of *in vitro* exopeptidase digestion experiments to predict distribution of peptides to organs. Lin *et al.* similarly focused on biotransformation, albeit on ginsenosides, which can elicit anti-cancer and anti-inflammatory effects (Lin et al., 2022). The work showed that enzymes can effectively biotransform major ginsenosides into minor ginsenosides by hydrolyzing the *β*-glucosidic linkage. Moreover, the bio-transformed ginsenosides were effective in inhibiting the proliferation of HCT-116 cells and suppressing lipopolysaccharide-induced nitric oxide production in RAW 264.7 murine macrophages. The journal collection closes with a paper by Luo *et al.* on Amadori rearrangement product formations in a competing Maillard system – a fitting conclusion to the special issue with a nod to Michael's food chemistry roots (Luo et al., 2022). The study showed that small peptides (diglycine and triglycine) exhibited better relative reactivity of Amadori rearrangement product formation than an amino acid (glycine) at lower temperature.

Overall, the papers published within the covers of this journal collection on a wide range of topics are a testament to Michael's broad expertise and renown. This special issue is dedicated in fond memory to Michael to celebrate his life and works and to act as a legacy for his important contributions to many specialty disciplines within the field of food science.

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