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Expression of Multidisciplinary Flavor Science: Research Highlights from the 12th Weurman Symposium

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The 12th Weurman Flavour Research Symposium contributed 177 lectures and posters to the wealth of flavor knowledge; these were presented in eight sessions: biology, retention and release, psychophysics, quality, thermal generation, bioflavors, impact molecules, and analytics. Emerging topics were discussed in three workshops dealing with flavor and health, in vivo flavor research, and flavor metabolomics. It has been an excellent forum for passionate exchange of recent results obtained in traditional and emerging fields of flavor research. The symposium allowed coverage of the broad diversity of flavor-related topics: comprising odor and taste; applying targeted and holistic approaches; using sensorial, chemical, biological, physical, and chemometric techniques; as well as considering nutrition and health aspects.

KEYWORDS: Flavor; olfaction; taste; research; symposium

INTRODUCTION

The Weurman Flavor Research Symposium has become established as one of the most renowned international meetings on flavor science taking place every 3 years in Europe (*1*−*11*). The first meeting was held in 1975 in The Netherlands, dedicated in memory of Cornelius Weurman, one of the pioneers of flavor research. Since then, this symposium series has become the reference for flavor scientists as a platform addressing both the width and depth of flavor science. Participants from academia and industry actively contribute to the symposium and discuss advances and trends in flavor science in an informal and open atmosphere. Traditionally, many young scientists can present their work, some of them sponsored by the Weurman symposium, and exchange views and experiences with well-known experts in the area.

In July 2008, the 12th Weurman Flavour Research Symposium was organized in Interlaken, Switzerland, by Prof. Renato Amadò and Prof. Felix Escher from the ETH Zurich. About 230 participants from 34 countries contributed 177 lectures and posters to the wealth of flavor-related knowledge. The contributions were grouped in eight sessions: biology, retention and release, psychophysics, quality, thermal generation, bioflavors, impact molecules, and analytics. Emerging topics were discussed in three workshops dealing with flavor and health, in vivo flavor research, and flavor metabolomics. Most of the contributions will be published in the proceedings of the 12th Weurman symposium (*12*). In this special issue of the *Journal of Agricultural and Food Chemistry*, only a small number of original works are published, which nevertheless represent well the diversity and trends in "flavor research".

STATUS AND TRENDS IN FLAVOR SCIENCE

Taste and olfactory biology have become driving forces in flavor research, implying biological and chemical methods. Great attention is paid to the molecular biology of olfactory and taste receptors, genetics, and the functional organization of taste buds and the olfactory epithelium. The symposium focused on bitter (*13*) and salt taste modalities and olfactory structure−activity relationships. Emerging topics are aroma-induced satiation (*14*) and whether bitter taste sensitivity is related to food intake behavior, nutrition, and health. Industrial applications were also shown using novel taste and chemosensory receptor discovery platforms complemented by chemical approaches to ingredient discovery.

Aroma retention and release have brought together experts from all boards and disciplines, that is, flavor scientists, chemists, physics, mathematicians, and material scientists, to explore experimentally and theoretically questions related to the entrapment and encapsulation of flavor compounds in food matrices and on their release and transport from the food matrix to the sensory receptors. For a flavor molecule to achieve its optimal impact during consumption, it has to be released and transported at the proper time and with the appropriate time−intensity profile to the sensory receptors. This has implications not only for the flavor quality but increasingly also for health and the cost of products. As an example, the effective release of salt from food (*15*) is essential to reducing the salt content in food products while achieving a high saltiness perception. Furthermore, flavor is often among the most expensive ingredients in food products, yet most of it is simply swallowed with the food matrix without

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reaching the receptors. Progress in understanding and engineering of advanced encapsulation and release systems will allow delivering key benefits to food through better flavor, improved nutritional value, and lower costs.

Psychophysics attempts to describe the complex link between the multidimensional space of sensory stimulations and the ensuing holistic perception. Various senses can be stimulated during consumption, such as smell, taste, touch, sight, sound, and sometimes pain and irritation. All of these stimulations may interact and combine to different degrees. To better understand the link between the physics of flavor stimulation and the psychology of flavor perception, a conceptual three-level model may be useful for understanding flavor perception by humans. The first includes all aspects that are related solely to the food, such as the aroma-active compounds present and their interactions among themselves (*16*) with the food matrix (i.e., concentration of aroma compounds and texture and composition of the food matrix). The second factor comprises all aspects related to the in-mouth situation (i.e., saliva composition and quantity, breathing and mastication characteristics, and swallowing). This makes the person eating the food an integral part of the system being analyzed and takes into account interactions between the food and the consumer. It also introduces into flavor science a truly consumer-centric and individualized approach. Finally, psychological, social, and cognitive effects modulate aroma perception (i.e., culture, memories, expectations, mood, and alertness). All three need to be addressed and studied to better understand the link between the physical world of flavor compounds and the ensuing consumer's perception. This session dealt primarily with the third level of this model of flavor perception, whereas the other two levels have been addressed in other sessions.

The "**bioflavor**" session has become an important part of the Weurman symposium during the past 20 years due to the promising and vital areas of science based on biotechnology. Recent advances in fungal and plant biotechnology, enzyme technology, genetic engineering, bioprocess monitoring, and product recovery techniques offer powerful opportunities for the biotechnological production of aromas. This is impressively demonstrated by a contribution in this special issue that deals with the generation of norisoprenoid flavors from carotenoids by recombinant fungal peroxidases (*17*). However, specific strategies for the bioengineering of aroma production can only be contemplated if the enzymology and regulation of the biosynthesis of aroma compounds are understood at the molecular level (*18*). Thus, biochemical research on flavor biosynthesis is also an important part in the "bioflavor" area and is highlighted by contributions dealing with vanillin biosynthesis in *Vanilla planifolia* (*19*) and induced changes of volatiles in Brassicaceae.

Thermal flavor generation has always been a key theme in the Weurman symposium. Many food processes comprise a heating step leading to flavor. It has been a goal for a long time to master heat-induced flavor formation leading to desirable sensory qualities (*20*). Recently, mitigation of undesirable compounds has become of vital interest to better control the overall result. Studies were performed in model systems, simplified food models, and complex foods. It has been stressed that work on model systems requires validation in food, as data cannot simply be extrapolated and may lead to misinterpretation (*21*). Aroma compounds are still the focus of research; however, also the formation of sensory active mouth-coating taste compounds was presented (*22*). An emerging topic is studying the Maillard reaction cascade in the presence of major food constituents such as lipids and polyphenols. As shown in this special issue, hydroxycinnamic acids indeed intervene in the Maillard reaction, generating new ferulic acid−Maillard adducts that may influence the flavor of whole-grain food and also result in health-beneficial effects (*23*).

Flavor quality is an important topic in the complex world of industrial flavorings as demonstrated by the keynote lecture in this session. The data provided by a comprehensive analytical toolbox have to show a good correlation to the sensorial data, to ensure that the pattern of analyzed flavor substances is relevant for the sensorial quality of a product. This prerequisite is difficult to achieve if, for example, interactions of odorants play an important role for the overall aroma by altering olfactory perception thresholds. Two contributions in the field of chocolate and wine flavor showed how these problems can be solved by using a combination of instrumental flavor analysis and tasting techniques. Interactions of packaging materials with food products may cause off-flavors by a transfer of odor-active volatiles into the food. Sources of the malodors can be inappropriate raw materials (*24*) or improper production of packaging materials such as cardboard (*25*). In a contribution dealing with this issue, the whole set of intense odorants has been identified for the first time by using the aroma extract dilution analysis approach.

Flavor research has again resulted in new **impact molecules**, indicating that there are still unknown key flavor-active molecules to be characterized. In particular, major advancements in taste chemistry and analytics have led to new chemical structures of orosensory impact molecules having interesting properties (*22*). This approach allows, contrary to the current receptor-based approaches, identifying not only taste-active compounds but also taste modifiers, eliciting sensory properties such as astringent, mouth-coating, and mouth-fullness. The well-known approach of sensory-directed chemical analysis has led to "new" key aroma compounds that have a unique contribution to a particular food product (*26*). However, in most cases these compounds are known from other food systems. It seems that there is a limited number of aroma compounds, which may elicit various types of aromas depending on their concentration and composition. Therefore, obtaining reliable quantitative data is a must in future flavor research, which is the basis of recombination experiments to substantiate the role of individual compounds to the overall flavor. This includes taste compounds and flavor modifiers complementing the overall sensory experience.

Flavor analytics are the eyes of scientists; analytical technologies are the backbone of scientific research and allow extracting, documenting, and communicating information about the subject under study. Although many of the analytical technologies used today in food flavor science are not specific to flavor research and were initially developed in other fields (e.g., GC, HPLC, NMR), flavor scientists have contributed a series of ingenious and innovative developments that have propelled progress in the field. The two most significant are the introduction of various protocols and strategies to include the human nose as a detector after GC separation (*25*, *26*) and the correlation of sensory profiles with instrumental data (*24*). During this session a large array of recent developments, critical to the progress of flavor science, were presented and discussed, including advanced hyphenated technologies in GC (*27*), time-resolved online approaches (e.g., PTR-TOFMS), extensive identification and quantification of flavor compounds in a variety of food matrices, stereochemical elucidation (*28*), correlation of sensory with instrumental profiles (e.g., on coffee), and of course GC−sniffing methodologies. The progress presented during the conference demonstrated how dynamic and active this field is, underscoring the paramount importance it has played and will continue to play in the progress of food flavor science.

Again, the 12th Weurman symposium has been an excellent forum for passionate exchange of recent results obtained by traditional and emerging methods in flavor research. The symposium allowed covering the broad diversity of flavor-related topics: comprising odor and taste; applying targeted and holistic approaches; using sensorial, chemical, physical, and biological techniques; as well as considering nutrition and health aspects. The few original works selected for publication in this special issue of the *Journal of Agricultural and Food Chemistry* represent well the complexity and multidisciplinary character of flavor science.

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