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Editorial

Flavor Chemistry and Technology: The Challenges of Working with Flavors in the Food Industry

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The term "flavor" refers to the overall sensory experience of a food or beverage, including olfaction (the perception of smell and aroma), gustation (the perception of taste), and trigeminal sensations, which combine the perception of texture, mouthfeel, temperature, and chemesthesis (i.e., pungency due to irritation by chemical stimuli such as capsaicin in chilli or freshness due to menthol in mint). Flavor is an essential aspect of our daily lives. It defines food quality and influences our appetite and food preferences [1,2]. It is a complex and subjective experience that is influenced by many factors, including age, gender, personal preferences, cultural background, and individual experiences [3–7].

Deficits in tasting and smelling not only reduce the pleasure and comfort of eating but are also nutritional risk factors. This is especially evident for the elderly and for people with specific diseases that limit their gustatory and olfactory senses [8–12].

Therefore, enhancing the flavor of foods can play an important nutritional role by bolstering the appeal of certain foods. For these reasons, scientists are actively engaged in research on the perception and manipulation of flavor in order to create more appealing foods that provide older people with nutritious foods and a pleasurable sensory experience that can improve their quality of life [13–16]. There is also some evidence of an increase in the consumption of foods with the use of food with enhanced flavors [13,17].

In addition to political and public health challenges, improving the quality of life of older people in a society where life expectancy is increasing faster than expected will pose new challenges for the food industry.

In response to consumer health expectations, some studies have explored reformulating foods by adding nutritional ingredients. The main challenge is to formulate foods that are stable, safe, palatable, and acceptable to target consumers.

Understanding the relationship between the physical and sensory properties of food products is a key task for the development of foods that meet consumer preferences [18–21].

Another important aspect of food flavor is the potential of certain odor compounds that stimulate the release of dopamine, which is implicated in the reward and regulation of eating. Dopamine is known to be one of the key neurotransmitters involved in food reward and the control of food intake, as well as mood and attention [22,23]. It is released when we have a rewarding experience, such as eating a food that we enjoy. Food smells can evoke positive emotions, making us more inclined to eat that food, even when we are not hungry. Consider, for example, the experience of eating chocolate [24,25].

For instance, some green/herbaceous odors may regulate brain functions by stimulating the release of dopamine [26]. Green odors might result from a synergic effect of several volatile compounds commonly referred to as leaf alcohols and aldehydes. Leaf alcohols and aldehydes are important odor components of plants and vegetables and are biosynthesized from both alpha-linolenic and linoleic acids. They are hexanol and hexanal in the saturated form and (E)-2-hexenol, (Z)-3-hexenol, (E)-3-hexenol, (E)-2-hexenal, (Z)-3-hexenal, and (E)-3-hexenal in the unsaturated form [27,28]. The release of dopamine depends on the concentration of the odorant and the type of molecule. For example, molecules consisting of

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a linear chain of carbon atoms release more dopamine in the saturated form than in the unsaturated form. Aldehydes also increase dopamine release linearly, while alcohols increase dopamine release sigmoidally [26,29–31]. These results were obtained in animal studies.

While animal studies are useful for screening and discovering the potential functions of flavoring compounds, it would be challenging but beneficial to conduct further human studies in this area.

It has also been hypothesized that the green/herbaceous odor of virgin olive oil may also mislead the brain and have a positive effect on food intake and satiety [32]. This effect has been attributed to the leaf alcohol and aldehyde compounds, the most abundant volatile compounds in virgin olive oil. Due to the associative learning involved in perceiving and recognizing the flavor of foods, these odorous volatile compounds induce the brain to think it is olive oil even when real olive oil has not been used. An experiment showed that adding olive oil flavor extract to low-fat yogurt produced the same hormonal responses in volunteers as eating plain (full-fat) yogurt. Could olive oil be a food that stimulates the release of dopamine through its flavor, making it rewarding to eat? Could the natural aromatic richness of good quality extra virgin olive oil play a role in the healthy Mediterranean diet by interacting with our satiety receptors?

Investigating which foods could be involved in dopamine release and therefore the sense of reward and control in eating among humans may be another future challenge.

It is important to note that dopamine is not the only factor that affects our desire to eat. Other factors such as hunger, addictive substances, and social cues can also play an important role.

Beverage odors may be effective tools for investigating reward-related networks in addiction, as they have been reported to activate areas of the brain similar to the areas activated by cues to addictive substances such as alcohol [33,34].

It may be more challenging to develop foods and beverages with flavors that induce satiety and limit consumption, especially those high in calories or alcohol [35].

As people become more aware of the importance of healthy lifestyles, flavorings can be used and developed by the food industry in many ways, such as foods for the special populations (the elderly, obese, or specific disease populations), special diets (vegan, vegetarian, etc.), and low-calorie and rewarding foods.

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