HUBER THE NOSE.

Interesting facts in our field.

Les mystères, Germaine Knecht 1976

PASSION FOR SCENTS

The Perception of Food and Beverages

Introduction

The human perception of food and beverages results from complex interactions among a number of sensory receptor systems, including the senses of smell (olfaction), taste, chemesthesis[1], touch, temperature, hearing and vision.

For the perception of flavors the following seem most relevant:

The Sense of Smell

In certain animals, the capacity to smell has become enormously specialized during evolution. Fish such as salmon, e.g., swim thousands of miles along gradients of certain lead substances to find their breeding grounds. Wildcats track their mating partner over long distances by their smell. And in the insect kingdom pheromones play a vital role in courting rituals and basic survival.

The human sense of smell is located in the nose. As a sense it is often considered inferior to the sense of hearing, touch or vision[2]. At a closer look, however, we find that the sense of smell rivals the others in complexity and enriches our lives substantially: We eat and drink with the nose[3], we judge our environment and our partners with it and are led by it in many other circumstances. In fact, the sense of smell still plays a key role in the search and control of food and is an important factor in human relationships, choice of partners and social behavior[4].

The volatile smelling part of food and beverages is perceived in the nose. Chewing and otherwise moving the food or beverage around the mouth makes the volatile flavor molecules circulate to the retronasal olfactory part of the nose where they get trapped by the receptors on the cilia in the nasal mucous membrane (about 2 sq. inches large) in the same way as fragrance molecules.

The sense of olfaction is a chemical sense like the sense of taste. I.e. the biochemical interaction between the single smelling molecules in the air and the receptor protein on the cilia stimulates the olfactory nerve cell[5] which triggers further reaction[6]. An electrical impulse is generated which travels from the peripheral end in the nose to the so-called "glomeruli"[7] in the brain, more precisely in the two olfactory bulbs[8].

The human nose has about ten million olfactory nerve cells and about one thousand different receptor protein types. Thus there are about ten thousand copies of each receptor type spread over the nasal mucous membrane in a more or less even way. The production of a specific receptor protein is originated by the corresponding gene. For one thousand receptor types one thousand respective genes are needed. The genetic code embedded in the cell-nucleus of men consists of a total of about thirty thousand genes for the complete organic building plan. That means that about three percent of all the genes are reserved for olfactory response: a very astonishing fact which clearly demonstrates the very importance of the sense of smell in men[9].

Chemically, a flavor is a mixture of odiferous molecules. Its impact on the brain may be described as the sum of the qualitative and quantitative influences of its individual smelling components on the receptors of the cilia in the nasal mucous membrane. The electrical impulse generated by this action creates a flavor character map in the olfactory bulbs which is transmitted to the limbic system of the brain, where it generates specific feelings, emotions and evokes corresponding behavior.

The Sense of Taste

The sense of taste is located on our tongue. On its oral (apical[10]) surface one can find about ten thousand taste buds[11]. A single taste bud contains 50–100 taste cells representing all 5 taste sensations. In fact the classic textbook pictures showing separate taste areas on the tongue are wrong[12].

Each taste cell has receptors[13] on its apical surface. These are transmembrane proteins which bind to the molecules and ions that give rise to the 5 taste sensations, i.e. for sweet, bitter, sour, salty and unami (savory, mouthfeel)[14].

Although a single taste cell may have representatives of several types of receptor, one type may be more active than the others on that cell. And, no single taste cell contains receptors for both bitter and sweet tastants.

Whereas sour (low pH), salty (sodium ions), and unami (nucleic acids and their derivatives, e.g. mono sodium glutamate MSG) sensations are related to few substances or substance groups sweetness or bitterness can be evoked by a great variety of different substance types.

These basic stimuli[15] deliver helpful information about the acceptance of food: sweet tends to be pleasurable; bitterness provokes caution (many toxic substances are perceived as bitter). Still, the contribution of our sense of taste in the evaluation and enjoyment of food and beverages is small compared to the sense of smell.

The Trigeminal Nerve System: Pungency

Our mouth and nose caves are covered with nerve endings belonging to the trigeminal nervous system which – when stimulated – generate a pungent[16] sensation. While Mexican, Indian and other Far East foods are typically associated with pungency (chilli, ginger, etc.) many Western style food preparations also "live" from pungent aspects. Chilli, pepper (mostly in the mouth), onions and horseradish (mostly in the nose) exhibit pungent characteristics, as well as carbon dioxide e.g. in carbonated drinks (both in the mouth and the nose). Quite in contrast to tasting sensations, pungency is rather slow to develop, and persists - which account for sometimes tricky and painful experiences. Also, whereas tastes tend to adaptation, increased dosage of pungent ingredients shows increased sensation, or pain without apparent adaptation[17].

Legislative Classification of Flavors

Unfortunately, there exist many classifications and definitions of flavors and flavoring materials by different organizations, associations or committees, countries or continental areas.

In the European Union, six categories of flavors are defined and regulated by the Council Directive 88/388/EEC in conformity with the definitions of the International Organisation of the Flavour Industry (IOFI):

- Natural flavoring substances
- Flavoring substances identical to natural substances (found in nature, synthetically manufactured)
- Artificial flavoring substances (not found in nature, manufactured synthetically)
- Flavoring preparations (extracts of natural origin)
- Process flavorings (flavorings achieved by chemical reactions[19])
- Smoke flavorings

Most individual countries have adopted this classification in differing ways. Most have issued their own (positive[20]) lists of substances admitted for use in foodstuff and beverages. Some flavors or their components may be restricted, or an upper limit of certain flavoring substances may be specified for certain types of food or beverages.

In Europe a commission of experts compiled a list flavor compounds and flavor carriers and evaluated them in terms of health aspects. This positive list[20] was published as "Blue Book"[21] in 1992, in close cooperation with the European Flavour and Fragrance Association (EFFA) which comprises most national flavor associations of the EC.

Later on the Commission also decided about an EEC positive list of about 2700 substances for use in foodstuff in the Directive 1999/217/EEC, and 2002/113/EEC.

In the US, the Federal Food, Drug and Cosmetics Act of 1938 and the Food Additive Amendment regulate the use of substances that influence the properties of a food. These substances are defined under §101.22 in part 21 of the Code of Federal Regulation (CFR). They are classified as additives, unless they are generally recognized as safe (GRAS) by a panel of experts.

In the US, the American Flavor Association (FEMA) has classified some 1500 individual and mixtures of substances as FEMA GRAS for safe use in foodstuffs. This list is accepted by the FDA. The use of substances not contained in this list lies in the responsibility of the flavor house.

Codex Alimentarius

The Codex Alimentarius Commission was created in 1963 by FAO (Food and Agriculture Organization) and WHO (World Health Organization) to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organizations.

Definitions

For products added to a food, the Codex Alimentarius differentiates between additives, flavors and impurities. In our context, flavors are of interest and defined as follows:

Natural Flavoring substances[22], obtained from vegetable or animal raw materials by means of physical, microbiological or enzymatic processes,

Nature identical flavour compounds, that are isolated from aromatic raw materials by means of chemical methods or are synthetically produced. They are chemically identical with substances that occur in natural products fit for human consumption,

Artificial flavour compounds, i.e. substances that have thus far not yet been found in natural products intended for human consumption.

Sensory Evaluation

Sensory evaluation is used widely in testing food and beverage acceptance by consumers. This kind of product evaluation is a multi-step process in which a group of individuals respond to a set of products by giving scores according to a specific set of instructions. The test panel should ideally comprise individuals with sensory skills with the kind of products tested[23].

It is paramount to understand that sensory evaluation means the evaluation (of food, food ingredients, but also products for the home or personal care, etc.) as perceived by a variety of senses, i.e. the sense of vision, smell, taste, touch and hearing.

A Flavorist's Job

A flavorist tries to achieve a flavor in a food or beverage which ideally is very close or identical to the one nature produces in fruit, spices, vegetables, etc., and is stable in its matrix. Thus, in general, the goal of a flavorist is precisely defined – quite contrary to the task of a perfumer whose choice of creative variation seems endless.

References

Endnotes

1 Chemesthesis has been called the common chemical sense and is mediated primarily by the trigeminal nerve which innervates many parts of the head. It reacts to pungency and irritation, frequently with a component of thermal sensation. Very hot spices like chilli, pepper, horseradish, ginger, etc. may give strong impulses to our trigeminal nervous system which works on mechanisms different from olfaction or taste. That is why most pungent substances do not smell.

2 Generally, one speaks of five senses: Seeing, hearing, touching, tasting and smelling. Today, science tends to add more: the sense of warmth and cold, the sense of pain, the sense of equilibrium and the sense of positional and motional perception and awareness of the body and its parts. This adds up to nine senses altogether.

3 See also: The sense of taste (below).

4 It is known, that in addition to the olfactory organ in most mammals (and probably in men as well) there exists another organ sensitive to smelling substances. This so-called "vomero-nasal" organ is specifically stimulated by pheromones and known to control innate social and emotional behavior. It also communicates sexual messages like readiness for mating, etc. During evolution the vomero-nasal organ developed independently from the sense of smell. It is strictly separated from the olfactory organ.

5 Olfactory nerve cells are primary cells, i.e. they lead directly to the brain without the help of other (secondary) nerve cells.

6 The receptor for fragrance molecules is an integral part of the olfactory (primary) nerve cell which at the other end leads directly (without synaptic translation) into the brain (olfactory bulbs). The sense of touch has a similar scheme, whereas in vision, hearing and taste the receptors are highly specialized epithelian, non-neuronal cells which are connected to the corresponding nerve cell only in a second step (similar to synapses).

7 The glomeruli are the recipients of the impulses generated by the interaction of the smelling molecule and the receptor. One specific glomerulus is linked with one receptor type, thus getting the input of ten thousand identical receptor units spread over the mucuous membrane in the nose.

8 The two so-called "bulbus olfactorius" in the brain, just across the skull behind the upper back part of the nose. Equal receptors lead to one and the same site (glomerulus). Thus, the olfactory bulbs in the brain are home of one thousand specific glomeruli which are the specific target areas corresponding to the thousand different olfactory nerve cell receptor types.

9 Research in animal olfaction has advanced considerably during the last years. Nevertheless, large pieces of information still seem to be missing. Furthermore, many results from the animal world do not seem to be compatible with the human sense. It is a fact, however, that as far as sensitivity and specificity, multiplicity and complexity of identification are concerned the human nose is far superior than it's animal counterpart. Some animals, however, excel men in their capability of quantitative smelling.

10 Apical is the part of the tongue exposed to the lumen.

11 According to experimental studies [L.M.Bartoshuk et al., Physiol. Behav. 56, 1165 (1994)] the number of taste buds may vary considerably. Supertasters have a higher count of taste buds as measured by video recordings. Since the taste buds are surrounded by trigeminal neurons supertasters have a much more intense perception of bitterness (and apparently also other taste sensations). Sex and hormones also play a role; women are more likely to be supertasters than men, and increased perception of bitterness was shown for pregnant women. Since many poisons are bitter this may be nature's protection of the foetus during development by making becoming mothers better poison detectors.

12 For a long time the common understanding was that the specific taste receptors were located in different areas of of our tongue, namely sweet at the tip, salty and sour at the sides and bitter near the throat. In addition, the large middle area of our tongue would not contain taste buds, i.e. would not involved in tasting. Although this notion has been reiterated in text books and other taste related publications up to the present times it is wrong. See also:L.M. Bartoshuk, Food Quality & Preference 4, 21 (1993), U.-K. Kim et al, J.Dent.Res. 83 (6), 448 (2004), H-S. Jung et al, Int. J. Dev. Biol. 48, 157 (2004), or a good review in the internet: http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/T/Taste.html

13 The receptors of the taste are highly specialized, non-neural epithelial cells like those of hearing and seeing which trigger the stimulus only after synapses-like transmission onto a primary nerve cell.

14 For tasting the stimulating molecules do not have to be volatile. They may also be salts or other non-volatile compounds. This is contrary to the sense of olfaction where the stimulating molecules have to be volatile in order to reach the receptors in the nose through the air.

15 A primary taste quality is defined as basic if the physico-chemical reaction (stimulation) takes place through unique transduction mechanisms, in specific parts (receptor areas) on the tongue or mouth. Sweet, sour, bitter, salty and umami fulfill this requirement. (See also J.G.Brand, B. P. Bryant, Food Quality and Preference 5 (1994), 31-40). Umami is a taste quality best described as "delicious" and "savory", or amino acid taste. The most prominent member of this group is mono sodium glutamate (MSG), a substance highly used in Far Eastern (Chinese) food. See also "Umami: A basic Taste" by Y. Kawamura, M.R. Kare, ISBN 0-8247-7636-4 (1987).

16 Pungency is a more general term including taste feelings of warmth, burning, numbing, tingling, stinging, biting, itching.

17 One of our laboratory assistants once had a painful experience of this phenomenon. When checking out the smell of zingerone, a white powder, she did not experience any smell, even when sniffing a little longer and stronger. Then the effect became evident after a few seconds and persisted over minutes during which she could hardly breathe from pain, increased blood pressure and extreme burning sensations in her nose and mouth.

18 Note that biotechnologically (e.g. by fungi, etc.) produced ingredients are considered "natural" by the present legislation, also.

19 Like Maillard reaction flavours

20 Substances NOT mentioned in these positive lists must not be used, i.e. are forbidden.

21 "Flavoring Substances and Natural Sources of Flavorings" Council of Europe, Strasbourg 1992 (Vol. I, chemically-defined Flavoring substances; ISBN 2-7160-0147-2) and 2000 (Natural Sources of Flavorings; ISBN 9-871-4324-2). Unfortunately, no electronic data base is available.

22 The industry in both Europe and the USA uses three main definitions of natural flavours:
From The Named Food (FTNF) flavors: They consist only of extracts or distillates taken from that named food.
With Other Natural Flavourings (WONF). These are FTNF flavours blended with other natural flavours. For example, banana WONF could consist of banana distillate fortified with other natural flavouring ingredients.
Natural Flavour: These may contain flavour ingredients from any source as long as it is classified natural. They do not have to be from the named source

23 One has to keep in mind that subjects, no matter how skilled, exhibit differences in sensitivity from one another, and differences in variability as an individual. Therefore expecting a sensory test to yield an invariant result will lead to disappointing results which may also discredit the methods of sensory evaluation in general.

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