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Received: August 2017 – Accepted: March 2018

Study of basic taste recognition among the tourism and catering management students of the Budapest Business School

Keywords: basic tastes, taste sensing, sense organs, preference

1. Summary

The role of sensory analyses in the food industry and in gastronomy has increased significantly in the last decade. The regulation of both quality and certification is of paramount importance in this area as well.

In this paper presenting our series of analyses, we endeavored to find out to what extent tourism and catering management students are able to recognize the four basic tastes (sweet, salty, sour, bitter) when using all of their senses, and whether their abilities are affected by the exclusion of sight and smell.

In the first part of the study, tasters could use all their sense organs. In this case, sweet and salty tastes were properly recognized by more than 75% of the students. However, sour and bitter tastes were correctly identified by only 30% of the students, many mixed them up, and a quarter of the students did not even attempt to identify the taste. In terms of sensing sweet, salty and sour tastes, there was no difference between men and women, but the bitter taste was properly identified by more than 40% of men, and only 30% of women.

False identification of bitter and sour tastes to such a large extent can be explained by significant consumption of coffee, tea or cigarettes, or by an inappropriate diet [7]. During smoking, substances in the tobacco smoke can greatly impair the functioning of taste buds. Consumption of energy drinks and tea can also add to the flavor reducing effect of coffee and cigarettes, so these factors together could be responsible for the large number of false identification of the bitter taste.

2. Literature overview

The sensing of taste (gustatory perception or gustation) is a chemical sensing process that can only be linked to water-soluble compounds, since the given chemical substance has to dissolve in the saliva to be able to stimulate the receptors. The location of the sensation of taste is exclusively the oral cavity, mainly the tongue and the soft palate, the throat and the pharynx. Receptors are found in the papillae, which contain different numbers of taste buds. There are about 20 to 25 receptor cells in a taste bud. Receptor cells are being replaced continuously, their half life is 10 to 14 days **[6]**.

The sensation of taste starts with the stimulation of the taste buds. Our sensitivity to taste is determined by the number of taste buds. The number of taste buds differs from person to person, in healthy individuals there could even be a fourteenfold difference in the amount of taste buds. Thus, those with more taste buds will feel a given taste more intense than individuals with fewer taste buds **[19]**.

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Based on psychophysiological studies, we can distinguish four basic tastes, but recently umami (the taste of sodium glutamate) has also been classified as a basic taste. The study of taste sensation means the recognition of these four basic tastes (sweet, salty, sour, bitter) and the measurement of their intensities, and these are supplemented two more tastes, umami and metallic taste, by standard MSZ ISO 3972:2014 **[11]**. Some scientific studies have already mentioned fat taste as a possible basic taste as well **[8]**.

There is a very close relationship between taste and smell. An example of this is that when the mucous membrane of a sick person swells during a cold or a flu, they can lose not only their sense of smell, but also their sense of taste. The sensation of taste may deteriorate in the case of certain poisoning or following the inhalation of highly volatile organic substances. Smell contributes to the sense of taste, because tasting and smelling interact with each other. When eating with your nose held, the elimination of smells inhibits the recognition of foods, the taste of food is weakened, or it fells completely tasteless. When, after freeing the nostrils, smells are added to the tastes, the sensation of taste becomes stronger. With regaining smells, aromas also return **[16]**. The intensity of a taste is influenced by several factors, for example, the temperature of the given substance (food or drink), the physiological state of the tasting person (e.g., hunger, pregnancy), smoking, eating habits, or even the time of day **[6]**. Similarly to smells, women have a higher sensitivity to tastes than men **[19]**.

The four basic tastes can be perceived without smells, but there are more complex tastes, where smelling plays a role in the sensation of taste. In two people, the same stimulus triggers different reactions, which can be traced back to genetic differences, but past experience may also have a decisive influence on the sensation of taste. For example, some people perceive saccharin bitter, while others not, and the difference seems to be genetically determined **[1]**.

This finding is supported by a New Zealand research in which the complex taste sensation of the participants was investigated by tasting paired mixtures (sweet-sour, sweet-bitter, salty-bitter, salty-sour). Results of the experiment showed, among other things, that the degree of tasting can also be determined by genetic factors. For almost everyone, a certain concentration can be determined, at which tastes become recognizable, however, at lower concentrations, tastes in the pairs do not become individually identifiable, not even in the group of "supertasters". The specific flavors could only be recognized by the groups when one of the tastes was present in a higher concentration in the mixture, however, at identical concentrations this could not be achieved **[14]**. About 25% of people are supertasters with 167 taste buds per square centimeter, while on the tongue of average tasters only 127 papillae are found on average **[16]**.

Differences in the taste and smell sensations of individuals can be caused by pathological changes, such as parosmia (distorted smell sensation), dysgeusia (distorted taste sensation) or hypogeusia (reduced taste sensation) **[13]**. Also decisive could be taste aversion, a learned process that helps individuals to avoid foods that cause diseases or that are toxic, or neophobia, i.e., shying away from new tastes **[4]**.

As a side effect of certain medicines, a loss of taste sensation can also be experienced, and the same can happen when consuming caffeine-containing or alcoholic beverages, or energy drinks regularly. When examining the bitter taste sensation of smokers, non-smokers and people who have given up smoking it was determined by Jacob et al. **[7]** that the recognition of salty, sweet and sour tastes was not influenced by smoking habits. At the same time, the worst bitter taste recognition abilities were detected among ex-smokers, and the bio-accumulation of toxic substances in cigarette smoke was identified as the reason for this by the authors.

Taste sensitivity also depends on the temperature, for example, it is harder to notice the bitter taste at higher temperatures, while the sensitivity to sugar increases with increasing temperature **[16]**.

Experiments related to taste sensation were already carried out by Goldscheider and Schmidt in 1890. With the help of liquids of different taste, the taste capturing ability of the tongue and the pharyngeal cavity, and as well as the effect of the given substances were examined separately. A thin fiber was dipped into the liquid to be examined and the papillae of the tongue were touched by these. According to their early findings, the papillae react to the tastes differently. Based on their study, salty taste is perceived at the back of the tongue, bitter taste at the edge of the tongue, while sweet taste was identified in the hard and soft palate **[15]**. Previously it was thought – and many people still think – that the perception of the basic tastes can be assigned to different regions of the tongue: sweet at the tip, salty at the edge in the front, sour at the edge in the back and bitter at the back. However, according to recent studies, almost all receptors react to all tastes, more strongly to some and less strongly to others **[2]**.

According to the German researcher Henning, primary tastes are sweet, salty, sour and bitter. The relationship between the different tastes was depicted by a taste tetrahedron, with the four taste qualities at the corners of the tetrahedron. Henning wanted to emphasize the unity of the four taste qualities, and rejected the idea that the four basic tastes can be perceived separately in complex taste mixtures **[16]**.

The so-called "umami" taste was discovered by Kikunae Ikeda, a Japanese researcher, at the beginning of the 20th century. In a 1908 publication umami was mentioned as protein flavor. It was proven in 1996 that there receptors for the umami taste on the tongue **[10]**.

With the help of tasting, to some extent, we can carry out the quality control of the given foods, for example, we can distinguish between edible and inedible foods, or harmless and harmful ones. Taste stimuli are also suitable for indicating the taste quality of a food, for example, bitter taste may indicate the presence of a toxin. Most people are most sensitive to the perception of bitter taste, because the taste threshold is generally lowest for this basic taste, so bitter taste can be felt at very low concentrations **[3]**. Tastes are often classified by us, they can be either pleasant or unpleasant. Bitter taste is usually considered unpleasant, while sweet taste is thought to be pleasant. We generally prefer to eat foods with a pleasant (sweet) taste, and usually avoid foods with an unpleasant (bitter) taste. There are inherited and learned preferences. The inherited preferences are strongly positive for the sweet taste, moderately positive for the salty taste, strongly negative for the bitter taste and moderately negative for the sour taste **[5]**. These preferences can be modified by learning **[4]**.

One of the mandatory subjects of the tourism and catering management students of the Budapest Business School is food and beverage knowledge, during the laboratory practice of which future catering experts gain insight into the laboratory analyses of alcoholic and non-alcoholic beverages, foods of plant and animal origin, natural stimulants, such as tea, coffee, cocoa, etc. The quality of the above-mentioned foods, their suitability for human consumption and, in cases, sensory properties expressing their composition characteristics and enjoyment value are studied by the students. Since the sensation of tastes and the ability to distinguish between them is essential in the world of cooking and gastronomy, in our research we sought to answer the question how the taste recognition ability and taste sensation of future catering experts can be characterized, and what the factors are that influence these abilities, important from a catering practice point of view (for example, gender, consumption habits of certain foods, the use of other sensory organs or colors).

In the present paper, our results regarding the basic taste recognition abilities and taste threshold values of the students are communicated.

3. Materials and methods

Standard testing of the basic taste recognition ability was performed according to MSZ ISO 8587:2014 **[12]** using the ranking method, involving students. For carrying out the tests, stock solutions corresponding to the four basic tastes (sweet, salty, sour, bitter) were prepared. Sucrose was used for the sweet taste, 98.3% purity iodinated vacuum salt (sodium chloride) for the salty taste, citric acid for the sour taste and caffeine for the bitter taste, dissolved in distilled water. All of the stock solutions and the dilutions made from them were transparent and colorless, and so taste recognition was not influenced by the color of the liquid. Concentrations of the stock solutions were as follows: sucrose – 0.15 w/v%, sodium chloride – 0.02 w/v%, citric acid – 0.0050 w/v%; caffeine – 0.0036 w/v%. The dilution series were prepared from the stock solutions according to ***Table 1***, where the given volume of the stock solution was made up to 250 ml with distilled water.

Earlier taste threshold value studies with the involvement of tourism and catering students of BBS revealed that tastes were recognized with certainty in the 6th and 7th dilution **[9]**. Therefore, in the present study, the 9th dilution series was selected, where the concentrations of the compounds responsible for the basic tastes were as follows: sucrose 0.55 w/v%, sodium chloride 0.18 w/v%, citric acid 0.025 w/v%, caffeine 0.01 w/v%. This way, we could be sure that participants of the study could perceive the basic tastes well and can identify them. Stock solutions and dilutions were prepared freshly on each test day, and were kept in labeled flasks with ground glass stoppers until use to prevent contamination.

The four solutions of different taste were given to each student separately in four translucent glasses of identical size and shape, labeled with a randomly selected three-digit code. Together with the samples, a test sheet was also provided, containing the three-digit code numbers of the samples and five possible choices (sweet, salty, bitter, sour, don't know). After tasting the liquids in the four glasses, students had to indicate on this test sheet the basic taste corresponding to the given code, or the fact that they could not identify the taste.

The study was carried out by the students in three different situations: first, they could use all their senses during the taste recognition, in the next step, they had to keep their eyes closed, and during the third tasting, they had to identify the taste of the four solutions in the glasses with their eyes closed and holding their noses. Between the three tastings, students could consume flavor neutralizing materials (bread, crescent roll). In the experiment, care was taken to make sure that taste recognition was not disturbed by successive tastings.

Prior to the testing of the basic taste recognition ability, students were asked to fill out a questionnaire measuring consumption frequency, in which we sought to find out how often they consumed dishes and foodstuffs that, according to the literature, may distort the perception of basic tastes. Products presumably influencing the recognition of basic tastes are coffee, tea (*Camellia sinensis*), cola drinks, energy drinks, chocolate, alcoholic beverages and artificial sweeteners **[18]**.

128 persons participated in our study, 123 of which submitted test sheets that could be evaluated. The age of the participants ranged from 20 to 23 years, there where 47 women and 75 men, with 1 person not indicating their gender, and so he/she was omitted from the evaluation of the results when analyzing gender-specific answers. Our results were analyzed by mathematical-statistical methods, and significance levels and, where possible, Cramer's coefficient were calculated.

4. Results

4.1. Basic taste recognition ability

83.7% of students (123 persons) recognized the sweet taste of the 0.55 w/v% solution with great certainty, 8.9% felt it bitter, 3.3% sour and 1.6% salty. 2.4% could not identify it. Salty taste (0.18 w/v%) was recognized by 93 persons (75.6%), 15.4% felt is bitter, 5.7% sour and 0.8% sweet, 2.4% could not identify it properly *(**Figure 1**)*.

Sour (0.025 w/v%) and bitter (0.01 w/v%) tastes were mixed up and could not be properly identified by the students *(**Table 2**)*. One quarter of the students did not even attempt to identify the tastes. In both cases, the given taste was recognized properly by 35% (43 persons). Sour taste was felt bitter by 28.5% of respondents (35 persons), while bitter taste was perceived sour to a similar extent (22.8%, 28 persons).

There were no significant differences between the sexes *(**Figure 2**)*. Salty (men: 78.3%; women: 76%), sweet (men: 82.6%; women: 84%) and sour tastes (men: 32.6%; women: 36%) were recognized by men and women to nearly the same extent, significant difference was only observed in the case of the bitter taste, in favor of men (42.5% vs. 32.0%).

Overall it can be stated that the students had fully developed sweet and salty taste recognition abilities, but sour and bitter tastes were not recognized or only with difficulty.

4.2. Basic taste recognition ability without the use of the eyes

In the next part of the study series, students could not use their eyes when tasting basic tastes. Students recognized sweet taste with great certainty (86.2%), but salty taste was only identified properly by 66.6% of them (***Figure 3***). Bitter taste was recognized by 39.8% of them, and sour taste by 30.9%, but in this case, these two basic tastes were mixed up again by many of them (***Table 3***). Compared to what was experienced when using all the senses, the proportion of students who did not even try to identify sour and bitter taste decreased (18.7% and 9.8%).

When tasting without using the eyes, salty taste was correctly recognized by 82.6% of men, sweet taste by 89.1%, sour taste by 34.8% and bitter taste by 47.8% (***Figure 4***). In contrast, the number of women who could identify salty (58.3%) and bitter (35.1%) tastes was significantly lower, while they recognized sweet (86.3%) and sour (32.4%) tastes to approximately the same extent as men (***Figure 4***).

4.3 Basic taste recognition ability without the use of the eyes and the nose

In the next part of the study series, the use of two sensory organs was avoided by the tasters, the eyes and the nose.

Considering the results of all tasters, salty taste was correctly identified by 76.4%, sweet taste by 89.4%, sour taste by 37.4% and bitter taste by 34.1% (***Figure 5***). In the absence of two sensory organs, similarly to what was experiences earlier, the latter two tastes were mixed up by a large proportion of students (***Table 4***). Sour taste was felt bitter by 37.1%, while bitter was felt to be sour by 32.5%. The proportion of students who did not feel these two tastes at all was greater in the absence of two senses, than it was when only the eyes could not be used.

Breaking down the data by gender, it can be observed that the taste recognition ability of men was better than that of the women in the case of the salty, sour and bitter tastes, while the sweet taste was recognized by a greater proportion of women when not using the eyes and the nose *(**Figure 6**)*.

4.4. Changes in the basic taste recognition ability as a function of the use of the different sensory organs

Taking into consideration the responses of all of the students, the effects of the exclusion of vision, and then vision and smell on the changes in the basic taste recognition ability are shown in ***Figure 7***. The figure clearly shows that in all three cases the sweet and salty tastes were identified by the students with the greatest certainty, while the identification of the sour and bitter tastes was difficult for the majority of the students.

Fewer students were able to recognize the salty taste when not using the eyes, while when the ability to smell was also eliminated, the taste was recognized by the same number of students as when using all the senses. The majority of students were capable of identifying the sweet taste.

Just over one third of the students could recognize the sour taste, and their proportion decreased slightly when eliminating the eyes, or the eyes and the nose together. 35% of the students were able to identify the bitter taste when using all of their senses, with the elimination of the eyes this ratio decreased slightly, to 32.6%. In the absence of both vision and smell, the same number of students felt this taste as when using all the senses.

5. Summary

In our investigations, results contradicting literature data and assumptions were obtained. In the case of the bitter and sour tastes, it was examined what the extent of the recognition of these two basic tastes was among consumers and non-consumers of coffee and energy drinks, as well as among smokers and non-smokers. When assembling the data for the consumption of foodstuffs and natural stimulants modifying the taste recognition ability, consumption frequencies (occasionally, monthly, weekly, several times, daily and several times each day) were taken into consideration. The proportion of consumers and non-consumers were as follows: coffee – 89.4:10.6; energy drinks - 59:41; smoking – 56.6:43.4.

The number of persons in the present study not consuming the other natural stimulants investigated (tea, cola drinks, chocolate, sweeteners, alcohol) was so low that their effect in our analyses was considered to be negligible.

When examining the extent of the recognition of the bitter taste among consumers (users) and non-consumers (non-users) of the given natural stimulant (coffee, energy drinks, cigarettes), it was found that the bitter taste was correctly recognized by a smaller proportion of coffee consumers and a greater proportion of energy drink consumers and smokers (***Figure 10***). In the case of the sour taste, this basic taste was recognized by a greater proportion of coffee consumers and smokers, and by a smaller proportion of energy drink consumers (***Figure 11***). 36% of those who consume coffee more or less often, but only 23.1% of non-consumers could identify the sour taste. Unfortunately, no data were collected regarding the time elapsed between drinking coffee and performing the test. Our results show that when consuming certain natural stimulants, the taste recognition ability might change, bit it does not necessarily weaken, in certain cases it even might be enhanced **[17].**

In our second examination, students participating in the experiment could not use their eyes. In this case, the taste recognition ability of men was enhanced for all four basic tastes. Women recognized the sweet and bitter taste in a greater, while the salty and sour taste in a smaller proportion.

The improvement in the taste recognition ability could be explained by the change in tasting conditions. Tests were carried out by the students in groups of 15 within the framework of regular classes, and in these circumstances, external stimuli, such as the presence of the companions, the instructor or the technician might have distracted their attention. When eliminating vision, visual stimuli ceased to exist, and so students could focus their attention on the experimental task at hand. However, this hypothesis can only explain the improvement in taste recognition in the case of male students, in the case of female students the recognition ability remained unchanged.

Most often, the bitter taste was identified as sour by the students, especially in cases where they could only rely on their sense of taste. The Cramer coefficient, measuring the closeness of the relationship, indicates a weak stochastic relationship (0.25).

In the third test, students could use neither their eyes, nor their nose, and in this case the recognition of basic tastes was similar to the results of the second test, both for women and men. A possible explanation for this phenomenon is that the recognition of taste can only be influenced by smelling, if the food/drink in question have a smell, i.e., at the temperature of the test volatile compounds are released into the atmosphere, and from there to the olfactory epithelium. Pleasant or unpleasant sensations in the nose are matched by the brain with the corresponding emotions, memories or a sense of danger, and a response is sent to the body whether to consume the given food/drink or not. Considering the fact that in our tests the non-volatile compounds giving rise to the basic tastes were dissolved in water at room temperature and the temperature of the glasses was the same, the solutions did not have a smell or only a slight one, and so smelling was involved in taste perception to a very small extent, therefore, the change in the number of correct answers was negligible.

In our present paper, the first results of a series of tests regarding tastes and tasting are presented. However, we consider it important to carry out further studies in the area of factors influencing taste recognition. Both in the hospitality industry and in the practice of the households it is good to be aware of the effects, smells and tastes that make the guests or even other members of the family feel something different during the consumption of a meal than the preparer of the food. That is why further studies are being carried out with respect to colors as factors that influence taste recognition. Results of this series of tests will be summarized in our next article.

This paper presents some of the results of the research titled „Investigation of taste threshold distortion among the students of BBS", a research that was funded by the 2016 Excellence Fund of the Budapest Business School.

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