Subject: Food Technology for undergraduate course.

Core Course 14: Food Quality and sensory evaluation

Unit2: Gustation (part 3)

e-content Topic: Taste quality, modification, thresholds and measurements

Dr (Mrs) K.S Premavalli, M.Sc., Ph.D, PG DOM

Scientist 'G' and Additional Director, Rtd. DFRL, Mysore.

Introduction

The basic tastes sweet, sour, salt, and bitter are independent entities. They do not have the ability to change into another. As known, these are reflected as the effect of molecular structure. The quality of these tastes is an intensity based, perception based feature. These exhibit different thresholds depending on the molecule and perception. Many a time the modification of the taste is attempted, practiced to suit the palate. Therefore, these properties are of great concern for better perception, food development and acceptance. We will be learning the taste under following sections:

Taste Quality:

Taste Modification:

Taste Thresholds:

Measurement of Taste

1. Taste Quality:

The taste quality has no clear cut dimension and is more a human perception. It is influenced by geographical, environmental, physical, physiological, psychological, technological and nutritional factors. Early studies of 19th Century expresses the opinion that four basic tastes qualities fall into a single taste modality just as colours are with qualities within vision. Kiesow (Birch et al, 1977) is the first one to conduct a systematic study on taste mixture interactions. He revealed that mixtures tasted less intense than the components. Also, the concentration of each component have an influence on the taste perceptions. Very low concentration component may not be recognizable for its quality impact but still adds to the overall quality of food. Even though, no chemical reactions occur, the mixture of taste qualities changes the intensity of perception. On the other hand, Ohrwall (Birch et al, 1977) compared the taste quality to the skin, which senses touch, warmth, cold and pain than the colour comparison. Thus they are independent entities which are not able to change to another. Amongst the taste qualities, bitterness resembles sweetness because of stereochemistry of stimulus molecules. For eg. when sugar molecules are chemically modified, the resulting derivatives are almost bitter or may be sweet-bitter. Thus it is truly a molecular effect depending on stereo chemical, hydrophobic and polar structure features showing varied responses. This gives an indication that molecular patterns ultimately are responsible for both basic tastes. In the case of saltiness and sourness, though the taste quality is on molecular pattern of cation and anions, the intermolecular changes do not arise. Sour, bitter and sweet taste decreases with increasing addition of monosodium glutamate. Salty taste increase with increasing monosodium glutamate only at the flavour threshold of sodium chloride. The pleasantness of sucrose increases with the increase in concentration, but at a higher concentration it decreases slightly. In case of sodium chloride, tartaric acid, quinine sulphate, the pleasantness will be experienced with slight increased concentration but later it will be unpleasant. There are many factors that alters taste perceptions. The factors are age, meals,hunger,tastemedium,temperature,smoking,obesity,pregnancy,cold,cough,allergies,diseases. Taste discrimination decrease with increase in age. Around 45 years of age, taste buds begin to degenerate. Taste loss become apparent in late 50's. In advanced age, taste thresholds for sweet,salt and bitter are 2.5 times higher than in the young. Sensitivity is reduced after the meals. It also depend on the type of the meal whether spicy or bland meal. Hungry persons are more sensitive to sweetness and saltiness. This makes to overcome the hunger which is not good. Taste medium of liquid helps the taste buds to detect flavours. Water is the best medium for sensitivity tests. Taste thresholds are lower in water than in fruit juice. Increasing temperature increases the response to sweetness but decreases with saltiness and bitterness. Decreasing temperature increase the response to bitterness, but decreases for sourness. Smoking reduces the taste bud's sensitivity to all the basic tastes. Children and adolescents who are obese have less sensitive taste buds. Therefore intensity of sweetness of sweets will be less, bitterness will be mild and salt may not be readily perceived. Pregnancy shows the reduced sensitivity for salty taste. During cold, cough obstruction of nasal &oral passages reduces the sense of smell first and taste bud's sensitivity later. Any disease reduces the sensitivity, but improves after treatment.

2. Taste Modification:

Taste modification is a very interesting phenomenon to the consumers. The taste modification physically modifies the perception of a compound, food, drink etc. The taste modification can be achieved by

a) Combination of the basic tastes and taste sensations.
b) By topical application
c) By the use of condiments
d) By the use of flavouring agents
e) By the use of texture modifiers
f) Synergism

However, the modification can also be met by a negative path of approach through

a) Suppression
b) Masking
c) Disorder

The basic taste and taste sensations at times may have a combined phenomenal action for the clarity in expression of perception of food. For eg. bitter taste and pungency of ginger; acid taste and astringency of betel leaves may provide a better impact for the sensory organs for expression of perception. In many of the fried snacks, vegetable salads, cut fruits, salt & pepper, cardamom powder, sugar powder are used for topical application prior to consumption. The taste quality modifies, but the independent taste remain during perception. Similarly, the use of condiments, flavouring agents result in mixed interactions among the four taste qualities. When substances are mixed, their taste change, but no chemical reaction occur among the substances. The use of starch, or dhal powders in food systems changes the texture as well as the taste. The taste quality is felt in terms of reduced intensity. The saltiness perception is reduced in starch thickened foods with the reduction in mouth amalyse activity (Ferry etal, 2006). In a model system of four sugars sucrose, fructose, glucose, maltose when subjects concentration versus the perceived intensity is seen, it reflected psychophysical function with a greater strength of perception which shows the expansion. The mixture of these sugars tasted much stronger than the simple sum of single components taste scores showing the synergism. The taste-flavour interactions in the study of sucrose-caffeine system have shown their reciprocal action on <u>suppression</u> ie. the perceived intensity of say sugar increase, the caffeine intensity decrease. Similarly sucrose with tartaric acid system, suppressive action of sucrose on the sourness of tartaric acid is greater than the suppressive action of tartaric acid on sweetness (Marin etal. 2002). Besides these, taste can be suppressed by local anaesthetic application on the tongue. Amiloride, a blocker of epithelial Na channels reduces the salt taste in humans. Adenosine monophosphate may block the bitterness of several bitter compounds. Gymnemic acid from Indian shrub Gymnema Sylvestre decreases the sweet perception. Chlorogenic acid and cyanarin by Suppression of sour and bitter taste receptors enhances the sweet taste. Miraculin in miracle fruit turns sour tastes sweet by binding the site near the sweet receptor.

Masking is another aspect of taste to eliminate undesirable taste. Acid taste is masked by using more quantity of sugar or sweet compounds. At times, the condition of disorder of taste is experienced and is associated with smell. It may be decreased perception of taste (hypogeneusia) due to the reduction in taste buds or loss of sense of taste (agneusia) or distorted ability to taste (dysgeusia).

Thus the taste modifications reflects on the relative intensity of basic tastes through one of the processes of suppression or expansion, masking and disorder depending on the components used and the system of application.

Besides these, the reaction time is also an important factor to express the changed perception. The reaction time is the interval between initial stimulation of the receptors and the report of the reaction. The reaction time to taste has been reported as 0.02-0.06secs as per the electrophysiological studies. However, the oral-response reaction time for salt, 0.307 sec; for sweet 0.446 sec; for sour 0.536 sec and for bitter 1.082 secs. The oral response reaction time depend on the concentration too and the technique adopted. Relatively, taste has slow reaction time as compared to other sensory stimuli. Receptor transduction mechanism with the comparison of retention time to various typical substances with the same taste quality, with the same subjects when studied, no significant effect was seen on the stimulus chemical composition. Though retention time is short for salt and longest for bitter, retention time among the four basic tastes is small. The taste retention time varies widely with its taste intensity. The reaction time in analysing the flavour of chewed gummy candies suggested that retention time of that of taste components was not responsible much for detection time as compared to intensity of odours.

3. Taste Threshholds

Taste Threshhold is a statistically determined point on the stimulus scale at which occurs a transition in a series of sensations or judgements. There are four types of thresholds that are generally known.

1. Absolute threshold
2. Difference threshold
3. Recognition threshold
4. Terminal threshold.

Absolute threshold is that magnitude of stimulus at which transition occurs from no sensation to sensation. It is also referred at times as detection threshold or stimulus threshold or sensation threshold.

Difference threshold is the least amount of change of a given stimulus necessary to produce the change in sensation.

Recognition threshold is the minimum concentration at which a substance is correctly identified. It is also referred as identification threshold.

Terminal threshold is that magnitude of a stimulus above which there is no increase in perceived intensity of the appropriate quality for the stimulus. Above this point, changed sensation of pain, burning, piercing often occurs.

The threshold measurement is the procedure of studying the Psychophysics of taste which concerns the functional relation between stimulus and response. Taste Thresholds is a complex phenomenon since the data depends on the subject, difference in techniques employed, and statistical compliance, the effect of temperature, environmental factors, and time of the day, experience, age, sex and physical condition. Even given the same subject and method, because of varied factors, the variations in the taste threshold is expected. In general, the absolute threshold is much lower than the recognition threshold. Each compound will have a unique threshold level which depends both on the properties of the receptor and the concentration of the molecules. It has been found that the integrated response of concentration of sodium chloride by the receptors on the tongue with the chorda tympani cranial nerve reveals that at 0.32M concentration response is maximum and later remains constant even up-to 1.1M.

That means to say that after certain level, the saturation is reached with no changed response. Generally, recognition threshold which identifies the minimum Concentration is followed and is expressed as percentage. But, it has been found that recognition threshold and absolute threshold is much closer together for bitter tasting than for sweet or sour tasting compounds. The threshold values of selected compounds are given in Table 1-4.

TABLE 1

Thresholds of Sugars

Sugar	Sensitivity		Identification	
	M	%	*M*	%
Sucrose	0.016	0.56	0.037	1.30
Glucose	0.045	0.80	0.090	1.63
Fructose	0.020	0.35	0.052	0.94
Maltose	0.038	1.36	0.080	2.89
Lactose	0.072	2.60	0.116	4.19

Source: Principles of sensory evaluation of foods,1965,page 97

TABLE 2

Taste Thresholds for Selected Acids

Acid	Range		Median	
	N	%	*N*	%
Hydrochloric	0.00005-0.01	0.00018-0.036	0.0009	0.0033
Nitric	0.001-0.0063	0.0063-0.040	0.0011	0.0069
Sulfuric	0.00005-0.002	0.000245-0.0098	0.001	0.0049
Formic	0.0007-0.0035	0.0032-0.0161	0.0018	0.0083
Acetic	0.0001-0.0058	0.0006-0.0348	0.0018	0.0108
Butyric	0.0005-0.0035	0.0044-0.0308	0.0020	0.0176
Oxalic	0.0020-0.0032	0.0090-0.0144	0.0026	0.0117
Succinic	0.0016-0.0094	0.0094-0.0555	0.0032	0.0189
Lactic	0.00052-0.0028	0.0047-0.0252	0.0016	0.0144
Malic	0.0013-0.0023	0.00871-0.0154	0.0016	0.0107
Tartaric	0.000025-0.0072	0.000188-0.0543	0.0012	0.00905
Citric	0.0013-0.0057	0.00858-0.0376	0.0023	0.0152

Source: Principles of sensory evaluation of foods,1965,page 88

TABLE 3

Thresholds Values for Selected Salts

Substance	Range		Median	
	M	%	*M*	%
Lithium chloride	0.009-0.04	0.038-0.170	0.025	0.106
Ammonium chloride	0.001-0.009	0.0053-0.048	0.004	0.021
Sodium chloride[α]	0.001-0.08	0.0058-0.468	0.01	0.058
Sodium chloride[b]	0.003-0.085	0.175-0.497	0.03	0.175

Potassium chloride	0.001-0.07	0.0075-0.522	0.017	0.127
Magnesium chloride	0.003-0.04	0.0286-0.381	0.015	0.143
Calcium chloride	0.002-0.03	0.0222-0.333	0.01	0.111
Sodium fluoride	0.001-0.04	0.0042-0.168	0.005	0.021
Sodium bromide	0.008-0.04	0.0823-0.412	0.024	0.247
Sodium iodide	0.004-0.1	0.0600-1.499	0.028	0.420

[a] Sensitivity threshold.
[b] Recognition threshold; Source: Principles of sensory evaluation of foods,1965,page 85

TABLE 4

Taste Thresholds Bitter Compounds

Substance	Range		Median	
	M	%	M	%
Quinine sulfate	0.0000004-0.000011	2.99×10^{-5}-8.22×10^{-4}	0.000008	5.98×10^{-4}
Quinine hydrochloride	0.000002-0.0004	7.22×10^{-5}-1.44×10^{-2}	0.00003	1.08×10^{-3}
Strychnine monohydrochloride	—	—	0.0000016	6.51×10^{-5}
Nicotine	—	—	0.000019	3.08×10^{-4}
Caffeine	0.0003-0.001	5.83×10^{-3}-1.94×10^{-2}	0.0007	1.36×10^{-2}
Urea	0.116-0.13	6.97×10^{-1}-7.81×10^{-1}	0.12	7.21×10^{-1}
Magnesium sulfate	0.0042-0.005	5.06×10^{-2}-6.02×10^{-2}	0.0046	5.54×10^{-2}

Source: Principles of sensory evaluation of foods,1965,page 107

The threshold value is effected by various factors such as lack of sleep, hunger, age, habits such as smoking, alcoholism, cold, fever and allergy. Besides these, the temperature influences the taster. The optimum temperatures have been reported for sucrose and hydrochloric acid 35-50^o C, salt 18-35^o C and 10^o C for quinine. The medium such as the liquid or solid also influence the receptors thereby the threshold value. The interaction of tastes say 2 or 3 basic sweets together has an impact on threshold value by way of increase or reporting the sensation of highest first and later others.

4. Measurement of Taste

The measurement of taste depends on which basic taste to be determined. Secondly, depends on the food products and quality control methods followed are compared with the sensory evaluation of tastes. Thus, both objective and subjective measurements have to be followed for evaluation of the taste of the product.

Some of the points of concern for subjective and objective measurements are

1. The samples for both tests should be identical.

2. There must be sufficient replication.
3. The same individuals should participate in all panels for comparison.
4. Sufficient range of test variable to be chosen.
5. Degree of variation from Sensory Panel to instruments results to be determined.

The objective instrumental methods vary depending on the basic taste to be determined or the product from which the taste component to be identified and quantified. Still the limitations exist in terms of specific factor determination by instruments where as human responds to various sensory attributes. Specificity for mouth feel will be more relevant for taste measurements. The evaluation of taste of any food product should be based on the fields of **Psychology** which describes the responses to sensory stimuli, **Psychophysics** which quantifies the relationship between stimuli and response and **Statistics** which formulates the precision judgments. The methods followed for taste evaluation are ranking, scoring, hedonic scaling and evalution.

Ranking is the test followed for selection of one or two best samples rather than testing all the samples thoroughly. This is often used for screening inferior from superior samples in product development and sometimes for training the judges.

Scoring is the most commonly adopted method to grade the quality to the property is taste in this case. This needs a methodical approach of development of score card, specificity of properties to be graded, concept known judges selection. Scoring has the advantage of statistical analysis and confidence level of the test. This test can be on structured scale or non structured scale.

Hedonic Scaling relates to the psychology of pleasurable or unpleasant property. In this method, the human discreatory values of like, dislike with the adjective of extremely, fairly, poorly are used with the scoring for evaluation. Therefore this is a direct method of defining the responses with the proper judgement. This is also advantageous for statistical analysis and inference.

Dilution method is a specific technique adopted to detect the smallest amount of unknown sample when mixed with the standard material. This is more used for determining the threshold levels of basic tastes.

The recent development for the taste evaluation is the use of **electronic tongue**. Professor Fredrik from Sweeden University has invented the electronic tongue which measures and compares tastes. In the biological system, taste signals are transducted by nerves in the brain into electric signals. E-tongue sensors process also generates electrical signals as potentiometric variations. Taste quality perception and recognition of activated sensory nerve patterns by the brain and on the taste fingerprint of the product. E-tongue's statistical software achieves the same and further interprets the sensor data into taste patterns. Reference electrode and sensors are the part of the system. The measurable current response as a result of oxidising reactions shows the voltage difference and after amplification recorded by the e-tongue's software. Electronic tongue have the applications in food & beverage and pharmaceutical industry.

Conclusion: Taste quality is rather more a human perception influenced by geographical, environmental, physical, physiological, psychological, technological and nutritional factors. Taste quality is intensity based perception and depends on the threshold concentration of particular component. Generally,the factors that affects the taste quality are age, hunger, duration between meals, taste medium either liquid or solid or viscous, smoking, drinking, body status in terms of obesity, pregnancy, cold, cough, diseases. Taste can be modified by combination of basic tastes, by use of spices , flavours and texture modifiers. The undesirable flavour can be overcome by suppression and masking. The increased temperature aids in increased intensity. The reaction time of perception ranges from fraction of a second to a few seconds for the basic tastes. Each compound has a unique threshold value. Both subjective and objective methods are followed for evaluation. Objective methods asses the taste and quantifies the component. Ranking, scoring ,hedonic scaling and dilution methods are followed for subjective evaluation. Recent development is the use of electronic tongue with the statistical software.

References/Links

1. Martin N, Minard,A and Brun. O. 2002, American Journal of Enology and viticulture, 53(1), 6-13.
2. Maynard A, Rose Marie P and Edward B. R 1965, Book on "Principles of Sensory Evaluation of food", Academic Press Publication.
3. Premavalli K. S and Satyanarayana Swamy Y.S,2011, Chapter on "Taste of Foods", in the Book "Sensory Taste", M/S Nova Publishers,US.

4. Freey, A.L.S., Mitchell, J.R, Hort, J, Hill, S.E. Taylor A.J, Lagarrigue S. And Valles Pamies B, 2006, Journal of Agriculture and Food Chemistry 54(23), 8869-73.
5. www.fona.com/sites/default/files/factors influencing taste perception
6. www.apps,fst,vt,edu/extension/enology/630.578.8600
7. https://en.wikipedia.org/wiki/electronictongue

*****