Subject: Food Technology for undergraduate course.

Core Course 14: Food Quality and sensory evaluation

Unit 2: Gustation (Part - 1)

e-content Topic: Gustation in human system

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Introduction

Gustation or taste is the human act of experiencing the senses spread over on the tongue, The soft palate along the lining of the throat through the taste buds, helps in the process of tasting.The sense of taste is limited to five basic tastes ie. sweet, sour, salt, bitter and umami. The dimensions of these tastes could be estimated chemically. However, their optima in relation to consumer acceptance, preference, especially, when they occur in combination in a complex food are not fully understood. The sense of taste is not only associated with taste buds. It also depends on the gustatory cortex at the back of the brain which processes the taste inputs. While, taste of foods is associated with the basic taste, it is also influenced by many other factors. These factors may be type of food, type of processing adopted, ingredients used, pre-concept of particular food. Age, situation, environmental conditions, cultural conditions and food habits also affects the taste. Under these conditions, the sense of taste and the chemical based stimuli influence the judgment. On the taste of food and its acceptance, the food palatability has a profound effect. The food palatability is determined by taste and other sensory attributes. The taste of food is a complex phenomenon in determining the quality, acceptance and enjoyment cum satisfaction. In this process, food is smelt by olfactory sensations, texture by mechanoreceptors also influences the judgement. Stevenson et all (1999) have reported that perception of taste is affected by the odours with reference to sweetness and sourness. Thus, the understanding of taste perception calls for the knowledge on the physiology of tongue, involvement of brain nerves and the taste receptors action. This impacts the overall experience on the taste of food.

Aristotle Postulated in 350 B.C that the two basic tastes were sweet and bitter and he also developed a list of basic tastes. Ayurveda, an ancient healing medicine has its own tradition of basic tastes, comprising sweet, salty, sour, pungent and astringent. The Ancient Chinese regarded spiciness as a basic taste.

This episode deal with the following important information related to taste.

1. Gustatory System
2. Structure of gustatory organs
3. Mechanism of action

1.Gustatory System

Gustatory system comprises of one of the sensory organs tongue covered with thousands of varied papillae which has hundreds of taste buds; gustatory calyculi called taste receptors, their chemical structures; interaction with receptor molecules or ions as per the brain nerves detective and its impact on the beneficial or harmful effect on the humans system.

The tongue is covered with thousands of small bumps called papillae and each papilla contain hundreds of taste buds. There are 2000-5000 taste buds which are located on the back and front of the tongue, some are located on the roof, sides and the back of the mouth towards the throat. Each taste bud contains 50 to 100 taste receptor cells. The taste sensation includes five established basic tastes ie. sweetness, sourness, saltiness, bitterness and umami. Taste buds are able to differentiate among different tastes through detecting interaction with different ions. Further, sweet, umami and bitter tastes are triggered by the binding of molecules to G protein-coupled receptors on the cell membranes of taste buds. Saltiness by the alkali metal detection while sourness is perceived when hydrogen ion touches the taste buds. The change in the flow of ions across the cell membrane is transmitted through the nerves to the brain from the electrical signals generated and thus the sensation is felt, expressed, enjoyed and so on.

2. Structure of gustatory organs

The gustatory organs refer to the tongue, papillae and taste buds. The anatomy and physiology of these reflects the structure with their location in the human system. In

mammals, taste buds are groups of 30-100 individual elongated “neuroepithelial” cells (50-60 mammals, taste buds are groups of 30-100 individual elongated neuroepithellial cells (50-60 microns in height, 30-70 microns in width). These cells are often embedded in special structure in the surrounding epithelium, termed papillae. At the apex of the taste bud, microvillar processes protrude through a small opening, the taste pore, into the oral milieu. Just below the taste bud apex, taste cells are joined by tight junctional complexes that prevent gaps between cells. Food molecules cannot therefore squeeze between taste cells and get into the taste bud. Taste papillae can be seen on the tongue as little red dots, or raised bumps, particularly at the front of the tongue. These ones are actually called “fungiform” papillae, because they look like little button mushrooms. There are three other kinds of papillae, foliate, circumavallate and the non-gustatory filliform. Taste buds, on the other hand, are collections of cells on these papillae and cannot be seen by the naked eye. You can see that the taste buds are collections of cells situated on top of, or on the sides of, the different papillae.

The figure1 shows the natural way taste papillae appear. On the left, there are fungiform, foliate and circumvallate papillae. Taste buds are situated on the taste papillae (middle section). At the base of the taste bud, different taste nerve axons invade the bud and ramify extensively, each fibre typically synapsing with multiple receptor cells within the taste bud.

In mammals, taste buds are located throughout the oral cavity, in the pharynx, the laryngeal epiglottis and at the entrance of the oesophagus. Taste buds on the dorsal lingual epithelium are the most numerous (total number of taste buds, all classes, = 4600 per tongue) and best-studied taste end-organs. Here, taste buds are contained within four major types of papillae.

These four types of papillae are fungi form papillae, foliate papillae, circumvallate papillae and filiform papillae.

a) Fungiform papillae are located on the most anterior part of the tongue and generally contain one to several taste buds per papilla. They are innervated by the chorda tympani branch of the facial (VIIth cranial) nerve. They appear as red spots on the tongue-red because they are richly supplied with blood vessels. The total number of

fungiform papillae per human tongue is around 200. Papillae at the front of the tongue have more taste buds (1-18)

b) Foliate papillae are situated on the edge of the tongue slightly anterior of the circum vallate line. They are predominantly sensitive to sour tastes. Innervated by the glossopharyngeal (IXth cranial) nerve. On average 5.4 foliate papillae per side of the tongue, 117 taste buds per foliate papillae, total = 1280 foliate taste buds per tongue are generally present.
c) Circumvallate papillae are sunken papillae, with a trough separating them from surrounding wall. The taste buds are in tiers within the trough of the papillae. They are situated on the circumvallate line and confer a sour/bitter sensitivity to the posterior 2/3 of the tongue. Innervated by the glossopharyngeal (IXth cranial) nerve. 3-13 circumvallate papillae per tongue with 252 taste buds per papillae, total = 2200 circum vallate taste buds per tongue are generally present.
d) Foliform papillae are mechanical and non-gustatory. It does not contain taste buds. The centre of the tongue has only filiform papillae and hence “taste-blind”.

In addition there are 2500 taste buds on the epiglottis, soft palate, laryngeal and oral pharynx. Many of these taste buds are innervated by the facial nerve (VIIth cranial nerve). The number of taste buds declines with age, thereby the taste sensations are not felt.

Taste Receptor is a type of receptor which facilitates the sensation of taste. Taste receptor cells are present in taste buds. These cells contain microvillai which appear to secret substances into the human of taste bud. The sensory receptor cells has peg like extensions projecting into lumen. These contain the sites of sensory transduction. The basal cells differentiate into new receptor cells. These are derived from surrounding epithelium. The cells are continuously renewed every 10 days. Taste receptors are also in the palate and early parts of the digestive system such as larynx and upper esophagus.

There are three **Cranial nerves** that innervate the tongue. These are **chorda tympani nerve** which conducts signals from the front and sides of the tongue; **glasso-pharyngeal nerve** which conducts signals from the back of the tongue and the **vagus nerve** conducts taste signals from the mouth and the larynx.

These nerves make connections in the brain stem in the nucleus of the solitary tract (NST) before going to the thalamus and then to two regions of the frontal lobe. The electrical signals generated in the taste cells are transmitted through these nerves. The lingual nerve (trigeminal) is deeply interconnected with chorda tympani nerve and it provides all other sensory information from the 2/3 of the tongue. The glossopharyngeal nerve innervates one third of the tongue including circumvallate papillae.

3. Mechanism of action

Taste is a form of chemoreception which occurs in the specialised taste receptors in the mouth. Taste helps to indentify toxins and maintain nutrition. To date, there are five different types of basic taste receptors known ie salt, sweet, sour, bitter and umami. The mechanism of these receptors is through transduction. Each receptor has a different manner of sensory transduction which detects the presence of certain compound and states the action potential which alerts the brain. Though each taste cell is expected to respond to specific one tastant, in reality it may react more strongly to one tastant, but responds to more than one kind of stimulus. Researchers believe that the brain interprets complete tastes by examining patterns from a large set of neuron responses. This enables the body to make the decision to eat, enjoy or spit out. No single neuron type alone is capable of discriminating different qualities and the each cell can respond the same way to disparate stimuli. **Serotinin**, a hormone is thought to act as an intermediary compound which communicates with taste cells within the taste bud, mediating the signals being sent to the brain. Sensory receptors change the stimulus from one form of energy to another. That means changing the presence of chemical, sound wave, source of heat, and touch to the skin into an electrical action potential which can be understood by the brain, the body's control centre. Sensory receptors are the modified ends of sensory neurons, modified to deal with specific type of stimulus. The neuron is the primary component of the nerves system, which transmits messages from sensory receptors to all over the body. Taste receptors mainly respond to the chemical stimuli, followed by hot, cold and mechanical , visual and olfactive types.

The standard bitter, sweet or umami taste receptor is a G protein-coupled receptor. The cells that detect sourness have been identified as sub population of protein PKD 2LI. The saltiness is sensed by the presence of sodium ions. In the transduction process, different substances affect the membrane in different ways. Bitter and sweet substances binds into receptor sites which release other substances into the cell. Sour substances contain H^+ ions that blocks the channels in the membrane. Salty substances break up into Na ions which flow through the membrane directly into the cell. The bitter receptor was first characterised in 2000 and called TAS2RI. Sweet receptor was characterised in 2001 as TASIR2. The ion channels for sourness are ACCN1 and Task-1 while ENac receptor for sodium ions in salt. Besides these, in 2010, researchers found bitter taste receptor in lung tissue which causes airways to release when bitter substance is encountered. In 2015, proposed naming for taste of fat as oleogustus

Conclusion

Thus the taste sensation on the tongue is experienced at different locations of the tongue. Sweet taste is easily sensed at the tip of the tongue. Salt tasted at the tip and edge of the tongue the sour taste is at the edge of the tongue and bitter taste at the back of the tongue.

To conclude, the taste sensations experienced during the eating of food, drinking the liquid form of food is a holistic feeling which involves the tongue, receptor cells, cranical nerves as well as the chemical constitution of the taste ingredients. The research findings for many of the basic tastes is seen. With the development of science, the sixth taste is identified as the senses, for fatty substances. In a nut shell, basic tastes, the receptors and their site of action is summarised as follows

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Basic Taste	Receptor Type	Site of action	Involved Brain nerves
1. Sweet	TAS1R2+TAS1R3	Circumvallate Papillae, Foliate Papillae	Chorda tympani, Glasso pharangeal
2.Bitter	TAS2R	Circumvallate Papillae, Palate Foliate Papillae epiglottis	Chorda tympani glasso pharangeal
3.Sour	ACCN1 TASK-1	Foliate Papillae Fungi form	Chorda tympani
4.Salt	ENac	Foliate Papillae Fungi form	Chorda tympani
5.Umami	GPCR	Circumvallate Papillae Foliate Papillae	

Figure 1, taste buds

(often mixed up-papillae are visible with the naked eye, taste buds are not)

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Figure 1 **Papillae and often mixed up papillae visible with naked eyes, taste buds can not be seen**

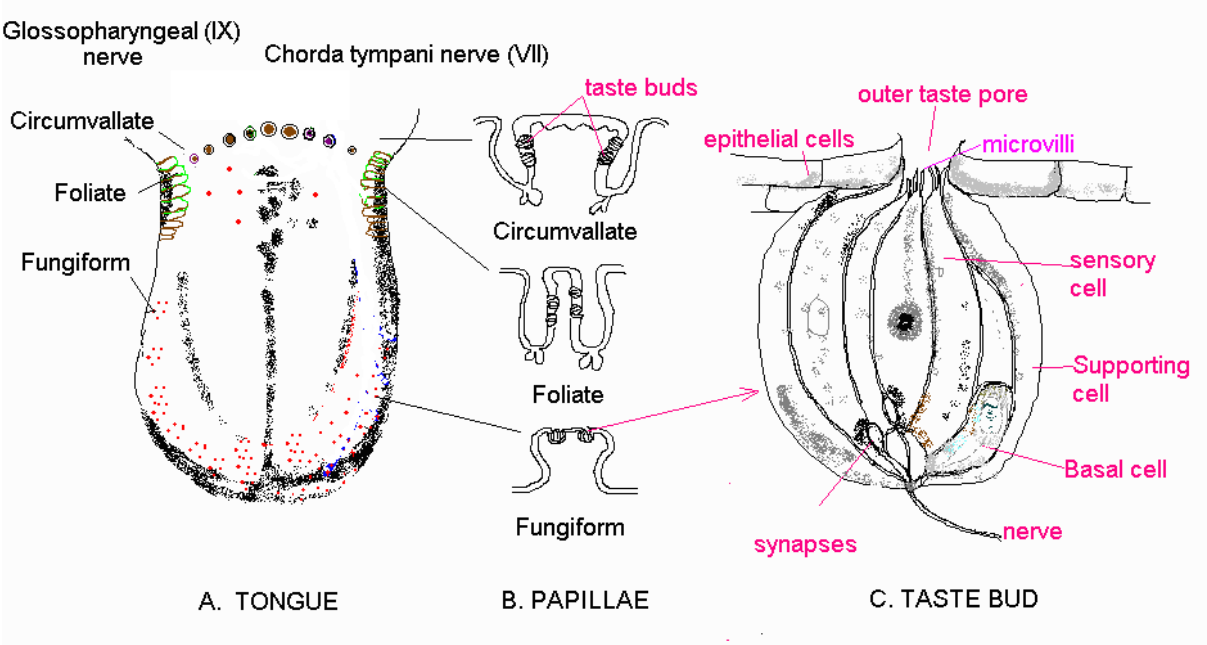


Figure 2: Taste receptor cell

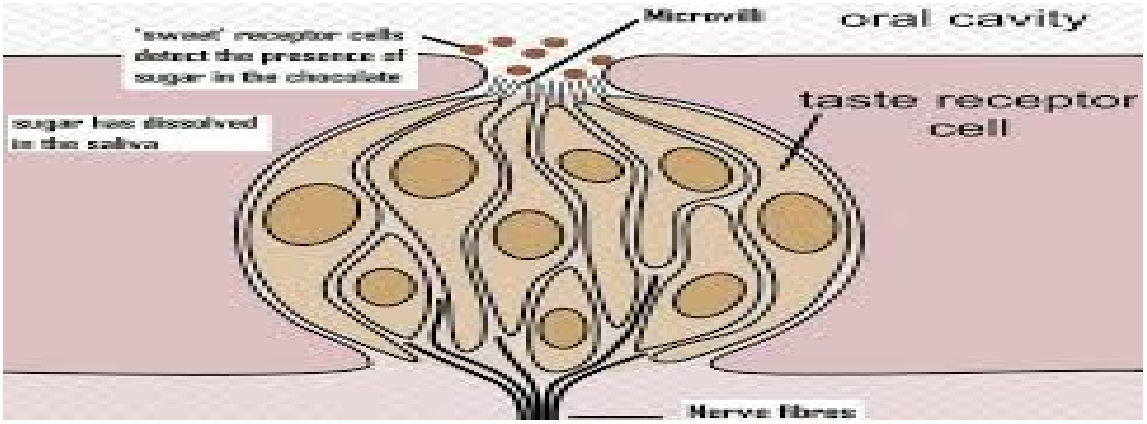


Figure 3: Nerves in the tongue

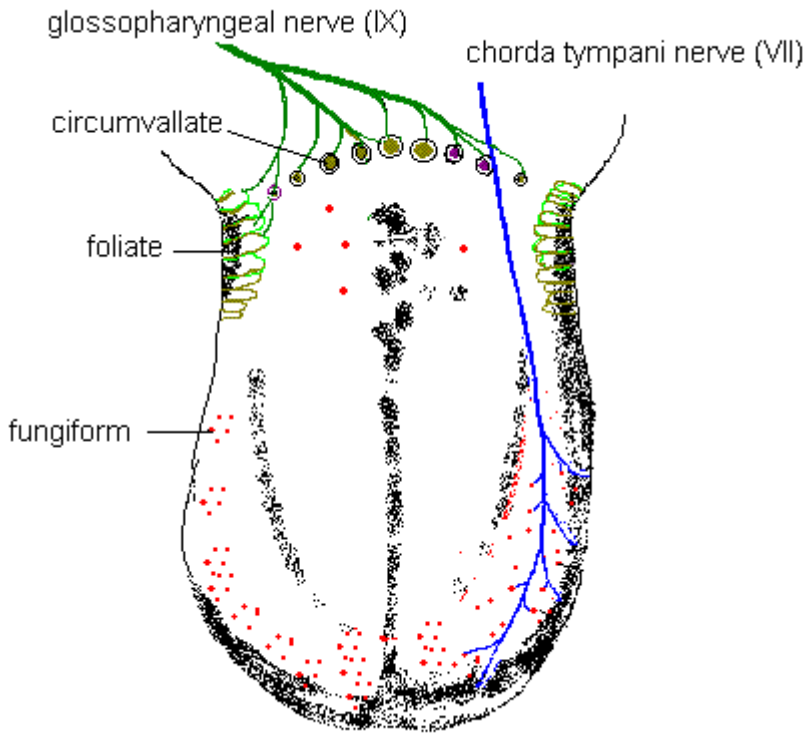
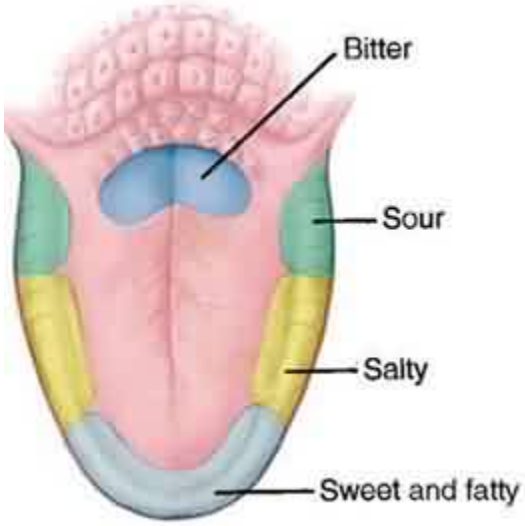


Figure **4: Taste sensations on the tongue**


Bitter
Sour
Salty
Sweet and fatty