Taste and Health: Nutritional and Physiological Significance of Taste Substances in Daily Foods

Application of Umami Taste Stimulation to Remedy Hypogeusia Based on Reflex Salivation

Takashi SASANO,*a Shizuko SATOH-KURIWADA,a Noriaki SHOJI,a Yuki SEKINE-HAYAKAWA,b Misako KAWAI,b and Hisayuki UNEYAMA,a

a Division of Oral Diagnosis and Radiology, Department of Oral Medicine and Surgery, Tohoku University Graduate School of Dentistry; 4–1 Seiryo-machi, Aoba-ku, Sendai 980–8575, Japan; and b Institute of Life Sciences, Ajinomoto Co., Inc.; 1–1 Suzuki-cho, Kawasaki-ku, Kawasaki 210–8681, Japan.

Received August 27, 2010

Enjoying taste should be one of the greatest pleasures in human life. However, aging is sometimes associated with decreased taste sensitivity, also known as hypogeusia. The loss of taste not only affects quality of life, but can also cause weight loss and health problems in the elderly. Our recent study has shown that 37% of test subjects over 65 years of age exhibited hypogeusia. Further, whole saliva secretion, including minor salivary secretion, was significantly decreased in elderly patients with gustatory impairment, but was normal in all elderly subjects with normal taste thresholds. These data indicate that hyposalivation is closely related to hypogeusia. Moreover, clinical studies have shown that treatment of hyposalivation diminishes hypogeusia, indicating that salivation is essential to maintain normal taste function. However, many medications for relief of dry mouth, such as parasympathomimetic (cholinomimetic) drugs, have serious adverse effects. Palpitation, sweating, nausea, diarrhea and dizziness have all been observed in elderly patients taking parasympathomimetic drugs. To circumvent this problem, glutamate, which produces umami taste, was demonstrated to increase salivary secretion and thereby improve hypogeusia by enhancing the gustatory-salivary reflex. Our data suggests that umami is an effective tool for the relief of hypogeusia without the side effects of parasympathomimetic drugs.

Key words umami; hypogeusia; taste sensitivity; reflex salivation; hyposalivation

Fig. 1. Proportion of the Elderly Subjects with Hypogeusia Determined by the Filter Paper Disc Method

Fig. 2. Relationship between Whole Saliva Secretion and Taste Sensitivity in the Elderly

Whole saliva secretion in subjects with hypogeusia was significantly decreased compared to those with normal taste sensation (p<0.01). Whole saliva secretion was measured by means of the gum test (normal level >10 ml/10 min).

* To whom correspondence should be addressed. e-mail: tsasano@dent.tohoku.ac.jp

© 2010 Pharmaceutical Society of Japan
taste thresholds (>10 ml/10 min). There were no significant differences in whole saliva secretion by gender or age in the subjects with taste disorder. This suggests hyposalivation is closely related to taste disorder, consistent with the finding that taste disorder is frequently observed in radiation-induced xerostomia and Sjögren’s syndrome. Further, Matsuo et al. reported an elevation of taste threshold and a reduction of the taste nerve response after surgical removal of the submandibular and sublingual glands. Consequently, we conclude that salivation is essential for normal taste function.

2. IMPORTANCE OF SALIVA FOR ORAL FUNCTION

Saliva is essential for oral functions such as speech, mastication, swallowing and taste sensation. We interviewed patients who visited our hospital with complaints of oral dryness due to decreased saliva secretion. These patients were also suffering from secondary symptoms such as difficulty speaking and swallowing, masticatory disturbance, mucosal pain and taste disorder. Figure 3 shows the severity of symptoms associated with decreased saliva secretion expressed using a visual analog scale, and their improvement following treatment to produce an increase in saliva secretion. As shown, patients’ symptoms were relieved following increased salivation. Thus, results demonstrate that saliva is important to maintain proper oral function. Further, saliva contains digestive enzymes (amylase and lipase) that initiate the digestion of starch and lipids. Saliva also contains anti-bacterial, -viral and -fugal agents which balance the oral bacterial flora and inhibit the bacterial colonization of oral tissues. The epidermal and transforming growth factors found in saliva promote tissue growth, differentiation and wound healing. Small proteins, immunoglobulin A (IgA), defensins, cytokines, hormones, mucins and other components in saliva have been considered to play a role in innate immunity and defense at the oral mucosa. For these reasons, it is critical to treat hyposalivation.

3. TASTE AND SALIVARY SECRETION

Taste buds consist of taste receptor cells and are distributed mainly in the oral mucosa, although some are located in the larynx, pharynx and epiglottis. Two roles for saliva in taste perception have been reported. Saliva has short-term effects on taste perception as taste substances must initially be dissolved by saliva to reach and stimulate the taste receptors. This process includes the solubilization of the taste substances in the saliva, the chemical interaction between the taste substances and components in the saliva, and the diffusion and dilution of the taste substances in saliva. Moreover, saliva itself contains components which can stimulate taste receptors and change taste sensitivity by chemical interaction with the receptor. Saliva also has long-term effects on the health and function of taste receptors. Saliva protects taste receptors from bacterial infection and mechanical and chemical stress. Saliva also provides a milieu in taste pores for the production of receptor sites on renewed cells because taste cells are continually replaced with new cells. Although the minor salivary glands produce less saliva than the major salivary glands (parotid, submandibular and lingual), they may predominate to maintaining taste sensitivity through the production and protection of taste receptors because the minor glands are distributed throughout the oral cavity. In fact, the minor salivary glands produce up to half of the secretory IgA as well as a substantial portion of the mucins present in the mouth.

4. CLINICAL MEASUREMENT OF SALIVARY FLOW

Accurate measurement of saliva flow rate are required for clinical protocols. Salivary flow rates have been measured during both resting and stimulated states. Resting salivary flow is characterized as the flow occurring in the absence of any obvious oral or physiological stimulation. The draining method, in which whole mouth saliva is allowed to drain into a receptacle for weight determination, can be used to measure resting salivary flow. Normal resting salivation is defined as a flow rate of >1 ml/10 min. Stimulated salivary flow is measured under oral or physiological stimulating conditions. Gustatory and masticatory stimuli are most frequently used to produce increased salivary flow, and the stimulus parameters have been well characterized. In the present study, we used chewing gum for masticatory stimulation to stimulate salivary flow. This method is widely used and is known as the gum test. Normal stimulated salivation is defined as a flow rate of >10 ml/10 min. White reported a significant correlation between resting and stimulated flow rate, whereas Becks and Wainwright found that individuals with low or high resting salivary flow did not produce proportional amounts of saliva upon masticatory stimuli. Thus, the correlation between resting and stimulated flow rate remains unclear.

It is also unclear whether resting or stimulated salivation influences oral dryness. Fox emphasized that complaints of oral dryness are not indicative of objective salivary gland hypofunction; however, dryness while eating a meal is a significant indicator of salivary dysfunction. These results suggest that salivation stimulated during mastication is more important than resting salivation for the diagnosis of oral dryness. However, Näärhi reported that neither unstimulated nor stimulated (wax method) salivary flow rates were significantly lower in subjects with dry mouth than in controls. These results indicate that the subjective feeling of oral dryness may occur in spite of normal whole salivary flow rate. In the same study, Näärhi suggested that the minor salivary...
gland secretions may play an important role in the sensation of dry mouth. We have also noted that oral dryness is not necessarily correlated with whole salivary flow rate, and have suggested that minor salivary gland salivation strongly relates to the sensation of dry mouth because minor glands are widely distributed in the oral mucosa but not elsewhere (see ‘Taste and Salivary Secretion’).

Minor salivary secretion is not used in clinical assessment because of the difficulty in collecting and quantifying the small amount of secretions from the minor salivary glands. Recently, we devised a method for detecting and quantifying secretions from minor salivary glands using the iodine-starch filter paper method. This method is simple because it employs the iodine-starch reaction, which requires only common materials, and allows both the distribution and secretion rate of minor salivary glands to be assessed in real-time with the naked eye (Fig. 4). Furthermore, this method could permit subsequent quantification by digitization of the data. The iodine-starch filter paper method has practical value due to its simplicity, accuracy, and reproducibility.

5. CLINICAL ASSESSMENT OF TASTE SENSITIVITY

Two types of clinical examination for taste sensitivity are available and used in Japan. The first is the electrogustometric test, in which electrical stimulation is applied to specific areas of the oral mucosa where taste receptors reside (Fig. 5). This method can evaluate quantitative taste sensitivity but cannot be applied to qualitative assessment of different tastes. The electrogustometric test is used to evaluate nerve dysfunction due to injury or infection in the taste sensory pathway. The second is the filter disk test, in which a filter soaked with a taste-inducing chemical solution is placed on specific areas of the tongue and oral cavity (Fig. 5). Generally, the lowest concentration of each of the four basic tastes (sweet, salty, sour and bitter) that a patient can detect and recognize is determined. A patient may also be asked to compare the tastes of different chemicals or to note whether the intensity of a taste increases when a chemical’s concentration is increased. Thus, this method evaluates both quantitative and qualitative taste sensitivity.

The specific areas for clinical assessment of taste sensitivity are the tip of the tongue (innervated by the chorda tympani nerve), the posterior of the tongue (the glossopharyngeal nerve area), and on the soft palate (the greater superficial petrosal nerve area), as shown. These nerves are known as taste sensory nerves, and innervate specific anatomical locations. Taste buds consisting of taste receptor cells are also located in the larynx, pharynx and epiglottis; however, these areas are not analyzed in clinical settings because their locations pose technical challenges.

6. IMPORTANCE OF UMAMI TASTE

In our taste clinics, we sometimes meet patients with gustatory disorders who complain of persistent impaired umami taste, although the other four basic taste sensations (sweet, salty, sour and bitter) are normal, or have improved in the recovery process. As a consequence, such patients say, “I can recognize tastes, but cannot feel umami, so I have no appetite because foods don’t taste good.” Unfortunately, patients with impaired umami taste are diagnosed with normal taste sensation during clinical examinations because they present with normal thresholds to the four basic taste tests. At present, there is no clinical test for umami, although the other four basic tastes have been widely used in quantitative and qualitative gustometry, as described above. To this end, we developed a new method for the clinical assessment of umami taste sensitivity.

First, we investigated the recognition threshold for umami taste in 80 healthy volunteers (age: 18 to 88 years) to determine an appropriate concentration range for the test solu-
tions. Next, we applied the method to patients with taste disorders to determine whether the umami recognition threshold differs from healthy volunteers. Recognition thresholds for umami taste were measured using six aqueous test solutions of monosodium glutamate (MSG) or inosine 5'-monophosphate (IMP), ranging in concentration from 1 to 200 mM. This protocol is similar to that used for the four basic tastes (see ‘Clinical Assessment of Taste Sensitivity’). A filter-paper disc, 5 mm in diameter, moistened with each solution was placed on specific anatomical areas of the mouth, as shown in Fig. 6. The mean recognition thresholds in the healthy volunteers were <50 mM for MSG and <10 mM for IMP when discs were placed on the posterior of the tongue and on the soft palate. The thresholds for both MSG and IMP were higher at the tongue tip than in other areas (data not shown). Of the 44 patients admitted to our clinic with complaints of taste disorder, 16% had high thresholds to the umami taste, but had normal thresholds to the four basic tastes. These patients were also suffering from decreased appetite, weight loss and poor health due to taste disorder, particularly due to decreased sensitivity to umami taste.

7. MANAGEMENT OF TASTE DISORDER

Because many factors contribute to taste disorder, successful treatment depends on accurate assessment of the cause of the disorder. We performed a variety of clinical examinations to assess the cause of taste disorder, such as the taste sensitivity test, the salivary test, blood tests and the oral hygiene test (e.g., periodontal index). In addition, we carefully interviewed the patients concerning systemic diseases and prescribed medications. Some diseases, such as viral infections, tumors or lesions associated with the taste pathways, head trauma, radiation therapy, epilepsy, psychiatric disorders and hypothyroidism, are known to cause taste disorder. Also, some drugs have side effects that directly impact taste sensitivity or cause hyposalivation, thereby resulting in decreased taste sensitivity. In these cases, the patient has been referred to a specialist. When serum data show decreased levels of zinc or ferrum, we administer these microelements, because zinc and/or ferrum is known to be effective in treating taste disorder. Interestingly, zinc treatment has been reported to improve even idiopathic taste disorder.

We recently reported that alleviation of hyposalivation is quite effective for patients with taste disorder because taste disorder is closely related to hyposalivation, as discussed above. However, current methods for increasing salivation are unsatisfactory. Recently, parasympathomimetic agents have been used and reported to be effective in increasing salivary secretion. However, these drugs have serious side effects such as heart palpitation, sweating, diarrhea and dizziness, particularly in the elderly. To circumvent this problem, we examined gustatory–salivary reflex stimulation to increase salivation. It is well known that acid causes the copious flow of saliva; however, this stimulant induces pain in the dried oral mucosa of patients with hyposalivation. Recent studies have shown that umami taste is the most potnet taste stimulus for saliva secretion, followed by sour taste. In the recent study, we demonstrate that increased salivary secretion produced by umami taste has the most long-lasting effect among the five taste stimuli (Fig. 7), similar to other findings. Further, we recently found a remarkable increase in saliva secretion from minor salivary glands by umami taste stimuli (data not shown). Consequently, umami stimuli might be an effective remedy for hypogeusia based on the improvement of hyposalivation without side effects.

As described, salivation and taste function are closely related to each other. Further, taste function and total health are connected and, thus, salivation and health are related. Finally, we emphasize an intimate relationship between oral health and total health.

REFERENCES