Original Article

pISSN, eISSN 0125-5614
M Dent J 2022; 42 (Suppl) : S1-S14

Prevalence of taste alteration in Thai older adults with dentures wearing in Nakhon Pathom province

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Objective: To investigate the prevalence of taste alteration in Thai older adults with dentures wearing and to study factors related to taste alteration, such as salivary flow rate, salivary pH, medical status, the number of *Candida albicans*, *Streptococcus mutans*, Lactobacilli species, and denture hygiene.

Materials and Methods: Fifty older adults aged over 60 years old and who wore dentures were included in this study. Filter paper disc taste test kits were used to assess taste sensation. The saliva spitting method was used to measure the participants' stimulated salivary flow rate. The MU dip slide test kits were used to determine the number of *Streptococcus mutans*, Lactobacilli species, and *Candida albicans*. Questionnaires were also made on smoking habit, denture hygiene practice, problems of taste sensation, and subjective reports of xerostomia.

Results: Only 4 out of 50 participants (8%) had normal taste sensation of all tastes. Umami had the highest mean recognition threshold, followed by sweet, salt, sour, and bitter taste. Denture hygiene did not have a statistically significant relationship with any taste sensations. Salivary pH and denture hygiene had statistically significant relationship with *Candida albicans* score (p-value = 0.016 for salivary pH and p-value = 0.003 for denture hygiene).

Conclusion: Denture hygiene had no significant relationship with a taste sensation. The number of *Candida albicans* showed a significant relationship between salivary pH and denture hygiene. Therefore, it is necessary to emphasize the importance of maintaining good denture hygiene in older adults.

Keywords: denture hygiene, prevalence, taste sensation

How to cite: Arunrungrutsamee N, Kiattavorncharoen S, Surarit R, Srimaneekarn N. Prevalence of taste alteration in Thai older adults with dentures wearing in Nakhon Pathom province. M Dent J 2022; 42 (suppl): S1-S14.

Introduction

Thai society is facing a rapidly growing number of older adults. It is predicted that by 2040, Thailand will have an older adult population that accounts for more than 28% of the total population, so Thailand will become a super-aged society [1]. This trend is accompanied by new disease patterns in the form of noncommunicable diseases (NCDs), such as hypertension and diabetes, which may affect the quality of life. Hypertension and diabetes were found to increase significantly in old age in Thailand. It was reported that among those aged 60 - 69 years old, 70 - 79 years old, and more than 80 years old, the incidence of hypertension was 55%, 67.2%, and 78.6%, respectively, and the incidence of diabetes mellitus was 25.2%, 26.4%, and 19.5%, respectively [2].

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Received: 5 April 2022 Revised: 25 May 2022 Accepted: 27 May 2022

From the 8th National Oral Health Survey, 2017 [3], the remaining teeth index was 18.6 and 10 teeth/person in older adults aged 60 to 74 years old and 80 – 85 years old, respectively. Moreover, 8.7% and 31% of older adults aged 60 to 74 years old and 80 – 85 years old lost all their teeth, and 15.6% of older adults aged 60 to 74 years old had either removable or fixed dentures. Loss of teeth and use of dentures significantly affect patients' oral health status and quality of life. Patients who are satisfied with their dentures have a better quality of life than their unsatisfied counterparts [4]

Taste alteration associated with advancing age may arise from changes that are a part of normal physiological aging or may occur because of certain diseases such as hypertension, diabetes mellitus, or the side effects of some drugs, such as antihypertensive drugs [5-7]. Moreover, losing a sense of taste or having bland food taste is a widespread problem complained of by many patients who wear dentures. Hypogeusia has been repeatedly observed as a symptom during the course of complete denture adaptation [8]. Whether the sensory loss was due to the prostheses, or primarily reflects age-associated changes in the gustatory and olfactory receptors, is still being explored [9]. The presence of prosthesis-associated plaque represents a local risk factor for candida overgrowth and the development of denture-related stomatitis and has been reported to be a risk factor for developing bacterial endocarditis, aspiration pneumonia, or generalized infections of the respiratory tract in predisposed individuals [10].

The problem of taste alteration among older adults has not been recognized by medical personnel and caregivers [11]. To our knowledge, no study in Thailand has reported taste alteration in older adults with dentures wearing. Therefore, this study aimed to investigate the prevalence of taste alteration in Thai older adults with dentures wearing, as well as the relationship between the number of *Candida albicans*, *Streptococcus mutans*, Lactobacilli species, salivary flow rate, salivary pH, medical status, and denture hygiene.

Materials and Methods

Materials

Filter paper disc taste test kits (Taste Disc®, Sanwa Chemical Laboratory Inc., Nagoya, Japan) were provided by Assoc. Prof. Dr. Noriaki Shoji, Division of Oral Diagnosis, Graduate School of Dentistry, Tohoku University, Japan. They consisted of 4 taste solutions (5 concentrations of each): sucrose, sodium chloride, tartaric acid, and quinine hydrochloride for sweet, salt, sour, and bitter tastes, respectively. For umami taste, 6 concentrations of monosodium glutamate (MSG) solution were prepared by dissolving MSG in distilled water [12]. MSG used in this study was the product of Ajinomoto Co, Inc., Thailand.

Participants

This project was approved by the Ethics Committee of the Institutional Review Board of Faculty of Dentistry/Faculty of Pharmacy, Mahidol University (COA. No. MU-DT/PY-IRB 2021/DT027). Our study included 50 participants from October to December 2021. The sample size was calculated using the N4 studies program, based on the previous study of Sasano T *et al* in 2012, which stated that 36.6% of older adults' Japanese people had taste disorders [5]. With a level of confidence at 95% and 12% of the distance from proportion to limit, the calculated sample size was 42. To prevent errors, we decided to collect 50 participants.

All participants were at least 60 years old and of Thai nationality and wore either fixed or removable dentures. Those with communication problems, cancer, chronic kidney disease, or

disorder of the mucous membranes in the nose, mouth, throat, or gastrointestinal tract, or who were taking antibiotics, received dental treatment within 6 hours prior to the test, were current smokers, using chlorhexidine mouthwash or toothpaste containing SnF_2, or having a history of allergy to any test substances, namely sucrose, quinine, tartaric acid, sodium chloride, or MSG, were excluded from the study.

Saliva collection

The participants were instructed not to brush their teeth, eat, or drink any beverages other than water one hour before the test session. Saliva specimens were collected between 1:00 – 4:00 p.m. to minimize variations associated with the circadian cycle [13]. Participants were given paraffin to chew for 5 minutes, during which time their saliva was spat into the tube provided. The stimulated salivary flow rate was calculated, and the salivary pH was measured with a pH-meter (UX 100, Huming probe®, Taiwan). The questionnaire was conducted concerning smoking habit, denture hygiene practice, problems of taste sensation, and subjective reports of xerostomia.

Oral Microbiological assessment

The MU dip slide test kits were used to determine the number of *Streptococcus mutans*, Lactobacilli species, and *Candida albicans* in stimulated saliva [14]. The number of colonies of *Streptococcus mutans*, Lactobacilli species, and *Candida albicans* was graded into 4 levels of the score, ranging from 1-4, according to the density of the colonies, which were scored and recorded in comparison with a chart of provided with the test kits.

Taste assessment

After completing the saliva collection process, a professionally trained dentist performed the test with a filter paper soaked in different concentrations of tastant solutions (sweet, salt, sour, and bitter) with scores 1, 2, 3, 4, and 5, respectively. However, if the participant could not determine the taste at the highest concentration, a score of 6 was assigned. There were 6 concentrations of umami solution, with scores 1, 2, 3, 4, 5, and 6, respectively. If the participant could not determine the taste despite the highest concentration, a score of 7 was assigned. Score 1 was the lowest concentration of tastant solution. The highest score (score 5 for sweet, salt, sour, and bitter taste, score 6 for umami taste) was the highest concentration of tastant solution. The filter paper disc was placed in 3 oral sites, according to the study by Satoh-Kuriwada S, *et al.* in 2014 [12] (as shown in Figure 1), for 3 seconds on each site. The test was started from low to high concentrations one by one until the participants could determine the taste correctly, or if the taste could not be determined, even at the highest concentration, and then switched to the next taste. The correct answer was their recognition threshold. The participants were given distilled water to rinse their mouths during the replacement of the filter paper disc to flush out the previous taste.

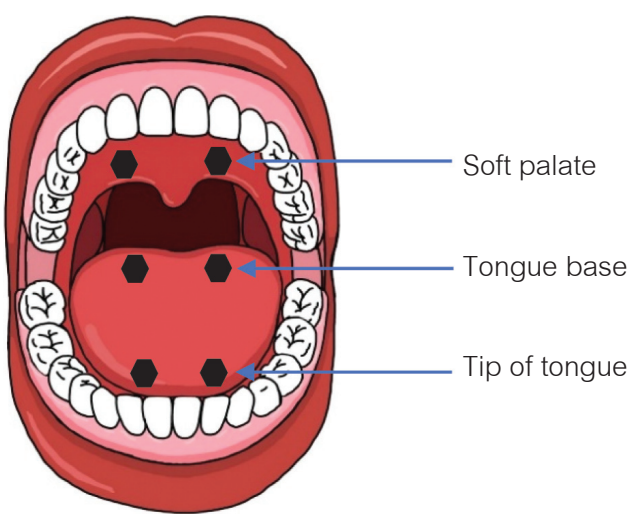

Figure 1 Measurement sites in the oral cavity where the filter paper discs were placed (black dots)

Statistical analysis

The data were analyzed for a taste sensation with normal taste sensation at a score of 1-4, and taste alteration at a score of 5 - 7. The SPSS version 28 for Windows program was used for statistical analysis (SPSS Inc., Chicago, IL, USA). All *p*-values given are based on the two-tailed test of significance, and a *p*-value of less than 0.05 was considered statistically significant [15].

Results

There were 50 participants, with 31 females (62%) and 19 males (38%). The average age was 66.77+/-6.72 years old. The remaining teeth index was 11.3 teeth/person, and the DMFT index was 19.7 teeth/person. Demographic data of participants are shown in Table 1.

Table 1 Demographic data of participants.

Characteristics		
Age:	Age (mean+/-SD), (years old)	66.77+/-6.72
	Age range (years old)	61 – 74
Gender:	Female: n, (%)	31, (62%)
	Male: n, (%)	19, (38%)
Body Mass Index:	BMI (mean+/-SD)	23.07+/-3.72
	BMI range	14.98 - 35.94
BMI classification (16):	Underweight (BMI < 18.5): n, (%)	2, (4%)
	Normal range (BMI = 18.5 – 22.9): n, (%)	26, (52%)
	Overweight (BMI = 23 – 24.9): n, (%)	8, (16%)
	Obese I (BMI = 25 – 29.9): n, (%)	11, (22%)
	Obese II (BMI > 30): n, (%)	3, (6%)
Systemic disease:	None: n, (%)	18, (36%)
	HT: n, (%)	18, (36%)
	DM: n, (%)	14, (28%)
Hypertension group:	Hypertension only: n, (%)	16, (88.89)
	Hypertension & Dyslipidemia: n, (%)	2, (11.11%)
Diabetic group:	Diabetes mellitus only: n, (%)	10, (71.4%)
	Diabetes mellitus & Dyslipidemia: n, (%)	3, (21.46%)
	Diabetes mellitus & Benign Prostatic hyperplasia: n, (%)	1, (7.14%)
Medication:	None: n, (%)	18, (36%)
	Single meditation: n, (%)	19, (38%)
	Poly meditations: n, (%)	13, (26%)

Table 1 Demographic data of participants. (Continued)

Characteristics		
Hypertension medicines:	Amlodipine 5 mg: n, (%)	8, (44.5%)
	Enalapril 5 mg: n, (%)	5, (28%)
	Losartan 50 mg: n, (%)	1, (5.5%)
	Amlodipine 5 mg & Enalapril 5 mg: n, (%)	1, (5.5%)
	Amlodipine 5 mg & Hydralazine 25 mg: n, (%)	1, (5.5%)
	Amlodipine 5 mg & Simvastatin 20 mg: n, (%)	1, (5.5%)
	Losartan 50 mg & Simvastatin 20 mg: n, (%)	1, (5.5%)
Diabetic medicines:	Metformin 500 mg & Glipizide 5 mg: n, (%)	5, (35.7%)
	Metformin 500 mg: n, (%)	3, (21.4%)
	Glipizide 5 mg: n, (%)	2, (14.3%)
	Metformin 500 mg, Glipizide 5 mg & Prazosin1mg: n, (%)	1, (7.15%)
	Metformin 500 mg, Glipizide 5 mg & Simvastatin 20 mg: n, (%)	1, (7.15%)
	Metformin 500 mg, ASA 81 mg Simvastatin 20 mg: n, (%)	1, (7.15%)
	Metformin 500 mg, Glipizide 5 mg, Simvastatin 20 mg & ASA 81 MG: n, (%)	1, (7.15%)
Saliva:	Salivary flow rate	1.22+/-0.66 ml/min
	- Very low salivary flow rate (<0.7 ml/min): n, (%)	11, (22%)
	- Low salivary flow rate (0.7 - 1 ml/min): n, (%)	10, (20%)
	- Normal salivary flow rate (>1 ml/min): n, (%)	29, (58%)
	Range of salivary flow rate	0.16 – 2.72 ml/min
	Salivary pH	7.54 +/- 0.30
	Range of salivary pH	6.81 – 8.53
Smoking status:	Never: n, (%)	42, (84%)
	Ex-smoker: n, (%)	8, (16%)
Dental status:	Remaining teeth index	11.3 teeth/person
	DMFT index	19.7 teeth/person
Denture status:	Upper & lower complete denture: n, (%)	13, (26%)
	Upper or lower acrylic partial denture: n, (%)	13, (26%)
	Single denture & Acrylic partial denture: n, (%)	10, (20%)
	Fixed partial denture: n, (%)	9, (18%)
	Upper & lower acrylic partial denture: n, (%)	5, (10%)
Denture hygiene:	Good: n, (%)	34, (68%)
	Poor: n, (%)	16, (32%)
Complaints of dry mouth:	Too little saliva	1, (2%)

Salivary flow rate

It was found that the salivary flow rate could be divided into 3 groups [17]. The major group was the normal salivary flow rate group (salivary flow rate >1 ml/min) comprising of 58% participants (29 out of 50 participants). The low salivary flow rate group (salivary flow rate 0.7 – 1.0 ml/min) comprised of 20% participants (10 out of 50 participants), while the very low salivary flow rate (salivary flow rate <0.7 ml/min) comprised of 22% participants (11 out of 50 participants).

Salivary microorganism

The MU dip slide test kits were used to count the number of *Candida albicans*, *Streptococcus mutans* and Lactobacilli species [14]. It was found that for *Candida albicans*, score 1 was found in 12 of 50 participants (24%), indicating that their saliva contained less than 10^2 CFU/ml of *Candida albicans* (low level). Nineteen out of 50 participants (38%) received a score of 2, indicating that their saliva contained 10^2 - 10^3 CFU/ml of *Candida albicans* (moderate level). Six of the 50 participants (12%) received a score of 3, indicating that their saliva contained 10^3-10^4 CFU/ml of *Candida albicans* (high level). Thirteen out of 50 participants (26%) received a score of 4, indicating that their saliva contained more than 10^4 CFU/ml of *Candida albicans* (very high level), as shown in Figure 2A.

For *Streptococcus mutans*, score 1 was found in 16 of 50 participants (32%), indicating that their saliva contained less than 10^3 CFU/ml of *Streptococcus mutans* (low level). Nineteen out of 50 participants (38%) received a score of 2, indicating that their saliva contained *Streptococcus mutans* 10^3 – 10^5 CFU/ml (moderate level). Nine of the 50 participants (18%) received a score of 3, indicating that their saliva contained *Streptococcus mutans* 10^5 – 10^6 CFU/ml (high level). Six of the 50 participants (12%) received a score of 4, indicating that their saliva contained more than 10^6 CFU/ml of *Streptococcus mutans* (very high level), as shown in Figure 2B.

For Lactobacilli species, twenty-three out of 50 participants (46%) were graded as score 1, indicating that their saliva contained less than 10^3 CFU/ml of Lactobacilli species (low level). Sixteen out of 50 participants (32%) received a score of 2, indicating that their saliva contained Lactobacilli species 10^3 - 10^4 CFU/ml (moderate level). Seven of the 50 participants (14%) received a score of 3, indicating that their saliva contained Lactobacilli species 10^4 - 10^5 CFU/ml (high level). Four of the 50 participants (8%) received a score of 4, indicating that their saliva contained more than 10^5 CFU/ml of Lactobacilli species (very high level), as shown in Figure 2C.

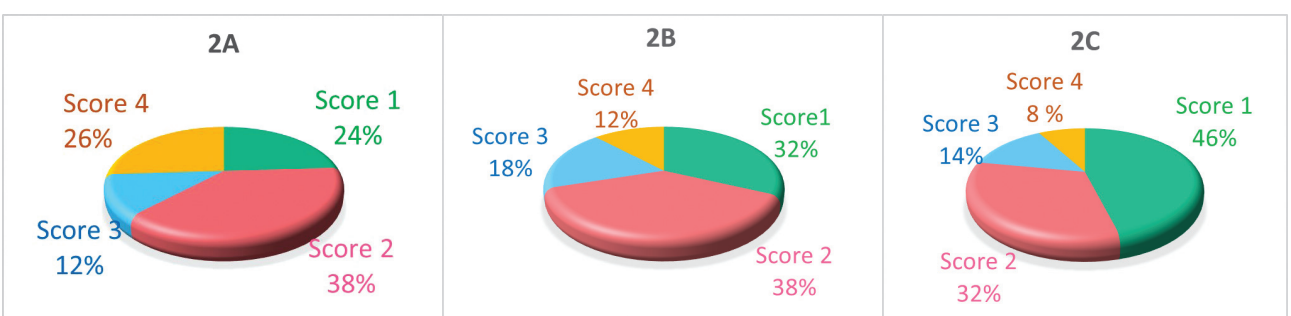

Figure 2 Distribution of oral microorganism score, 2A: *Candida albicans*, 2B: *Streptococcus mutans*, 2C: Lactobacilli species.

Taste Sensation

In this study, if the participants could determine the taste at one site out of the three sites (the tip of the tongue, the tongue base, and the soft palate), they were counted as having normal taste sensation for that taste. The results of taste sensation showed that only 4 out of 50 participants (8%) had 5 normal taste sensations, all of whom (100%) were female. Seven out of 50 participants (14%) had 5 altered taste sensations or ageusia, most of whom (6 out of 7, 86%) were male (Figure 3).

Thirteen out of 50 participants (26%) had only one normal taste sensation, most of whom (10 out of 13, 77%) were female. The most perceptible taste was bitter taste (53.8%), followed by sour taste (30.8%), salty taste (7.7%), and sweet taste (7.7%), respectively. None of these participants could detect the umami taste.

Six out of 50 participants (12%) had 2 normal taste sensations, most of whom (4/6, 66.67%) were female. The two perceptible tastes were sour and bitter tastes (100%).

Six out of 50 participants (12%) had 3 normal taste sensations, with half being female (3/6, 50%). The three most perceptible tastes were salt, sour, and bitter tastes (50%) followed by sweet, sour, and bitter tastes (16.7%), which was equal to sweet, salt, and bitter tastes (16.7%) and sweet, salt, and sour tastes (16.7%).

Fourteen out of 50 participants (28%) had 4 normal taste sensations, most of whom (9/14, 64.3%) were female. The four most perceptible tastes were sweet, salt, sour and bitter (78.6%), followed by salt, sour, umami and bitter (21.4%) (Figure 4).

With regards to the mean recognition threshold, umami had the highest mean threshold (5.68), followed by sweet (5.26), salt (4.77), sour (4.69), and bitter (4.48), respectively, as shown in Figure 5.

Umami had the highest frequency of taste alteration among the 5 tastes. Only 7 out of 50 participants (14%) were able to detect umami taste. The sweet taste was the second most altered taste, with only 19 out of 50 participants (38%) being able to detect sweet taste. The salty taste was the third most altered taste, with 24 out of 50 participants (48%) being able to detect salty taste. About 66% of the participants (33/50) could detect the sour taste. Seventy-two percent of participants (36/50) could detect the bitter taste.

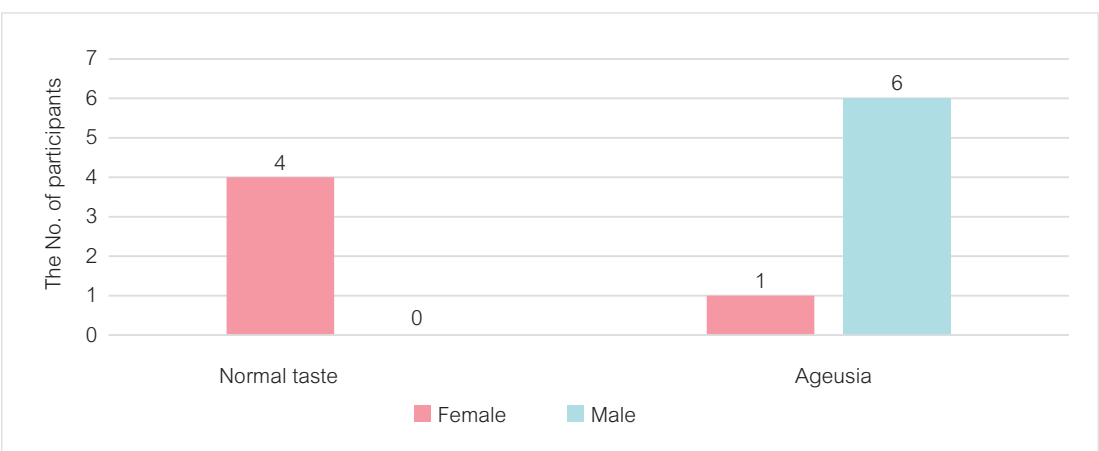

Figure 3 Gender distribution of participants having 5 normal taste sensations and ageusia.

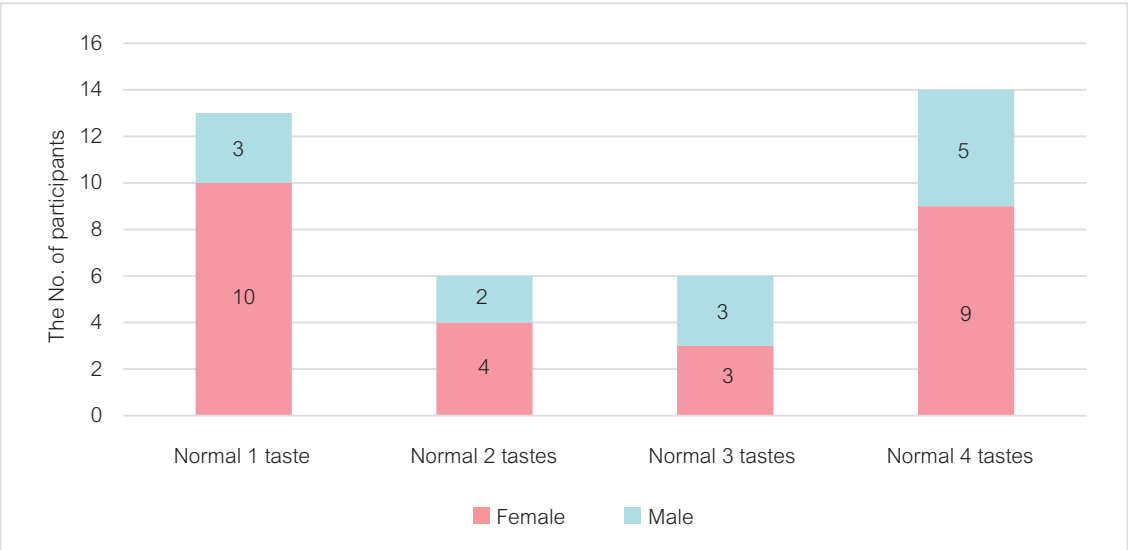

Figure 4 Gender distribution of those with normal 1-4 taste sensations.

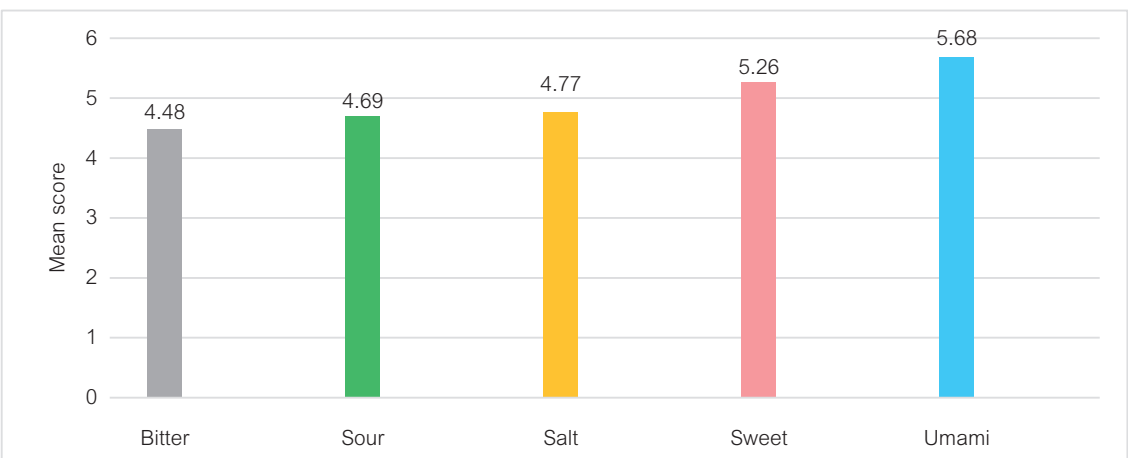

Figure 5 Mean recognition threshold of each taste.

Umami was the most altered taste across all three sites, with 94% at every site. Following umami, the altered taste sensations were sweet, salt, sour, and bitter, respectively. The sweet taste was the second most altered taste across all three sites, with 76%, 90%, and 84% for the tip of the tongue, the tongue base, and the soft palate, respectively. The salty taste was the third altered taste with 66%, 68%, and 70% for the tip of the tongue, the tongue base, and the soft palate, respectively. The sour taste was the fourth altered taste with 52%, 72%, and 60% for the tip of the tongue, the tongue base, and the soft palate, respectively. Bitter taste was the fifth altered taste across all three sites, with 52%, 54%, and 56% for the tip of the tongue, the tongue base, and the soft palate, respectively.

Salivary Flow Rate and Taste Sensation

In the very low salivary flow rate group, 1 out of 11 participants (9%) had 5 altered taste sensations or ageusia. Seven out of 11 participants (64%) had only 1 normal taste sensation. One out of 11 participants (9%) had 2 normal taste sensations. One out of 11 participants (9%) had 3 normal taste sensations. One out of 11 participants (9%) had 4 normal taste sensations. No one in this group who had 5 normal taste sensations.

In the low salivary flow rate group, 2 out of 10 participants (20%) had 5 altered taste sensations or ageusia. One out of 10 participants (10%) had only 1 normal taste sensation. One out of 10 participants (10%) had 2 normal taste sensations. One out of 10 participants (10%) had 3 normal taste sensations. Four out of 10 participants (40%) had 4 normal taste sensations. One out of 10 participants (10%) had 5 normal taste sensations.

In the normal salivary flow rate group, 4 out of 29 participants (14%) had 5 altered taste sensations or ageusia. Five out of 29 participants (17%) had only 1 normal taste sensation. Four out of 29 participants (14%) had 2 normal taste sensations. Four out of 29 participants (14%) had 3 normal taste sensations. Nine out of 29 participants (31%) had 4 normal taste sensations. Three out of 29 participants (10%) had 5 normal taste sensations.

Denture Hygiene and Taste Sensation

According to the quantity of plaque on the denture base, participants could be divided into two groups. Good denture hygiene was defined as none or only few spots of plaque deposited on the denture, and poor denture hygiene was defined as more than half of the denture base covered by plaque.

In this study, 34 out of 50 participants (68%) had good denture hygiene, and 16 out of 50 participants (32%) had poor denture hygiene. It was found that denture hygiene did not show any statistically significant relationship with all taste sensations (Table 2).

When considering gender, age, medical status, salivary flow rate, salivary pH, and denture hygiene, it was found that salivary pH and denture hygiene did not show a statistically significant relationship with *Streptococcus mutans* score and Lactobacilli score, as shown in Tables 3 and 4. However, salivary pH and denture hygiene showed statistically significant relationship with Candida score (*p*-value= 0.016) for salivary pH and (*p*-value= 0.003) for denture hygiene. Higher salivary pH yielded a significantly lower Candida score. Poor denture hygiene had a significantly higher Candida score than good denture hygiene (Table 5).

Table 2 Statistically insignificant relationship between denture hygiene and each taste.

Taste	Variables	Odds ratio	95% Confidence Interval for Odds ratio	*p*-value
Sweet	Denture hygiene	1.774	0.238 - 13.233	0.576
Salt	Denture hygiene	1.024	0.188 - 5.567	0.978
Sour	Denture hygiene	0.787	0.126 - 4.908	0.797
Umami	Denture hygiene	13.345	0.120 - 1498.569	0.281
Bitter	Denture hygiene	1.744	0.203 - 14.978	0.612

Note: Statistical analysis was performed using binary logistic regression analysis, and *p*-value* < 0.05 was considered statistically significant.

Table 3 The statistical relationship between each variable and *S. mutans* score.

Variables	Beta	95% Confidence Interval for Beta	*p*-value
Gender	-0.052	(-0.750) - 0.538	0.742
Age	0.058	(-0.038) - 0.055	0.711
Medical status	0.089	(-0.258) - 0.478	0.550
Salivary flow rate	-0.120	(-0.660) - 0.297	0.449
Salivary pH	-0.195	(-1.726) - 0.437	0.236
Denture hygiene (poor)	-0.165	(-0.994) - 0.296	0.281

Note: Statistical analysis was performed using linear regression analysis, and *p*-value* < 0.05 was considered statistically significant.

Table 4 The statistical relationship between each variable and Lactobacilli score.

Variables	Beta	95% Confidence Interval for Beta	p-value
Gender	0.112	(-0.398) - 0.833	0.480
Age	0.004	(-0.044) - 0.045	0.982
Medical status	0.186	(-0.1310 - 0.573	0.213
Salivary flow rate	-0.069	(-0.558) - 0.358	0.661
Salivary pH	-0.114	(-1.394) - 0.674	0.486
Poor denture hygiene	-0.184	(-0.989) - 0.245	0.230

Note: Statistical analysis was performed using linear regression analysis, and *p*-value* < 0.05 was considered statistically significant.

Table 5 Statistical relationship of each variable and Candida score.

Variables	Beta	95% Confidence Interval for Beta	*p*-value
Gender	0.017	(-0.559) - 0.636	0.896
Age	-0.048	(-0.051) - 0.035	0.710
Medical status	0.150	(-0.131) - 0.552	0.222
Salivary flow rate	-0.38	(-0.508) - 0.380	0.771
Salivary pH*	-0.336	(-2.256) - (-0.249)	0.016
Denture hygiene (poor)*	0.395	0.344 - 1.541	0.003

Note: Statistical analysis was performed using linear regression analysis, and *p*-value* < 0.05 was considered statistically significant.

Discussion

This study was performed in Nakhon Pathom province, a small province located in the central region of Thailand. Participants had ages of over 60 years old and mainly were farmers living in rural areas. Taste alteration in older adults has been reported in several countries, but a study of taste alteration in Thai people is still extremely limited. Moreover, it is well known that several diseases, e.g., diabetes or hypertension, can be found as major diseases in older adults. According to the 8th National Oral Health Survey, 2017(3), 15.6% of older adults aged 60 to 74 had either removable or fixed dentures. Therefore, this paper is focused on taste alteration in older adults with dentures wearing.

In this study, the mean salivary flow rate of the healthy group (1.31+/-0.42 ml/min) was found to be higher than the hypertension group (1.22+/-0.77 ml/min). This result agrees with a previous study on hyposalivation in hypertensive patients (18), where the mean stimulated salivary flow rate of the medicated hypertensive group (0.73+/-0.30 ml/min) was lower than that of the control group (1.31+/-0.34 ml/min). Moreover, in this study, the prevalence of hyposalivation was 35.7% in the diabetic group, compared to 5.5% in the healthy group. Our result was consistent with the study about hyposalivation in diabetic patients, which found that the prevalence of hyposalivation in patients with type 2 DM was 46% compared with 28% in the control group [19].

Our studies showed that 21 out of 50 participants (42%) had low and very low salivary flow rate (salivary flow rate <1.0 ml/min). However, 15 out of 21 participants (71.4%) answered the questionnaire saying they had normal saliva amounts. Three out of 21 participants (14.3%) answered that they did not know about their saliva amounts, while 2 out of 21 participants (9.5%) answered that they had too much saliva. Only 1 out of 21 participants (4.8%) answered that they had too little saliva. Most participants did not recognize that they had hyposalivation. These answers demonstrate that complaints about dry mouth may not be a good indicator of hyposalivation, which is consistent with a dehydration study, reporting that older adults were less likely to complain of thirst and thus less likely to replace lost fluids [20]. This is probably due to multiple factors (e.g., oral mucosal changes and saliva constituents) contributing to age-related differences in xerostomia and thirst complaints [21].

Unfortunately, none of the participants in our study was a current smoker, and only 8 out of 50 participants (16%) used to smoke but stopped a long time ago. As a result, no relationship between smoking status and taste alteration could be observed in this study.

Candida albicans is the most common yeasts species found in the human oral cavity, while other species such as *C. glabrata,* and *C. tropicalis* are less frequently found [22]. The reported prevalence of *Candida albicans s* in normal healthy adults varies considerably among population groups, ranging from 6 - 55.4%, with a median of 34.4% [23]. In denture wearers, the prevalence of *Candida albicans* increases to 60-100% [24-25]. The organisms can cause opportunistic infection, and poor denture hygiene leads to a statistically significant higher *Candida albicans* score than good denture hygiene due to the cleanliness of the denture. This result was similar to the results found by Figueiral MH, *et al.* [26] and Dagistan S, *et al.* [27].

This is the first study in Thailand to report the prevalence of taste alteration in Thai older adults with dentures wearing. Our findings show that only 8% of participants had 5 normal taste sensations, while 92% had altered 1 – 5 taste sensations. However, only 6% of participants reported problems with a taste sensation. They had appetite

loss because the food was not as tasty as before, so they ate less food and had unintentional weight loss.

According to the study by Assantachai, *et al.* of older adults in the central region of Thailand, including Nakhon Pathom province, malnutrition was reported as one of the reasons for taste alteration. The three age groups, the 60 – 69-year age group, the 70 – 79-year age group, and the more than 80-year age group, had protein-energy malnutrition of 8%, 13.6%, and 22%, respectively [28]. It has been suggested that protein malnutrition may cause impaired production of taste cells and lead to reduced taste sensitivity [29].

Food culture may play a key role in taste sensation. According to Trachootham *et al.* in 2018, Thais who preferred spicy food had much poorer taste sensitivity and perception than those with milder preferences like Japanese [30].

Thai people appear to have preferences for sweet and salty food. According to the World Health Organization (WHO) recommends that salt consumption does not exceed 5 g/day, equivalent to 2 g of sodium per day [31]. Still, Thailand's mean dietary sodium intake was 3.636±1.722 g/day [32], which is nearly two times higher. In addition, the average daily consumption of sugar in Thailand is about 20 teaspoons of sugar per day [33] which is over three times higher than the WHO recommendation of 6 teaspoons per day [34]. The Thai population has stronger preferences for sweet and salty food, which may lead to poor taste sensitivity and perception in Thais.

The mean recognition threshold for bitter, sour, salt, sweet, and umami in this study were 4.48, 4.69, 4.77, 5.26, and 5.68, respectively, which was higher than the study of Trachootham *et al.* [30], where the mean recognition threshold of bitter, sour, salt, and sweet tastes was 3-4 and of umami was 5. Both studies assessed the recognition taste threshold by the filter paper disc method, and the mean age of the participants was similar. In this study, the mean age was 67.96+/-6.2 years old, while the mean age was 67.82 +/-6.14 years old in their study. The differences could be explained by the fact that the sample size and the sites of taste assessment were different. This study enrolled 120 participants, whereas their study enrolled 84. The total number of taste assessment sites in this study was six sites: anterior tongue (left and right sites), posterior tongue (left and right sites), and soft palate (left and right sites). However, in their study, taste assessment occurred at a single site, either the anterior or posterior tongue. Additionally, both studies had a distinct proportion of male and female participants. In this study, 59% of participants were female, and 41% were male, whereas in their study, 74% of participants were female, and 26% were male. As previously stated in this study, females had superior taste sensations to males. Moreover, gender differences may exist as a result of females having a higher density of papillae than males [35]. Furthermore, papillae density decreased with increasing age, a trend that was more prominent in males than females, indicating that males were more susceptible to papillae density decline with age [36].

The results from the present study indicated that wearing dentures has no significant difference in taste alteration, but increased numbers of *Candida albicans* were found, related to salivary pH and denture hygiene. Further study on food preference, dietary pattern, and lifestyle may be needed to identify the significant factors that affect taste sensation in the older adults, which would eventually aid in a deeper understanding of age-related taste alterations and dietary recommendations in older adults experiencing taste alteration, so as to maintain and/or improve their nutritional status and to prevent and/or alleviate age-related malnutrition.

Conclusion

No correlation was found between denture hygiene and taste alteration in older adults. The number of *Candida albicans* showed a significant relationship between salivary pH and denture hygiene. Therefore, it is necessary to emphasize the importance of maintaining good denture hygiene in older adults.

Acknowledgments

This study was supported by a grant on "Development of Taste Sensitivity and Mouth Odor Care in the Older adults Program, Dental Innovation for Older adults Work Plan," provided by a Government Budget Grant 2019. Moreover, the authors are grateful to Assoc. Prof. Dr. Noriaki Shoji for generously providing taste kits.

Funding resource:

Development of Taste Sensitivity and Mouth Odor Care in the Older adults Program, Dental Innovation for Older adults Work Plan, Government Budget Grant 2019.

Conflicts of interest

All authors have no conflicts of interest.

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