Taste Sensitivity Modulating Factors in the Elderly

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Taste Sensitivity Modulating Factors in the Elderly

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Joo Hee Lee

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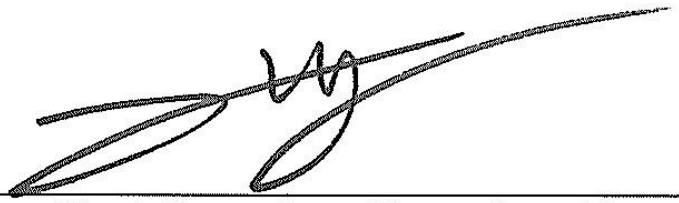
This certifies that the doctoral dissertation

of Joo Hee Lee is approved.



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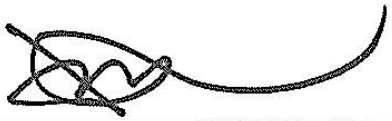

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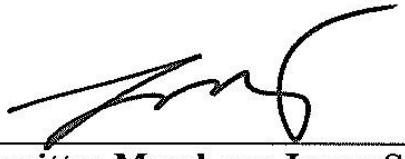

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감사의 글

어느 새 구강내과 의국을 떠난 지 4년이란 시간이 흘렀습니다. 구강내과 전문의로 하나의 매듭을 지었지만, 구강내과학교실의 일원으로서는 이제서야 하나의 매듭을 완성하며 큰 짐을 내려놓게 되는 것 같습니다. 논문을 작성하면서, 하나의 연구가 결실을 맺어 세상에 나오기까지 연구자의 많은 고민과 노력이 필요하다는 것을 알았습니다. 잠시나마 연구자의 마음과 자세를 배우는 시간이었습니다.

먼저, 본 논문이 완성될 수 있도록 지도해 주신 교수님들께 진심을 담아 감사드립니다. 졸업의 문을 넘어갈 수 있도록 마지막까지 관심과 애정을 담아 이끌어 주신 안형준 지도교수님께 무한한 감사를 드립니다. 칭찬과 응원으로 제가 작아지는 순간마다 용기를 북돋아 주셨던 최종훈 교수님께 감사드립니다. 바쁘신 와중에도 꼼꼼하게 첨삭해 주셨던 권정승 교수님께 감사드리며, 논문이 잘 진행되고 있는지 관심 가져 주신 김성택 교수님께도 감사드립니다. 또한, 저의 논문을 꼼꼼하게 살펴봐 주시고 부족한 점을 알려주셨던 허경석 교수님, 문석준 교수님께 감사드립니다.

학위 과정 중 함께 한 분들 덕분에 힘든 순간이 있어도 의지하고, 힘을 낼 수 있었습니다. 학교를 떠나 외부에서 논문을 쓰며 도움이 필요한 순간마다 먼저 손을 내밀어 주시고 이 논문이 완성될 수 있도록 큰 도움 주셨던 정효정

선생님께 감사합니다. 지금은 멀리 계시지만 연구 진행을 도와주었던 민영광 선생님에게도 감사함을 전합니다. 격려의 말을 아낌없이 건내 주셨던 김영건 선생님, 우건철 선생님, 박연정 선생님, 이희진 선생님, 김재정 선생님, 김서린 선생님에게도 감사합니다. 무사히 학위를 마무리하기까지 도움을 주셨던 구강내과의 모든 분들께도 감사드립니다.

학위를 마치기까지 무한한 신뢰와 사랑을 담아 응원해 주신 아버님과 어머님께도 깊은 감사드립니다. 그리고 인생의 갈림길에서 언제나 가장 든든한 버팀목이 되어주었던 언니에게도 감사합니다. 삶의 파고를 잔잔하게 만들어주는 좋은 친구 김준영과 무한한 사랑의 깊이를 알려주는 구름이에게도 감사의 마음을 전합니다.

앞으로도 배움을 통해 더 성장하고 발전하며 어디서든 선한 영향력을 미치는 사람이자 좋은 치과의사가 되겠습니다.

2022 년 2 월

이주희 드림

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Abstract

Taste Sensitivity Modulating Factors in the Elderly

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Aging is a process that causes changes of the organs in the body and can change the social position and psychological condition of an individual. Taste sensitivity also changes with age. Taste sensitivity helps maintain a good nutritional state because it increases appetite and prevents the consumption of spoiled food. Therefore, decreases of taste sensitivity in the elderly could affect their general health. Most prior studies have attempted to identify taste-modulating factors by assessing four basic taste types, not umami; furthermore, the psychological state of an individual has not been considered. This study was designed to identify taste (including umami)-modulating factors and to assess the

relationship between taste sensitivity and psychological states such as depressive symptom level and self-esteem in elderly Korean individuals.

A total of 98 participants, aged 65–103 years and 71 were females and 27 were males, were evaluated their general health, psychological health, and taste sensitivity. After performing univariate analysis, the following variables were identified as the factors that could affect taste: age, diabetes, cognition, self-esteem, sex, and number of drugs. Consequently, these variables were tested using multivariable logistic regression analysis with the R program.

The lower cognition group had significantly lower bitter and lower total taste sensitivity (odds ratio [OR]=0.34, P=0.02 and OR=0.34, P=0.02, respectively) than the higher cognition group. The lower self-esteem group showed significantly lower salty (OR=0.29, P<0.01) and sour taste sensitivity (OR=0.38, P=0.03) than higher self-esteem group. Males had significantly lower total taste sensitivity (OR=0.23, P=0.01) than females.

Cognition, self-esteem, and sex were identified as factors that significantly modulated taste sensitivity in elderly Korean individuals. The factor affecting umami taste sensitivity was not found.

Key words : taste, aged, aging, cognition, self-concept, sex.

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I. INTRODUCTION

Aging is defined as physical changes that occur in organs of the body throughout life (Dziechciaz and Filip, 2014; Kirkwood, 2002). It is accompanied by decreases in physiological, psychological, and social abilities (Charles and Carstensen, 2010). Throughout the aging process, organs such as the brain, heart, kidneys, and muscles decrease in size and lose functionality; and auditory and visual senses deteriorate (Dziechciaz and Filip, 2014). Psychologically, an individual may lose his/her interest in life, remain dissatisfied with life, and experience loneliness (Charles and Carstensen, 2010; Dziechciaz and Filip, 2014). A loss of digestive function due to loss of teeth and a decrease

in salivary secretion, mucus secretion, and gastrointestinal motility occurs (Dziechciaz and Filip, 2014). Taste sensitivity also changes with age (Methven et al., 2012).

Taste plays an important role in managing health, stimulating appetite, and avoiding the consumption of spoiled food (Solemdal et al., 2014; Uota et al., 2016; Yoshinaka et al., 2016). Sensitivity to a specific taste affects the flavor and food preferences of an individual, and food choice may be associated with diseases, such as obesity, diabetes, hypertension, and taste disorder (Drewnowski, 1997). Mortality rates are also increased in elderly hospitalized patients with impaired taste since it leads to undernutrition (Solemdal et al., 2014). Deterioration in taste sensitivity is related to multiple factors, including aging, sex, nutrition, specific diseases (hypertension, diabetes mellitus [DM], and Sjogren's syndrome, as well as renal, liver, and thyroid diseases), cognition, and depressive symptoms; however, the extent and significance of identified factors vary based on the study considered (Liljas et al., 2020; Qazi et al., 2020; Stewart-Knox et al., 2005; Uota et al., 2016; Wayler et al., 1990). Methven et al. (2012) reported that the significance of taste sensitivity changes with aging differed based on taste modality, tastant, and study. No definitive factors affecting taste sensitivity have been reported. Furthermore, there are limited studies concerning taste sensitivity change in elderly Korean individuals. In a study of 68 elderly Koreans, Jeon et al. (2021) reported that age, medication intake, nutritional components (iron, zinc, folic acid, phosphorus, and thiamin, etc.), quality of life score, body mass index, and physical activity are taste-modulating factors. However, in the study, psychological and social factors such as depressive symptoms, self-esteem, and cognition were not assessed.

Therefore, assessment of psychological and social factors in elderly Korean individuals is needed.

Umami was discovered 100 years ago. It is sensed using G-protein coupled receptors (Lindemann, 2001). However, umami taste had been considered as a flavor enhancer, not an independent taste (Kurihara, 2015). Umami was accepted as the fifth basic taste in 1998. (Kurihara, 2015; Yamaguchi and Ninomiya, 2000). The elderly who have umami taste disorder could lose weight and experience malnutrition as a result of appetite loss (Sasano et al., 2014). Nevertheless, many previous studies have used taste solutions consisting of the following four basic tastes: sweet, salty, sour, and bitter. This study was designed to identify taste (including umami)-modulating factors and to assess the relationship between taste sensitivity and psychological states such as depressive symptom level and self-esteem in elderly Korean individuals.

Ⅱ. MATERIALS AND METHODS

1. Subjects

This was a cross-sectional study. Data were collected from 98 individuals aged >65 years who lived in Seoul and Gyeong-gi province. Study participants were recruited from senior citizen centers. The volunteers who were capable of understanding the instructions, reading and speaking Korean, and visiting the office independently were included. The exclusion criteria were recent dental treatment history due to toothache or periodontitis, inability to communicate with others or move independently, feeling of poor taste sensitivity, and having severe cognitive impairment. Informed consent was obtained from all participants. This study was approved by the institutional review board of the Yonsei University Dental Hospital (approval number: 2-2018-0032) and conforms to the standards of the Declaration of Helsinki.

2. Assessment of General Health Status

All participants were asked questions on their general health (i.e., hypertension, DM, medication, smoking, drinking, and exercise) and dietary satisfaction. Dietary satisfaction was assessed using satisfaction with food-related life questionnaires comprised of five questions that assessed whether patients were pleased or satisfied with the food and meals that they consumed in their daily lives. Moreover, they aimed to examine whether living conditions of participants were suitable for food consumption. Higher scores were indicative of increased satisfaction (Lee et al., 2014). The participants were divided into two groups based on the mean value of the score.

Self-reported oral dryness and olfactory changes of study participants were also assessed using modified, Korean-translated questionnaires from another study. Participants were designated as having olfactory changes when they had a worse sense of smell, or smelled an unpleasant, bad, or burning odor when no smell was present (Hur et al., 2018). Questions that assessed perceived oral dryness, difficulty swallowing, or requirement of water consumption to facilitate swallowing were also included. All participants answered yes or no to a question that asked whether they would like to add salt when eating a meal to distinguish high and low salt intake groups.

3. Assessment of Psychological and Social Health Status

1) Assessment of cognition

The Korean version of the mini-mental state examination-dementia screening (MMSE-DS) scale was used to grade the cognitive ability of each participant (Tombaugh and McIntyre, 1992). The MMSE-DS score is generally classified into the following three levels: 24–30, no cognitive impairment; 18–23, mild cognitive impairment; and <17, severe cognitive impairment. In this study, 88 and 10 participants were included in the no cognitive impairment and mild cognitive impairment groups, respectively. Only two individuals included in the severe impairment group were excluded from the study. Therefore, the 98 included individuals were divided into the no cognitive impairment and cognitive impairment groups using a mean MMSE-DS cut-off score of 26.5.

2) Assessment of self-esteem

The Korean version of the Rosenberg self-esteem scale was used to test the self-esteem of the study participants. The Rosenberg self-esteem scale consists of 10 questionnaires (Kim et al., 2017). A higher score indicates a greater level of self-esteem. We divided the participants into two groups (low and high self-esteem score groups) based on mean Rosenberg self-esteem scores.

3) Assessment of depressive symptom

The presence of depressive symptoms in the participants was measured using the Zung self-rating depression score, which consists of 20 questionnaires with scores ranging from 20 to 80 (Choi et al., 2017). A higher score indicates a greater level of depressive symptoms. The participants were divided into two groups (the lower and higher depressive-symptom level groups) based on the mean value of the score.

4. The number of teeth and denture usage

A qualified dentist performed an oral examination and used panoramic radiography to confirm the number of teeth and denture usage.

All participants were divided into two groups according to the mean value of the number of teeth.

5. Unstimulated Salivary Flow rate

A trained dentist measured the amount of unstimulated saliva using the spitting method (Navazesh and Christensen, 1982). The test progressed from 9 to 12 am. The participants were instructed not to eat, drink, smoke, or brush their teeth for at least 1 h before the test. Thereafter, they sat in an upright position with a slightly forward head posture. Saliva was collected in the mouth for a 1-min period and participants spitted saliva in pre-weighed containers at every 1-min throughout 5-min tests. Patients were divided into lower and higher salivary flow groups based on the mean value of their salivary flow test score.

6. Determination of Taste Sensitivity

In this study, the Burghart taste strip (Burghart Messtechnik GmbH, Holm, Germany) was used to determine taste sensitivity. The taste strip is a simple and appropriate tool for measuring personal taste sensitivity, including umami taste (Mueller et al., 2003; Wolf et al., 2016; Mueller et al., 2011). The tool consists of the following 22 strips: four concentrations of each of five basic tastes, and two tasteless strips. The concentrations of tastes used in taste strips are listed in Table 1.

The participants were instructed not to eat, drink, smoke, or brush their teeth for at least 1 h before the test. Each taste strip was placed on the middle of the tongue, and the participants were asked to choose a taste among six answers: sweet, bitter, salty, sour, umami, and tasteless. They were given low to high concentrations of each taste along with two tasteless strips in a random order. Each correct answer corresponded to a score of 1 point. The score of each taste ranged from 0 to 4, and the total score ranged from 0 to 20. A higher taste score indicated better taste sensitivity.

Table 1. The concentrations in the taste strips (unit: g/mL)

Taste modality	Concentration level			
	1	2	3	4
Sweet (sucrose)	0.05	0.1	0.2	0.4
Bitter (quinine-hydrochloride)	0.0004	0.0009	0.0024	0.006
Salty (sodium chloride)	0.016	0.04	0.1	0.25
Sour (citric acid)	0.05	0.09	0.165	0.3
Umami (MSG)	0.016	0.04	0.1	0.25

MSG, Monosodium glutamate

7. Statistical Analysis

All data analyses were performed using the R program version 4.0.0 on the Windows OS (R Foundation for Statistical Computing, Vienna, Austria). The participants were divided into two groups based on all factors except education. Age based group designation was performed by dividing all participants into two groups based on a mean value of 75.92 years.

The taste sensitivity score did not show a normal distribution, and the Mann–Whitney test was used to analyze each factor affecting taste sensitivity. The participants were divided into four groups based on the education level, and the Kruskal–Wallis test was used to perform univariable analysis. The logistic regression analysis was performed with the statistically significant factors from univariable results. The level of significance was set at $P<0.05$.

Ⅲ. RESULTS

1. General characteristics of the subjects

Out of 98 participants, 71 were females and 27 were males (age range, 65–103 years; average age, 75.92 [±6.42] years). Of them, 7.1%, 37.8%, 58.1%, and 26.5% were smokers, were alcohol drinkers, had hypertension, and had diabetes, respectively. Moreover, 50% of the participants received more than three kinds of drugs (Table 2).

Table 2. Basic characteristics of subjects

	Total (n = 98)	Males (n = 27)	Females (n = 71)
Age(years)	75.92 ± 6.42	76.56 ± 6.22	75.68 ± 6.53
Denture usage: n, %			
Upper	22 (22.4)	12 (44.4)	10 (14.1)
Lower	28 (28.6)	12 (44.4)	16 (22.5)
Number of Teeth	21.76 ± 8.91	16.05 ± 11.41	23.93 ± 6.66
Hypertension: n, %	57 (58.1)	15 (55.6)	42 (59.2)
Diabetes mellitus: n, %	26 (26.5)	2 (7.4)	24 (33.8)
Number of drugs: n, %			
more than 3 kinds of drugs	49 (50)	11 (40.7)	38 (53.5)
Less than 3 kinds of drugs	49 (50)	16 (59.2)	33 (46.5)
Smoking: n, %	7 (7.1)	5 (18.5)	2 (2.8)
Drinking: n, %	37 (37.8)	18 (66.7)	19 (26.8)
Exercise: n, %	71 (72.4)	23 (85.2)	48 (67.6)
Education: n, %			
Elementary school	40 (40.8)	6 (22.2)	34 (47.9)
Middle school	29 (29.6)	11 (40.7)	18 (25.4)
High school	26 (26.5)	9 (33.3)	17 (23.9)
University	3 (3.1)	1 (3.7)	2 (2.8)
Dietary satisfaction score	8.48 ± 3.22	8.00 ± 2.92	8.66 ± 3.32
Self-esteem score	24.10 ± 3.77	24.52 ± 3.30	23.94 ± 3.94
Depressive symptom score	33.59 ± 9.09	32.11 ± 9.99	34.15 ± 8.73
MMSE-DS score	26.48 ± 2.72	26.67 ± 2.47	26.41 ± 2.83
Subjective olfactory sense: n, %			
Normal	79 (80.6)	21 (77.8)	58 (81.7)
Decreased	19 (19.4)	6 (22.2)	13 (18.3)
Subjective oral dryness sense: n, %			
Normal	78 (79.6)	18 (66.7)	60 (84.5)
Dried	20 (20.4)	9 (33.3)	11 (15.5)
Objective saliva flow rate(mL/min)	0.27 ± 0.17	0.36 ± 0.23	0.24 ± 0.12
High salt intake: n, %			
Yes	45 (45.9)	9 (33.3)	36 (50.7)
No	53 (54.1)	18 (66.7)	35 (49/3)

IQR : interquartile range (25-75th percentile)

2. Taste Sensitivity Score

The median of each taste sensitivity score was 3 (sweet), 2 (bitter), 2 (salty), 1 (sour), 1 (umami), and 10 (total) (Fig. 1).

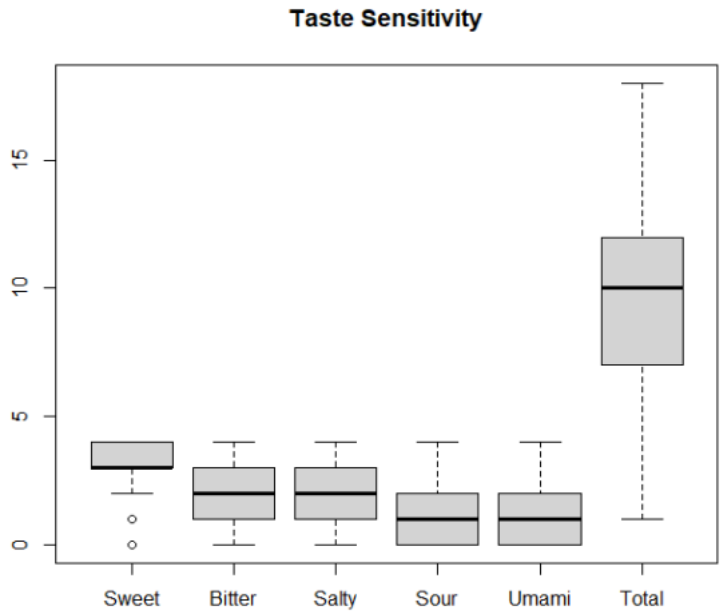

Figure 1. Taste sensitivity score

3. Taste-modulating factors of univariate analysis

The older group (over the 75.92 years, mean value of the age) had a significantly lower total and bitter and salty taste sensitivity than the younger group ($P<0.01$, $P=0.03$, and $P=0.03$, respectively). The DM group showed a significantly lower taste sensitivity to sweet and sour tastes ($P=0.02$ and $P=0.01$, respectively) versus non-DM group. The higher cognition group had a significantly higher taste sensitivity to bitter and umami tastes, along with total taste sensitivity ($P=0.04$, $P=0.04$, and $P=0.01$, respectively) than the lower cognition group. Bitter taste sensitivity was significantly lower in participants who received a greater number of drugs ($P=0.02$) than other participants. Salty taste sensitivity was significantly reduced in those with low self-esteem group ($P=0.04$) than high self-esteem group. Umami taste sensitivity was significantly lower in males versus females. (Table 3).

Table 3. Univariate analysis of factors of taste sensitivity

		Sweet		Bitter		Salty		Sour		Umami		Total	
		median(IQR)	P	median(IQR)	P	median(IQR)	P	median(IQR)	P	median(IQR)	P	median(IQR)	P
Sex†	F	3(3-4)	0.26	2(1-3)	0.71	2(1-3)	0.77	1(0.5-2)	0.96	1(0.5-2)	0.02*	10(7-12)	0.15
	M	3(2.5-3.5)		2(1-3)		2(0-3)		2(0.5-2)		0(0-1.5)		9(6.5-11)	
Age†	Younger	3(3-4)	0.66	3(1.5-3)	0.03*	2(1-3)	0.03*	2(1-2)	0.05	1(0-3)	0.22	11(9-13)	<0.01**
	Older	3(2.5-4)		1(0.5-3)		1(0.5-3)		1(0-2)		1(0-2)		8(6-11)	
Denture†													
Upper	No	3(3-4)	0.92	2(1-3)	0.49	2(1-3)	0.81	1(1-2)	0.61	1(0-2)	0.91	10(7-12)	0.96
	Use	3(3-4)		2.5(1-3)		2(1-3)		1(0-2)		1(0-2)		9(7-12)	
Lower	No	3(2.25-4)	0.61	2(1-3)	0.74	2(1-3)	0.95	1(0.25-2)	0.63	1(0-2)	0.32	10(7-12)	0.46
	Use	3(3-4)		2(1-3.25)		2(1-3)		1(0.75-2)		1(0-2)		9(6-12)	
Number of Teeth†	Higher	3(3-4)	0.71	2(1-3)	0.49	2(1-3)	0.62	1(1-2)	0.23	1(0-2)	0.21	10(7-12)	0.19
	Lower	3(3-4)		2(1-3)		2(1-3)		1(0-2)		1(0-2)		9(6-12)	
Hypertension†	No	3(3-4)	0.95	2(1-3)	0.77	2(1-3)	0.86	1(0-2)	0.21	1(0-3)	0.88	9(6-12)	0.65
	Yes	3(3-4)		2(1-3)		2(1-3)		2(1-2)		1(0-2)		11(7-12)	
Diabetes mellitus†	No	3(3-4)	0.02*	2.5(1-3)	0.11	2(1-3)	0.87	2(1-2)	<0.01**	1(0-2)	0.64	10(8-12)	0.09
	Yes	3(2-3)		1.5(0-3)		2(1-3)		1(0-1.75)		1(1-2)		7.5(5.25-11.75)	
Number of drugs†	Less	3(3-4)	0.39	3(1-4)	0.02*	2(1-3)	0.77	2(1-2)	0.07	1(0-2)	0.80	11(8-13)	0.05
	More	3(2-4)		2(1-3)		2(1-3)		1(0-2)		1(0-2)		9(6-12)	
Smoking†	No	3(3-4)	0.87	2(1-3)	0.56	2(1-3)	0.79	1(1-2)	0.60	1(0-2)	0.13	10(7-12)	0.77
	Yes	3(3-3.5)		3(1.5-3.5)		1(0-3.5)		1(0-2)		0(0-1)		9(7-12)	
Drinking†	No	3(3-4)	0.31	2(1-3)	0.56	2(1-3)	0.40	1(1-2)	0.97	1(0-2)	0.38	10(7-12)	0.76
	Yes	3(3-4)		2(1-3)		2(0-3)		1(0-2)		1(0-2)		9(7-12)	
Exercise†	Yes	3(3-4)	0.78	2(1-3)	0.87	2(1-3)	0.32	1(0-2)	0.81	1(0-2)	0.80	10(7-12)	0.63
	No	3(3-4)		3(0.5-4)		1(1-2.5)		1(1-2)		1(0-2)		10(6-12.5)	
Education‡	Elementary	3(3-4)	0.93	2(1-3)	0.39	2(1-3)	0.70	1(0-2)	0.27	1(0-2)	0.90	9(6-12)	0.41
	Middle	3(2-4)		2(1-3)		2(1-3)		2(1-2)		1(0-2)		9(7-12)	
	High	3(3-4)		3(2-3)		2(0.25-3)		1.5(1-2)		1(1-2)		11(7.25-13)	
	University	4(3-4)		4(2-4)		2(2-2.5)		2(1.5-2.5)		1(0.5-1.5)		11(9.5-13)	
Dietary satisfaction score†	Higher	3(3-4)	0.87	2(1-3)	0.39	2(1-3)	0.42	1(0-2)	0.47	1(0-2)	0.19	9(7-12)	0.50
	Lower	3(3-4)		3(1-3)		2(1-3)		1(1-2)		1(0-2.75)		10(7-12)	
Self-esteem score†	Higher	3(3-4)	0.16	2(1-3.75)	0.57	2(1-3)	0.04*	2(1-2)	0.07	1(0-2)	0.68	11(7-12.5)	0.14
	Lower	3(2-4)		2(1-3)		2(1-2)		1(0-2)		1(0-2)		9(7-12)	
Depressive symptom score†	Higher	3(3-4)	0.20	2(1-3.75)	0.52	2(1-3)	0.34	1(0.25-2)	0.47	1(0-2)	0.19	10.5(8-12)	0.11
	Lower	3(2-4)		2(1-3)		2(1-3)		1(0.75-2)		1(0-2)		9.5(6-11)	
MMSE-DS score†	Higher	3(3-4)	0.64	3(1-4)	0.04*	2(1-3)	0.40	1.5(1-2)	0.15	1(0.25-2)	0.04*	11(8-12.75)	0.01*
	Lower	3(2.75-4)		2(1-3)		2(1-3)		1(0-2)		1(0-2)		9(6-11)	
Subjective olfactory sense†	Good	3(3-4)	0.97	2(1-3)	0.15	2(1-3)	0.45	1(1-2)	0.44	1(0-2)	0.31	10(7-12)	0.16
	Bad	3(3-4)		1(0.5-3)		2(1-2)		1(0-2)		1(0-2)		9(6-11.5)	
Subjective oral dryness sense†	No	3(2.25-4)	0.29	2(1-3)	0.08	2(1-3)	0.52	1(0-2)	0.11	1(0-2)	0.20	10(7-12)	0.52
	Yes	3(3-4)		1(0-3)		2(0-3)		2(1-2)		1(0-1.25)		9(7.5-11.25)	
Saliva flow rate†	Higher	3(3-4)	0.74	2(1-3)	0.78	2(1-3)	0.36	1(1-2)	0.75	1(0-2)	0.91	10(7-12)	0.96
	Lower	3(2.5-4)		2(1-3)		2(1-3)		1(0-2)		1(0-2)		10(7-12)	
High salt intake†	Higher	3(3-4)	0.67	2(1-3)	0.15	2(1-3)	0.67	1(0-2)	0.11	1(0-2)	0.29	9(6-12)	0.12
	Lower	3(3-4)		3(1-3)		2(1-3)		2(1-2)		1(0-2)		10(8-12)	

IQR, interquartile range (25-75th percentile); MMSE-DS, Mini-Mental State Examination-Dementia Screening.

†Mann-Whitney test, ‡Kruskal-Wallis test

* p <0.05, **p<0.01.

4. Taste-modulating factors of logistic regression analysis

The logistic regression analysis was performed using the following six statistically significant factors previously identified in the univariable analysis: sex, age, diabetes, number of drugs, self-esteem, and the MMSE-DS score. The lower cognition group had significantly lower bitter and lower total taste sensitivity (odds ratio [OR]=0.34, P=0.02 and OR=0.34, P=0.02, respectively) than the higher cognition group. The lower self-esteem group showed significantly lower salty (OR=0.29, P<0.01) and sour taste sensitivity (OR=0.38, P=0.03) than the higher self-esteem group. Males had significantly lower total taste sensitivity (OR=0.23, P=0.01) than females. (Table 4).

Table 4. Multivariate analysis of factors of taste sensitivity

	Sweet	Bitter			Salty			Sour			umami	total		
		OR	95%CI	P	OR	95%CI	P	OR	95%CI	P		OR	95%CI	P
Sex												0.23	(0.07-0.68)	0.01*
Age														
Diabetes Mellitus														
Number of drugs														
Self-esteem score					0.29	(0.11-0.71)	<0.01**	0.38	(0.15-0.91)	0.03*				
MMSE-DS score		0.34	(0.14-0.81)	0.02*								0.34	(0.13-0.83)	0.02*

Logistic regression analysis using 6-key factors.

Gender (female = 0, male = 1), Age (younger = 0, older =1), Diabetes mellitus (no = 0, yes = 1), Number of drugs (low = 0, high = 1), Self-esteem score (high = 0, low = 1), MMSE score (high = 0, low =1)

OR, odds ratio; CI, confidence interval; MMSE-DS, Mini-Mental State Examination-Dementia Screening.

Ⅳ. DISCUSSION

Previous studies have reported that the factors that modulated sweet, bitter, salty, and sour tastes are age, sex, upper denture usage, smoking, drinking, hypertension, number of teeth, stimulated salivary flow rate, cognition, body mass index, years of education, salt intake, and zinc intake (Stewart-Knox et al., 2005; Uota et al., 2016; Wayler et al., 1990).

In this study, the higher MMSE-DS score group had an increased degree of taste sensitivity (bitter, umami, and total) than the lower MMSE-DS score group. A study revealed a significant correlation between the MMSE scores and taste perception in patients with Alzheimer's disease (Suto et al., 2014). Lang et al. (2006) also found a positive correlation between the MMSE score and taste perception in patients with dementia. Uota et al. (2016) reported that lower cognitive scores in the elderly were associated with decreased salty taste sensitivity. Steinbach et al. (2010) explained that gustatory value was associated with the MMSE score and suggested that there were two correlating central nervous system areas affecting cognitive impairment and taste sensitivity. First, in the mild cognitive impairment group, glucose metabolism reduction was observed in the posterior cingulate cortex; this region affected taste-processing. Second, the ventral anterior pathway involved in taste-processing was related to the limbic region, including the hippocampus. Moreover, changes in this region were also observed in the mild cognitive impairment group (Steinbach et al., 2010). The decrease in taste sensitivity may be affected by the sensory process, but it may also be affected by the cognitive process (Suto et al., 2014). To minimize the influence of the cognitive process, the severe impairment group was excluded.

Afterward, the statistically significant correlation between cognition and taste sensitivity remained after this exclusion. The findings indicate that changes in the taste process, except for the cognitive process, were most likely to occur in the group with low MMSE-DS scores

Interestingly, the higher self-esteem group showed higher salty and sour taste sensitivities than the lower self-esteem group. Self-esteem is a complex idea concerning the participants themselves, and is also a multi-dimensional and dynamic concept, including character, values, and memories (Cotter and Gonzalez, 2009). This self-esteem can be modified by life events and age-related physiological and social changes (Cotter and Gonzalez, 2009). Patients with eating disorders may have low self-esteem (Serpell et al., 2020); thus, there may be a link between self-esteem and taste, and this phenomenon was evaluated. A theory was derived from reports on functional magnetic resonance imaging, which revealed that negative self-esteem activated the dorsal anterior cingulate cortex and the anterior insula, and that those areas were activated by physiological and psychological pain (Kawamichi et al., 2018). The anterior insula is also a core gustatory region that is activated by taste stimuli (Small and Apkarian, 2006). This overlap in active areas for taste and psychological pain suggests a potential association between negative self-esteem and taste.

A logistic regression analysis revealed that female participants had greater total taste sensitivity than male participants. Other studies have also shown that females have a higher degree of taste sensitivity than males (Uota, et al., 2016; Ogawa, et al., 2017) This could be attributed to lifestyle choices (i.e., males drink or smoke more often than females), differences in biological age originating from their lifestyles (Yoshinaka et al., 2016), and

the effects of sex hormones (Uota et al., 2016; Ogawa et al., 2017). Moreover, in traditional Korean culture, females cook more often than males. Therefore, females may develop a greater degree of taste sensitivity than males. Regarding lifestyle factors, when smoking and drinking rates of males and females were compared, results showed that males had higher rates for both (smoking rate: female, 2.8%; male, 18.5%; drinking rate: female, 26.8%; male, 66.7%). However, in this study the relationship between smoking and drinking and taste sensitivity has not yet been established. Therefore, further studies should be conducted to determine the precise relationship between lifestyle and taste sensitivity, which assess the frequency and quantity of smoking and drinking. Furthermore, in this study, only 27.6% of study participants were male. Sex hormone levels and food making-related factors were not evaluated; therefore, further research involving a higher proportion of male participants is needed.

Umami is a taste and serves to add delicious flavor to food (Kurihara, 2015; Yamaguchi and Ninomiya, 2000). When used with salt, umami could also contribute to maintaining health by reducing the amount of salt required and maintaining the taste of food(Yamaguchi and Ninomiya, 2000). Yamaguchi et al. (2000) confirmed that the response of human infants to monosodium glutamate-seasoned vegetable broth was similar to the response to sweet taste, whereas the response to unseasoned vegetable broth was similar to that to sour taste. There were also cases of decreased appetite, weight loss, and poor general health in older people with reduced umami taste sensitivity (Sasano et al., 2014). Umami substances include glutamate, 5'-inosinate, and 5'-guanylate, which are found in meat, proteins of

soybeans or milk, and vegetables (i.e., mushrooms) (Kurihara, 2015). Korean soy sauce contains a high concentration of free glutamic acid (Yamaguchi and Ninomiya, 2000). Koreans are also accustomed to the taste of umami, which is likely to affect their health. However, logistic regression analysis in this study did not reveal any factors affecting umami taste sensitivity. Nevertheless, sex and the MMSE-DS score were found to be significant factors affecting umami taste sensitivity in the univariable analysis. Additional research on umami taste-influencing factors may be helpful to improve the health of the elderly.

Aging was found to be correlated with taste sensitivity in the univariable analysis, but no correlation was found after logistic regression analysis. Since this study only involved elderly individuals, additional studies involving participants of varying ages are needed. Herein, DM and the number of drugs were also found to be statistically related to taste sensitivity after performing a univariable analysis, but the correlation was not supported using a logistic regression model.

Liljas et al. (2020) and Hur et al. (2018) have reported that there was a correlation between depressive symptoms and taste sensitivity, but the authors studied the relationship between subjective changes in taste sensitivity and depressive symptoms. Qazi et al. (2020) also confirmed the relationship between subjective changes in taste sensitivity and depressive symptoms. Interestingly, in contrast to our study, these previous studies did not objectively examine taste sensitivity (i.e., using a taste strip). Actual decreases in taste sensitivity and decreases in taste sensitivity subjectively reported by an individual may differ. If this is true,

depressive symptoms are thought to affect subjective decreases in taste sensitivity.

A previous study has confirmed the statistical significance of salivation in terms of taste sensitivity via stimulated salivary flow tests (Uota et al., 2016). Nevertheless, in this study, the unstimulated salivary flow test was used. If an unstimulated salivary flow test score decreased, a decrease in taste sensitivity could occur due to atrophy of the tongue papilla; however, this was not confirmed. ‘

One previous study stated that the number of teeth had an effect on the chewing function and, thus, affected taste sensitivity; however, another study, to which findings in this study are aligned, reported no correlation (Uota et al., 2016).

Hypertension, salt intake, education level, and denture usage may affect taste sensitivity; however, none of the factors affected taste sensitivity in this study. Information on hypertension status was provided only via participant responses to questions of the general health condition questionnaire. Further, the participants' salt intake data was also obtained based on the self-reported questionnaire because precise quantity of salt added their food was difficult to accurately assess. Participants who reported eating additional salt were placed in the high salt intake group.

This study had some limitations. First, the DM and hypertension status in the participants were only evaluated (presence or absence of DM), and their medical condition were not evaluated (e.g., complications, blood glucose level control, and stage of the disease). Moreover, when examining the number of received drugs, the exact type of medication was not investigated. In addition, in this study, it was not possible to confirm whether there was

a confounding variable between the received drug and the diagnosed disease because information on the type of drug taken at the time of the study was unavailable. Further studies are needed to investigate these factors.

In conclusion, sex, self-esteem, and cognition were found to be the major factors affecting taste sensitivity in elderly Korean individuals. In addition, no factor affecting umami taste sensitivity was identified. By identifying factors that affect umami taste sensitivity, the causal relationship among umami taste, specific disease groups, and the influence of food preference may be examined. This would also facilitate a deeper understanding of taste itself. This study may help investigators design and conduct future studies investigating taste sensitivity modulating factors.

V. CONCLUSION

1. The lower cognition group had significantly lower bitter and lower total taste sensitivity (odds ratio [OR]=0.34, P=0.02 and OR=0.34, P=0.02, respectively) than the higher cognition group.

2. The lower self-esteem group showed significantly lower salty (OR=0.29, P<0.01) and sour taste sensitivity (OR=0.38, P=0.03) than the higher self-esteem group.

3. Males showed significantly lower total taste sensitivity (OR=0.23, P=0.01) than females.

4. Sex, self-esteem, and cognition were found to be the major factors affecting taste sensitivity in elderly Korean individuals.

5. The factor affecting umami taste sensitivity was not found.

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Abstract (in Korean)

노인 미각민감도에 영향을 주는 요인

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이 주 희

연구목적: 노화는 신체 기관의 퇴화가 일어나는 과정이며, 개인의 사회적 위치나 심리적인 상태를 변화시킬 수 있다. 미각민감도 역시 나이에 따라 변화한다. 미각은 식욕을 유지하고 상한 음식을 피할 수 있게 함으로써 건강한 영양상태를 유지하는데 도움을 준다. 따라서 노인의 미각민감도 변화는 노년기 건강에 영향을 줄 수 있다. 미각민감도에 영향을 주는 요인을 연구한 기존의 대다수 연구는 감칠맛을 포함한 연구를 진행하지 않았다. 또한 심리사회적인 개인의 상태와의 관계 또한 확인하지 않은 경우가 많았다. 따라서 본 연구는 감칠맛을 포함하여 노인의 다섯가지 기본 미각의 민감도에 영향을 주는 요인

을 확인하고자 미각민감도 검사와 신체적, 심리적 다양한 인자들을 검사하였다.

연구대상 및 방법: 65세 이상 노인(연령 분포: 65-103세)을 대상자로 하였으며, 총 98명(남성: 27명, 여성: 71명)의 데이터를 분석하였다. 기본적인 건강 상태, 심리적 건강 상태, 미각민감도 검사를 진행하였다. 이후 각각의 인자들에 대한 통계적 유의성 평가를 위해 윌콕슨 테스트와 크루스칼-왈리스 테스트를 시행하였으며 이 중 유의성을 나타낸 6개의 인자를 바탕으로 노인의 미각민감도에 영향을 주는 인자를 알아보기 위하여 다중회귀분석을 수행하였다.

연구결과: 인지능력이 낮은 그룹에서 쓴맛, 전체 미각민감도가 낮게 나타나는 양의 상관관계가 있었다(각각 OR=0.34, P=0.02/ OR=0.34, P=0.02). 또한 자존감이 낮은 그룹에서 짠맛과 신맛의 미각민감도가 낮게 나타났다 (각각 OR=0.29, P<0.01/ OR=0.38, P=0.03). 남성의 전체 미각민감도가 여성에 비해 낮았다 (OR=0.23, P=0.01).

결론: 노인 미각 민감도에 영향을 미치는 요인으로는 성별, 자존감, 인지능력이 있었다. 감칠맛에 영향을 주는 요인은 본 연구에서 발견되지 않았다.

핵심어 : 미각, 노화, 인지, 자존감, 성별, 노인