

# Digital Image Quantification of Fungiform Papillae to Assess Decreased Taste Sensation Among Geriatric Patients

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## ABSTRACT

**Background:** the taste sensation contributes to evaluate the quality of nutrients, distinguishing between safe and hazardous foods, determining food preferences and food intake. Nowadays taste disorders among geriatric age group is a common health problem which may results in undernutrition and impaired the quality of life. Measurement of papillae number or density, therefore, can provide information about taste function of population.

**Objectives:** to estimate taste scores for basic tastes (sweet, sour, salt, bitter and density of fungiform papilla by digital tongue image analysis among geriatric patients. To correlate the density of fungiform papillae with taste scores of basic tastes.

**Material and Method:** 60 elderly individuals of either sex were included for the study, subjective assessment was done for taste perception and later a blue dye which was Food drug administration approved was used to identify the fungiform papillae. The images were taken using a 48-megapixel camera and analyzed on Adobe Photoshop for clarity of images.

**Results:** mean and standard deviation of total score was  $11.22 \pm 1.9$  and mean standard deviation of fungiform papillae density was  $13.3 \pm 2.01$ . The density of fungiform papillae was correlated with taste scores of basic tastes and strong positive correlation ( $r= 0.79$ ) was seen, which was also statistically significant ( $p<0.001$ )

**Conclusion:** identification of fungiform papillae and assessing density proved to be a noninvasive tool and this result can be adapted in a positive way by dieticians and medical practitioners for improving the food intake of the elderly and improving their health status for a better tomorrow.

**Key words:** Fungiform papillae; Taste; Digital imaging; Geriatric patients

## Introduction

WHO has declared that 2.5% of the global population of those over 65 years is increasing and there will be expected marked shift in the age distribution of the population by 2050. In India, with its population of over one billion people, 6.18% of the total population constitute people older than 65yrs<sup>1,2</sup>. Nutrition among elderly is determined by multiple factors, including specific health problems and individual's level of physical activity, energy expenditure, calorie requirements and personal food preferences. Decreased nutrition due to taste loss in geriatric age group is often poorly recognised and it may be associated with frailty, sarcopenia and poor health outcomes<sup>3</sup>. Impaired gustatory function in elderly people is influenced by non-communicable diseases, upper respiratory infections, oral infections, dental problems, cognitive impairment, depression, radiotherapy, chemotherapy, polypharmacy etc.<sup>4</sup> Many clinical taste problems in the elderly population are likely to be undiagnosed and not many studies on geriatric population have been reported in India.

The four basic tastes which have been identified so far are sweet, salt, sour, and bitter.

The influence of taste on food intake depends on how perceptible sweet, fat, or bitter components are in foods and beverages, as well as the value of sensory factors vs other factors (e.g., health, convenience) on personal dietary choices. Taste buds present on fungiform papillae contains three types of taste cells which helps in taste perception<sup>5</sup>. Researchers have reported 50% of total papillae is present on the anterior quarter, 28% on the next quarter and 22% on the posterior half of the tongue<sup>6</sup>. The number of taste buds differ among fungiform papillae and there are large variations in the distributions of fungiform papillae and taste buds among subjects<sup>7</sup>.

Taste sensation can be measured using both chemical and electrical methods; however, the number of fungiform papillae has a direct effect on chemogustometric and electrogustometric values during evaluation Denver papillae protocol was proposed by Nuessle et al for manually counting the number of papillae in a 10-mm circular section of

the tongue stained with a blue-coloured dye. The fungiform papillae were characterised using image analysis software and digital photography<sup>8</sup>.

Determination of the number of fungiform papillae (FP) on the human tongue is an important measure that has frequently been associated with individual differences in taste sensitivity. At present, there is no standardised method consistently used to identify the number of Fungiform papillae, and primarily scientists manually count papillae over a small region(s) of the anterior tip of a stained tongue<sup>9</sup>. The standard procedure for fungiform papillae counting involves visual identification and manual counting of specific parts of the tongue by trained operators. This is a tedious task and automated image analysis methods are desirable<sup>10</sup>. Taste perception is influenced by various factors such as gender, smoking, nutritional habits and saliva function<sup>11</sup>. It has been reported that perception of sweet taste was higher in 18–25 years of age and bitter sensation was more above 40 years<sup>12</sup>.

Geriatric patients have a number of dental care problems than younger patients and oral changes associated with aging can have a significant effect on the efficacy of dental treatment.

Food can become tasteless and unappetizing for geriatric patients as the result of declining taste and smell perception<sup>13</sup>. There is indeed thrust to discover the extent of taste problems, especially for older individuals as very few studies have been reported in India.

Measurement of number or density of fungiform papillae therefore, can provide information about taste function in elderly subjects. In this context we attempted to assess density of fungiform papillae based on the decreased taste perception for basic tastes among geriatric patients. The purpose of this study was to investigate if there is any relationship between their fungiform density and taste scores. This experiment was a noninvasive tool to help the patients complaining of decreased taste sensitivity.

## Methodology

A hospital-based cross-sectional study was conducted in the Department of Geriatric Medicine, JSS Medical College & Hospital, Mysuru. After obtaining ethical clearance from Institution ethics Committee of JSS Medical College (JSSMC/IEC/220121/10 STS/2020-21) 60 geriatric patients above 65 years of either sex who are satisfying the inclusion and exclusion criteria were included for the study. Prior informed consent was obtained from study participants.

**Inclusion criteria:** Elderly individuals aged above 65 of either sex and who complains of decreased taste sensation and willing to participate

### Exclusion criteria:

- Persons with history of smoking, oral habits (tobacco/pan/gutka chewing) history of head trauma,

surgery, irradiation, chemotherapy, neurological related diseases

- History of recent (dental treatment past 1 week) or oral diseases (xerostomia, hypo salivation, tongue coating, atrophic glossitis) ear, nose and throat infections and other non-communicable diseases

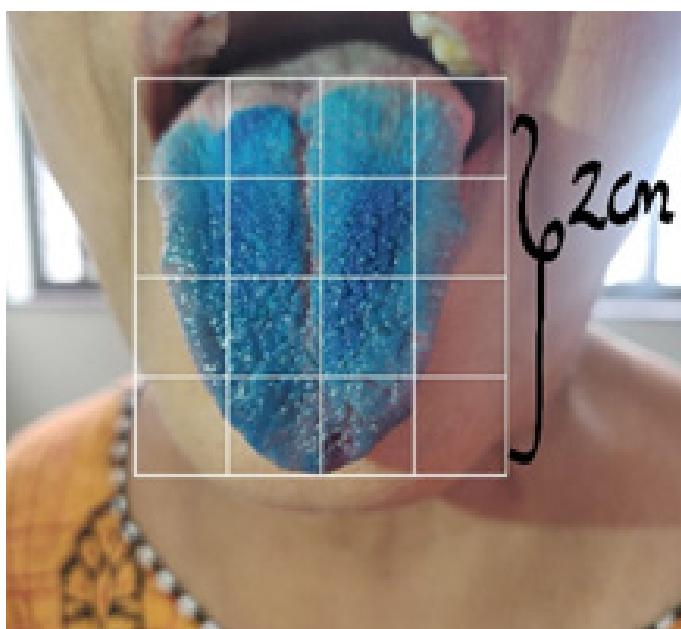
- History of recent drug intake (in past 15 days) or chronic drug intake and food allergies which is known to cause alteration in taste function was excluded from the study.

**Study Design:** All geriatric patients aged above 65 years of either sex attending outpatient/ inpatient was initially screened for assessing decreased taste sensation using pre-structured and pre-validated Questionnaire. Those patients who were identified as decreased taste sensation was included for the study until the sample size is reached. The questionnaire includes details of socio-demographic data, personal history, history of upper respiratory infections, drug intake and allergy, neurological problems, non-communicable diseases and other basic clinical history and examination. As a proxy assessment of nutrition, Anthropometric measures- height, weight, mid arm circumference, and waist circumference were measured with patients barefoot and wearing light clothes. Body mass index (kg/m<sup>2</sup>) was then calculated.<sup>14</sup> Assessment tool of taste perception for basic tastes was used as standardised by Neelima Gupta. Patients were instructed not to eat or drink one hour prior to the test. The filter paper strips of 8 cm length and tip area of 2sq cms were dipped in the respective solutions (four concentrations each of the four basic tastes) and was placed on dorsal surface of anterior part of tongue<sup>15</sup>. Taste scores was estimated for each concentration for all four basic tastants. Score 1 was given for correct identification of each concentration and maximum Score 16 for identification of all the taste strips.

### Digital tongue image analysis of fungiform papillae

Patients were asked to cleanse their mouth by water so that any debris from the oral cavity was wiped out. The patient was positioned comfortably on the armed chair and was instructed to extend his tongue completely. The tongue was dried with filter paper (Whatmann No. 1). The anterior 2cm of dorsal surface of tongue was swabbed with blue colored FDA (Food and drug administration) approved food dye using a cotton tipped tweezer. Then the patient was asked to keep the tongue in steady position and image was taken using Samsung S10 lite android phone with 48-megapixel camera. The images captured were transferred to computer and each participant image was coded and analyzed using Adobe Photoshop by applying method adopted by Shahbake et al.<sup>7</sup> Prior to image analysis, a computerized grid was superimposed and anterior 2cm of tongue was divided into 8 areas of

1 sq cm each on both right and left sides of tongue to prevent overlapping during counting<sup>9,16</sup>. (Figure1). The number of fungiform papillae on each area of tongue images of each participant were counted twice to reduce error.



**Figure 1.** Showing stained anterior 2cms of tongue divided into 8 areas using Adobe Photoshop.

**Statistical analysis:** Socio demographic characteristics is represented using arithmetic Mean and standard deviation. The intensity of taste for each basic tastants is expressed in percentages. Taste scores for basic tastes and density of fungiform papillae was compared in between gender by using independent sample t test. Chi square test was applied to find the association of altered taste and loss of taste with respect to gender.  $p<0.05$  will be considered statistically significant. Pearson correlation test was applied to see the correlation between taste scores and fungiform papillae density. Data was analyzed using SPSS version 22(licensed to JSS AHER).

## Results

60 geriatric patients aged above 65 years of either sex(32 males and 28 females) were initially screened for decreased taste sensation using pre-structured and pre-validated questionnaire. The mean age of the study participants was  $71.58\pm6.2$  years, BMI was  $17.8\pm2.04$  with all 100% of study participants in category 1 and category 2 (There were no participants belonging to Category 3 and 4) according to WHO Asian classification of BMI. 39 Participants had altered taste and 31participants reported loss of taste and 27 participants had both altered taste and loss of taste. 7% showed maximum score 4 for sweet taste, 4% for salt taste, 8% for sour taste and 4% for bitter taste. After subjective assessment perception of taste sensitivity was higher for sour taste. The mean and standard

deviation for sweet taste score was  $2.55\pm0.99$ , salt score was  $2.88\pm0.64$ , sour taste score was  $2.83\pm0.615$ , bitter taste score was  $2.92\pm0.72$ . Mean and standard deviation of total score was  $11.22\pm1.9$  and mean standard deviation of fungiform papillae density was  $13.3\pm2.01$ . On applying independent t Test and Chi-square test none of the variables showed statistically significant difference or association of taste with respect to gender as shown in Table1, Table 2.

The density of fungiform papillae was correlated with taste scores of basic tastes using Pearson's correlation test and strong positive correlation ( $r=0.79$ ) was seen, which was also statistically significant ( $p<0.001$ ) as shown in Table 3 and Figure 2

**Table 1.** Comparison of mean taste scores and fungiform density between the males and females.

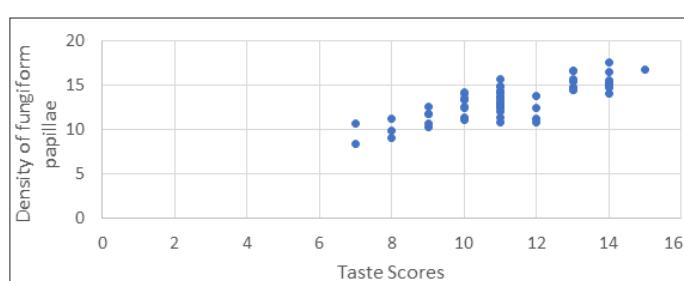
Variable	Males	Females	t-value	p-value
Sweet	$2.41\pm1.0$	$2.71\pm0.937$	-1.19	0.234
Salt	$2.88\pm0.7$	$2.89\pm0.56$	-0.1	0.141
Sour	$2.78\pm0.6$	$2.89\pm0.62$	-0.69	0.682
Bitter	$2.88\pm0.75$	$2.96\pm0.69$	-0.476	0.849
Total score	$11\pm1.9$	$11.4\pm1.8$	-0.941	0.759
FP density	$13.15\pm2.01$	$13.51\pm3.03$	0.682	0.97

**Table 2.** Association of altered taste and loss of taste with respect to gender.

Variable	Gender		Total	Chi-square value	p-value
	Males	Females			
<b>Altered Taste</b>					
Present	24	15	39	3.0	0.083
Absent	8	13	21		
<b>Loss of taste</b>					
Present	18	13	31	0.577	0.448
Absent	14	15	29		

**Table 3.** Correlation between density of fungiform papillae with total taste scores of basic tastes

Variable	Mean	Correlation co-efficient	p-value
Density of fungiform papillae	$13.3\pm2$	0.793	<0.001
Taste scores	$11.22\pm1.9$		



**Figure 2.** Correlation between density of fungiform papillae and taste scores of basic tastes

## Discussion

The present study was intricately designed and carried out among 60 individuals of either sex aged 65 years and above who were willing to participate. There were 28 females and 32 males included in this study. We are aware that with increasing age, taste decreases, fungiform papillae density decreases and geriatric age group has not been studied in depth with respect to this aspect. Taste affects the eating pattern, leading to unhealthy lifestyle and deteriorating health. Understanding taste scores is needed for modifying the diet, contributing to increased life expectancy. The geriatric patients are reported to have declining taste thresholds for salt, sweet, bitter and sour. Evaluating the four varying concentrations of each flavor, it was observed that even in cases of elderly patient complaining of hypogeusia, many were able to detect changes in the concentrations, with increasing the taste intensity.

In present study after subjective assessment, 39 individuals (65%) had altered taste and 31 participants (57%) reported loss of taste and 27 participants (45%) had both altered taste and loss of taste. Mean and standard deviation of total taste score was  $11.22 \pm 1.9$  and mean standard deviation of fungiform papillae density was  $13.3 \pm 2.01$ .

Male children 8–9 years of age are reported to have a higher sensitivity than male adults to the sweet taste of sucrose when small regions of the anterior tongue are stimulated<sup>17</sup>.

In another study, statistically significant increase in threshold values with age were found for all sweet, salty, sour, bitter, and umami taste compounds, indicating a decline in sensitivity toward these tastes<sup>18</sup>. However we did not include umami taste for our study.

8% of study participants showed maximum score 4 for sour taste in the present study. It is in accordance to another study which shows significant associations were found between a higher perception of sour taste and a higher preference for it in females. It was done to analyse the influence of age on the intensity rating of the five basic tastes: sweet, salty, bitter, sour and umami (separately and jointly in a "total taste score") and their modulation by sex and genetics in a relatively healthy population of either sex aged 18–80 years<sup>19</sup>.

In our study Mean and standard deviation of fungiform papillae density in 60 participants was  $13.3 \pm 2.01$ . Mean $\pm$ SD of fungiform density in Males was  $13.15 \pm 2.01$  and  $13.51 \pm 3.03$  in females. In a well-known study of Fischer and his colleagues with 2371 participants (females = 1,263, males = 1,108), aged 21–84 years showed significantly inverse linear relationship between Fungiform density and age<sup>20</sup>.

The Mean $\pm$ SD of fungiform density in the age group 19–87 years of age showed that value within all subjects was  $18.02 \pm 15.95$  fungiform papillae per sq cms, the lowest and the highest values were  $0.25 \pm 0.57$  per cm sq and  $65.00 \pm 1.66$  per cm sq of the tongue tip, respectively<sup>21</sup>. The variation might be there because of the age group of ours being exclusively 65 years and

above. Researches have shown clearly that the density of fungiform papillae plays an important role for taste acuity in females aged >60 years and males aged >50 years. Morphology of fungiform papillae, its vessels and density at the tip of the tongue, as tested by Clinical examination emerge as factors influencing taste function in subjects of both sexes aged >60 years<sup>22</sup>. This result is evidently supported by our study, the density of fungiform papillae showed strong positive correlation ( $r= 0.79$ ) with taste scores of basic tastes, which was also statistically significant. ( $p<0.001$ ).

In the present study Mean $\pm$ SD of taste scores was  $11 \pm 1.9$  in males and  $11.4 \pm 1.8$  in females respectively. The study conducted in Brazilian population supports this in which 46 volunteers participated in the research, thirteen of whom were adult employees and thirty-three of whom were elderly residents. (>65years) in which the gender was not significantly associated with the taste perception of the individuals evaluated. This was in accordance to the present study<sup>23</sup>.

A study conducted in Norway in elderly individuals aged above 70 years, impaired taste was assessed by filter strip method and reported that impaired taste strongly associated with mortality in acutely hospitalized elderly people<sup>24</sup>.

This clearly depicts that the Fungiform papillae density, taste scores and survival of the elderly is like a web of causation and if we are able to spot the right thing at the right time we will be able to make a huge difference. Further investigation in this direction with more subjects and even including patients with comorbidities is necessary to enlighten the minds, and help the geriatric patients for a better diet, nutrition and longevity of life.

## Conclusion

The study of identifying fungiform papillae, assessing density and correlating with taste scores proved to be a noninvasive tool. We included geriatric age group as previously no dedicated study has been done, so this opens a new window for exploration of the unknown. As, there is a strong correlation between the Fungiform density and taste scores, the same could be used to guide the dieticians for modifying food habits in geriatrics accordingly so they could lead a better and healthy life. Despite the prevalence of taste deficit in elderly individuals, there is wide gap of knowledge in this research area. Therefore, understanding the concept of taste perception and its correlation with fungiform density is of prime importance and to discover the extent of taste problems, especially for older individuals, and to educate them about potential hazards and ways to avoid these hazards.

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