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ORIGINAL ARTICLE

Comparative evaluation of gustatory function between postmenopausal women and age-matched men

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OBJECTIVE: The aim of the study was to compare the gustatory function between postmenopausal women and age-matched men.

SUBJECTS AND METHODS: During a period of 4 months, 30 postmenopausal women and 30 age-matched men were prospectively evaluated for gustatory function. Each subject was given a symptoms questionnaire for self-assessment of taste function. Then, whole mouth taste test was performed in which the quality identification and intensity ratings of taste solutions were measured.

RESULTS: Regarding correct quality identification, the results were statistically non-significant ($P > 0.05$). As far as the intensity judgments are concerned, significant difference exists between postmenopausal women and age-matched men. Intensity of taste perception for sucrose was significantly lower in postmenopausal women than intensity of taste perception for other tastes ($P < 0.05$). One of the noticeable findings is that 15 (50%) postmenopausal women reported a change in dietary habits; all expressed liking for sweeter food.

CONCLUSION: Postmenopausal women appeared to have a reduced perception of sucrose, which can alter eating habits, such as intake of more sweet foods, whereas no significant difference is observed in taste perception of NaCl, citric acid and quinine hydrochloride between postmenopausal women and age-matched men. Fifteen (50%) postmenopausal women stated fondness for sweet taste.

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Keywords: taste; dysguesia; menopause; gustatory function; perception

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Introduction

'Taste' is the ability to respond to dissolved molecules and ions called tastants. The sense of taste is one of the most important human senses and plays a critical role in an individual's food preferences, which ultimately guide the dietary behaviour and thus the nutritional status of humans. Taste abnormalities are common in general population and oral physicians are generally the first healthcare professionals who identify taste abnormality.

Human taste perception may be categorised into four well known and widely accepted descriptors, viz. sweet, bitter, salty and sour. Even though a person can perceive literally hundreds of different tastes, they are supposed to be the combination of these four basic tastes. Different tastes either fulfil the requirements of the human body (sweet – carbohydrates and salty – sodium chloride) or cause aversive, avoidance reactions (bitter and acidic). Thus, it is said that the taste drives appetite as well as protects us from poisons (Guyton and Hall, 2006; Scott and Verhagen, 2000). To complete an absolute need for protein, the 'new' (fifth) taste quality umami which is the meaty, savoury taste is introduced and included in four basic tastes (Herness and Gilbertson, 1999; Reed *et al*, 2006).

In humans, taste sensation originates in taste buds in the mouth. It was once thought that particular areas of the tongue are specialised in detecting specific taste, but investigators now believe that every taste bud has some degree of sensitivity to all of the primary taste sensations (Winkler *et al*, 1999). Taste perception begins when a taste-eliciting molecule, or tastant interacts with specialised receptors in the membrane of a taste cell. Taste is the direct detection of chemical composition, usually through contact with chemoreceptor cells (Herness and Gilbertson, 1999; Scott and Verhagen, 2000). It is very similar to olfaction, the sense of smell in which the chemical composition of an organism's ambient medium is detected by chemoreceptors and helps to determine flavour. Many patients complain of taste loss and yet testing reveals the presence of normal taste. In most of these cases, it is flavour that has been impaired. Flavour is a complete sensory experience arising from ingested

stimulant molecules and involves taste, smell, texture and temperature (Mann, 2002).

The aetiopathogenesis of gustatory dysfunction is multifactorial, amongst which one of the factors is menopause, a normal developmental stage in woman's life that occurs at around the age of 50 and is accompanied by a number of characteristic physical changes. A few changes are seen in the oral cavity, such as mucosal dryness, burning sensation and dysguesia, the probable cause of which may be hormonal modifications (Forabosca *et al*, 1992; Wardrop *et al*, 1989). Dysguesia makes food tasteless and thus compromises food intake, nutrition and the quality of life. Therefore, accurate clinical assessment of taste function is essential. But, little information is available on measured gustatory function in postmenopausal women.

The present study was undertaken with the following aims: (i) to evaluate the possible alterations of the gustatory function in postmenopausal women and (ii) to compare the alterations in taste between postmenopausal women and age-matched men.

Materials and methods

This Institutional Ethical Committee approved case–control study included sixty patients, who were selected from those attending the outpatient Department of Oral Medicine and Radiology, Sharad Pawar Dental College, Wardha, for routine dental treatment. Of these total 60 subjects, the study group included 30 postmenopausal women in the age range of 50–75 years (mean age 60.75 ± 7.89) and control group included 30 age-matched men, in the age range of 50–74 years (mean age 60.23 ± 5.60). Female subjects were selected randomly by confirming the complete amenorrhoea time from the patients. Male subjects were recruited randomly among volunteer patients.

Inclusion criteria were patients with history of complete amenorrhoea, patients not taking any medication [including hormone replacement therapy (HRT) for female patients], not a denture wearer and having good oral hygiene. Exclusion criteria were patients having any oral diseases (like oral submucous fibrosis and candidiasis), systemic diseases (such as diabetes, nutritional deficiency, cardiovascular, respiratory and endocrinal disorders), history that could affect gustatory function (history of radiotherapy) or habit of smoking in all subjects.

Patients were informed about the research study, procedure and their written consents were obtained. Considering close correlation of intensity of taste perception with diurnal quantitative salivary secretions, all measurements were recorded in the late morning or afternoon, at least one hour after each patient had finished eating (Between 11:00 a.m. and 2:00 p.m.) in a comfortable room free from noise and distraction. Before the experiments, each subject was given a symptoms questionnaire for self-assessment of taste function that included five general questions, five specific taste questions and three questions for women only as follows: (Ship and Chavez, 2001)

Questionnaire

A. General questions:
   1. Have you experienced a loss in taste?
   2. How long have you had taste loss? Was the loss sudden or gradual?
   3. What was the precipitating event for your taste problem?
   4. Have you experienced changes in hot and cold sensations in your mouth?
   5. Have you experienced reduced salivation or dry mouth?

B. Specific taste questions:
   1. Can you taste the sweetness of ice-cream?
   2. Can you taste the saltiness of potato chips?
   3. Can you taste the sourness of lemons?
   4. Can you taste bitterness of coffee?
   5. Which taste you prefer most?

C. Questions for women only:
   1. What is the duration of complete amenorrhoea?
   2. Can you taste four basic tastes as strongly as before menopause?
   3. After menopause, did your dietary habits change?

To test gustatory function, a whole mouth above threshold taste test was carried out in which a concentration series of sucrose, sodium chloride, citric acid and quinine hydrochloride solutions were used for sweet, salty, sour and bitter types of taste respectively (Akal *et al*, 2004; Delilbasi *et al*, 2003a,b). This test was used to detect, identify and evaluate the intensity of different concentrations of taste solutions. In this test, quality judgments and intensity ratings for each stimulator solution were evaluated. Five concentration levels (in ½ log steps) of sodium chloride (0.01–1.0 mM), citric acid (0.32–0.032 mol l^{-1}), quinine hydrochloride (0.01–1.0 mM) and sucrose (0.01–1.0 mM) were prepared in 5 ml samples (Delilbasi *et al*, 2003a,b; Delilbasi *et al*, 2003a,b). All the solutions were made with distilled water. The intensity threshold of taste perception of each solution was determined by scoring the lowest concentration as '5' and the highest concentration as '1' (Akal *et al*, 2004).

Each tastant included five millilitre taste solutions, at room temperature, which were presented to the patient in a cup along with two cups of distilled water on the tray in a random order. Each patient was told to hold the test solution in the mouth for 15 s after rinsing with water (at least once before, between and after last use of rinse of test solution), and to expectorate the solution thereafter. The solutions were given in increasing concentrations. The patient was then called to identify the quality (salty, sour, sweet, bitter or tasteless) and intensity of each test solution (Delilbasi *et al*, 2003a,b) Quality judgments for each solution were coded as correct, incorrect or tasteless by asking subjects to name the taste they perceived (Formaker and Frank, 2000). To evaluate the significance of the parameters used between the two investigated groups chi-square test and students unpaired *t* test were used. For the parameters, 95% confidence intervals were calculated.

Results

The gustatory function was evaluated in 30 postmenopausal women (mean age 60.75 ± 7.89) and 30 age-matched men (mean age 60.23 ± 5.60) and comparisons of the results were made between two groups. In this study, instead of young premenopausal women, age-matched men were selected for comparison in the control group to avoid age-related taste alteration bias.

Regarding correct quality identification, the results were statistically non-significant. ($P > 0.05$) as shown in Table 1, Figure 1. Both groups detected salt, sour and bitter tastes correctly. Two postmenopausal women were unable to identify the quality of sweet taste and one man from the control group failed to identify the quality of sweet taste. They coded this quality as tasteless.

As far as the judgments of intensity of taste perception are concerned, intensity of taste perception for sweet was significantly lower in postmenopausal women than judgments of intensity of taste perception for other tastes ($P < 0.05$) as shown in Tables 2, 3, 4 and 5. There was a highly significant difference in mean total taste intensity ratings for sucrose between postmenopausal women and age-matched men ($P < 0.05$), but considering mean total taste intensity ratings for sodium chloride, citric acid, quinine hydrochloride, no significant difference was observed between the groups ($P > 0.05$) as shown in Table 6 and Figure 2.

All the participants answered the questionnaire appropriately. Amongst all, six (20%) women and two (6%) men experienced loss of taste sensation particularly for the sweetness of ice-cream and the saltiness of potato chips, duration of which ranged from 5 to 15 years. In approximately all the subjects, taste loss was gradual and not associated with any specific event. In the symptom questionnaire, no participant reported oral somatosensory problems or diminution in salivary flow.

Duration of complete amenorrhoea varied from 3 to 25 years. There was no correlation between the duration of amenorrhoea and duration of taste alteration. Only six (20%) female subjects noticed failure in tasting all basic taste substances as strongly as before menopause and 15 (50%) reported a change in dietary habits; all expressed liking for sweeter food. Preference to 'sweet'

Table 1 Correct quality identification: whole mouth taste test

	Study group	*Control group*	
Taste solutions	*Number (%)*	*Number (%)*	P-*value*
NaCl	30 (100)	30 (100)	0.013
Citric acid	30 (100)	30 (100)	NS
Quinine hydrochloride	30 (100)	30 (100)	$P > 0.05$
Sucrose	28 (93.33)	29 (96.66)	

NS, not-significant.

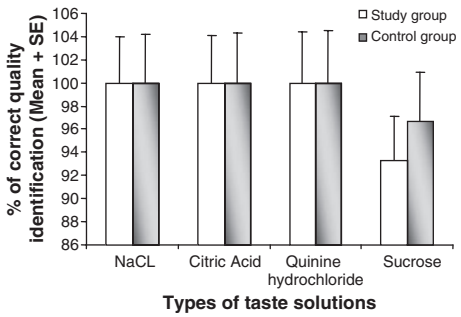

Figure 1 Percentage of correct taste quality identification by the patients

Table 2 Percentage of intensity of salty (NaCl) taste perception identification

Concentration levels of taste solutions	*Study group number (%)*	*Control group number (%)*	P-*value* χ^2-*value*
1	03 (10.00)	00 (00.00)	6.36
2	02 (06.66)	02 (06.66)	NS
3	07 (23.33)	05 (16.66)	$P > 0.05$
4	15 (50.00)	14 (46.66)	
5	03 (10.00)	9 (30.00)	

NS, not-significant.

Table 3 Percentage of intensity of sour (citric acid) taste perception identification

Concentration levels of taste solutions	*Study group number (%)*	*Control group number (%)*	P-*value* χ^2-*value*
1	01 (03.33)	00 (00.00)	5.76
2	00 (00.00)	02 (06.66)	NS
3	06 (20.00)	03 (10.00)	$P > 0.05$
4	17 (56.66)	14 (46.66)	
5	6 (20.00)	11 (36.66)	

NS, not-significant.

Table 4 Percentage of intensity of bitter (quinine hydrochloride) taste perception

Concentration levels of taste solutions	*Study group number (%)*	*Control group number (%)*	P-*value* χ^2-*value*
1	01 (03.33)	00 (00.00)	2.64
2	01 (03.33)	00 (00.00)	NS
3	03 (10.00)	04 (13.33)	$P > 0.05$
4	13 (43.33)	11 (36.66)	
5	12 (40.00)	15 (50.00)	

NS, not-significant.

Table 5 Percentage of intensity of sweet (sucrose) taste perception identification

Concentration levels of taste solutions	*Study group number (%)*	*Control group number (%)*	*P-value* χ^2-*value*
1	06 (20.00)	01 (03.33)	18.15
2	07 (23.33)	01 (03.33)	Significant
3	08 (26.66)	06 (20.00)	$P < 0.05$
4	07 (23.33)	13 (43.33)	
5	00 (00.00)	08 (26.66)	

Table 6 Mean total taste intensity ratings from whole-mouth taste test (summed across concentrations)

	Total taste score (mean ± s.d.)			
Taste solutions	*Study group* (n = 30)	*Control group* (n = 30)	t-value	P-*value*
NaCl	3.43 ± 1.05	3.90 ± 0.80	1.87	0.06 NS $P > 0.05$
Citric acid	3.90 ± 0.84	4.13 ± 0.86	1.06	0.29 NS $P > 0.05$
Quinine hydrochloride	4.13 ± 0.97	4.36 ± 0.71	1.05	0.29 NS $P > 0.05$
Sucrose	2.40 ± 1.24	3.66 ± 1.37	3.73	0.00 S $P < 0.05$

n, number; S, significant; NS, non-significant.

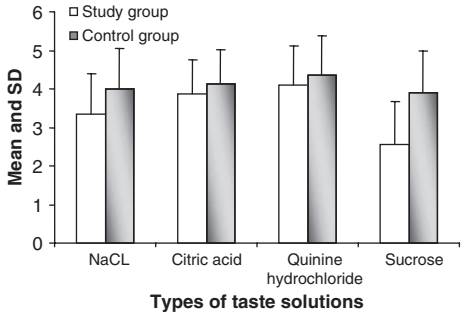

Figure 2 Mean total taste intensity ratings from whole-mouth taste test (summed across concentrations)

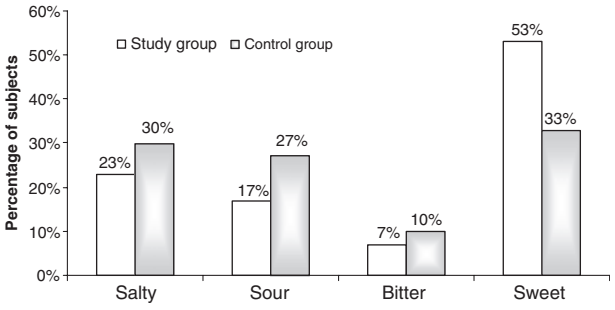

Figure 3 Basic taste preferences in all subjects (data from self assessment questionnaire)

Table 7 Basic taste preferences in all subjects (data from self-assessment questionnaire)

	Basic tastes preferences			
Study population (%)	*Salty (%)*	*Sour (%)*	*Bitter (%)*	*Sweet (%)*
Study group 30 (100)	07 (23)	05 (17)	02 (7)	16 (53)
Control group 30 (100)	09 (30)	08 (27)	03 (10)	10 (33)
χ^2-value	2.52			
P-value	0.47, not significant, $P > 0.05$			

taste was exposed by 16 (53%) postmenopausal women, whereas no such noticeable preference for sweet was observed by the age-matched men as shown in Table 7 and Figure 3 Even though 10 (33%) age-matched men mentioned first preference to sweet taste, there was no obvious difference amongst sweet, salty and sour tastes. Both groups showed an overall disliking for food with bitter taste.

Discussion

Postmenopausal changes occur in various sensory organs which include taste organ also leading to dysguesia and thus oral discomfort (Mott *et al*, 1993; Forabosca *et al*, 1992). Although direct cause and effect relationship is not established between taste alteration and menopause, the increase in incidence of oral discomfort among women during menopause is probably because of hormone modifications (Forabosca *et al*, 1992; Wardrop *et al*, 1989). Wardrop *et al* (1989) found significantly higher prevalence of oral discomfort in perimenopausal and postmenopausal women (43%).

There have been a number of studies that have searched for possible causes of dysguesia in postmenopausal women. As far as the hormonal cause is considered, the controversial results are reported in different studies regarding resolution of discomfort with appropriate HRT. According to Wardrop *et al* (1989), in approximately two thirds of the menopausal women, symptoms of oral discomfort were relieved after HRT in their study, whereas a study by Tarkkila *et al*, 2001, 2008 showed no difference in oral health status between women using or not using HRT. According to Delilbasi *et al* (2003a), oral discomfort reported in postmenopausal women may have a number of different causes and may not be related to hormonal changes that occur. An association between oral discomfort and psychological symptoms in menopausal women is also reported in a previous study (Wardrop *et al*, 1989). Bercovici *et al* (1985) concluded that oral discomfort in postmenopausal women is caused by local irritants. So, on the basis of available literature, reasons for dysguesia in postmenopausal women appears to be multiple involving the interaction of biological and psychological systems and whatever may be the reason, correct evaluation and its management is the main consideration for dentist.

The principal findings of this study are significantly reduced intensity of taste perception for sweet and reduced mean total intensity rating for sucrose in postmenopausal women and are consistent with the findings of Delilbasi *et al* (2003a) and suggest decline in sweet sensitivity. On the other hand, the mean total taste intensity ratings of sodium chloride, citric acid and quinine hydrochloride amongst two groups are not enough to conclude that there is decline in sensitivity to salty, sour and bitter taste respectively in postmenopausal women.

Delilbasi *et al* (2003a) linked decline in sucrose sensitivity in postmenopausal women with altered diet. Bartoshuk *et al* (2006) suggested a correlation between hedonic properties of sweet and fat with body mass index. They stated that higher body mass index (BMI) is associated with lower perceived sweetness and lower perceived sweetness is associated with increased difference between liking for fat foods and liking for sweet foods (Bartoshuk *et al*, 2006). Formaker and Frank (2000) mentioned about the lowered intensity ratings to NaCl and sucrose in burning mouth syndrome and they hypothesised that pain pathway activation may affect neural and behavioural taste function. Kaneda *et al* (2000) observed no significant difference between elderly and young in the detection threshold for sucrose, whereas this study showed decreased sweet perception significantly in postmenopausal women, but not in age-matched men.

The healthy male volunteers had higher mean total taste intensity ratings than the postmenopausal women in the present study. In contrast to this, with regard to gender, studies by Ahne *et al*, 2000; Hummel *et al*, 1997 described that women generally exhibit a more sensitive sense of taste than male subjects. Mojet *et al* (2001) also concluded that there is a general loss with age in taste acuity and in the specificity of taste sensitivity and men are more prone to losses than women.

In this study, almost all the subjects noticed gradual taste loss and that was not associated with any specific event. Delilbasi *et al* (2003b) described the factors besides ageing like habit of smoking, dietary habits, dentition status that could contribute to gradual loss of taste. Ahne *et al* (2000) noticed frequent confusion of salty and sour taste as they both sting slightly on tongue. None of the patient in our study had such a confusion regarding taste identification.

Decrease in gustatory function in postmenopausal women is not only of importance in terms of enjoyment of food but it also directly affects the food intake and thus nutritional status. Deterioration of gustatory perceptions and the tendency towards higher salt and sugar intake in diet can lead to health-hazardous conditions in the life of the elderly people (Delilbasi *et al*, 2003b). In this study, women reported preference for sweeter food. The sweetness preference derives from multiple separate genetic and environmental factors and may lead to adverse health effects through the excess use of sugar (Keskitalo *et al*, 2007 and Reed *et al*, 2006).

Swithers and Davidson (2008) affirmed that animals may use sweet taste to predict the caloric contents of food. They also suggested that consumption of products containing artificial sweeteners are more harmful, as it may lead to increased body weight and obesity by interfering with fundamental homeostatic, physiological processes.

With regard to the alteration in dietary habits in postmenopausal women, the findings of the present study are comparable with the study by Delilbasi *et al* (2003a). Postmenopausal women rated 'sweet' to be most pleasant taste and thus preferred to eat more sweet food; however, age-matched men did not mention affinity for particular taste. A fondness for particular taste during the developmental journey of a woman from birth to menopause is documented in previous studies also. Verma *et al* (2005) observed cyclic variation in salt preference in females during different phases of menstrual cycle whereas Kuga *et al* (2002) in their study stated preference for sour taste in women during pregnancy. The pregnancy is accompanied by decreased gustatory sensitivity to consume adequate electrolytes and to support their child with all nutrients (Belzer *et al*, 2009; Kolble *et al*, 2005).

One-third of a woman's remaining life stays ahead after her last menses and thus protecting and maintaining her oral and general health should be major considerations.

Improvement in taste perception is possible by tongue brushing, adding seasonings and flavouring agents in food, which will add to the enjoyment of food and compensate for the decline in taste acquity (Winkler *et al*, 1999). Mann (2002) suggested the use of tricyclic antidepressant and clonazepam in patients having dysguesia and burning mouth syndrome, but these drugs should be used cautiously. Reassurance is one of the most important aspects of treatment in these disorders because cures are often difficult to obtain and may take weeks, months or years.

In this study, a whole mouth taste test was used which showed statistically significant results between study and control groups indicating that gustatory function can be evaluated by means of this test. However, regional or spatial taste-testing system is also one of the methods used to evaluate the gustatory function, but has few limitations. If the tastant or stimulant solution is applied by means of cotton swabs or small pieces of filter paper, there is poor diffusion of the stimulus and if the drops of solution are used for presentation to the tongue, then it does not allow for precise control of the spatial/regional extent of the stimulus on the tongue's surface. That means even though a stimulant is applied locally, it suddenly dissolves in saliva and spreads over a larger area (Ahne *et al*, 2000; Hebhardt *et al*, 1999). It is well known that saliva and taste mutually influence each other (Spielman, 1990). In our study, none of the subjects complained of dry mouth or insufficient saliva production. Thus, regional or spatial taste testing method, we feel, is ineffective in these cases. Spatial taste testing method is helpful, especially in cases of post surgery, tumour, stroke, viral infections in which localised area of taste impairment is present. However, whole-mouth tests of gustatory function are needed to assess 'everyday' taste experiences that are not reflected by regional tests (Ahne *et al*, 2000). To overcome the limitations of regional taste testing method, Ahne *et al* (2000), assessed gustatory function by means of tasting tablets.

The present study is suitable, easy to perform, inexpensive, requires minimal time, least discomfort to patient. However, the study shows few shortcomings such as being a subjective test, no accurate quantification of the disorder is possible. The study does not demonstrate structural and functional defects. These shortcomings can be fulfilled by using new methods like an automated regional taste testing system and objective modalities such as gustatory-evoked potential testing (Taylor & Francis, 2002; Hebhardt *et al*, 1999).

In the present study, even though questionnaire data are comparable to statistical data, it should be kept in mind that assessment of taste function on the basis of questionnaire is relatively insensitive in detecting persons who have true taste problem. Soter *et al* (2008), described a number of possible reasons for poor detection of taste function by self-report.

Conclusion

As gustatory dysfunction directly influences the nutritional status, its evaluation in postmenopausal women could be a good attempt to know their intensity of individual type of taste perception. In this study, intensity of taste perception for sweet was significantly lower in postmenopausal women, but there was no significant difference in taste perception of salty, sour and bitter between postmenopausal women and age-matched men. Postmenopausal women specifically showed their fondness for substances of sweet taste.

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Author contributions

Dr SB Dangore-Khasbage – The corresponding author of this manuscript, assumed the overall responsibility for the study (selection of patients, evaluation of patients, carrying out taste tests) and prepared the original manuscript. Dr SS Degwekar and Dr RR Bhowate decided the aims & objectives of the study, planned the research design and interpretated the results. Dr MB Motwani and Dr AD Indurkar – Contributed during revision of manuscript (revision of English language and explanation to queries raised by reviewers). Dr VK Lohe – Collected and analysed the data. Dr VY Babar – Statistical analysis.

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