Original Article

Threshold sensitivity of taste perception and the role of saliva and Zinc level in some physiological & pathological conditions

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Summary:

Background: Decreased taste acuity to the four basic tastes is closely related to health problems (diseases & medications), aging, and smoking. This study aimed to determine taste detection and recognition thresholds to the four basic tastes in some physiological and pathological conditions, determine saliva flow rate, serum and saliva zinc levels in these groups.

Objective and Methods: The study includes 218 individuals (35–80) years old divided into six groups; the control, aging (subjects over 60 years), smokers, diabetics, haemodialysis patients and hypertensive patients on chronic use of captopril.The taste detection and recognition thresholds of sweet, salty, sour and bitter tastes, saliva flow rate were determined. Zinc concentration was assessed in serum and saliva spectrophotometricaly.

Results: The results showed a significant increase in the taste detection and recognition thresholds of the four basic tastes of all groups than in the control, except the salty taste thresholds of the haemodialysis group and the salty taste detection threshold of the diabetics.

Saliva flow rates, serum and saliva zinc levels decreased significantly at $p<0.001$ in study groups as compared to the control group.

Conclusions: The taste acuity was impaired in aged subjects, smokers, diabetics, haemodialysis patients, and hypertensive patients on chronic use of captopril.

Decreased saliva flow rate and saliva zinc concentration could be causative factors for hypogeusia.

Key words: taste threshold, serum zinc, saliva zinc.

Introduction:

Taste is the sensory system devoted primarily to a quality check of food to be ingested. Although aided by smell and visual inspection, the final recognition and selection relies on chemoreceptive events in the mouth (1). Dysgeusia defined as(distorted sense of taste), which is often used as a general description for any taste abnormality, more specific terms include ageusia (complete loss of taste sensation); hypogeusia (impairments of the sense of taste or decrease in taste perception, leading to an increase in the taste threshold);hypergeusia (increased sensitivity for taste stimuli); parageusia (bad taste in the mouth); phantogeusia that is a gustatory hallucination (perception of a taste in the absence of a stimulus); gustatory agnosia (loss of the ability to identify a given taste stimulus, although still able to recognize between different stimuli), while normogeusia (is the name given to normal taste)(2). Saliva plays an important role in taste perception (3).As taste stimulants require salivary secretion to get to the taste buds, so patients with decreased or absent saliva exhibit decreased taste acuity (4).

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Similarly, zinc plays an important role in taste perception as several investigators linked the trace metal zinc with changes in taste function (5). Most of these studies were performed on subjects who apparently developed zinc deficiency secondary to a health problem.

The purposes of this study were: - Determine the taste detection and recognition thresholds of the four basic tastes in some physiological and pathological conditions and compare them with a group of healthy volunteers, Determine saliva flow rates, serum and saliva zinc levels of these groups.

Material and methods

Subjects Selection:

Two hundred eighteen subjects were included in this study, between 35-60 years, except the aging group which was between 65-80 years. They were divided as follow: Control group: consists of 36 healthy, non smoker subjects, 18 were males and the remaining18 were females.

Aging group: Consists of 30healthy, non smoker subjects, over the age of 60 years, 12 were males and 18 females.Smoking group: Consists of 40 healthy, smoker subjects, 30 were males and 10 were females.

Diabetes Mellitus group: Consists of 40, non smoker, diabetic patients (Type II), 16 were males and 24 were females.Chronic Renal Failure (Haemodialysis) group: Consists of 36, non smoker, haemodialysis patients with chronic renal failure, 20 were males and 16 were females.Hypertension group: Consists of 36, non smoker, hypertensive patients on chronic use of captopril, 18 were males and 18 were females.

Patients were collected from Ibn-Seena teaching hospital in Mosul city during the period from February/2007 to August/2007.

Methods:

Taste Threshold Tests

Sensorial analysis: Quantitative tests for the four basic tastes (sweet, salty, sour, and bitter) have been used to determine, the taste detection and recognition thresholds. The four basic tastes, sweet, salty, sour, and bitter were represented by solutions of sucrose, sodium chloride, citric acid, and quinine HCl, respectively. All solutions were prepared with deionized water and stored at 4 °C in screw-cap glass bottles for no longer than one week. Each taste gradient consisted of fifteen solutions of different concentrations which are given in table (1). After every participant clearly distinguished and identified each taste, detection and recognition thresholds were determined using the method of least noticeable differences, also known as Test of Limits (6), which was the sensorial test used to determine the taste thresholds.

Samples collection:-

Serum: Three ml of venous blood was aspirated from each subject, using a disposable syringe with a stainless steal needle and collected in plane tubes. The blood was let to clot and serum was obtained by centrifugation which was immediately transferred into other tube and frozen at (-20) °C for subsequent analysis.

Saliva and salivary flow rate: The sample of unstimulated whole saliva was collected from the subjects by using spitting method .Collection was performed at least two hours after breakfast.

Salivary Flow Rate: was calculated as the volume in (ml) of the sample collected divided by the time in (minute) required for collection.

Salivary Flow Rate (ml/minute).

Serum and saliva zinc levels: Zinc concentration was assayed by using flame atomic absorption spectrophotometer (AAS). Assay was done within one month of collection at the College of Civil Engineering in the University of Mosul, according to (Milne,1999)(7)

Statistical Analysis: A computerized program, the statistical package for the social sciences (SPSS) was used for data analysis.

Mean, Standard deviation (SD), Student t-test (unpaired), Unpaired Z-test were used.

Results:

Age & Sex: The highest mean age was in the aging group with (69.7±5.66 year), while the mean age of the other groups ranged between (46.06±8.23 year) for the haemodialysis group and (52.28±5.43 year) for the medication group, as shown in table (2).

The distribution of the groups included in the study according to sex shows that the higher male to female ratio was in the smokers, as smoking is more common in adult males (table 2).

Comparison of Taste Thresholds with the Control Group

Aging Group: The results showed highly significant increase ($p<0.001$) in the detection and recognition thresholds of the basic tastes (sweet, salty, sour, and bitter) of this group compared with control group (table3).

Smokers Group: The detection and recognition thresholds of the basic tastes increased significantly in smokers compared with control group (table3). The highest increase was in the detection and recognition of bitterness thresholds, while the lowest was in sourness detection threshold only.

Diabetic Group: Diabetic patients showed significant increase in the detection and recognition thresholds for the basic tastes compared with control group except for detection threshold of saltiness which exhibited a non significant increase (table 4).

Haemodialysis Group: Haemodialysis patients with chronic renal failure exhibited a significant increase in the detection and recognition thresholds for the basic tastes when compared with the control group, except for salt detection and recognition thresholds which exhibited a non-significant decrease (table 4).

Hypertension Group: The results showed a highly significant increase in the detection and recognition thresholds of the hypertensive patients on chronic use of captopril for the basic tastes compared with the control group (table4). Saliva Flow Rates: The results showed a highly significant decrease in saliva flow rate of the study groups in comparison with the control group at $p<0.001$ as shown in (table5). The maximum decrease occurred in haemodialysis group by more than 70%.

Serum and saliva Zinc Concentrations : The results showed a highly significant decrease in serum and saliva zinc concentrations of the groups included in this study in comparison with the control group at $p<0.001$, except in diabetic patients which recorded non significant difference in serum zinc concentration (table5).

Discussion:

Aging Group: Taste acuity was impaired in aged subjects, as their taste detection and recognition thresholds of the four basic tastes increased significantly in comparison to the younger control group, which agreed with the results of Fukunaga *et al*. (8).This reduction in the salivary flow rate could be explained on the basis of the physiological decline that accompany aging process, which results in structural changes in the salivary glands, with loss of the secretary epithelium (9). Serum and saliva zinc levels decreased significantly with age. The decrease in serum zinc was also reported by Turnlund *et al*. (10).The age related changes in zinc concentrations could result from age related changes in zinc – associated proteins. Zinc is commonly found associated with a protein in biological fluids, salivary zinc protein called gustin; serum zinc protein is mostly albumin in addition to other proteins (11).Thus, the decrease in serum albumin levels and saliva protein with age could be responsible for the age associated decrease in zinc levels. Smoking Group: Smoking resulted in hypogeusia and significantly higher taste detection and recognition thresholds of the four basic tastes than nonsmokers, which agreed with the result of Sato *et al*. (12).The reduction in salivary flow rate may be due to the direct effect of nicotine and other cigarette poisons on the salivary glands, which could lead to degeneration of the salivary glands. Serum and saliva zinc levels in smokers were significantly decreased. The decrease in zinc levels could be due to oxidative stress caused by cigarette smoke. Several studies documented that smoking may increase oxidative stress and impaired oxidant defense system .As zinc is considered as part of antioxidant enzyme superoxide dismutase SOD (13). Diabetes Mellitus :Taste detection and recognition thresholds of the four basic tastes increased significantly as compared to control group, except the salty taste detection threshold, which also increased, but not significantly, which may be due to decreased salivary sodium level (14).

Salivary flow rate was significantly decreased. This is probably due to the dehydration from excessive urination (polyuria), metabolic control of the diabetic state, medications, and neuropathy of the autonomic nervous system since salivary flow is controlled by the sympathetic and parasympathetic pathways (15).Serum zinc levels were comparable between diabetic and non diabetic subject. Saliva zinc level was significantly decreased; this result was in agreement with the results of Diwan *et al*. (16). Haemodialysis Group: The salty taste acuity is found to be related to salivary sodium level. Saliva is a dilute solution of salt, taste receptors are bathed in saliva, constantly exposed to the stimulus and adapt to the sodium level of this fluid. To elicit a salty sensation, this level must be exceeded by a given concentration (17).The reduction in the salivary flow rate in haemodialysis patients is probably caused by a combination of direct involvement of salivary glands, chemical inflammation, dehydration, mouth breathing (Kussmaul's respiration), and salivary adenitis (18).

Serum and saliva zinc levels in haemodialysis patients were significantly decreased. The occurrence of zinc deficiency in patients with renal disease can be attributed to loss of protein – zinc complexes in proteinuria or to decreased tubular reabsorption of zinc (7), or it may be due to the general malnutrition.

Hypertension Group: Hypertensive patients on chronic use of captopril had impaired taste acuity and significantly increased taste detection and recognition thresholds of the four basic tastes, which was agreed with the result of Zervakis *et al*. (19). Salivary flow rate of hypertensive patients on chronic use of captopril was significantly decreased because Captopril may reduce the salivary flow rate by reducing the body'sfluids, since captopril is angiotensin converting enzyme inhibitor, which lower the blood pressure by blocking the angiotensin converting enzyme in the renin – angiotensin – aldosterone system, decreased secretion of aldosterone resulting in decreased sodium and water retention (20). Serum and saliva zinc levels in hypertensive patients on chronic use of captopril were significantly decreased; this is due to increased zinc loss. Captopril is one of a number of drugs that contain a sulphydryl group (SH), there is a possibility that the ability of the SH group of captopril to bind to bivalent metals induces a state of urinary zinc loss (21).

Table (1) Concentrations of solutions used to determine taste detection and recognition thresholds.

Sucrose (mmol/L)	Sodium Chloride (mmol/L)	Citric Acid (mmol/L)	Quinine HCl (µmol/L)
5	5	0.08	0.056
15	15	0.2	0.1
25	25	0.4	0.18
50	50	0.8	0.31
75	75	1.8	0.56
100	100	2.8	1.0
125	125	3.8	1.8
150	150	4.8	3.1
200	200	5.8	5.6
250	250	6.8	10
300	300	7.8	18
350	350	8.8	31
400	400	9.8	56
450	450	10.8	100
500	500	11.8	180

Table (2) Mean, standard deviation, and range of age with sex distribution of the groups included in the study.

Groups	N	Mean age	±SD	Male %.	Female %
Control	36	48.72	±7.3	50	50
Aging	30	69.7	±5.66	40	60
Smokers	40	46.9	±6.39	75	25
Diabetes	40	47.9	±6.64	40	60
Haemodialysis	36	46.06	±8.23	55.5	44.5
Hypertension	36	52.28	±5.43	50	50

Table (3) Comparison of detection and recognition thresholds for the basic tastes between aging, smokers and the controlgroup

Threshold	Taste	Mean ± SD		p-value	Mean ± SD		p-value
		Control (n=36)	Aging (n=30)		Control (n=36)	Smokers (n=40)	
	Sweetness	24.7± 13.2	47.5 ± 13.6	<0.001	24.7 ± 13.2	48.7 ± 50.3	<0.001
Detection	Saltiness	36.1± 20.6	57.5 ± 22.8	<0.001	36.1 ± 20.6	62.8 ± 43.7	0.003
	Sourness	0.7± 0.5	1.9 ± 0.9	<0.001	0.7 ± 0.5	1.1 ± 0.7	0.050
	Bitterness	0.5± 0.3	1.7 ± 0.9	<0.001	0.5 ± 0.3	2.8 ± 1.8	<0.001
	Sweetness	28.6± 14.5	67.5 ± 36.0	<0.001	28.6± 14.5	67.5 ± 53.1	<0.001
Recognition	Saltiness	39.4± 21.7	65.0 ± 28.3	<0.001	39.4± 21.7	80.0 ± 56.9	<0.001
	Sourness	0.7± 0.5	2.0± 1.1	<0.001	0.7 ± 0.5	1.3 ± 0.8	0.005
	Bitterness	0.5± 0.30	1.7 ± 0.9	<0.001	0.5± 0.30	2.8 ± 1.8	<0.001

All units in mmol/L except for bitterness in µmol/L, using unpaired t-test and Z-test.

Table (4) Comparison of detection and recognition thresholds for the basic tastes between the control group and diabetic, hemodialysis and hypertension groups.

Threshold	Taste	Mean ± SD			
		Control (n=36)	Diabetic (n=40)	Haemodialysis (n=36)	Hypertension (n=36)
	Sweetness	24.7 ± 13.2	38.2± 25.7	71.11 ± 41.01	44.17 ± 21.46
Detection	Saltiness	36.1± 20.6	48.8± 31.9	32.22 ± 22.57	91.94 ± 73.74
	Sourness	0.7± 0.5	1.2± 0.7	1.54 ± 1.05	2.43 ± 1.26
	Bitterness	0.5± 0.3	3.1± 2.8	0.88 ± 0.63	3.39 ± 2.73
	Sweetness	28.6± 14.5	65.0± 36.1	79.17 ± 36.11	68.06 ± 49.86
Recognition	Saltiness	39.4± 21.7	75.5± 57.4	44.72 ± 23.99	97.22 ± 71.66
	Sourness	0.7 ± 0.5	1.6± 0.8	2.87 ± 1.46	2.53 ± 1.13
	Bitterness	0.5± 0.3	3.1± 2.8	0.88 ± 0.63	3.39 ± 2.73

All units in mmol/L except bitterness in µmol/L.

Table (5) Comparison of serum and saliva zinc concentration and saliva flow rate between control and study groups.

Groups	saliva flow rate (ml/min) Mean ± SD	Saliva Zn (ppm) Mean ± SD	Serum Zn (ppm) Mean ± SD
Control	0.65 ± 0.27	0.77 ± 0.05	0.68 ± 0.08
Aging	0.24 ± 0.05***	0.26 ± 0.08***	0.53 ± 0.05***
Smokers	0.26 ± 0.05***	0.18 ± 0.06***	0.58 ± 0.09***
Diabetes	0.20 ± 0.07***	0.20 ± 0.11***	0.67 ± 0.11
Haemodialysis	0.17 ± 0.05***	0.32 ± 0.14***	0.27 ± 0.08***
Hypertension	0.19 ± 0.06***	0.36 ± 0.03***	0.18 ± 0.04***

*** Significant difference from control at p<0.001, using Z-test for all groups, except for aging group unpaired t-test was used.

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