Salty and umami tastes perception in hypertensive patients and its relationship to dietary sodium intake

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Abstract

Background: Reducing the dietary sodium intake is one of the most important factors for controlling blood pressure. The changes that occur in perceiving saltiness and umami tastes in people with hypertension can be associated with the level of sodium intake. The aim of this study was to investigate the gustatory perception of these two tastes in patients with hypertension and its association with the level of dietary sodium consumed by these patients.

Material and methods: In this case control study, 40 patients with hypertension and 40 healthy individuals were chosen. The blood pressure was measured for both groups. The power of perceiving saltiness and umami tastes was investigated using sodium chloride and monosodium glutamate solutions respectively both with concentrations of 200 mmol/lit. The individuals specified the power of each taste along a 10-number criterion. Based on the compounds of foods in Iran, the level of sodium consumed per day was calculated by food frequency questionnaire. The data were analyzed by Mann-Whitney, Pearson, Spearman tests.

Results: The mean saltiness perception in the control and case group was 5/8 and 6/6 respectively($p < 0/05$) and the mean umami perception the control and case group was 5/5 and 7/6 respectively ($p < 0/05$).There was an inverse relationship between the level of sodium intake and perceived intensity of saltiness perceptionin case group ($p < 0.05$).The level of sodium intake had no relationship with perceived intensity of umami taste in none of the groups ($p > 0.05$). There was also a direct relationship between blood pressure and intensity of perceiving umami taste in case group ($p < 0.05$).However, no significant relationship was found between blood pressure and the intensity of perceiving saltiness ($p > 0.05$).

Conclusion: Perceived intensity of both umami and saltiness in case group were higher than control group. With increase in the blood pressure, the power of perceiving saltiness and umami increases; with increase in sodium intake, saltiness perception diminishes, but umami perception is left unaffected.

Key words: gustatory system; hypertension; umami; saltiness; sodium

Arterial Hypertens. 2022, vol. 26, no. 3, pages: 129–134
DOI: 10.5603/AH.a2022.0013

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Introduction

Hypertension is a disease affecting around 25% of the world's adult population, causing fatal consequences such as heart attack, stroke, and even premature death [1, 2]. One of the causes of this disease is improper dietary habits and overuse of sodium as NaCl. It is itself a precursor for the mentioned diseases and their debilitating consequences [3–5]. Thus, to mitigate these negative outcomes, one of the public health approaches has been based on reducing the overall sodium intake and correcting the dietary habits [6].

Monosodium glutamate (MSG) is another form of sodium, whose consumption is progressively increasing, because it improves the taste of foods especially fast food, and its derived taste is known as umami. Umami is one of the five main tastes known and perceivable by humans, which has its own specific receptors and stimulators as with other tastes [7, 8]. This taste has independent receptors called TR1 and TR3, located in the mouth, tongue, palate, some regions of epiglottis, and the upper part of the esophagus. The difference in perceiving the taste of monosodium glutamate has been attributed to the diversity of expression of umami taste receptor in humans.

Blood pressure is a factor that can affect the quality of perceiving taste [9]. Investigations in the past have suggested a relationship between hypertension and changes in the threshold of perceiving saltiness [10, 11].

A limited number of studies have reported the relationship between hypertension and changes in the gustatory perception of umami taste similar to the relationship between hypertension and NaCl [12–14]. It should be noted that the sodium in NaCl and MSG plays an important role in giving a favorable taste to the food, as they reduce the bitterness and enhance the sweetness of food. Further, high daily sodium intake can change the preference of saltiness taste in humans [15]. Some evidence showed that in hypertensive patients there is an increasing in sodium intake and their taste perception threshold altered and gustatory sensitivity diminished [9, 16, 17]. The difference of individuals in perceiving umami taste may play an important role in choosing different diets; thus it can become problematic regarding diet-associated health.

Kim et al. [18] investigated the gustatory threshold of sense of saltiness in patients with hypertension. They concluded that the threshold of perceiving saltiness may not be related to the blood pressure status and the extent of sodium excreted in 24-hour urine. Shi et al. [6] examined the effect of MSG consumption on blood pressure within a five-year period, and found that glutamate consumption had a direct and positive relationship with systolic blood pressure elevation, while glutamate had an independent effect on blood pressure elevation especially among women and those who consumed antihypertensive drugs.

Considering the contradictory results of previous studies [9, 16, 17], more evidence is needed to clarify the relationship between hypertension and saltiness and umami perception threshold.No systematic study has been performed on gustatory perception of saltiness and umami in hypertensive individuals in Iran meanwhile it was shown that the consumption of salt among the Iranian population is higher than the level recommended by WHO [19]. So we decided to investigate the sense of taste in patients with hypertension regarding saltiness and umami, as well as its relationship with the level of daily sodium intake among these patients.

Material and methods

In this cross-sectional study, with the ethics code of IR.SBMU.RIDS.REC.1396,576, 80 clients referring to the cardiovascular ward of Taleghani hospital were assigned into two groups: test (40 patients with hypertension with the mean age of 60) and control group (40 healthy individuals with the mean age of 43 years).

The subjects in the test group should have had blood pressure of 130/80 mmHg and above. Nevertheless, those with systemic diseases, individuals suffering sinusitis and common cold at the time of investigating the sense of taste, those with a history of tobacco consumption, individuals with removable dental prostheses and processes containing resin acryls, those with oral mucosal lesions and mouth dryness, as well as the pregnant and breast-feeding women, and finally individuals with a history of stroke were excluded.

Those in the case group were all hypertensive patients undergoing treatment controls within a time period of at least 6 months and at most 36 months. Written consent form was taken from all subjects (both hypertensive and healthy).

Primary measurement of blood pressure was performed using digital blood pressure monitor on the right hand. After a 5-min rest, the subjects were readmitted and blood pressure was taken from the same hand again [20]. This blood pressure was recorded in the relevant form alongside their age and gender characteristics.

Assessment of sensitivity of saltiness and umami tastes was done based on the regulations of international standards organization (ISO). The solution used to test the saltiness taste was sodium chloride 200 mmol/lit, while the solution for the umami taste was sodium glutamate 200 mmol/lit [21].

Assessment of the accuracy of the concentration of final solutions used in the test was done using spectrophotometry (UNICO, America).

To conduct the gustatory test, first 2 ml of one of the sodium glutamate or sodium chloride solutions, without the subjects knowing the type of solution, was poured on the moist surface of the dorsal of the tongue, and the subjects were asked to keep the solution for 10 s in their mouth and then spit it out. After testing the first solution, the patients were requested to specify the intensity of taste using a 10-number criterion (0 representing tasteless such as water up to 10 indicating very intense). After washing the mouth, another solution was tested on the same site on the dorsal surface of the tongue. After testing the second solution, again the patients were asked to specify the intensity of taste along a 10-number criterion, similar to the previous case [22]. The intensity specified for each taste was recorded in the data form.

In order to obtain the level of daily sodium intake, food frequency questionnaire developed by endocrine and metabolism sciences research faculty, Shahid Beheshti University of medical sciences was used, which assesses the level of annual sodium intake of every subject during interview [23].This questionnaire examines 147 cases of frequency of use of various substances by individuals. The question asked in this questionnaire for the average amount of consumption of each food in the form of volume, amount and time indicators appropriate to the type of food. Finally, the obtained information was analyzed and based on the table of Iranian food compounds, the amount of sodium in each food item was calculated per 100 grams of that food item and expressed in grams per day. To investigate the accuracy of calculations performed to obtain the amount of sodium intake per day, the daily caloric intake of individuals was calculated per kCal by nutritionists [24].

The case and control groups were categorized into three classes in terms of the level of sodium intake (mg/day): Group I: low-consumption group (786–1688 mg/day), Group II: medium consumption (1725–2714 mg/day), and Group III high consumption (2743–7386 mg/day). The type of group of each subject was recorded in the data form in terms of the level of sodium consumption [24].

Kolmogorov Smirnov test was used to check the normality of data distribution. The data obtained were analyzed by Kruskal-Wallis one-way (comparing the differences of the perceived intensity of saltiness and umami in each of the case and control groups), Chi-score (investigating the difference of sodium intake between case and control groups), Cross-tabulation test (in order to classification of sodium intake in mg per day in each of case and control groups), Pearson correlation test and Spearman correlation test(investigating the relationship between the level of sodium intake and perceived intensity of saltiness and umami taste in both case and control groups and relationship between the level of sodium intake and blood pressure and relationship between the perceived intensity of saltiness and umami taste with blood pressure),and Mann-Whitney U(comparing of the mean perceived intensity of saltiness and umami taste between the two case and control groups) using SPSS 23. The significance level was considered as 0.05.

Results

In comparing the differences of the perceived intensity of saltiness and umami in each of the case and control groups by Kruskal-Wallis one-way test, the results indicated that in the case and control groups, there was no significant difference between three levels of sodium intake regarding perceived intensity of umami and saltiness tastes ($p < 0.05$) (Tab. 1 and 2).

In investigating the relationship between the level of sodium intake and perceived intensity of saltiness taste in both case and control groups by Spearman and Pearson test respectively, the results showed that in the case group, there was an inverse significant relationship between the level of sodium intake and perceiving saltines($p < 0/05$, $r = –0/377$).however, there was no significant relationship between level of sodium intake and perceived intensity of umami($p > 0/05$, $r = 0/062$).

In comparing the mean value of perceiving saltiness and umami between the two groups by Mann-Whitney U test, the results showed that there was a significant difference between the groups in terms of perceiving both saltiness and umami ($p < 0.05$), implying that perceived intensity of saltiness and umami is higher in the case group individuals compared to the control (Tab. 3).

Investigating the relationship between level of sodium intake and systolic as well as diastolic blood pressure by Spearman correlation test, the results

Table 1. The mean of perception of salty taste in each of the control and case groups for salty taste

Amount of sodium intake	Control			Case		
	Frequency (%)	Mean	Standard deviation	Frequency (%)	Mean	Standard deviation
Group 1	6 (15%)	6.5	1.8	21 (52.5%)	7	1.5
Group 2	18 (45%)	5.9	1.9	9 (22.5%)	6/4	1.4
Group 3	16 (40%)	5.4	1.7	10 (25%)	6/2	1.4

Table 2. The mean of perception of umami taste in each of the control and case groups for umami taste

Amount of sodium intake	Control			Case		
	Frequency (%)	Mean	Standard deviation	Frequency (%)	Mean	Standard deviation
Group 1	6 (15%)	5.1	2.3	21 (52.5%)	7.4	0.9
Group 2	18 (45%)	5.4	1.6	9 (22.5%)	7.7	1.3
Group 3	16 (40%)	5.8	1.5	10 (25%)	7.7	1.5

Table 3. Perceived intensity of saltiness and umami taste between the two groups

Perceived intensity	Control		Case	
	Mean	Standard deviation	Mean	Standard deviation
Saltiness	5.8	1.8	6.6	1.4
Umami	5.5	1/.7	7.6	1.5

showed that there was a significant and inverse relationship between sodium intake level and systolic blood pressure ($r = -0.2$, $p = 0.045$) as well as diastolic ($r = -0.045$, $p = 0.001$) blood pressure.

In investigating the relationship between perceived intensity of saltiness and systolic as well as diastolic blood pressure by Spearman correlation test, it was found that there wasn't a significant relationship between perceived intensity of saltiness and systolic ($r = 0.2$, $p = 0.75$) as well as diastolic ($r = 0.02$, $p = 0.838$) blood pressures. In examining the relationship between perceived intensity of umami and systolic as well as diastolic blood pressure by Spearman correlation test, it was found that there was a direct and significant relationship between the threshold of perceiving umami taste and systolic ($p < 0.0001$, $r = 0.543$) and diastolic ($r = 0.325$, $p < 0.003$) blood pressure.

Discussion

The present study was done to investigate the gustatory perception of saltiness and umami in hypertensive individuals. Although hypertension may occur at any age, most studies suggest its higher incidence in older individuals [2, 25–27]. In this regard, Nsanya et al. [28] considered the risk of incidence of hypertension in those above 20 to be five times greater than in individuals younger than 20 .Nevertheless, since the symptoms of this disease emerge late and as nonspecific, most of the time it causes referral of patients at older ages.

In the present study, the mean blood pressure of the case group was 145/84 mm Hg, suggesting relative control of the blood pressure of patients and their categorization as beginning of the second stage (stage II) of the disease. Accordingly, most patients with hypertension fall into the group of low or medium sodium consumption. On the other hand, in the control group, most individuals fell in the group of moderate or high sodium consumption. This is due to medical and practitioners' recommendations on reducing sodium consumption for these patients to reduce the complications and probability of mortality in them, rather than their lower preference to consume sodium [29].

Based on the results of the present study, the average gustatory perception power for saltiness was significantly higher in those with hypertension than among the control individuals. This is due to establishment of the treatment course and dietary control in patients with hypertension. This is in line with the studies of Fallis et al. as well as Bisht et al. [10, 30]. In the study by Kim et al. [18] along with Michikawa et al. [17], the gustatory threshold of saltiness was lower in hypertensive individuals compared to normal people. In the study by Michikawa, there was an inverse relationship between blood pressure elevation and gustatory threshold [17], which is discordant with our results. In some other studies, no relationship was found between saltiness threshold and hypertension [31–33]. These discrepancies can be attributed to different factors. These include the method of measuring gustatory threshold, different NaCl concentrations to find the gustatory threshold, the patient's perceptive power for saltiness, which in the present study was greater in hypertensive individuals compared to the control group. This was discordant with the findings of Mattes et al. [16]. The effect of antihypertensive drugs on sense of taste can be another reason for these differences. For example, diuretic drugs that reduce zinc ion can affect the sense of taste [34]. Since in the present study, it was not possible to match the samples in terms of the type and dose of antihypertensive drugs because of different limitations, thus different results would have been obtained with other studies.

According to the present study, the average perception of umami taste was significantly higher in hypertensive patients compared to the control group. Assuming that the perceived intensity of umami can affect the level of sodium intake by patients, these finding can be notable. Possibly, by increasing the population of the studied samples, a significant relationship could be found between the level of sodium intake and perceived intensity of umami. Nevertheless, it should be noted that considering the limitations of this research, the patients were not uniform in terms of consuming antihypertensive drugs. Also, since a wide range of these drugs affect the sense of taste, thus in the interpretation and generalization of this finding, the mentioned point should be noted.

Based on the results of the present study, there was a significant relationship between level of sodium intake and blood pressure of individuals, with lower sodium intake being associated with higher systolic and diastolic blood pressure. It is discordant with other studies examining the relationship between sodium intake and elevated blood pressure [18, 35]. This can be due to adhering to medical recommendations by hypertensive individuals undergoing medical control. For this reason, limiting sodium consumption is one of the therapeutic solutions for hypertensive patients. Nevertheless, it has been found that both diets rich in sodium and low sodium containing diets can be the cause of increased mortality in these patients [35–37]. Also, in this study, there was no significant relationship between perceiving saltiness and systolic or diastolic blood pressure, which was in line with the findings of Kim et al. [18]. Nevertheless, in the study by Kim, instead of perceiving saltiness, the threshold of saltiness perception had been measured. The results of Kare et al. [38] and Mattes et al. [39] indicated that the response of hypertensive patients and normal individuals to elevated doses of sodium did not differ with each other. In the present study, there was a significant relationship between perceiving umami taste and systolic as well as diastolic blood pressure. With elevation of these two blood pressures, the power of perceiving umami also increased. Although Shi et al. [6] in their study reported elevated blood pressure in response to consuming sodium glutamate, the relationship between perceiving umami and elevated blood pressure is one of the findings reported for the first time in this study.

Conclusion

Perceived intensity of both umami and saltiness in case group were higher than control group. The weaker the gustatory perception of individuals about saltiness, the higher their daily sodium intake was. However, no significant relationship was found between level of sodium intake from daily diet and perceiving umami taste. Also, the higher the blood pressure, the greater the power of perceiving saltiness and umami taste was.

References

1. World Health Organization. Global status report on noncommunicable diseases 2014. www.who.int/nmh/publications/ncd-status-report-2014/en/.
2. Bin Abdulhak A, Birbeck G, Blyth F, et al. Comparative Risk Assessment Collaborating Group, Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. Lancet. 2002; 360(9343): 1347–1360, doi: 10.1016/S0140-6736(02)11403-6, indexed in Pubmed: 12423980.
3. Whelton PK, Carey RM, Aronow WS, et al. 2017ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA-Guideline for thePrevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am CollCardiol. 2018; 71(19): 2199–2269, doi: 10.1016/j.jacc.2017.11.005, indexed in Pubmed: 29146533.
4. Cook NR, Cook NR, Cutler JA, et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). BMJ. 2007; 334(7599): 885–888, doi: 10.1136/bmj.39147.604896.55, indexed in Pubmed: 17449506.
5. Bibbins-Domingo K, Chertow GM, Coxson PG, et al. Projected effect of dietary salt reductions on future cardiovascular disease. N Engl J Med. 2010; 362(7): 590–599, doi: 10.1056/NEJMoa0907355, indexed in Pubmed: 20089957.

6. Shi Z, Yuan B, Taylor AW, et al. Monosodium glutamate is related to a higher increase in blood pressure over 5 years: findings from the Jiangsu Nutrition Study of Chinese adults. J Hypertens. 2011; 29(5): 846–853, doi: 10.1097/HJH.0b013e328344da8e, indexed in Pubmed: 21372742.
7. Barretto RPJ, Gillis-Smith S, Chandrashekar J, et al. The neural representation of taste quality at the periphery. Nature. 2015; 517(7534): 373–376, doi: 10.1038/nature13873, indexed in Pubmed: 25383521.
8. DeVere R. Disorders of Taste and Smell. Continuum (Minneap Minn). 2017; 23(2, Selected Topics in Outpatient Neurology): 421–446, doi: 10.1212/CON.0000000000000463, indexed in Pubmed: 28375912.
9. Roura E, Foster S, Winklebach A, et al. Taste and Hypertension in Humans: Targeting Cardiovascular Disease. Curr Pharm Des. 2016; 22(15): 2290–2305, doi: 10.2174/1381612822666160216151545, indexed in Pubmed: 26881437.
10. Fallis N, Lasagna L, Tetreault L. Gustatory Thresholds in Patients with Hypertension. Nature. 1962; 196(4849): 74–75, doi: 10.1038/196074a0.
11. Wotman S, Mandel ID, Thompson RH, et al. Salivary electrolytes, urea nitrogen, uric acid and salt taste thresholds in hypertension. J Oral Ther Pharmacol. 1967; 3(4): 239–250, indexed in Pubmed: 6025507.
12. Wakita A. Dietary Salt and Health: UMAMI Seasoning as an Attempt to Reduce Salt Intake. J Nutr Food Sci. 2013; 01(S10), doi: 10.4172/2155-9600.s10-008.
13. Bellisle F, Tournier A, Louis-Sylvestre J. Monosodium glutamate and the acquisition of food preferences in a European context. Food Quality and Preference. 1989; 1(3): 103–108, doi: 10.1016/0950-3293(89)90013-x.
14. Bellisle F. Experimental studies of food choices and palatability responses in Europeansubjects exposed to the Umami taste. Asia Pac J ClinNutr. 2008; 17(Suppl 1): 376–9.
15. Wati Y, Hamied L, S A, et al. Moderate Correlation Between High Salt Taste Preference and High Sodium Intake. J Hypertens. 2015; 33(Supplement 2): e35, doi: 10.1097/01.hjh.0000469850.39188.7f.
16. Mattes RD. Salt taste and hypertension: a critical review of the literature. J Chronic Dis. 1984; 37(3): 195–208, doi: 10.1016/0021-9681(84)90147-4, indexed in Pubmed: 6365942.
17. Michikawa T, Nishiwaki Y, Okamura T, et al. The taste of salt measured by a simple test and blood pressure in Japanese women and men. Hypertens Res. 2009; 32(5): 399–403, doi: 10.1038/hr.2009.31, indexed in Pubmed: 19343036.
18. Kim CY, Ye MK, Lee YS. The salt-taste threshold in untreated hypertensive patients. Clin Hypertens. 2017; 23: 22, doi: 10.1186/s40885-017-0079-8, indexed in Pubmed: 29163986.
19. Rezaei S, Mahmoudi Z, Sheidaei A, et al. Salt intake among Iranian population: the first national report on salt intake in Iran. J Hypertens. 2018; 36(12): 2380–2389, doi: 10.1097/HJH.0000000000001836, indexed in Pubmed: 30005027.
20. Vischer AS, Burkard T. Principles of Blood Pressure Measurement — Current Techniques, Office vs Ambulatory Blood Pressure Measurement. Adv Exp Med Biol. 2017; 956: 85–96, doi: 10.1007/5584_2016_49, indexed in Pubmed: 27417699.
21. International Organization for Standardization. Sensory analysis. Methodology.Method of investigating sensitivity of taste. BSI, London 2013.
22. McMahon EJ, Campbell KL, Bauer JD. Taste perception in kidney disease and relationship to dietary sodium intake. Appetite. 2014; 83: 236–241, doi: 10.1016/j.appet.2014.08.036, indexed in Pubmed: 25192896.
23. Asghari G, Rezazadeh A, Hosseini-Esfahani F, et al. Reliability, comparative validity and stability of dietary patterns derived from an FFQ in the Tehran Lipid and Glucose Study. Br J Nutr. 2012; 108(6): 1109–1117, doi: 10.1017/S0007114511006313, indexed in Pubmed: 22251608.
24. Esmaeili H, Hoshyarzad A. [Iranian Food Composition Table]. National Nutrition & Food Technology Research Institute, Tehran: 1397.
25. Yusufali AM, Khatib R, Islam S, et al. Prevalence, awareness, treatment and control of hypertension in four Middle East countries. J Hypertens. 2017; 35(7): 1457–1464, doi: 10.1097/HJH.0000000000001326, indexed in Pubmed: 28486270.
26. Sadghi M, Roohafza H, Asgary S, et al. et al.. Prevalence of high blood pressure and its relation with cardiovascular risk factors. J Qazvin Univ Med Sci. 2003; 7(2): 46–52.
27. Meraci M, Feizi A, BagherNejad M. Investigating the Prevalence of High Blood Pressure, Type 2 Diabetes Mellitus and Related Risk Factors According to a Large General Study in Isfahan- Using Multivariate Logistic Regression model. Health Syst Res. 2012; 8(2): 193–203.
28. Nsanya MK, Kavishe BB, Katende D, et al. Prevalence of high blood pressure and associated factors among adolescents and young people in Tanzania and Uganda. J Clin Hypertens (Greenwich). 2019; 21(4): 470–478, doi: 10.1111/jch.13502, indexed in Pubmed: 30811099.
29. Grillo A, Salvi L, Coruzzi P, et al. Sodium Intake and Hypertension. Nutrients. 2019; 11(9), doi: 10.3390/nu11091970, indexed in Pubmed: 31438636.
30. Bisht DB, Krishamurthy M, Rangaswamy R. Studies on threshold of taste for salt with specialreference to hypertension. Indian Heart J. 1971; 23(2): 137–40, indexed in Pubmed: 5154105.
31. Schechter PJ, Horwitz D, Henkin RI. Salt preference in patients with untreated and treated essential hypertension. Am J Med Sci. 1974; 267(6): 320–326, doi: 10.1097/00000441-197406000-00001, indexed in Pubmed: 4841902.
32. Henkin RI. Salt taste in patients with essential hypertension and with hypertension due to primary hyperaldosteronism. J Chronic Dis. 1974; 27(4-5): 235–244, doi: 10.1016/0021-9681(74)90048-4.
33. Ben-Aryeh H, Schiller M, Shasha S, et al. Salivary composition in patients with essential hypertension and the effect of Pindolol. J Oral Med. 1981; 36(3): 76–78, indexed in Pubmed: 6945404.
34. Cowart BJ. Taste dysfunction: a practical guide for oral medicine. Oral Dis. 2011; 17(1): 2–6, doi: 10.1111/j.1601-0825.2010.01719.x, indexed in Pubmed: 20796233.
35. Aburto NJ, Ziolkovska A, Hooper L, et al. Effect of lower sodium intake on health: systematic review and meta-analyses. BMJ. 2013; 346: f1326, doi: 10.1136/bmj.f1326, indexed in Pubmed: 23558163.
36. Cohen HW, Hailpern SM, Fang J, et al. Sodium intake and mortality in the NHANES II follow-up study. Am J Med. 2006; 119(3): 275.e7–275.14, doi: 10.1016/j.amjmed.2005.10.042, indexed in Pubmed: 16490476.
37. Stolarz-Skrzypek K, Kuznetsova T, Thijs L, et al. European Project on Genes in Hypertension (EPOGH) Investigators. Fatal and nonfatal outcomes, incidence of hypertension, and blood pressure changes in relation to urinary sodium excretion. JAMA. 2011; 305(17): 1777–1785, doi: 10.1001/jama.2011.574, indexed in Pubmed: 21540421.
38. Kare MR, Fregly MJ, Bernard RA. (eds). Biological and Behavioral Aspects ofSalt Intake. Academic Press, New York 1980: 397–409.
39. Mattes RD. Salt taste and hypertension: A critical review of the literature. J Clin Epidemiol. 1984; 37(3): 195–208, doi: 10.1016/0021-9681(84)90147-4.