



ORIGINAL ARTICLE

The association between periodontal diseases and halitosis among Saudi patients

Hamad Alzoman*

Department of Periodontics and Community Dentistry, College of Dentistry, King Saud University, Riyadh, Saudi Arabia

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KEYWORDS

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Abstract Objectives: To assess the relationship between the presence of periodontal disease and halitosis.

Methods: A total of 120 patients were enrolled and divided into 2 groups, 60 patients with probing depth (PD) > 3.0 mm (group 1) and 60 patients with PD ≤ 3.0 mm (group 2). Clinical parameters including, plaque index (PI), bleeding index (BI), and PD were obtained. Breath samples were collected and analyzed using a portable gas chromatograph to measure the concentration of volatile sulfur compounds (VSC).

Results: Halitosis was found to affect 58.3% of the total patients. The means of PI, BI, and VSC were significantly higher in group 1 (PD > 3.0 mm) than in group 2 (PD ≤ 3 mm).

Conclusions: The percentage of patients suffering from halitosis in the Saudi population are comparatively high. In addition, there was a positive association between periodontal disease and halitosis.

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1. Introduction

Halitosis or oral malodor are common terms used to define a hostile or unpleasant odor emitted from the oral cavity. It can cause both health and social dilemmas that affect the life of

subjects who suffer from this condition (Silva et al., 2020, de Jongh et al., 2016, de Jongh et al., 2014, de Jongh et al., 2013, Zalewska et al., 2012). The cause of halitosis is connected to both systemic and oral disorders. Several studies demonstrate that the oral cavity is one of the important sources for halitosis (Scully and Greenman, 2012). Through an analysis of 491 subjects with oral malodor, Delanghe et al. (1999) demonstrated that approximately 87% originated primarily from the oral cavity, while 5–8% of halitosis were related to ear, nose, and throat (ENT) problems. Another report specified that 90% of halitosis cases were initiated by sources from the oral cavity (Tonzetich, 1977).

There are certain oral diseases and disorders which are connected with oral halitosis, such as gingivitis, periodontitis (De Geest et al., 2016, John and Vandana, 2006, Liu et al., 2004,

* Address: Department of Periodontics and Community Dentistry, College of Dentistry, King Saud University, P.O. Box 60169, Riyadh 11545, Saudi Arabia.

E-mail address: halzoman@ksu.edu.sa.

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Morita and Wang, 2001a), and acute herpetic gingivostomatitis (Kolokotronis and Doumas, 2006). In addition, other oral conditions could be connected with oral malodor, such as dental abscesses, aphthous ulcers, oral cancer, and xerostomia (Nachnani, 2011, Al Buquerque et al., 2010, Nally, 1990).

Volatile sulfur compounds (VSC) have been deliberated as the primary gases responsible for causing halitosis. VSC are generated as a result of protein putrefaction by gram-negative bacteria (Nakano et al., 2002). There are several VSC associated with halitosis, such as hydrogen sulfide (H₂S), methyl mercaptan (CH₃SH), dimethyl sulfide (CH₃SCH₃), phenol, and pyridine. Numerous studies have confirmed that oral halitosis is caused mainly due to the presence of H₂S, CH₃SH, and CH₃SCH₃ in the exhaled breath (De Boever et al., 1994, Volozhin et al., 2001, Huang et al., 2002).

Periodontitis is reported as one of the important etiological factors of halitosis (Alshehri, 2016). Previous studies demonstrated that the occurrence of oral malodor is considerably greater in periodontal patients when compared to healthy persons. They further stated that there was positive correlation between oral malodor and the presence of sites with pockets of 5 mm or more (Bolepalli et al., 2015, Huang et al. 2002). Figueiredo et al. (2002) reported in their study that the relationship of periodontitis with oral malodor and VSC level was significantly higher in subjects with probing depth > 3 mm; further, they also observed that gingival inflammation contributes the intensity of oral malodour (Aizawa et al., 2005). The aim of this present study was to evaluate the relationship between the presence of periodontal disease and halitosis.

2. Materials and Methods

2.1. Patients and study design

This study was conducted among a total of 120 patients at a single center in Riyadh, Saudi Arabia. The protocol of the study was approved by the Ethical Review Committee of the College of Dentistry Research Center (CDRC), at King Saud University (IR 0028). Informed consent was obtained by all study participants.

A total of 120 systemically healthy patients with and without chronic periodontitis were selected from the outpatient clinic of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. The inclusion criteria were (i) no periodontal therapy in the previous 3 months, (ii) systemically healthy, and (iii) 18 years old and older. Patients were excluded if (i) they smoked, (ii) had < 12 teeth, or (iii) had received antibiotics within 3 months preceding the study.

The patients that met the inclusion criteria were assigned into 2 groups based on their periodontal condition: group 1 patients with periodontal disease with probing depth (PD) > 3 mm or group 2 (control) periodontally healthy patients with PD ≤ 3 mm.

2.2. Periodontal examination

The clinical periodontal parameters including PD and bleeding on probing (BOP) were assessed in all subjects using a periodontal probe at 6 points around all teeth. Moreover, the pla-

que index (PI) was used to calculate adherent dental plaque score.

2.3. Oral malodour assessment

Three hours before oral breath assessment, all subjects were asked to avoid eating, drinking, chewing, brushing, and using mouthwash. The VSC concentrations in their oral cavity were examined using a portable gas chromatograph (OralChroma™, Kyoto, Japan) equipped with a flame photometric detector. A breath sample (1 ml) was taken using a gas-tight plastic syringe, then injected into the gas chromatography column at 70 °C. The concentrations of Hydrogen sulphide, Methyl mercaptan, and Dimethyl sulfide were determined. Halitosis was defined when the VSC of the breath sample was greater than or equal to the cognitive threshold as follows: H₂S ≥ 112 PPB, CH₃SH ≥ 26 PPB and CH₃SCH₃ ≥ 8 PPB (Aizawa et al., 2005).

3. Results

A total of 120 patients (60 men and 60 women) participated in this study with a mean age of 27.19 years (± 6.3). Halitosis was found among 58.3% (n = 70) of the patients (Fig. 1).

Halitosis was significantly more prevalent among the group 1 (PD > 3 mm) patients, 81.7% (n = 49), versus 35 % (n = 21) in group 2 (PD ≤ 3 mm) patients Table 1. Clinical parameters showed a higher mean score for PI, BI, and PD in group 1 compared to group 2 (Table 1).

Fig. 2 shows the VSC scores of the study population. The VSC mean scores were found to be significantly higher among patients with periodontitis (group 1) compared to healthy patients (group 2).

Table 2 shows the clinical measurements of the study population. Comparing group 1 to group 2 patients, significant results were obtained in the clinical parameters of PD (p = 0.0001), BOP (p = 0.001) and PD (p = 0.001).

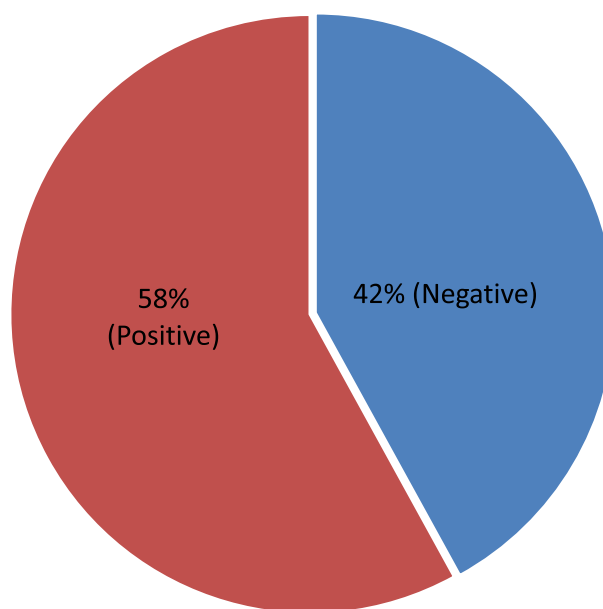
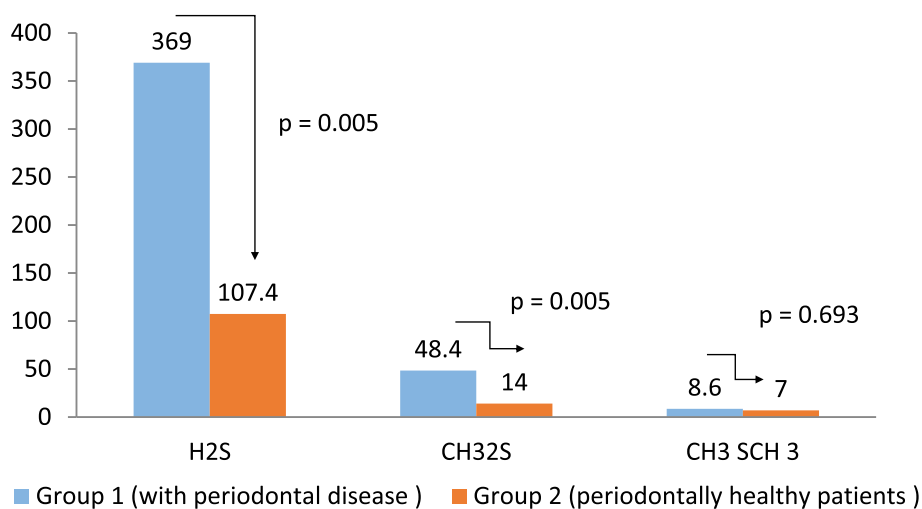


Fig. 1 Presence of Halitosis.

Table 1 Periodontal diseases and gender wise presence of halitosis.

	Negative		Positive		Total
	%	N	%	N	
Group 1 (PD > 3 mm Periodontitis)	18.3	11	81.7	49	60
Group 2 (PD ≤ 3 mm Healthy)	65.0	39	35.0	21	60
Total	41.7	50	58.3	70	120
p value	0.0001				
	Negative		Positive		Total
	%	N	%	N	
Male	21.1	11	78.9	41	52
Female	58.0	39	42.6	29	68
Total	41.7	50	58.3	70	120.0
p value	0.001				

**Fig. 2** Measurement of Volatile Sulfur Compounds.**Table 2** Clinical measurement of the study population.

Clinical measurement	Group 1		Group 2		p value
	Mean	SD	Mean	SD	
Plaque index	69.6	21.5	28.2	34.2	0.000
Bleeding index	32.9	18.5	19.8	18.1	0.001
Probing depth	4.19	3.5	2.2	0.471	0.001

4. Discussion

Earlier studies have reported that the important VSC that are related to halitosis are: H₂S, CH₃SH, and CH₃SCH₃ (Coli and Tonzetich, 1992, De Boever et al., 1994, Schmidt et al., 1978). Another study reported that VSC are the end result of bacterial putrefaction of proteins found in saliva, blood, and

gingival crevicular fluid (Kleinberg and Westbay, 1992). Further, the amino acids comprising the sulfur compound leads to the formation of VSC (Waler, 1997, Yano et al., 2009).

In the present study, breath samples were taken from 120 patients to estimate the relationship between the presence of periodontal disease and halitosis using gas chromatography to identify the level of VSC. Gas chromatography is regarded as a reliable method to detect oral gases; it is specific and sen-

sitive for all three VSC i.e. H₂S, CH₃SH, and CH₃SCH₃ (Tonzetich et al., 1991, Tangerman and Winkel, 2008, Murata et al., 2006), and is thus recognized as the gold standard for measuring VSC levels in the oral cavity (Tangerman and Winkel, 2008, Yaegaki et al., 2012).

In the present study, 58.3% of the patients were diagnosed with halitosis. This finding is consistent with a previously reported self-assessment of halitosis among Saudi patients, wherein 52% of were aware of having halitosis (Ashri, 2007). In addition, Al-Zahrani et al. (2011) reported self-reported halitosis to be 42.1% among patients with type 2 diabetes. In contrast to the above findings, Al Sadhan (2016) stated the prevalence of self-perceived halitosis to be 22.8% among adults living in Riyadh. This difference in prevalence of this study could be attributed to halitosis being assessed using a survey questionnaire without clinical assessment or breath examination. This asserts the magnitude of the problem that sensitivity of self-diagnosed halitosis is low, which therefore has a social impact (Bornstein et al., 2009a, Bornstein et al., 2009b). Pham et al. (2012) compared self-perceived halitosis with the actual clinical diagnosis of 565 patients using both the organoleptic test and Oral Chroma and revealed that patients were incapable of precisely perceiving their own oral malodour. In their study, they reported that 52.6% of patients failed to recognize that they had halitosis (Pham et al., 2012a). They further reported that there are several factors that might affect self-perception of oral halitosis, such as occupation, level of education, knowledge of the self-definition of halitosis, and sensitivity of the nose to their own halitosis.

In this present study, the percentage of patients identified with halitosis in group 1 (PD > 3 mm) was 81.7%, whereas in group 2 (PD ≤ 3 mm) it was 35%, indicating a statistically significant difference between the two groups (p < 0.05). Further, this shows a high relationship between the presence of periodontal disease and halitosis. The result of this study coincides with an earlier report conducted by Morita et al. (2001) which revealed that VSC increased significantly with an increase in the amount of bone loss, and were highly associated with other clinical parameters such as PD, clinical attachment level, and BOP (Morita and Wang, 2001b). Other studies reported a strong relationship between periodontal inflammation and halitosis (Figueiredo et al., 2002). In addition, Figueiredo et al. (2002) reported direct correlation of the severity of halitosis with periodontal disease. In patients with periodontal disease, the mouth harbors anaerobic bacteria such as *T. denticola*, *P. gingivalis*, *B. forsythus*. These bacteria are adept at producing VSC, which may lead to halitosis (Loesche, 2003, Yasukawa et al., 2010, Kato et al., 2005). Further development of periodontal disease has been connected to the hastening in the fabrication of VSC (Pham et al., 2012b, Takeuchi et al., 2010). Non-surgical treatments have proven to be an effective method in improving the periodontal clinical status of a person, as well as reducing halitosis (Silveira et al., 2017, Soares et al., 2015, Pham et al., 2011).

5. Conclusion

Within the limitations of this study, it could be concluded that the percentage of patients suffering from halitosis among the Saudi population are relatively high and there is a strong

association between the presence of periodontal disease and halitosis.

6. Funding

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7. Ethical statement

This study was conducted in accordance with the declaration of Helsinki and the study protocol of the study was approved by the Ethical Review Committee of the College of Dentistry Research Center (CDRC), King Saud University, Riyadh, Saudi Arabia (IR 0028).

CRedit authorship contribution statement

Hamad Alzoman: Conceptualization, Methodology, Software, Data curation, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sdentj.2020.02.005>.

References

- Alshehri, F.A., 2016. Knowledge and attitude of Saudi individuals toward self-perceived halitosis., Saudi. J. Dent. Res. 7, 91–95.
- Aizawa, F., Kishi, M., Moriya, T., Takahashi, M., Inaba, D., Yonemitsu, M., 2005. The analysis of characteristics of elderly people with high VSC level. Oral. Dis. 11 (Suppl 1), 80–82.
- Al-Zahrani, M.S., Zawawi, K.H., Austah, O.N., Al-Ghamdi, H.S., 2011. Self reported halitosis in relation to glycated hemoglobin level in diabetic patients. Open. Dent. J. 5, 154–157.
- Al Buquerque, D.F., De Souza Tolentino, E., Amado, F.M., Araka, W.A.C., Chinellato, L.E., 2010. Evaluation of halitosis and sialometry in patients submitted to head and neck radiotherapy. Med. Oral. Patol. Oral. Cir. Bucal. 15, e850–e854.
- Al Sadhan, S.A., 2016. Self-perceived halitosis and related factors among adults residing in Riyadh, Saudi Arabia. A cross sectional study. Saudi Dent. J. 28, 118–123.
- Ashri, N., 2007. Self-assessment of halitosis among diabetic Saudi Female Patients. Egyptian Dent. J., 53.
- Bolepalli, A.C., Munireddy, C., Peruka, S., Polepalle, T., Choudary Alluri, L.S., Mishael, S., 2015. Determining the association between oral malodor and periodontal disease: a case control study. J. Int. Soc. Prev. Community. Dent. 5 (5), 413–418.
- Bornstein, M.M., Kislig, K., Hoti, B.B., Seemann, R., Lussi, A., 2009a. Prevalence of halitosis in the population of the city of Bern,

- Switzerland: a study comparing self-reported and clinical data. *Eur. J. Oral. Sci.* 117, 261–267.
- Bornstein, M.M., Stocker, B.L., Seemann, R., Burgin, W.B., Lussi, A., 2009b. Prevalence of halitosis in young male adults: a study in swiss army recruits comparing self-reported and clinical data. *J. Periodontol.* 80, 24–31.
- Coli, J.M., Tonzetich, J., 1992. Characterization of volatile sulphur compounds production at individual gingival crevicular sites in humans. *J. Clin. Dent.* 3, 97–103.
- De Boever, E.H., De Uzeda, M., Loesche, W.J., 1994. Relationship between volatile sulfur compounds, BANA-hydrolyzing bacteria and gingival health in patients with and without complaints of oral malodor. *J. Clin. Dent.* 4, 114–119.
- De Geest, S., Laleman, I., Teughels, W., Dekeyser, C., Quirynen, M., 2016. Periodontal diseases as a source of halitosis: a review of the evidence and treatment approaches for dentists and dental hygienists. *Periodontol* 2000 (71), 213–227.
- De Jongh, A., De Baat, C., Horstman, M., Van Wijk, A.J., 2013. Self-perceived oral odour and social interaction. *Ned. Tijdschr. Tandheelkd.* 120, 194–198.
- De Jongh, A., Van Wijk, A.J., Horstman, M., De Baat, C., 2014. Attitudes towards individuals with halitosis: an online cross sectional survey of the Dutch general population. *Br. Dent. J.* 216, E8.
- De Jongh, A., Van Wijk, A.J., Horstman, M., De Baat, C., 2016. Self-perceived halitosis influences social interactions. *BMC. Oral. Health.* 16, 31.
- Delanghe, G., Bollen, C., Desloovere, C., 1999. Halitosis–foetor ex ore. *Laryngorhinootologie* 78, 521–524.
- Figueiredo, L.C., Rosetti, E.P., Marcantonio Jr., E., Marcantonio, R. A., Salvador, S.L., 2002. The relationship of oral malodor in patients with or without periodontal disease. *J. Periodontol.* 73, 1338–1342.
- Huang, X., Li, X., Fan, X., Liu, H., 2002. Levels of volatile sulfur compounds and the analysis of related factors in oral cavities of 384 health subjects in Chengdu. *Hua Xi Kou Qiang Yi Xue Za Zhi* 20, 380–382.
- John, M., Vandana, K.L., 2006. Detection and measurement of oral malodour in periodontitis patients. *Indian. J. Dent. Res.* 17, 2–6.
- Kato, H., Yoshida, A., Awano, S., Ansai, T., Takehara, T., 2005. Quantitative detection of volatile sulfur compound-producing microorganisms in oral specimens using real-time PCR. *Oral. Dis.* 11 (Suppl 1), 67–71.
- Kleinberg, I., Westbay, G., 1992. Salivary and metabolic factors involved in oral malodor formation. *J. Periodontol.* 63, 768–775.
- Kolokotronis, A., Dumas, S., 2006. Herpes simplex virus infection, with particular reference to the progression and complications of primary herpetic gingivostomatitis. *Clin. Microbiol. Infect.* 12, 202–211.
- Liu, Y., Huang, H.Y., Zhang, J.C., Wang, S.L., 2004. The study of the relationship of malodor and microbial composition of interdental and subgingival plaques in periodontitis patients. *Hua Xi Kou Qiang Yi Xue Za Zhi* 22, 466–470.
- Loesche, W.J., 2003. Microbiology and Treatment of Halitosis. *Curr. Infect. Dis. Rep.* 5, 220–226.
- Morita, M., Wang, H.L., 2001a. Association between oral malodor and adult periodontitis: a review. *J. Clin. Periodontol.* 28, 813–819.
- Morita, M., Wang, H.L., 2001b. Relationship between sulcular sulfide level and oral malodor in subjects with periodontal disease. *J. Periodontol.* 72, 79–84.
- Murata, T., Rahardjo, A., Fujiyama, Y., Yamaga, T., Hanada, M., Yaegaki, K., Miyazaki, H., 2006. Development of a compact and simple gas chromatography for oral malodor measurement. *J. Periodontol.* 77, 1142–1147.
- Nachnani, S., 2011. Oral malodor: causes, assessment, and treatment. *Compend Contin Educ Dent.* 32, 22–24, 26–28, 30–31; quiz 32, 34.
- Nakano, Y., Yoshimura, M., Koga, T., 2002. Methyl mercaptan production by periodontal bacteria. *Int. Dent. J.* 52 (Suppl 3), 217–220.
- Nally, F., 1990. Dry mouth and halitosis. *Practitioner* 234, 603.
- Pham, T.A., Ueno, M., Shinada, K., Kawaguchi, Y., 2012a. Comparison between self-perceived and clinical oral malodor. *Oral. Surg. Oral. Med. Oral. Pathol. Oral. Radiol.* 113, 70–80.
- Pham, T.A., Ueno, M., Shinada, K., Kawaguchi, Y., 2012b. Factors affecting oral malodor in periodontitis and gingivitis patients. *J. Investig. Clin. Dent.* 3, 284–290.
- Pham, T.A., Ueno, M., Zaitu, T., Takehara, S., Shinada, K., Lam, P. H., Kawaguchi, Y., 2011. Clinical trial of oral malodor treatment in patients with periodontal diseases. *J. Periodontal. Res.* 46, 722–729.
- Schmidt, N.F., Missan, S.R., Tarbet, W.J., 1978. The correlation between organoleptic mouth-odor ratings and levels of volatile sulfur compounds. *Oral. Surg. Oral. Med. Oral. Pathol.* 45, 560–567.
- Scully, C., Greenman, J., 2012. Halitology (breath odour: aetiopathogenesis and management). *Oral. Dis.* 18, 333–345.
- Soares, L.G., Castagna, L., Weyne, S.C., Silva, D.G., Falabella, M.E., Tinoco, E.M., 2015. Effectiveness of full- and partial-mouth disinfection on halitosis in periodontal patients. *J. Oral. Sci.* 57, 1–6.
- Silva, M.F., Nascimento, G.G., Leite, F.R.M., Horta, B.L., Demarco, F.F., 2020. Periodontitis and self-reported halitosis among young adults from the 1982 Pelotas Birth Cohort. *Oral. Dis.* 2020. <https://doi.org/10.1111/odi.13286>.
- Silveira, J.O., Costa, F.O., Oliveira, P.A., Dutra, B.C., Cortelli, S.C., Cortelli, J.R., Cota, L.O., Oliveira, A.M., 2017. Effect of non-surgical periodontal treatment by full-mouth disinfection or scaling and root planing per quadrant in halitosis—a randomized controlled clinical trial. *Clin. Oral. Investig.* 21, 1545–1552.
- Takeuchi, H., Machigashira, M., Yamashita, D., Kozono, S., Nakajima, Y., Miyamoto, M., Takeuchi, N., Setoguchi, T., Noguchi, K., 2010. The association of periodontal disease with oral malodour in a Japanese population. *Oral. Dis.* 16, 702–706.
- Tangerman, A., Winkel, E.G., 2008. The portable gas chromatograph OralChroma: a method of choice to detect oral and extra-oral halitosis. *J. Breath. Res.* 2, 017010.
- Tonzetich, J., 1977. Production and origin of oral malodor: a review of mechanisms and methods of analysis. *J. Periodontol.* 48, 13–20.
- Tonzetich, J., Coli, J.M., Ng, W., 1991. Gas chromatographic method for trapping and detection of volatile organic compounds from human mouth air. *J. Clin. Dent.* 2, 79–82.
- Volozhin, A.I., Petrovich, I., Filatova, E.S., Barer, G.M., Fomina, O. L., Kreit, K., Volozhina, S.A., Dieva, S.V., 2001. Volatile compounds in air and oral saliva in healthy people, and in periodontitis and gingivitis patients. *Stomatologiya (Mosk)* 80, 9–12.
- Waler, S.M., 1997. On the transformation of sulfur-containing amino acids and peptides to volatile sulfur compounds (VSC) in the human mouth. *Eur. J. Oral. Sci.* 105, 534–537.
- Yaegaki, K., Brunette, D.M., Tangerman, A., Choe, Y.S., Winkel, E. G., Ito, S., Kitano, T., Ii, H., Calenic, B., Ishkitiev, N., Imai, T., 2012. Standardization of clinical protocols in oral malodor research. *J. Breath. Res.* 6, 017101.
- Yano, T., Fukamachi, H., Yamamoto, M., Igarashi, T., 2009. Characterization of L-cysteine desulhydrase from *Prevotella intermedia*. *Oral. Microbiol. Immunol.* 24, 485–492.
- Yasukawa, T., Ohmori, M., Sato, S., 2010. The relationship between physiologic halitosis and periodontopathic bacteria of the tongue and gingival sulcus. *Odontology* 98, 44–51.
- Zalewska, A., Zatonski, M., Jablonka-Strom, A., Paradowska, A., Kawala, B., Litwin, A., 2012. Halitosis—a common medical and social problem. a review on pathology, diagnosis and treatment. *Acta Gastroenterol. Belg.* 75, 300–309.