Review Article

Oral malodor: A review

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ABSTRACT

Breath odor research captured the scientific community's attention during the last few decades. Evidence-based studies have justified that halitosis causes social restriction and decreased life quality, and that it may be an indicator for periodontal as well as systemic diseases. This has led to the advances in analytical monitors used for the identification and measurement of the malodourous compounds. The present discussion intends to focus on the etiology, pathophysiology, diagnostic criteria, and the various treatment strategies for halitosis.

Key words: Chemical approach, gas chromatography, halitosis, organoleptic, periodontal disease, volatile sulfur compounds (VSCs)

INTRODUCTION

Halitosis, the general term, describes any unpleasant odor perceived in the exhaled air of the individual, regardless of its origin (oral or extraoral) while the term oral malodor is used to describe any offensive odor originating from the oral cavity.[1,2]

HISTORY

Historic references on halitosis include the Jewish *Talmud* as well as Greek and Roman writings.[3]

1500 BC — Egyptians used a recipe named *Papyrus Ebers* for the treatment of halitosis. Its main ingredient was garlic.[4]

460–400 BC — Hippocrates formulated a mouthwash of unadulterated wine, anise, dill seed, and myrtle.[5]

254-184 BC — Marcus Platus recorded the occurrence of malodor.[5]

1874 — Joseph Howe, a physician, first described halitosis in modern literature, making it a clinical entity.[2] He postulated that halitosis was the result of sulfurated hydrogen, which is found in great abundance in the intestinal canal as well as in decayed teeth, dead teeth, and inflamed gums. Stresses in the form of fear, excitement, or tension may sufficiently alter the body system to produce a disagreeable breath odor.[5]

1921 — The company Listerine coined the term halitosis.[6]

1930 — G. L. Grapp hypothesized that the back of the tongue was the major source of oral malodor.[7]

1930 — Prinz distinguished between oral and nasal malodor.[7]

1936 — Costellani reported that the ear, nose, and throat are not uncommon sources of malodor.[8]

1971 — Dr. Joseph Tonzetich, considered to be the modern-

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day pioneer in bad breath research, discovered that the odoriferous compounds are volatile sulfur compounds.[8]

1972 — McNamara recognized the microorganisms responsible for oral malodor.[8]

1980 — Kostele discovered that diamines also cause oral malodor.[8]

1982 — Davidson and Mukherjee stated that haliphobia is accompanied by clear psychological pathologies.

1987 — Pruet and Duplan identified tonsil and tonsilloliths also as sources or oral malodor.

1990 — Persson identified hydrogen sulfide and methyl mercaptan that were produced by bacterial metabolism of sulfur-containing amino acids, cysteine and methionine.[8]

1992 — Yaegaki identified the relationship of volatile sulfur compounds with pocket depth in patients with periodontal disease.[9]

1994 — Bosy stated the relationship of halitosis to periodontal health.[8]

1995, 1996 — De Boever and Loeshe and Hartley identified the major site that harbors microflora as the tongue.[8]

1995 — Miyazaki was the first to measure volatile sulfur compound levels by a portable sulfide monitor. He correlated the levels with periodontal status.[9]

1995-1999 — De Boever and Loeshe, Waler, Harley: They conducted a series of studies on the chemical reduction of bacterial load in the oral cavity and correlated it with halitosis.[8]

1997 — Delanghe and Steenberghe reported that over 90% of all malodor originates in the mouth.[7]

1998 — Quirynen discovered that treatment of periodontal disease caused reduction in oral malodor.[9]

1998 — Greenman correlated the levels of oral malodor with the number of gram-negative anaerobes and sulfide-producing organisms on the tongue surface.[8]

1999 — Greenman said that halitosis was primarily due to metabolite products generated by bacteria in the oral cavity but may also arise as a result of systemic disease.[8]

CLASSIFICATION

In the year 2000, Yaegaki and Coil classified halitosis as genuine, pseudo, and halitophobia.[10]

Genuine halitosis: In genuine halitosis, oral malodor above socially agreeable levels. It is again classified as physiological and pathological.[10]

Physiological halitosis: This is usually transient and does not hold much clinical significance as for example, morning breath and ingestion of certain foods such as spices, garlic, cabbage, or onion. This can often be rectified by performing oral hygiene measures.[11]

Pathologic halitosis: This develops secondary to pathologic conditions such as periodontitis, gingivitis, necrotizing ulcerative gingivitis, aphthous ulcers, and xerostomia or even tongue coating.[5]

It can also be of extraoral origin. Malodor can originate from any pathology in the nasal, paranasal, and pulmonary tracts or digestive tract. Diabetes mellitus, uremia, and cirrhosis of the liver all cause the emission of characteristic odors.[12] 90% of all malodor is of oral origin[5] and 10% is of extraoral origin.[13]

Pseudohalitosis: The patient complains of the presence of malodor but it is not sensed by others.[5,12]

Halitophobia: Even after treatment of genuine halitosis or pseudohalitosis, the individual stubbornly insists that malodor is present. There is no clinical or social evidence to support this.[5,12]

The dental team can identify the etiology and determine the treatment protocols by following this classification [Table 1].[12]

ETIOLOGY

Morning breath is considered as physiologic halitosis. It is transient and is readily rectified.[11] Prinz (1930)[14] suggested that the oral cavity is a source of more than 90% of all the cases of objectionable breath. Halitosis can be caused due to local factors of pathological origin such as poor oral hygiene, extensive caries, gingivitis, chronic periodontal disease, and open contacts allowing for food impaction, fissured tongue, Vincent's disease, hairy or

Table 1: Treatment need for oral malodor

Category	Classification	Treatment
TN-1	Physiologic halitosis	Patient education, oral hygiene instructions, and periodic reinforcement
TN-2	Pathologic halitosis Oral	TN-1+oral prophylaxis, diagnosis, and treatment of oral diseases
TN-3	Pathologic halitosis Extraoral	TN-1+patient to be referred for medical opinion
TN-4	Pseudo-halitosis	TN-1+discussing the examination data with the patient and reassuring the patient
TN-5	Halitophobia	TN-1 + seeking the aid of a clinical psychologist

coated tongue, healing extraction wounds, excessive smoking, and necrotic tissues from ulcerations. Chronic sinusitis with postnasal drip, rhinitis, tonsillitis, syphilitic ulcers, pharyngitis, cancrum oris, tumors of the trachea and bronchi, and infected malignant neoplasm of the oral and pharyngeal cavities are other conditions implicated in causing halitosis.[11] The major regulating factor in the formation of oral malodor is pH.[15] The two main sources of volatile sulfur compounds (VSCs) in the oral cavity in both periodontally healthy and diseased populations are the gingival sulcus and tongue.[16-18]

Stagnation of the saliva, excessive smoking, and dentures are local factors of nonpathologic origin that can produce halitosis.[11]

Halitosis can be the result of systemic factors of pathologic origin.[11] Attia and Marshall (1982)[18] discussed the various nonoral conditions, which could give rise to "bad breath." Their list includes systemic diseases such as diabetes mellitus, chronic renal failure, and cirrhosis of the liver. These odors serve as noninvasive indicators of systemic metabolism.[18] In severe hepatic failure, the breath, known as fetor hepaticus, produces a sweet, feculent, amine odor resembling a fresh cadaver. An acid sweet odor suggests acute rheumatic fever, and a foul putrefactive breath is indicative of lung abscess or bronchiectiasis. In almost all cases of acute scurvy and chronic scurvy, patients have the typical foul breath of persons with fusospirochetal stomatitis.

System diseases such as agranulocytosis, polycythemia vera, hemophilia, aplastic anemia, and thrombocytopenia have halitosis due to infection, necrosis, and decomposed blood from spontaneous bleeding in the oral cavity. In trimethylaminuria, there is deficiency of an enzyme that normally breaks down trimethylamine giving a fishlike odor to the urine, saliva, and sweat.[11]

Halitosis can even be due to the systemic administration of drugs such as isosorbide dinitrate (antianginal drug) and drugs with iodine or chloral hydrate. Some antineoplastic agents, antihistamines, amphetamines, tranquilizers, diuretics, and atropine-like drugs are used to reduce saliva production and therefore, decrease the self-cleansing ability of the oral cavity.[11]

Xerostomia due to mouth breathing, heavy smoking, aging, salivary gland aplasia, Sjogren's syndrome, Mikulicz's disease, macroglobulinemia with salivary gland involvement, diabetes, menopause, radiation therapy, systemic and metabolic diseases, emotional disturbances, and poor oral hygiene can all induce halitosis.[18]

PATHOPHYSIOLOGY OF ORAL MALODOR

The odoriferous substances that produce malodor arise from the interaction of microorganisms in the oral cavity and their specific substrates. Proteolytic degradation of substrates containing sulfur in the saliva, blood, food debris, and epithelial cells by these anaerobic gram-negavtive bacteria result in the formation of agents that can give rise to oral malodor.[19] Amino acids such as cysteine, methionine, arginine, tryptophan, and lysine are biotransformed by the anaerobic bacteria into VSCs (odiferous hydrogen sulfide, methylmercaptan, indole, putrescine, and cadaverine) and sugars are biotransformed by the anaerobic bacteria into short-chain organic compounds[Figure 1].[11,20]

The gram-negative bacterial species commonly associated with oral malodor are *Treponema denticola*, *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella endodontalis*, *Bacteriodes loescheii*, *Tannerella forsythensis*, *Enterobacteriacea*, *Eikenella corrodens*, and *Fusobacterium nucleatum*.[19,11,28]

Prevotella intermedia have been reported to generate produce CH_3SH and H_2S from L-methionine and L-cysteine, respectively.[21,24]

Gram-positive microorganisms such as *Streptococcus salivarius* also have been found to contribute to malodor production. They can deglycosylate the salivary glycoproteins, therefore helping in exposing the protein core for further denaturation by gram-negative bacteria.[22]

ASSOCIATION BETWEEN HALITOSIS AND PERIODONTAL DISEASE

Evidence has suggested a clear relationship between compromised periodontal conditions and halitosis. In 1998, a study conducted by Yaegaki stated that the periodontal pocket is the main source for VSCs in aggressive periodontitis. Specific periodontal parameters and oral malodor have been found to have considerable associations. Periodontal pockets encourage the trapping of food. The

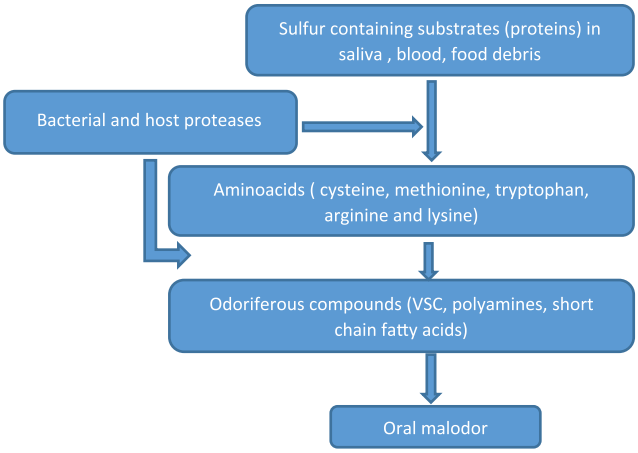

Figure 1: Pathophysiology of volatile sulphur compounds.[19,20]

VSCs emitted by an individual suffering from chronic periodontits is eight times more than one having a healthy periodontium. After the treatment of chronic periodontitis (surgical or nonsurgical), the levels of oral malodor were drastically reduced.[23]

VSCs have also been implicated in the progression of periodontal disease.[5,24]

VSCs aggravate periodontitis by:[25]

- Disrupting the oral mucosa (pocket epithelium), thereby increasing bacterial invasion.
- Impede wound-healing by altering metabolism of fibronectin.
- Increase the release of interleukin- 1 and PGE2.

High VSC concentration might be a predictor of periodontal disease progression.[26]

DIAGNOSIS OF ORAL MALODOR

The first step in the diagnosis of oral malodor is determining whether halitosis is present or not (genuine, pseudo, or halitophobia).[11] This includes taking a proper history of the patient — Chief complaint, medical history, dental history, diet history and habit history, oral malodor history, extraoral examination, intraoral examination, and periodontal examination.[27]

SELF-ASSESSMENT TESTS

Self-assessment tests include whole mouth malodor (cupped breath), wrist-lick test, home microbial testing, spoon test, dental floss test, and saliva odor test.

OBJECTIVE TESTS

The three main methods of analyzing oral malodor are organoleptic measurement, gas chromatography (GC). and sulfide monitoring.[11] Table 2 describes the various objective tests used for the assessment of halitosis.

MANAGEMENT OF HALITOSIS

Mechanical approach[37]

Breakfast, improving hyposalivation, and chewing gum: These lead to removal of stagnant epithelial and food debris from the soft tissues. Chewing gum can mechanically stimulate salivary flow, thus helping in the cleaning the teeth.

Brushing teeth, flossing, and using toothpicks: These reduce the amount of oral bacteria and substrates, therefore reducing oral malodor.

Tongue-cleaning: Brushing the dorsum of the tongue using toothpaste is much more effective than brushing the teeth to reduce halitosis.

Table 2: Objective tests

Tests	Description
Organoleptic measurement (sniff test)	Organoleptic measurement is a sensory test scored on the basis of the examiner's perception of a subject's oral malodor. This is considered to be the gold standard.[11] The test is simple and does not require any specialized equipment. The examiner smells the air exhaled by the subject through a plastic tube or straw inserted in to the patient's mouth. Upon evaluation of the odor, it is given a score (0-5).[28,30]
Gas chromatography (GC)	Gas chromatography is the preferable method if precise measurements of specific gases are required.[11] However, the GC equipment is sophisticated and the procedure requires a skillful operator; therefore, it is impractical for practitioners to equip their offices for GC.[28,29,23]
Saliva incubation test	The analysis of the headspace above the incubated saliva by gas chromatography. It is a less invasive test.[31]
Dark field/phase contrast microscopy	For monitoring of microbial shift in proportion. For the patient's education
Sulfide monitors (halimeter)[1,3]	The level of intraoral VSCs can be estimated chairside, using portable sulfide monitors. The instrument is equally sensitive to H_2S and CH_3SH in the range of 0-500 ppb.[5] The equipment is cheap, handy, and simple to use.[23,32]
The electronic nose	The "electronic nose" is a hand-held device, being developed to rapidly classify and quantify exact smells. This device has the potential to be used as a diagnostic tool to detect odors.[5,33]
Ninhydrin method of detecting amine compounds	Colorimetric reaction that is a method that is simple, rapid, and inexpensive, which may be used for the examination of amino acids and low-molecular-weight amines.[34]
Halitox system	Halitox reagent containing mixture of chemicals reacts with anaerobic bacterial metabolites to produce yellow colored reaction products. Five color scales ranging from clear (no toxins) to bright yellow (high level of toxins)
Topas (toxicity prescreening assay)	Detection of bacterial and fungal toxins from the tongue scraping or GCF samples
Zinc oxide and nitrogen chemiluminescence detectors[5]	The precise measurement of nitrogen compounds such as indole and cadaverine in organic matrices
Bana tests[5,35,36]	Chairside test that is used to determine the proteolytic activity of certain oral anaerobes that contribute to oral malodor
Perio 2000 diamond probe system[36]	Periodontal probe designed to measure the VSCs produced by periodontal pathogens in the periodontal pocket

Table 3: Chemical agents used in the treatment of oral malodor

Chlorhexidine (CHX) gluconate	0.2% of solution gives an anti- VSC effect even after 1 h and due to its substantivity, shows improves results at 2 H and 3 h.[39,19]
Essential oils	Solutions of thymol, menthol, eucalyptol, and methyl salicylate. Rinsing reduces anaerobic bacterial count on the tongue and in plaque.[39,19]
Triclosan	Triclosan solubilized in sodium lauryl sulfate, propylene glycol, and water gives a prolonged anti-VSC effect
Cetylpyridinium chloride	Although lack substantivity benzalkonium and cetylpyridinium chloride can inhibit bacterial growth. Its activity is only for 3 h.[38]
Dehydroascorbic acid	Oxidizing lozenges can effectively reduce tongue malodor over 3 h.[37]
Zinc	Zinc, sodium, tin, and magnesium can interact with sulfur and form sulfides with low solubility.[38] Zinc has low toxicity and does not stain the dentition.[19]
Chlorine dioxide rinse	It is a strong oxidizing agent. It reacts with cysteine and methionine, preventing the production of VSCs.[38]
Hydrogen peroxide	Percent reduction in salivary thiols was found to be 59%.[37]
Eucalyptus extracts	Toothpastes and mouthrinses with antimicrobial properties can chemically reduce plaque accumulation by reducing the number of causative microorganisms.[40]
Combination of agents used:	
Chlorhexidine and zinc	Effective for 9 h.[38,19]
Cetylpydinium and zinc ions	Effective for 1 h.[38,19]
Chlorhexidine, CPC, and zinc lactate	The formulation containing 0.05% CHX, 0.05% CPC, and 0.14% zinc lactate was found to be most effective.[38,19]

Professional oral health care: This reduces the levels of VSCs in the exhaled air drastically.

CHEMICAL APPROACH

The aim of any antimicrobial treatment is to reduce the proteolytic anaerobic microbial flora found in the oral cavity. The treatment protocol should always combine mechanical and chemical approaches, for example, using a tongue scraper and an antimicrobial rinse.[38] A multitude of chemical agents is available in the market for the treatment of oral malodor [Table 3].

CONCLUSION

Halitosis is an embarrassing symptom with a significant social impact. Halitosis affects millions of people worldwide and many resources are spent annually on products to improve the breath. Evidence-based studies have justified that halitosis causes social restriction, decreased life quality, and may be an indicator of periodontal as well as systemic diseases.

Over the years, the social impact of halitosis has gained much importance. It is humiliating for the patients, making them feel insecure to relate to other people who have halitosis. Hence, this field has been a subject of extensive research during the recent years. This has led to the advances in analytical monitors used for identification and measurement of the malodourous compounds.

Along with important socioeconomic consequences, breath malodor can reveal systemic diseases. Therefore, halitosis must be treated as a serious condition, a multifactorial and rational approach essential for good results. Proper diagnosis and determination of the etiology allow initiation of proper etiologic treatment.

Identification of halitosis is in itself a problem due to subjectivity of the perception of the examiner and the patient. The last few years have seen innovative methods being conducted on sulfide monitoring, leading to improvements in the designs of monitors.

Management of oral malodor is dependent on diagnosing the foul breath as physiological or pathological. The therapy should then be appropriately and specifically directed to the cause of the oral malodor to ameliorate or totally eliminate the condition.

It is recommended that health care professionals be aware about the etiology of some taste and smell disorders that may also lead to halitosis. From this perspective, the concept of halitosis should be reviewed because it is not just the emanation of an unpleasant odor through the expired air but also the self-perception of it.

Dental researchers worldwide have ignored the subject of oral malodour for long. During recent times, along with the growing public interest and media interest in oral malodor, dental professionals are becoming more aware of their patients' concern/needs. It is hoped that future studies will overcome the difficulty of diagnosing this longstanding problem and provide effective treatments to relieve individuals who suffer from oral malodor.

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REFERENCES

1. Blom T, Slot DE, Quirynen M, Van der Weijden GA. The effect of mouthrinses on oral malodor: A systematic review. Int J Dent Hyg 2012;10:209-22.

2. Gnanasekhar JD. Aetiology, diagnosis and management of halitosis: A review. Perio 2007;4:203-14.
3. Pratibha PK, Bhat KM, Bhat GS. Oral malodor: A review of the literature. J Dent Hyg 2006;80:8.
4. Groppo FC, Ramacciato JC, Motta RH, Ferraresi PM, Sartoratto A. Antimicrobial activity of garlic against oral streptococci. Int J Dent Hyg 2007;5:109-15.
5. Kapoor A, Grover V, Malhotra R, Kaur S, Singh K. Halitosis - Revisited. Indian J Dent Sci 2011:3:102-11.
6. Rayman S, Almas K. Halitosis among racially diverse populations: An update. Int J Dent Hyg 2008;6:2-7.
7. Rosenberg M. Bad breath and periodontal disease: How related are they? J Clin Periodontol 2006;33:29-30.
8. Riggio MP, Lennon A, Rolph HJ, Hodge PJ, Donaldson A, Maxwell AJ, *et al*. Molecular identification of bacteria on the tongue dorsum of subjects with and without halitosis. Oral Dis 2008;14:251-8.
9. Tsai CC, Chou HH, Wu TL, Yang YH, Ho KY, Wu YM, *et al*. The levels of volatile sulfur compounds in mouth air from patients with chronic periodontitis. J Periodontal Res 2008;43:186-93.
10. Tanwir F, Momin IA. Halitosis. Pak Oral Dental J 2011;31:304-8.
11. Scully C, Greenman J. Halitosis (breath odor). Periodontol 2000 2008;48:66-75.
12. Armstrong BL, Michelle L, Stoltenberg JL. Halitosis: A review of current literature. J Dent Hyg 2010;84:65-74.
13. Lindhe J, Lang NP, Karring T. Clinical Periodontology and Implant Dentistry. 5th ed. Oxford: Blackwell; 2008.
14. Tonzetich J. Production and origin of oral malodor: A review of mechanisms and methods of analysis. J Periodontol 1977;48:13-20.
15. Tolentino Ede S, Chinellato LE, Tarzia O. Saliva and tongue coating pH before and after use of mouthwashes and relationship with parameters of halitosis. J Appl Oral Sci 2011;19:90-4.
16. Faveri M, Feres M, Shibli JA, Hayacibara RF, Hayacibara MM, de Figueiredo LC. Microbiota of the dorsum of the tongue after plaque accumulation: An experimental study in humans. J Periodontol 2006;77:1539-46.
17. Calil C, Liberato FL, Pereira AC, de Castro Meneghim M, Goodson JM, Groppo FC. The relationship between volatile sulphur compounds, tongue coating and periodontal disease. Int J Dent Hyg 2009;7:251-5.
18. Preti G, Clark L, Cowart BJ, Feldman RS, Lowry LD, Weber E, *et al*. Non-oral etiologies of oral malodor and altered chemosensation. J Periodontol 1992;63:790-6.
19. Basavaraj P, Khuller N. Halitosis: A review. Indian J Stomatol 2011; 2:183-6.
20. Wåler SM. On the transformation of sulfur-containing amino acids and peptides to volatile sulfur compounds (VSC) in the human mouth. Eur J Oral Sci 1997;105:534-7.
21. Yang F, Huang S, He T, Catrenich C, Teng F, Bo C, *et al*. Microbial basis of oral malodor development in humans. J Dent Res 2013; 92:1106-12.
22. Sterer N, Rosenberg M. Streptococcus salivarius promotes mucin putrefaction and malodor production by porphyromonas gingivalis. J Dent Res 2006;85:910-4.
23. Sopapornamorna P, Uenoa M, Shinadaa K, Vachirarojpisana T, Kawaguchia Y. Clinical application of a VSCs monitor for oral malodour assessment. Oral Health Prev Dent 2006;4:91-7.
24. Yano T, Fukamachi H, Yamamoto M, Igarashi T. Characterization of L-cysteine desulfhydrase from prevotella intermedia. Oral Microbiol Immunol 2009;24:485-92.
25. Ratcliff PA, Johnson PW. The relationship between oral malodor, gingivitis, and periodontitis. A review. J Periodontol 1999;70:485-9.
26. Makino Y, Yamaga T, Yoshihara A, Nohno K, Miyazaki H. Association between volatile sulfur compounds and periodontal disease progression in elderly non-smokers. J Periodontol 2012; 83:635-43.
27. Saini N, Ajwani P, Kaur K, Kumar A. Oral malodor: A common oral problem. J Bioengineer Biomedical Sci 2011;2.
28. Donaldson AC, McKenzie D, Riggio MP, Hodge PJ, Rolph H, Flanagan A, *et al*. Microbiological culture analysis of the tongue anaerobic microflora in subjects with and without halitosis. Oral Dis 2005;11(Suppl 1):61-3.
29. Van den Velde S, van Steenberghe D, Van Hee P, Quirynen M. Detection of Odorous Compounds in breath. J Dent Res 2009; 88:285-9.
30. Bornstein MM, Kislig K, Hoti BB, Seemann R, Lussi A. Prevalence of halitosis in the population of the city of Bern, Switzerland: A study comparing self-reported and clinical data. Eur J Oral Sci 2009;117:261-7.
31. Quirynen M, Zhao H, Avontroodt P, Soers C, Pauwels M, Coucke W, *et al*. A salivary incubation test for evaluation of oral malodor: A pilot study. J Periodontol 2003;74:937-44.
32. Newman MG, Takei HH, Klokkevold PR, Carranza FA. Carranza's Clinical Periodontology. 11th ed. St. Louis, MO: Elsevier Saunders; 2012. p. 430-2.
33. Kaltschmitt J, Eickholz P. Halitosis: A short overview. Perio 2005;2:267-73.
34. Iwanicka-Grzegorek K, Lipkowska E, Kepa J, Michalik J, Wierzbicka M. Comparison of ninhydrin method of detecting amine compounds with other methods of halitosis detection. Oral Dis 2005;11(Suppl 1): 37-9.
35. Loesche WJ, Kazor C. Microbiology and treatment of halitosis. Periodontol 2000 2002;28:256-79.
36. Kini VV, Pereira R, Padhye A, Kanagotagi S, Pathak T, Gupta H. Diagnosis and treatment of halitosis: An overview. J Contemp Dent 2012;2:89-95.
37. Broek VD, Feenstra L, Baat C. A review of the current literature on management of halitosis. Oral Diseases .2008;14:30-9.
38. Cortelli JR, Barbosa MD, Westphal MA. Halitosis: A review of associated factors and therapeutic approach. Braz Oral Res 2008;22(Suppl 1):44-54.
39. Farrell S, Baker RA, Somogyi-Mann M, Witt JJ, Gerlach RW. Oral malodor reduction by a combination of chemotherapeutical and mechanical treatments. Clin Oral Invest.2006;10:157-63.
40. Tanaka M, Toe M, Nagata H, Ojima M, Kuboniwa M, Shimizu K, *et al*. Effect of eucalyptus-extract chewing gum on oral malodor: A double-masked, randomized trial. J Periodontol 2010;81:1564-71.