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Review of Menthol in Oral Care Formulation as Freshner and Preventing Halitosis

Fenti Fatmawati[1], Alvina Putri Wachyuni[1], Denny Puriyani Azhary[1]
[1]*Faculty of Pharmacy, Bhakti Kencana University, Indonesia*

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ABSTRACT:Menthol (camphormint) is the main component of the essential oils M. piperita L. (peppermint) and Mentha canadensis L. (cornmint). Menthol together with Isomementone, Menthone, and other compoun ds, gives a refreshing mint taste and aroma, especially to members of the Mentha genus. Menthol is the main component of essential oils found in very limited quantities from aromatic plants which are known to exhibit diverse biological properties such as antibacterial, antitumor, and anti-inflammatory properties. Halitosis (bad breath) is caused by bacteria and proteins in the oral cavity. This condition causes an unpleasant odor and is often complained of. Toothpaste that adds menthol to its preparation will produce a distinctive aroma like candy and can be used as a refresher because menthol gives a cold or refreshing sensation. Peppermint extract is usually made in the form of essential oil or also called mint oil. Essential oil from mint leaves, besides functioning to inhibit the growth of S.mutans bacteria, also has antibacterial activity against several pathogens. The purpose of this journal review is to provide information on formulations of mouth fresheners and halitosis preventers containing menthol.

KEYWORDS: Halitosis, Menthol, Peppermint.

I. INTRODUCTION

[1].Menthol (2-Isopropyl-5 methylcyclohexanol) is a naturally occurring organic compound that has a wide range of biological responses. Menthol produces a sensation of coolness, without a decrease in temperature, through activation of cold sensory pathways to the thalamus and somatosensory cortex. Menthol can be applied externally to the skin through creams, gels, sprays, or solutions, while the internal application is achieved through the ingestion of a drink or mouthwash.

[2].Menthol is an organic compound with the ability to exert a non-thermal cooling effect on the targeted receptors. The FDA generally considers menthol as the main ingredient of peppermint oil which is safe and its toxicity is rarely reported. Mint oil and its main ingredient, l-menthol, are widely used in cooking, food, seasoning, and medicine. Menthol crystals are obtained directly from mint oil and are used in several commercial preparations. Mint species are characterized by widespread stolons that grow both below and above the ground and have erect, square, branched stems. The leaves are oval to lanceolate, arranged oppositely, have serrated edges, and are often downy. The essential oil of the mentha species, mainly from M. piperita is obtained through the steam distillation process. About 50-55% of the frozen oil yields menthol in crystalline form. When administered orally in small doses, menthol has a carminative effect. The permissible concentration of menthol in toothpaste preparations is around 0.4%, mouthwash 0.1-0.2%, and in oral spray with a concentration of 0.3%.

[3].Menthol is a covalent organic compound obtained from peppermint or mint oil with a pervasive mint aroma and cool taste made synthetically through a chemical process. Menthol is usually used in oral hygiene products and bad breath remedies such as mouthwash, toothpaste, tongue spray, and mint leaves which are added to toothpaste, and mouthwash products are safe to use without side effects that can help overcome bad breath. Oral hygiene products are used as additives that serve to provide significant cooling benefits to consumers, particularly to mask bad breath, and the more common use of menthol is as a food flavoring agent (such as in chewing gum and candy). Its antimicrobial activity has been demonstrated against several strains of Gram-positive and Gram-negative bacteri.

[4].Mint (Mentha piperita) is an aromatic plant belonging to the Lamiaceae family. Mentha genus consists of three types that are used as a producer of mint oil, namely mint leaf oil (M, piperita), spearmint oil (M.spicata) and cormint oil from the poko leaf plant (M. arvensis). This plant is

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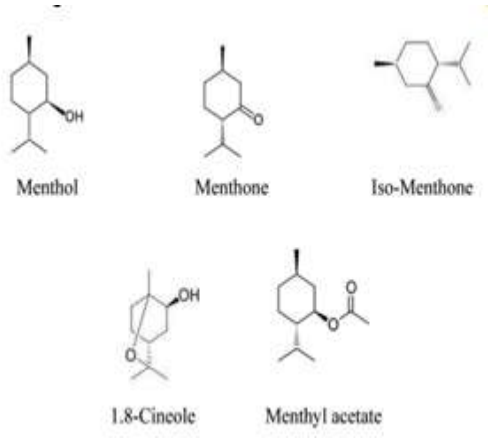
a perennial herb, with a large trunk, serrated leaf tips, and opposite leaves. Mint (Mentha piperita) is the most widely developed and marketed type of mentha which is used as a raw material for pharmaceutical preparations, beverage, and food flavorings as well as in cosmetics.

Peppermint

[5].Mint (Mentha spp.) is a popular aromatic and medicinal herb belonging to a large family of perennial herbs and is commonly cultivated worldwide for its superior plant properties such as antimicrobial and antioxidant properties.[6].Peppermint leaves contain about (0.5-4%) essential oils consisting of (25-78%) menthol, (14-36%) menthone, (1.5-10%) isomenthon, (2.8-10%), menthyl acetate, and (3.5-14%) cineol. [7].A total of 36 components were identified in fresh peppermint leaves, representing 93.84% of the total volatiles. In fresh samples, the main components were menthol (44.39%), mentofuran (10.27%), menthone (15.36%), 1,8-cineole (5.81%), limonene (1.87%) ,neoisomenthol (2.37%), and menthyl acetate (4.78%). The difference in the amount of peppermint chemical compounds, in general, can be attributed to the geographical origin of the plant, genetics, harvest time, and xtraction method.



Components of Peppermint [8]

[9].Peppermint is a plant that results from a cross between watermint (Mentha aquatica) and spearmint (M. spicata). Peppermint oil is used as a raw material for dental preparations, mouth fresheners, perfumes, analgesic balms, confectionery, cough medicines, chewing gums, candies, soaps, and shampoos.[10].Peppermint essential oil is obtained from fresh mint leaves or dried leaves through a hydrodistillation process. Peppermint oil mainly contains monoterpene and sesquiterpene hydrocarbons, phenylpropanoids, and their oxygenated derivatives. Peppermint essential oil is widely used in the pharmaceutical industry for both external and internal use. For internal use, mint oil is used in flatulence, nausea, and gastralgia due to the presence of menthol which has a pleasant taste. Mint oil has various external applications in rheumatism, neuralgia, congestive headaches, and toothaches. It is stated that the prescribed amount of peppermint essential oil for intake in adults is about 0.2-0.4 ml of oil, three times a day. [11].The genus Mentha belongs to the family Lamiaceae and consists of 25 to 30 species. It is native to Europe, grows naturally in the northern United States, Canada, and is produced worldwide.[12].The main component of peppermint oil is menthol (35-65%), which acts as an antibacterial and mouth freshener. [13].Peppermint oil contains many important terpenoids, such as mentone, menthol, mentofuran, isomentone, pulegone, caryophyllene, neomentol, 1,8-cineol, sabinene, and limonene, as well as having antimicrobial, antioxidant and cytotoxic activities. Peppermint extract is usually made in the form of essential oil or also called mint oil and has a distinctive taste. Mentha piperita or commonly called mint leaves has a cool taste sensation and a refreshing aroma. This fresh aroma is produced from mint leaf essential oil which contains menthol compounds.

[14].Peppermint leaves contain a large number of volatile compounds, which are commonly found in essential oils and are usually analyzed in this fraction. Monoterpenes, including menthol, menthone, and menthyl acetate, are the predominant terpenic volatiles in peppermint essential oil. High content of non-volatile compounds, including flavonoids and phenolic acids, is also found in peppermint extract. Rosmarinic acid, rutin, and caffeic acid are the main phenolic compounds. [15].Essential oils can be prepared by hydrodistillation (HD), supercritical fluid extraction (SFE), ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), or other methods. Essential oil preparation methods usually require a long extraction duration at high temperatures (HD) or expensive special equipment (SFE and MAE). Of the main methods of preparation, HD essential oil is the most frequently used. Terpenoids are the main class of lipophilic compounds in peppermint, so gas chromatography-mass spectrometry (GC-MS) was used to determine their profile.

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Halitosis

[16].Halitosis is a condition in which bad breath originates in the oral cavity or outside the oral cavity. The oral cavity is part of the digestive tract with unique anatomy, which is made up of hard and soft tissues. There is one anomaly in the oral cavity, namely halitosis which is not a disease but is considered an indication of several systemic diseases, therefore an unpleasant odor in the oral cavity is not a reference to the presence of certain diseases.

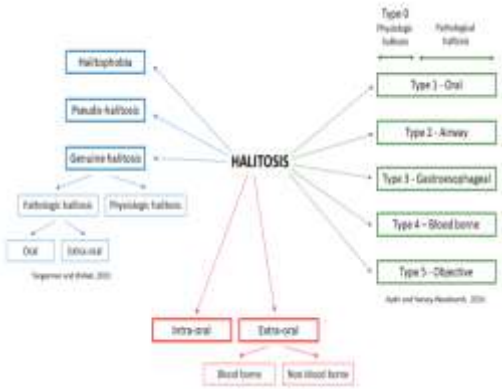
[17].Halitosis is a common complaint that is popularly known as bad breath. The factors that cause halitosis are caused by bacteria and proteins in the oral cavity of everyone. The emergence of this unpleasant odor is caused by several factors, but the most common is due to problems with the digestive organs and dirty oral hygiene. The severity of bad breath varies, some are mild (doesn't bother those around them) and there are people with severe bad breath (very annoying to others) so that it can affect their self-esteem.

[18].A dirty mouth can be one of the causes of halitosis. Contaminated food and bacteria in food can be a factor causing halitosis, therefore it is necessary to prepare an oral cleanser containing menthol which serves to freshen the mouth. Hygiene of the oral cavity which consists of the tongue, teeth, and salivary glands is something that must be considered. Bad breath, canker sores, and oral infections are problems that often occur in oral health, while more serious oral health problems are oral cancer, gingivitis, and dry mouth.[19].Bad breath can come from the oral cavity (local) called foetor ex ore, or from outside the mouth (systemic) called halitosis. [20].Halitosis is classified into pseudo-bad breath and true bad breath. True halitosis (genuine halitosis) is a condition of the occurrence of problems in oral health that can be diagnosed through organoleptic examination, gas chromatography, and sulfide monitoring, while false halitosis (pseudo-bad breath) is a condition in which there is no actual bad breath, but the patient does not have bad breath. believe it. If the person still thinks that they have bad breath after treatment, the diagnosis is called halitophobia.

[21].Halitosis is caused by gases called volatile sulfur compounds that are produced by bacteria in the mouth as a result of the metabolism of sulfur-containing proteins. The back of the tongue is believed to be the main source of inhalation of Volatile Sulfur Compound (VSC), and gases released by gram-negative anaerobic bacteria such as Treponema denticola, Porphyromonasgingivalis , Tannerellaforsythensis, Porphyromonas endo donalis, Centipe da periodontii, Bacteroides loesche, Prevotella intermedia, Enterobacteriaceae, danEikenellacoorodens. [22].This Volatile Sulfur Compounds (VSC) contains methyl mercaptan (CH_3SH), hydrogen sulfide (H_2S), dimethyl disulfide $(CH_3)_2S_2$ and dimethyl sulfide$(CH_3)_2S$, this compound is an odorous gas produced during the breakdown of protein by bacteria. This volatile sulfur compound must be present in everyone's oral cavity because this substance is always formed during the metabolic process of oral bacteria. When levels of volatile sulfur compounds and the activity of anaerobic bacteria in the mouth increase, halitosis becomes a serious problem, causing the odor of these volatile sulfur compounds to be felt by humans. [23].Conventional methods for treating bad breath are carried out by disinfecting the mouth using mouthwash and mechanical intervention using a tongue scraper and toothbrush.

Halitosis Mechanism

[24].Halitosis is a common disease that occurs in the human population, halitosis is classified into 3 parts, namely genuine halitosis, false halitosis (pseudo halitosis), and halitophobia, genuine halitosis is subclassified into physiological halitosis and pathological halitosis. Pathological halitosis can be of extra-oral (EOH) and intra-oral (IOH) origin, wherein extra-oral halitosis is further subdivided into non-blood-borne halitosis, such as halitosis of the upper and lower respiratory tract, and blood-borne halitosis.



[25].Halitosis classification.

[26].The unpleasant odor is mainly due to the decomposing action of microorganisms on endogenous or exogenous proteins and peptides.

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Factors that increase the likelihood of halitosis include periodontal disease, dry mouth, smoking, alcohol consumption, dietary habits, diabetes, and obesity. Halitosis can also be affected by general body hygiene (i.e., dehydration, hunger, and high physical activity), advanced age, bleeding gums, decreased tooth brushing frequency, and also by stress.

[27].Halitosis oral extract (EOH) can be caused by diabetes, respiratory system disorders, nasopharyngeal disorders.Pathological conditions of the oral cavity caused by aerobic and anaerobic bacteria are responsible for intra-oral halitosis ranging from 80-90%. These microorganisms tend to produce a foul odor from sulfur-containing gases called volatile sulfur compounds (VSCs). The most common bacteria that produce this compound are gram-negative anaerobic bacteria, such as Prevolla intermedia, Porphyromonas gingivalis, Fusobacteri um nucleatum, Treponema denticola, and Bacteroid es forsythus. The main nutrients for oral bacteria come from saliva, gingival crevicular fluid, and desquamated epi thelium, which contains glycoproteins, proteins, peptides, and amino acids.

[28].These are bacteria that produce Volatile Sulfur Compounds (VSC), volatile sulfur compounds are the main contributors to bad breath resulting from the decomposition process of bacteria in the mouth. Many oral bacteria that cause intraoral halitosis contain similar enzymes. These enzymes are proteins. This protein is obtained from organic substrates derived from saliva, sulcus fluid, epithelial cells exfoliated from the mucous membranes of the mouth, and food debris which is degraded by microorganisms into amino acids. The resulting sulfur-containing amino acids such as L-cysteine desulfhydrase, methionine-lyase, and L-methionine-deamino-ÿ-mercaptomethane-lyase.
One example of hydrogen sulfide producers are Gram-negative anaerobic bacteria such as Treponema denticola, Tannerella forsythia, Prophyromonasgingivalis. Examples of producers of methyl mercaptans are representatives of the genera Prevotella, Atopobium, Veillonella, Selenomonas, and Megasphaera. [29].Significant contributors to the production of methyl mercaptans can also be caused by bacteria in the gut, which can inhabit the oral cavity, such as E. coli, Citrobacter spp., and Proteus spp.

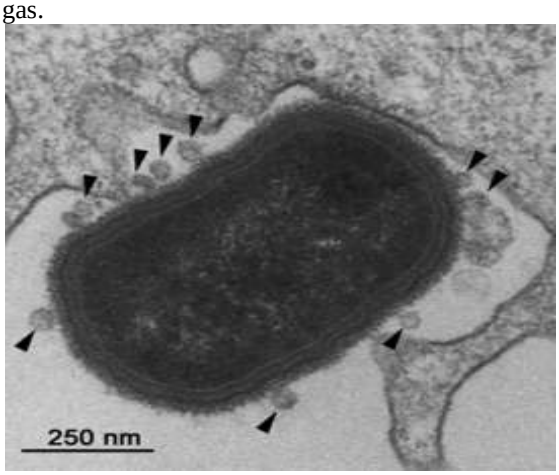
Hydrogen sulfide from L-cysteine :Bacteroides spp., Bacteroides intermedius, Lipan periodontii, E.limosum, F.nucleatum, Fusobacterium alocis ,Eubacterium brachy, Eubacterium spp., Peptostreptococcusanaerob, F.sulei, S.flueggei, P.microsanaerob, Porphyromonasendodontalis, F.periodonticum , Selenomonasartemidis, S. dianae, Tannerella forsythia, S.infelix, Propionibacterium propionicum, S. sputigena S. noxia.

Methyl mercaptan from L-methionine : Eubacterium spp., V. parvula Bacteroides spp., nucleatum, Veillonelladispar, orphyromonas, F. periodonticum.

Hydrogen sulfide from serum :Porphyromonasgingivalis , B.intermedius, Eubacterium spp, Peptostreptococcus magnus, B.loescheii, Mitsuokelladentalis, B. oralis, P. micros, Eubacterium lentum, P. prevotiipropionicum, F. nucleatum, Treponema denticola, T. forsythia.

Methyl mercaptan from serum :P. gingivalis, T. denticola, V. parvula, P. endodontalis

[16].Halitosis is formed by volatile compounds, which are produced mainly by bacteria in the oral cavity, these volatile compounds in the form of methyl mercaptan (CH_3SH), hydrogen sulfide (H_2S), dimethyl disulfide $(CH_3)_2S_2$and dimethyl sulfide $(CH_3)_2S$. Volatile sulfur compounds can be toxic to human cells even at low concentrations.They contain thiols (-SH groups) that interact with other proteins and favor the negative interaction of bacterial antigens and enzymes.The result of this effect is chronic inflammation, periodontal gingivitis, and periodontitis, which result from protein degradation to sulfur-containing amino acids producing VSC gas.



[30].Porphyromonasgingivalis

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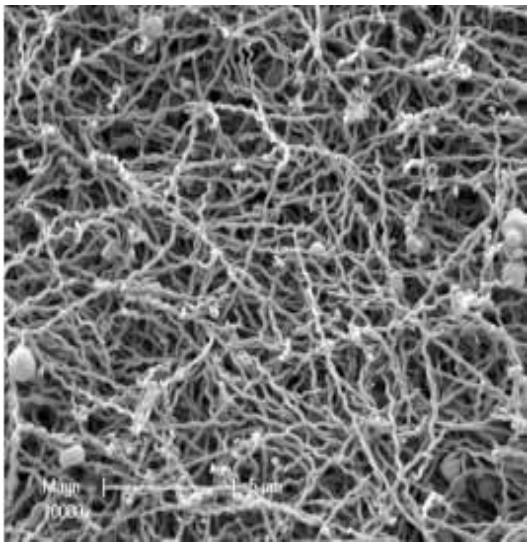
[31].Porphyromonas gingivalis (P.gingival is) is a microorganism that is commonly found in dental plaque, this bacterium belongs to gram-negative anaerobic bacteria, does not spore, and is not motile. These bacteria have fimbriae which are important as adhesion molecules when they interact with oral epithelial cells, periodontal ligament fibroblasts, extracellular matrix proteins, endothelial cells, salivary proteins, and other microorganisms. Porphyromonasgingivalis has a strong proteolytic activity and can degrade protein, so this bacterium can produce large amounts of methyl mercaptan (CH_3SH) from the enzymatic reaction of the amino acid L-methionine.



[32].Treponema denticola.

[33].Treponema is a member of the phylum Spirochaetes, a clade that is often grouped separately from gram-positive and gram-negative bacteria. Treponema is motile, asaccharolytic, anaerobic spirochaetes with characteristic helical morphology, some of which are associated with human chronic disease, Treponema denticola belongs to the human oral microbiota and exists as part of a polymicrobial biofilm (subgingival dental plaque) that is accreted to the roots of teeth in clefts. gingiva. Hydrogen sulfide can induce apoptosis in the human periodontal epithelium, ligament and fibroblast cells, hydrogen sulfide has also been shown to cause hemooxidation and hemolysis of human red blood cells, and its activity is enhanced if is generated from cysteine by the enzyme T. denticolacystalysin.

REFERENCES

[1] O. Jeffries and M. Waldron, "The effects of menthol on exercise performance and thermal sensation: A meta-analysis," J. Sci. Med. Sport, vol. 22, no. 6, pp. 707–715, 2019.

[2] I. Giannopoulou, F. Saïs, and R. Thomopoulos, "Linked data annotation and fusion driven by data quality evaluation," Rev. des Nouv. Technol. l'Information, vol. E.28, pp. 257–262, 2015.

[3] N. A. Ali, M. J. Abbas, and F. H. Al-Bayaty, "Evaluation of potential effect of menthol solution on oral hygiene status of dental students in a university in Iraq," Trop. J. Pharm. Res., vol. 14, no. 4, pp. 687–692, 2015.

[4] Y. Widiyastuti, R. Widyastuti, I. M. Sholikah, and D. Subositi, "Karakterisasi Morfologi dan profil kromatogram Minyak Atsiri 3 jenis Mentha Koleksi Balai Besar Penelitian dan Pengembangan Tanaman Obat dan Obat Tradisional (B2P2TO2T)," Pros. Semin. Nas. dalam Rangka Dies Natalis UNS ke-42 tahun 2018 Vol 2, No 1, vol. 2, no. 1, pp. 317–326, 2018.

[5] B. Mallick, S. Sinha, and D. Roy, "Evaluation of Antioxidative Potential of Field Grown and Tissue Culture Derived Mentha piperita L.Plants," Int. J. Curr. Microbiol. Appl. Sci., vol. 5, no. 3, pp. 382–391, 2016.

[6] A. A. A. Abdel-Wareth, S. Kehraus, and K. H. Südekum, "Peppermint and its respective active component in diets of broiler chickens: growth performance, viability, economics, meat physicochemical properties, and carcass characteristics," Poult. Sci., vol. 98, no. 9, pp. 3850–3859, 2019.

[7] M. Beigi, M. Torki-Harchegani, and A. G. Pirbalouti, "Quantity and chemical composition of essential oil of peppermint (Mentha × piperita l.) leaves under different drying methods," Int. J. Food Prop., vol. 21, no. 1, pp. 267–276, 2018.

[8] Ž. Marjanović-Balaban et al., "Chemical Composition and Antibacterial Activity of the Essential Oil of Menthae piperitae L.," Qual. Life (Banja Luka) - APEIRON, vol. 16, no. 1–2, 2018.

[9] A. F. Khalil, H. O. Elkatry, and H. F. El Mehairy, "Protective effect of peppermint and parsley leaves oils against

hepatotoxicity on experimental rats," Ann. Agric. Sci., vol. 60, no. 2, pp. 353–359, 2015.
[10] P. Nayak, T. Kumar, A. K. Gupta, and N. U. Joshi, "Peppermint a medicinal herb and treasure of health: A review," Phytopathology, vol. 9, no. 3, pp. 1519–1528, 2020.
[11] M. Hawrył et al., "Micro Two-Dimensional Thin-Layer Chromatography and Chemometric Analysis of Essential Oils from Selected Mentha Species and Its Application in Herbal Fingerprinting," J. Liq. Chromatogr. Relat. Technol., vol. 38, no. 20, pp. 1794–1801, 2015.
[12] I. M. Cahyani, I. A. C. Anggraini, M. F. Sari, S. Tamara, and S. Zaemonah, "Pengaruh Penggunaan Jenis Pati Pada Karakteristik Fisik Sediaan Edible Film Peppermint Oil," J. Pharmascience, vol. 4, no. 2, pp. 202–209, 2017.
[13] Ö. Çoban and N. Göktürk Baydar, "Brassinosteroid effects on some physical and biochemical properties and secondary metabolite accumulation in peppermint (Mentha piperita L.) under salt stress," Ind. Crops Prod., vol. 86, pp. 251–258, 2016.
[14] L. G. Riachi and C. A. B. De Maria, "Peppermint antioxidants revisited," Food Chem., vol. 176, no. December, pp. 72–81, 2015.
[15] B. Pavlić et al., "Antioxidant and enzyme-inhibitory activity of peppermint extracts and essential oils obtained by conventional and emerging extraction techniques," Food Chem., vol. 338, p. 127724, 2021.
[16] L. H. Foo, P. Balan, L. M. Pang, M. L. Laine, and C. J. Seneviratne, "Role of the oral microbiome, metabolic pathways, and novel diagnostic tools in intra-oral halitosis: a comprehensive update," Crit. Rev. Microbiol., vol. 47, no. 3, pp. 359–375, 2021.
[17] H. I. Robbihi, "Kajian Manfaat Kemangi (Ocimum Basilicum) Terhadap Halitosis," J. Ilm. Keperawatan Gigi, vol. 1, no. 1, pp. 51–58, 2020.
[18] A. F. Oktaviani, S. Rahmatullah, and D. B. Pambudi, "FORMULASI SEDIAAN OBAT KUMUR EKSTRAK ETANOL DAUN SELASIH (Ocimum basilicum L .) SEBAGAI UJI AKTIVITAS ANTIBAKTERI Streptococcus mutans," vol. 03, no. 01, pp. 1–9, 2021.
[19] N. K. Ratmini, "Bau Mulut (Halitosis)," J. Kesehat. Gigi (Dental Heal. Journal), vol. 5, no. 1, pp. 25–29, 2017.
[20] Y. R. Wijayanti, "Metode Mengatasi Bau Mulut," Cakradonya Dent J, vol. 6, no. 1, pp. 619–677, 2014.
[21] A. C. Costa da Mota et al., "Effect of photodynamic therapy for the treatment of halitosis in adolescents – a controlled, microbiological, clinical trial," J. Biophotonics, vol. 9, no. 11–12, pp. 1337–1343, 2016.
[22] A. Caygur, M. R. Albaba, A. Berberoglu, and H. G. Yilmaz, "Efficacy of glycine powder air-polishing combined with scaling and root planing in the treatment of periodontitis and halitosis: A randomised clinical study," J. Int. Med. Res., vol. 45, no. 3, pp. 1168–1174, 2017.
[23] A. A. Alshahrani, A. Alhaizaey, M. A. Kamran, and I. Alshahrani, "Efficacy of antimicrobial photodynamic therapy against halitosis in adolescent patients undergoing orthodontic treatment," Photodiagnosis Photodyn. Ther., vol. 32, p. 102019, 2020.
[24] M. Aydin and C. N. Harvey-Woodworth, "Halitosis: A new definition and classification," Gene Ther., vol. 21, no. 3, p. E1, 2014.
[25] A. Tangerman and E. G. Winkel, "Extra-oral halitosis: An overview," J. Breath Res., vol. 4, no. 1, 2010.
[26] S. Erovic Ademovski, P. Lingström, and S. Renvert, "The effect of different mouth rinse products on intra-oral halitosis," Int. J. Dent. Hyg., vol. 14, no. 2, pp. 117–123, 2016.
[27] B. L. Armstrong, M. L. Sensat, and J. L. Stoltenberg, "The Journal of Dental Hygiene Halitosis: A Review of Current Literature," vol. 84, pp. 65–74, 2010.
[28] S. Awano, K. Gohara, E. Kurihara, T. Ansai, and T. Takehara, "The relationship between the presence of periodontopathogenic bacteria in saliva and halitosis," Int. Dent. J., vol. 52, no. 3 SUPPL., pp. 212–216, 2002.
[29] I. Mogilnicka, P. Bogucki, and M. Ufnal, "Microbiota and Malodor — Etiology and Management," pp. 1–21, 2020.
[30] A. Amano, C. Chen, K. Honma, C. Li, R. P. Settem, and A. Sharma, "Genetic characteristics and pathogenic mechanisms of periodontal pathogens," Adv. Dent. Res., vol. 26, no. 1, pp. 15–22, 2014.
[31] A. P. Yusinta, I. A. Wahyudi, and A. H. Dewi, "Effect of Citrus aurantifolia swingle essential oils on methyl mercaptan

production of Porphyromonas gingivalis," Dent. J. (Majalah Kedokt. Gigi), vol. 46, no. 1, p. 50, 2013.

[32] H. L. Mitchell et al., "Treponema denticola biofilm-induced expression of a bacteriophage, toxin-antitoxin systems and transposases," Microbiology, vol. 156, no. 3, pp. 774–788, 2010.

[33] L. Chu, Y. Wu, X. Xu, L. Phillips, and D. Kolodrubetz, "Glutathione catabolism by Treponema denticola impacts its pathogenic potential," Anaerobe, vol. 62, p. 102170, 2020.