

## Bacterial Inhibition Effect of Essential Oil Toothpaste against Dental Plaque of Children with Autism Syndrome Disorder (Asd)

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### Abstract

Children with Autism Spectrum Disorder (ASD) was found to have poorer oral health and hygiene compared to normal children due to insufficient motor skill. One of the prophylaxis efforts is using toothpaste with antibacterial effects such as natural Essential Oil that can help prevent biofilm regrowth. This study aimed to find out the effectiveness of Clove (*Eugenia caryophyllata*), Spearmint (*Mentha spicata* L.), lemon grass (*Cymbopogon citrates*), and cinnamon (*Cinnamomum burmanii*) against bacteria from dental plaque of children with ASD

Dental plaque is collected and incubated using Brain-heart Infusion Broth overnight. Toothpaste was formulated using Clove EO, Lemongrass EO, Spearmint EO and Cinnamon leaves EO. The bacteria then moved to Mueller Hinton Agar to examine the inhibition zone of EO toothpaste. Followed statistical analysis of the inhibition zone measurement using Kruskal Wallis and Mann Whitney post hoc

All EO toothpaste has formed an inhibition zone ( $p < 0.05$ ) with the highest zone formed by Cinnamon leaves EO toothpaste, followed by Clove EO toothpaste, Lemon Grass toothpaste, and Spearmint toothpaste. no significant difference in the inhibition size of cinnamon leaves EO and positive control-chlorhexidine ( $p = 0.82$ )

Cinnamon leaves EO toothpaste has the highest inhibition zone compared to Clove, Lemongrass, and Spearmint EO toothpaste.

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### Introduction

The number of children with Autism Spectrum Disorder (ASD) has increased recently worldwide.<sup>1</sup> Autism Spectrum Disorder is a complex neurodevelopmental disorder that has continued to be studied in recent decades. This disorder affects language skills, social interaction, and lack of attention and is also characterized by repetitive behavior.<sup>2</sup> Because of this disorder, children with ASD have difficulty performing daily activities such as eating, drinking, dressing, and bathing, including the ability to brushing teeth.<sup>3</sup>

This is due to behavioral disorders, communication, lack of understanding of social cues, sensory problems to poor oral muscle tone.<sup>4</sup>

Several studies have shown that children with ASD have a higher risk of developing oral diseases such as caries and periodontal disease than other children.<sup>5</sup> Caries and periodontal disease are diseases with a high prevalence in the world with a dental plaque as the main etiology.<sup>6</sup> Plaque is a thin and sticky layer on the surface of the teeth or oral cavity that is overgrown with various types of bacterial colonies.<sup>7</sup> The condition of the microbiota in dental plaque and saliva of children with ASD was found to be different from other children without ASD.<sup>8,9</sup> Several indicators of dental caries such as DMFT, Plaque Index, and Gingival Index were also found to be higher in children with ASD.<sup>5</sup> In addition, insufficient motor skills related to sensory sensitivity when brushing

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teeth also affect their daily oral hygiene.<sup>10</sup> Therefore, it is also necessary to use materials that can protect and prevent the occurrence of oral dental disease besides assisting and training their independence in maintaining oral health.

Prophylactic efforts to remove plaque mechanically by brushing teeth using toothpaste or chemically using mouthwash are preventive measures that can be done in the pathogenesis of these two diseases.<sup>11</sup> Plaque can be removed by brushing teeth, however, brushing itself can't guarantee that all plaque that has been removed will not be built again immediately after brushing.<sup>12</sup> Various antibacterial ingredients are added to toothpaste and mouthwash to prevent or inhibit plaque regrowth.<sup>13</sup>

One of the ingredients that are believed to prevent plaque formation or called an anti-plaque agent is an essential oil that is widely used in mouthwash and toothpaste.<sup>14</sup> essential oil are a group of various natural chemicals that are volatile and oily with a pungent aroma and consist of several chemical compounds obtained from various herbal sources through several processes such as distillation.<sup>15,16</sup>

The chemical composition that can be found in EOs usually is sesqui-terpenes ( $\beta$ -caryophyllene), terpenes-monoterpenes (linalool, ocimene, limonene,  $\alpha$ -pinene), ketones (carvone), alcohols (geraniol, menthol), aldehydes (cinnamaldehyde, vanillin), and phenols (eugenol, thymol, carvacrol). But some complex terpenes with higher molecular weights cannot be extracted by distillation.<sup>16</sup>

Clove (*Eugenia caryophyllata*), Spearmint (*Mentha spicata* L.), lemon grass (*Cymbopogon citrates*), and cinnamon (*Cinnamomum* sp) are herbs there at commonly used in the kitchen, and interestingly also have an antimicrobial effects.<sup>16-19</sup>

Spearmint has been widely used as a food garnish, beverage, and even for therapeutic and health purposes. Besides being recognized for the management of colds, flu, respiratory tract problems, and stomach ache, it also has antifungal properties, diuretic, carminative, and antioxidant agent, and is known to treat hemorrhoids. Spearmint essential oils (SEOs) have been known to have anti-microbial activity and are also rich in oxygenated monoterpenes. SEO has been proven its promising anti-inflammatory and analgesic activities when tested in vivo in experimental animal models.

This activity could be related to the interactions of its chemical substances such as carvone, limonene, and eucalyptol. Spearmint EO proved to be effective against *Staphylococcus aureus*.<sup>20</sup>

A native Indonesian spice, Clove bud grows from an aromatic tree. From ancient times clove has been used to treat roundworms and tapeworms, asthma, toothache, sore throat, carminative, appetizer, respiratory disorders, digestive system ailments, dyspepsia, gastritis, diarrhea, antipyretic, aphrodisiac, expectorant, antiemetic, anxiolytic, myorelaxant, analgesic, decongestant, anti-inflammatory, hypnotic, vermifuge, antibacterial agent, etc. Clove is also used in Indian Ayurvedic medicines, Chinese medicines, Unani medicines of Asian countries, and Western herbal medicines. Even in dentistry, eugenol has long been used to relieve pain and antimicrobial.<sup>21</sup>

Potent antifungal (*Candida albicans*, *Aspergillus niger*, *Penicillium glabrum*, *Penicillium italicum*, *Fusaria oxysporum*, *Saccharomyces cerevisiae*, *Trichophyton mentagrophytes*, *Lenzites betulina*, *Laetiporus sulfurous*, and *Trichophyton rubrum*), anti-viral (such as Herpes simplex, Hepatitis C virus) and antibacterial effect (against several bacteria including *Escherichia coli*, *Helicobacter pylori*, *Staphylococcus aureus*, *Enterococcus faecalis*) has been reported from several studies.<sup>21-23</sup>

Lemon grass is commonly used for cooking in South East Asia dishes. The citrus-like aromas and also widely used as a herbal cocktail that believes to have the ability to relieve anxiety and diuretic effect against bloating. The essential oil of this plant is mainly composed of citral, a natural geraniol and neral, and some myrcene, geraniol, and geranyl acetate, which is a potential natural biocide for use as a disinfectant and mosquito repellent.<sup>24</sup> Lemon grass EO has antibacterial, anti-fungal, anti-protozoan, and other medical benefits such as being anti-inflammatory, anti-cancer, anti-oxidant, etc.<sup>24</sup>.

Cinnamon has been used as a spice for thousands of years in many countries and in Ayurvedic medicine, the bark has the benefit of antiemetic, antidiarrhea, anti-flatulent, etc. The genus *Cinnamomum* consists of 250 species, but the volatile oil is mostly produced from the *C. zeylanicum* bark and leaf oils, *C. cassia* (Chinese cinnamon), and *C. camphor*. Indonesia has another species (*Cinnamomum burmannii*) that grows wildly on the Island Sumatera and Java.

One of the central production came from Kerinci, Sumatera which has unique thick bark and is one of the export commodities in Kerinci-Jambi.<sup>25,26</sup>

Commonly, when people harvest the cinnamon bark, they will cut out and dispose of the leaves. Many studies prove that many beneficial compositions can be utilized such as essential oil. The antibacterial effect of *Cinnamomum zeylanicum* and Indonesian *Cinnamomum burmanii bulme* leaf has been proven in previous study.<sup>27-30</sup>

Currently, there are quite a few commercial kinds of toothpaste that use essential oil as an anti-plaque agent. However, no one has compared the effectiveness of the essential oil content in toothpaste in inhibiting bacterial growth. No scientific evidence compares the effectiveness of the antibacterial power of various toothpaste that contains these essential oils.

This study aimed to compare the effectiveness of the inhibition of bacterial growth from toothpaste with various essential oil contents in dental plaque samples of children with Autism Spectrum Disorder.

### Materials and methods

The design of this study is a quasi-experimental study comparing the effectiveness of the antibacterial power of toothpaste with essential oil in inhibiting bacterial growth from plaque samples of children with ASD. Participants were recruited from Kiddy Autism Centre in Jambi, Indonesia after obtaining informed consent from their parents.

Toothpaste was formulated using 4 different essential oils referring to the previous study with some modifications. The formula comprises 3 ml of essential oil (clover, lemon grass, spearmint, or Kerinci's cinnamon leaves), 0,5 gr of Karboppol 934, 0,25 ml of Tween 80, 0,25gr of Gliserin, 0,25 gr of Sodium Benzoate, 0,31 gr of Trietanolamin, and 20,4 ml. of Aquadest.

*Streptococcus mutants* were isolated from the dental plaque of 4 children with Autism Syndrom Disorder and cultured using Brain-heart Infusion Broth (BHIB) overnight. 6 wells were created on agar plates using a sterile 6 mm punch. Each well was filled with Positive control (Chlorhexidine), pure essential oil, 100% essential oil toothpaste, 75% diluted essential oil toothpaste, 50% diluted essential oil toothpaste,

and negative control using aquadest. The inhibition zone diameter was measured after all plates were incubated at 36°C for 24 hours.

The diameter of inhibition was measured to evaluate the effectiveness of essential oil paste on dental plaque bacteria. Data collected was then analyzed using the Kruskal Wallis test, followed by the post hoc Mann Whitney U test to evaluate which of the group has the best effectivity on bacterial inhibition.

### Results

The Growth inhibition zone of pure EO and toothpaste containing Clove EO, Lemon Grass EO, Spearmint EO, and Cinnamon Leaves EO were showed in table 1.

	Mean Inhibition (cm)(±SD)	p-value	
Control +	2,33 (±0,38)	0,026 <sup>1</sup>	0,000 <sup>§</sup>
Pure Clove Essential Oil (CEO)	1,77 (±0,12)		0,007 <sup>§§</sup>
100% CEO toothpaste	1,74 (±0,12)		0,005 <sup>§§§</sup>
75% CEO toothpaste	1,65 (±0,09)		
50% CEO toothpaste	1,49 (±0,06)	0,226 <sup>1</sup>	
Pure lemongrass essential Oil (LGEO)	1,55 (±0,09)		
100% LGEO toothpaste	1,54 (±0,08)		
75% LGEO toothpaste	1,47 (±0,06)		
50% LGEO toothpaste	1,39 (±0,14)	0,093 <sup>1</sup>	
Pure Spearmint Essential Oil (SEO)	1,47 (±0,21)		
100% SEO toothpaste	1,37 (±0,09)		
75% SEO toothpaste	1,29 (±0,11)		
50% SEO toothpaste	1,20 (±0,12)	0,229 <sup>1</sup> 0,82 <sup>11</sup>	
Pure Cinnamon Leaves Essential Oil (CLEO)	2,34 (0,29)		
100% CLEO toothpaste	1,99 (±0,29)		
75% CLEO toothpaste	1,90 (±0,28)		
50% CLEO toothpaste	1,88 (±0,30)		

<sup>1</sup> Kruskal Wallis Test between different concentration of EO  
<sup>11</sup> Mann Whitney U Test between Control + and Pure Cinnamon leaves EO  
<sup>§</sup> Kruskal Wallis Test of all variable  
<sup>§§</sup> Kruskal Wallis Test between pure EO  
<sup>§§§</sup> Kruskal Wallis Test between different 100 % toothpaste

**Table 1.** Growth Inhibition Zone of pure EO and toothpaste containing Clove EO, Lemon Grass EO, Spearmint EO and Cinnamon Leaves EO.

Results showed that all the toothpaste containing EO showed a growth inhibition zone, although has a different wide zone. Formulation of the toothpaste or dilution of the toothpaste has no significant effect on the inhibition zone except for the clove EO. In clove EO paste, the lower concentration has decreased the inhibition zone. For other EO, although the inhibition zone narrowed with the dilution of the toothpaste, no significant effect was found. The highest inhibition zone was shown in cinnamon leaves EO. Followed by Clove EO, Lemon Grass EO and the lowest inhibition Zone was Spearmint EO. Pure Cinnamon EO has no significant difference in inhibition zone wide with control (p value=0,82).

## Discussion

Children with special needs have a higher risk of dental caries due to their limitation in performing oral hygiene, and sensory and intellectual disabilities resulting in higher anxiety, leading to undesirable oral health maintenance and the lack of seeking dental treatment.<sup>31-33</sup>

We analyzed the bacterial inhibition potential of essential oil when incorporated into a toothpaste formula. The essential oil was naturally produced by the plants to protect against herbivores. The oil produced is originally colorless and the majority occurs in liquid form at room temperature, but some are solids (camphor) and dissolve in alcohol and fats. Except for cinnamon and clove oils, the density of the essential oil was mostly lower than water.

The antibacterial effect is one of the benefits of the EO through various mechanisms on a variety of bacterial structures. Since gram-positive bacteria structures were able to facilitate the penetration of hydrophobic molecules such as EO's molecules into the cell, act on the bacterial wall, cytoplasmic membrane, or cytoplasm. Even at low concentrations, EO can react with enzymes responsible for producing energy by influencing the transfer of H<sup>+</sup> to reduce the synthesis of adenosine triphosphate (ATP), and thus the intracellular store of ATP was decreased. At higher concentration, they can denature proteins, causes degradation of bacterial cell walls, damage cytoplasmic membranes, and coagulation of the cytoplasm.<sup>16</sup>

Permeability of the membrane will damage after protein denaturation and will lead to leakage of the cell contents. Thus, gram-negative (G<sup>-</sup>) bacteria are mostly more resistant against EOs in comparison to gram-positive (G<sup>+</sup>) due to the thin layer of peptidoglycan and lipopolysaccharide layer (LPS) on their outer membrane composition of the G<sup>-</sup> bacterial cell walls. Although small hydrophilic molecules can penetrate through the porin proteins of G<sup>-</sup> bacteria.<sup>16</sup>

Our finding showed that all essential oil has growth inhibition effect with different wide zone. In clove EO, the growth inhibition zone is decreased significantly as the concentration of the EO is lower. Clove *Eugenia caryophyllata* contains 15-20% essential oil, 13% tannins, 10% fixed oil, and 6-12% non-essential ether extract. Essential oil of clove is a colorless or light yellowish fluid, a distillate of dried flowers, stalks,

and leaves. Eugenol (C<sub>10</sub>H<sub>12</sub>O<sub>2</sub>), eugenyl acetate and β-caryophyllene were the major components of the oil extracted from clove which makes up 70 to 90% of the oil composition. Clove also consists of tannins (gallotannic acid), flavonoids (eugenin, rhamnetin, and eugenitin), and triterpenoids (oleanolic acid, stigmasterol, and campesterol) which made the strong aromatic properties.<sup>21</sup>

Other studies showed that *E.caryophyllata* oils has significant in vitro anti-biofilm properties against *P.gingivalis* and *F.nucleatum* biofilm and prominently altered the bacterial wall morphology.<sup>34</sup>

Eugenol act by damaging the cytoplasmic membrane against Gram-negative bacteria, it can easily penetrate the lipopolysaccharide cell membrane and enter the cytoplasm since the molecule is hydrophobic resulting in the leakage of intracellular components.<sup>23</sup> Eugenol from clove EO is also capable to inhibit some bacterial enzymes such as ATPase, and protease, decrease the metabolic activity of bacterial cells to form biofilm also inhibit bacterial virulence factors production, such as violacein, elastase, and pyocyanin, and.<sup>23</sup>

Lemon grass EO toothpaste in our study has a moderate inhibition effect on oral bacteria. A study by Mitrakul et.al also showed that lemongrass EO has the potential of biofilm growth and formation inhibitory effect on *Streptococcus mutans* strain. The main antimicrobial responsible in this EO are α-citral (geranial), β-citral (neral), linalool, myrcene, Passenger α-citral (geranial), β-citral (neral), and linalool. The lipophilic property of Myrcene can helps penetrate the cell via the lipid-bilayer and thus can damage the cell membrane. Furthermore, the geranial have been shown to reduce ATP within the bacterial cell, resulting in pH changes in cells and hyperpolarization.<sup>24</sup>

In the present study, Cinnamon has the higher inhibition area compared to Clove EO, Lemongrass EO and Spearmint EO. This finding has similar results to the previous study in Thailand. Cinnamon bark has the most outstanding bacterial inhibition effect compared to Sweet Basil leaf, Peppermint leaf, Spearmint leaf, Black pepper Seed, Sweet Fennel Seed, Keffir lime peel, and Keffir lime leaf against *Streptococcus mutans*, and *Lactobacillus casei* which are some of the bacteria responsible in the pathogenesis of dental caries. Furthermore,

cinnamon essential oil also effective in inhibiting the biofilm formation of streptococcus mutans in vitro.<sup>27</sup> Another study using *Cinnamomum burmanii* leaves EO also verify the antibacterial effect against *Staphylococcus aureus* and *Escherichia coli*.<sup>29</sup> The main constituent of cinnamon leaves oil was eugenol,  $\alpha$ -ylangene, methyl, and ethyl cinnamate.<sup>26</sup> Combination of cinnamon bark and leaves oil is also effective against *E coli* and *L monocytogenes*.<sup>35</sup> The antibacterial activity of the EO is mostly caused by formaldehyde and eugenol contents.<sup>26</sup>

Another study by Lapinska *et al* also confirmed our finding that showed the eminence antibacterial effect of cinnamon EO compared to anise, citronella, clove, geranium, lavender, Linette, mint, and rosemary thyme against *S. mutans*, *L. acidophilus* and *C. albicans* (bacterial predominant in caries and periodontal disease pathogenesis).<sup>36</sup>

## Conclusions

Essential Oil toothpaste of Clove EO, Lemon grass EO, Spearmint EO, and Cinnamon leaves EO affects inhibition of bacterial growth in dental plaque samples of children with Autism Spectrum Disorder. Toothpaste containing Cinnamon EO toothpaste has the highest effect followed by Clove EO toothpaste, Lemon Grass EO toothpaste, and Spearmint EO Toothpaste.

## Declaration of Interest

The authors report no conflict of interest.

## References

- Maenner MJ, Shaw KA, Baio J, Washington A, Patrick M, DiRienzo M, et al. Prevalence of autism spectrum disorder among children aged 8 Years-Autism and developmental disabilities monitoring network, 11 Sites, United States, 2016. *MMWR Surveill Summ*. 2020;69(4):1–12.
- Kang DW, Park JG, Ilhan ZE, Wallstrom G, LaBaer J, Adams JB, et al. Reduced Incidence of *Prevotella* and Other Fermenters in Intestinal Microflora of Autistic Children. *PLoS One*. 2013 Jul; 8(7):e68322.
- Cahyani LA. The Effectiveness Of Self-Development Learning Based On The Teacch Method Towards Increasing The Ability Of Autist Students To Brush. *JPK (Jurnal Pendidik Khusus*. 2017; 13(1):22–37.
- YY Lu IWCH. Dental health - a challenging problem for a patient with an autism spectrum disorder. *Gen Hosp Psychiatry*. 2013;35(214):e211-213.
- Pi X, Liu C, Li Z, Guo H, Jiang H, Du M. A meta-analysis of the oral health status of children with autism. *J Clin Pediatr Dent*. 2020 Jan 1;44(1):1–7.
- Hajishengallis G. Periodontitis: from microbial immune subversion to systemic inflammation. *Nat Rev Immunol*. 2014;15(1):30–44.

- Valm AM. The Structure of Dental Plaque Microbial Communities in the Transition from Health to Dental Caries and Periodontal Disease. *Journal of Molecular Biology*. 2019; 431(16): 2957–69.
- Qiao Y, Wu M, Feng Y, Zhou Z, Chen L, Chen F. Alterations of oral microbiota distinguish children with autism spectrum disorders from healthy controls. *Sci Rep*. 2018; 8(1):1–12.
- Morales-Chávez MC, Villarroel-Dorrego M, Salas V. Salivary factors related to caries in children with autism. *J Clin Pediatr Dent*. 2019 Jan 1;43(1):22–6.
- Khrautieo T, Srimaneekarn N, Rirattanapong P, Smutkeeree A. Association of sensory sensitivities and toothbrushing cooperation in autism spectrum disorder. *Int J Paediatr Dent*. 2020;30(4):505–13.
- Huebner C, Milgrom P. Evaluation of a parent-designed program to support tooth brushing of infants and young children. *Int J Dent Hyg*. 2015; 23:65-73
- Serbiak B, Fourre T, Geonnotti AR, Gambogi RJ. In vitro efficacy of essential oil mouthrinse versus dentifrices. *J Dent*. 2018;69:49–54.
- Kharouf N, Haikel Y, Ball V. Bioengineering Review Polyphenols in Dental Applications. *bioengineering*. 2020;7(72).
- Lynch MC, Cortelli SC, McGuire JA, Zhang J, Ricci-Nittel D, Mordas CJ, et al. The effects of essential oil mouthrinses with or without alcohol on plaque and gingivitis: A randomized controlled clinical study. *BMC Oral Health*. 2018;18(1):1–10.
- Kulaksiz B, Er S, Üstündağ-Okur N, Saltan-İşcan G. Investigation of antimicrobial activities of some herbs containing essential oils and their mouthwash formulations. *Turkish J Pharm Sci [Internet]*. 2018;15(3):370–5.
- Horváth P, Koščová J. In vitro Antibacterial Activity of Mentha Essential Oils Against *Staphylococcus aureus*. *Folia Vet*. 2017 Sep 1;61(3):71–7.
- Karadağlıoğlu Öİ, Ulusoy N, Başer KHC, Hanoğlu A, Şık İ. Antibacterial activities of herbal toothpastes combined with essential oils against streptococcus mutans. *Pathogens*. 2019;8(1).
- Aires A, Barreto A, Antibiotics TS-L-, 2020 undefined. Antimicrobial effects of essential oils on oral microbiota biofilms: the toothbrush in vitro model. *Antibiotics*. 2021;10(21)
- Elchaghaby MA, Abd El-Kader SF, Aly MM. Bioactive composition and antibacterial activity of three herbal extracts (lemongrass, sage, and guava leaf) against oral bacteria: An in vitro study. *J Oral Biosci*. 2022;64(1):114–9.
- Kehili S, Boukhatem MA, Belkadi A, Boulaghmen F, Ferhat MA, Setzer WN. Spearmint (*Mentha spicata* L.) essential oil from tipaza (Algeria): in vivo anti-inflammatory and analgesic activities in experimental animal models. *Acta Pharm Hung*. 2020;90(1):15–26.
- Singh J, Baghotia A, Of SG-IJ, 2012 U. *Eugenia caryophyllata* Thunberg (family myrtaceae): a review. *Int J Res Pharm Biomed Sci*. 2012;3(4):1469–75.
- Thosar N, Basak S, Bahadure RN, Rajurkar M. Antimicrobial efficacy of five essential oils against oral pathogens: An in vitro study. *European Journal of Dentistry*. 2013;7(supplement 1):71-7
- Ulanowska M, Olas B. Biological Properties and Prospects for the Application of Eugenol—A Review. *Int J Mol Sci*. 2021;22(7):3671.
- Mitrakul K, Srisatjaluk R, Srisukh V, Lomarat P, Vongsawan K, Kosanwat T. *Cymbopogon citratus* (Lemongrass oil) oral sprays as inhibitors of mutans streptococci biofilm formation. *J Clin Diagnostic Res*. 2018;12(12):6–12.
- Hidayani N. Analysis of Cinnamon (*Cinnamomum burmanii* BLUME) Trading System in Kerinci Regency, Jambi Province. 2012 ; Thesis; Bogor Agricultural University (IPB)
- Jayaprakasha GK, Rao LJM. Chemistry, biogenesis, and biological activities of *cinnamomum zeylanicum*. *Crit Rev Food Sci Nutr*. 2011;51(6):547–62.
- Wiwattanarattanabut K, Choonharuangdej S, Srithavaj T. In Vitro Anti-Cariogenic Plaque Effects of Essential Oils Extracted from Culinary Herbs. *J Clin Diagn Res*. 2017;11(9):DC30.

28. Tran HNH, Graham L, Adukwu EC. In vitro antifungal activity of Cinnamomum zeylanicum bark and leaf essential oils against *Candida albicans* and *Candida auris*. *Appl Microbiol Biotechnol*. 2020;104(20):8911–24.
29. Angelica N. Antibacterial Activity of Cinnamon Leaf and Bark Ethanol Extract (*Cinnamomum burmannii* (Nees & Th. Nees)) against *Escherichia coli* and *Staphylococcus aureus*. *Calyptra J Ilm Mhs Univ Surabaya*. 2014;2(2):1–8.
30. Nabila R, Purnamasari CB, Alhawaris A. Antibacterial Activity Test of Cinnamon Leaf Ethanol Extract (*Cinnamomum burmannii* blume) Against *Porphyromonas gingivalis* Bacterial Growth Using Disc Diffusion Method. *J Kedokt Mulawarman*. 2021;8(2):64–72.
31. Latifi-Xhemajli B, Begzati A, Kutllovci T, Ahmeti D. Dental health status of children and adolescent with special health care needs. *J Int Dent Med Res*. 2018;11(3):945–9.
32. da Silva SN, Gimenez T, Souza RC, Mello-Moura ACV, Raggio DP, Morimoto S, et al. Oral health status of children and young adults with autism spectrum disorders: systematic review and meta-analysis. *Int J Paediatr Dent*. 2017;27(5):388–98.
33. Nagendra J, Jayachandra S. Autism spectrum disorders: Dental treatment considerations. *J Int Dent Med Res*. 2012;5(2):118–21.
34. Azizan N, Mohd-Said S, Firdaus Mazlan MK, Chelvan KT, Hanafiah RM, Zainal-Abidin Z. In-vitro inhibitory effect of *Cinnamomum zeylanicum* and *Eugenia caryophyllata* Oils on Multispecies Anaerobic Oral Biofilm. *J Int Dent Med Res*. 2019;12(2):411–7.
35. Cava-Roda R, Taboada-Rodríguez A, López-Gómez A, Martínez-Hernández GB, Marín-Iñiesta F. Synergistic Antimicrobial Activities of Combinations of Vanillin and Essential Oils of Cinnamon Bark, Cinnamon Leaves, and Cloves. *Foods*. 2021;10.
36. Lapinska B, Szram A, Zarzycka B, Grzegorzczak J, Hardan L, Sokolowski J, et al. An in vitro study on the antimicrobial properties of essential oil modified resin composite against oral pathogens. *Materials (Basel)*. 2020;13(4383):1–18.