2nd Basic and Applied Science Conference (BASC) 2022
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2514

NST PROCEEDINGS

OPEN ACCESS

Conference Paper

Cariogenic Antibacterial Potential of *Stevia rebaudiana Bertoni* Leaves Extract Against *Lactobacillus acidophilus*

Sinta Deviyanti*

Oral Biology Department, Faculty of Dentistry, University of Prof. Dr. Moestopo (B)

*Corresponding author:
E-mail:
sinta.deviyanti@gmail.com

ABSTRACT

Dental caries is a chronic infectious disease in hard tooth tissues with various factors etiology. The prevalence of dental caries in Indonesia is relatively high. One of the factors of dental caries etiology is cariogenic bacteria known as *Lactobacillus acidophilus*. These type of bacteria is acidogenic, aciduric, and can adhere to tooth enamel by synthesizing sticky glucan from sucrose to form dental biofilms. The existence of these bacteria in saliva proved to be contributing to the frequency and activity of dental caries, therefore it is important to inhibit their growth to prevent caries. *Stevia rebaudiana Bertoni* leaves extract is now being developed as an alternative to overcome the problems that are still encountered with the chlorhexidine, as the gold standard for controlling dental biofilms. The review aims to explain the cariogenic antibacterial potential of *Stevia rebaudiana Bertoni* leaves extract against *Lactobacillus acidophilus*. Literature search was carried out with sources from the EBSCO, PubMed, and ResearchGate database from the year 2012 to 2022 employing relevant keywords akin to the article titles. Antibacterial activity of *Stevia rebaudiana Bertoni* leaves extract in various solvents has been shown to be effective against *Lactobacillus acidophilus.* In this case, it may be due to the content of bioactive components of *Stevia* leaves extract, such as flavonoids, alkaloids, saponins, sterols, and tannins. *Stevia rebaudiana Bertoni* leaaves extract has the potential to inhibit the growth of *Lactobacillus acidophilus* hence, can be used as a natural alternative antibacterial agent to prevent dental caries.

Keywords: Stevia rebaudiana Bertoni, Lactobacillus acidophilus, cariogenic bacteria, antibacterial activity

Introduction

Dental caries is a chronic infectious disease in hard tooth tissues that may be caused by various factors (Rathee & Sapra, 2020). Factors involved in the process of occurrence of dental caries include the attachment of bacteria to the surface of the teeth, the formation of biofilms (plaque) of the teeth, and the local demineralization of the tooth surface by acids produced by bacteria from the fermentation of carbohydrates consumed (Ajagannanavar et al., 2014; Rathee & Sapra, 2020). The process of dental caries generally occurs slowly influenced by the ecological balance between dental minerals and dental biofilms (Yadav, 2016). Dental caries that cause tooth crown damage until the tooth root is exposed, can be experienced by all age groups, both in deciduous and permanent teeth (Pitts et al., 2017).

Dental caries is still a problem today around the world. Based on research data from the Global Burden of Disease (2019), oral diseases are experienced by approximately 3.5 billion people worldwide with caries in permanent teeth as the most suffered oral disease. An estimated 2 million people worldwide suffer from caries in permanent teeth and 520 million children suffer from caries in the firstborn teeth (WHO, 2022). Riskesdas (2018), stated that the proportion of tooth decay (dental caries)

How to cite:
Deviyanti, S. (2022). Cariogenic antibacterial potential of *Stevia rebaudiana Bertoni* leaves extract against *Lactobacillus acidophilus*. *2nd Basic and Applied Science Conference (BASC) 2022*. NST Proceedings. pages 96-103. doi: 10.11594/ nstp.2022.2514

problems in Indonesia reaches 45.3%, which indicates that dental caries are still an important problem in Indonesia (Health & Indonesia, 2018).

Streptococcus mutans, Streptococcus sobrinus, Lactobacillus acidophilus, Actinomices viscusus, and *Bifidobacterium dentium* are pathogenic bacteria that generally cause of dental caries from a number of 200 species of bacteria isolated from dental biofilms (Cura et al., 2012; Samaranayake L, 2018). Lactic acid from the fermentation of carbohydrates mainly produced by *Lactobacillus acidophilus* as a cariogenic bacterium of the genus *Lactobacilli,* along with the bacteria *Streptococcus mutans,* is responsible for the demineralization of tooth enamel that triggers dental caries (Cura et al., 2012; Samaranayake L, 2018). The bacterium *Lactobacillus acidophilus* is often associated with dental caries in humans because it is able to tolerate acidic environments. This bacteria is also the main flora of the oral cavity involved in the development of caries particularly in dentin (Yadav & Prakash, 2017). The number of *Lactobacilli* bacteria in saliva has also been used to predict dental caries activity in an individual (Samaranayake, 2018).

Prevention of dental caries can be achieved in various ways including control of dental biofilms (plaque) by regular tooth brushing every day using toothpaste containing fluoride (Ajagannanavar et al., 2014; Yadav & Prakash, 2017). This method should also be combined with the use of chemical antimicrobial agents or chemoprophylactic agents such as chlorhexidine, to more effectively reduce cariogenic bacteria and inhibit the formation of dental biofilms of the oral cavity (Ajagannanavar et al., 2014). Chlorhexidine, is a broad-spectrum antiseptic, so it is used as a gold standard to chemically control dental biofilms. However, the long-term use of chlorhexidine mouthwash, can cause stains (staining) on the teeth and tongue, changes in taste and have a detrimental impact on the oral mucosa, and can cause bacterial resistance (Ajagannanavar et al., 2014; James et al., 2017). Consequently, researchers are now trying to find and apply natural antimicrobial ingredients from plants as therapeutic agents, given the low risk of side effects (Ajagannanavar et al., 2014; Moselhy et al., 2016).

Plant extracts are known to have many components of new compounds with extensive pharmacological activity (Ajagannanavar et al., 2014). *Stevia rebaudiana Bertoni* is a subtropical perennial shrub of the sunflower family (Asteraceae) native to Paraguay and Brazil (Brambilla et al., 2014; Lemus-Mondaca et al., 2012). This plant is known as sugar leaf or sweet leaf (lemus-Mondaca et al., 2012; Shinde & Winnier, 2020b). *Stevia* leaves contain glycoside diterpenes such as stevioside, isosteviol, steviolbioside, rebaudioside A-F and dulcoside (Ibrahem et al., 2020; Lemus-Mondaca et al., 2012). Rebaudioside A and stevioside have a sweet taste 200-300 times sweeter than sucrose (Ajagannanavar et al., 2014; Das, 2013). *Stevia* is a noncalorical natural sweetener that is sweeter than sucrose with no adverse side effects on health. *Stevia rebaudiana Bertoni* has been proven to show various benefits to the systemic health of the body, especially for the health of the oral cavity (Contreras, 2013). The leaves of *Stevia rebaudiana Bertoni* also contain various bioactive components or secondary metabolites that contribute to its ability to treat diseases (Chughtai et al., 2020; Lemus-Mondaca et al., 2012). Several studies have reported the antimicrobial activity of *Stevia rebaudiana Bertoni* leaves extract against fungi and various gram-positive and gram-negative bacteria (Ibrahem et al., 2020; Siddique et al., 2014). In vitro studies have shown that *Stevia* leaves extract has antibacterial activity against *Streptococcus mutans*, but few studies have evaluated the antibacterial activity of *Stevia rebaudiana Bertoni* leaves extract against *Lactobacillus acidophilus* as a bacteria involved in dental caries (Mohammadi-Sichani, 2012; Sreekumar & Hegde, 2018; Usha et al., 2017). This literature review was carried out to explain the antibacterial potential of *Stevia rebaudiana Bertoni* leaves extract against *Lactobacillus acidophilus.*

Material and Methods

The literature search from this study was carried out using the EBSCO, PubMed and ResearchGate databases from the year 2012 to 2022 using keywords related to the article title: "*Stevia rebaudiana Bertoni*", "*Lactobacillus acidophilus*", "cariogenic bacteria" and "antibacterial activity". Article selection

is carried out by reading the title, abstract and analyzing the overall content of each article. Articles that did not meet the inclusion criteria will be excluded. Article were withdrawn due to several reasons : not published between 2012 and 2022, they were not relevant to the topic, they were duplicated and were not written in English

Results and Discussion

Result

Lactobacillus acidophilus is a cariogenic bacteria that can ferment carbohydrates to form acids (acidogenic) and can live in an acidic environment (aciduric). *Lactobacillus acidophilus* is gram-positive bacteria, generally rod-shaped , α- or non-haemolytic and is facultative anaerobic. *Lactobacilli* are often isolated from deep dentin caries lesions with acidic pH conditions (Samaranayake, 2018). *Lactobacilli,* is a lactic acid bacterium capable of synthesizing extracellular polysaccharides such as glucans through extracellular enzymes, as one of the components that play a role in the formation of the matrix of extracellular biofilms, which cause dental caries (Jurášková et al., 2022). Efforts to inhibit the growth of these bacteria are necessary for the framework of preventing dental caries.

Current dental caries prevention strategies mainly include removing dental biofilms or killing oral cavity bacteria with antibacterial components (Ajagannanavar et al., 2014). The inhibition of growth or selective killing of cariogenic bacteria in pathogenic dental biofilms will allow the formation of commensal bacterial communities that act as an effective barrier to prevent the colonization of cariogenic bacteria on the surface of the teeth thus supporting anti-caries therapy (Ajagannanavar et al., 2014). Chlorhexidine as a bis-biguanide kills bacteria (bactericidal) and kills fungi (fungicidal). Chlorhexidine as an antibacterial agent with this broad spectrum is effective against gram-positive and gram-negative bacteria (Nagappan & John, 2012). The use of chlorhexidine as an antibacterial agent with this broad-spectrum can damage the balance of bacteria inside the oral cavity, so it is necessary to control the dose only for patients with a high risk of caries for a limited period (Usha et al., 2017).

Natural products such as herbal extracts have been proven to be biocompatible with body tissues compared to synthetic chemicals (Usha et al., 2017). Herbal remedies of plant origin, have been used in dentistry to inhibit microorganisms, reduce inflammation, relieve irritation, and relieve pain (Gupta et al., 2015). *Stevia rebaudiana Bertoni* is a plant that has received a lot of attention recently. The two main components isolated from *Stevia* leaves, stevioside and rebaudioside, have a sweetness level 200-300 times sweeter than sucrose (Ajagannanavar et al., 2014; Das, 2013). *Stevia* as a natural sweetener has good stability, does not contain calories, and have medicinal benefit as well (Ajagannanavar et al., 2014; Rezaei-Soufi et al., 2016). *Stevia rebaudiana Bertoni* leaves also contain a number of bioactive components or secondary metabolites that contribute to treatment, such as phenolics, flavonoids, tannins, saponins, and sterols (Chughtai et al., 2020; Lemus-Mondaca et al., 2012). *Stevia* leaves extract also contains water-soluble chlorophylls, xanthophylls, hydroxycinnamic acids (caffeine, chlorogenic), water-soluble oligosaccharides, amino acids, fats, essential oils, minerals, vitamins, and fiber (Khiraoui et al., 2017; Lemus-Mondaca et al., 2012; Shinde & Winnier, 2020a). *Stevia* leaves extract has antibacterial, antifungal, antiviral, anti-inflammatory, antioxidant, anticancer, antidiabetic, antihypertensive and antimutagenesis activities (Chughtai et al., 2020; Elashtokhy & Taha, 2017; Gupta et al., 2013; Shinde & Winnier, 2020a; Yildiz-Ozturk et al., 2015). *Stevia* can grow up to 1 m or more on moist soils as well as suitable drainage systems (Lemus-Mondaca et al., 2012). *Stevia* has an extensive root system and a weak stem. *Stevia* leaves do not have petioles, spatula-shaped with a blunt leaves tip and jagged leaves edge from the middle to the tip of the leaves with a leaves length of 3-4 cm. *Stevia* plant has small flowers of white color. The temperature required for optimal growth is 20-24^0 C (Ajagannanavar et al., 2014; Rezaei-Soufi et al., 2016). *Stevia's* natural sweetener has been known to be noncariogenic (Gamboa & Chaves, 2012). *Stevia rebaudiana Bertoni* leaves extract has been shown to have a property to prevent caries because it contains antibacterial properties and can reduce carbohydrate intake that can be fermented by bacteria (Brambilla et al., 2014).

Research by Usha et al. (2017) was conducted to determine the effect of mouthwash *Stevia rebaudiana Bertoni* leaves extract 0.5% (aqueous leaves extract) in patients with a high risk of caries. The study concluded that *Stevia rebaudiana Bertoni* 0.5% leaves extract was able to improve the pH and buffering capacity of saliva in patients with high risk of caries and effectively reduced cariogenic bacteria in saliva in a period of 1 week after rinsing the mouth 2 times a day for 7 days. The chlorhexidine mouthwash group of 0.12% and the *Stevia rebaudiana Bertoni* leaves extract mouthwash 0.5% showed a reduction in the number of *Streptococcus mutans* and *Lactobacilli* bacteria up to 10^5 colony forming units (CFUs)/ml in all patients after stimulated saliva from both groups of mouthwash treatments were cultured and incubated for 48 hours.

Another study by Gamboa and Chaves (2012) has explained the antibacterial potential of *Stevia* leaves extract in various types of solvents against sixteen groups of the bacterial genus *Streptococcus* and *Lactobacillus* related to the development of caries. The antibacterial activity of *Stevia* leaves extract was tested using the method of diffusion of Agar wells (well diffusion) with vancomycin and azithromycin as the positive control group and each type of solvent as a negative control. The minimal inhibitory concentration (MIC) values of *Stevia* leaves extract in hexane, methanol, ethanol, ethyl acetate, and chloroform solvents against 16 bacterial strains of the genus *Streptococcus* and *Lactobacillus* were 30 mg/ml, 120 mg/ml, 120 mg/ml, 60 mg/ml, and 60 mg/ml, respectively. The bacterial inhibition zone of *Stevia* leaves extract in 5 types of such solvents varies from 9 mm to 17.3 mm. The bacterial inhibition zone of *Stevia* leaves extract in the 5 types of solvents was slightly larger against 4 strains of *Lactobacillus* compared to 12 strains of *Streptococcus*, with the smallest value of 12.3 mm and the largest of 17.3 mm. The inhibition zone of *Stevia* leaves extract against *Lactobacillus acidophilus* bacteria ATCC 4365 in solvents hexane, methanol, ethanol, ethyl acetate, and chloroform is 13.6 mm, 13.0 mm, 14.0 mm, 15.0 mm, and 17.3 mm, respectively, The positive control group (vancomycin 180 g/ml and azithromycin 150 g/ml) had bacterial growth inhibition activity varying from the 16 strains tested, with inhibition zone values of 18 mm to 25 mm. The results of this study showed that all *Stevia* leaves extracts had antibacterial activity on MICs between 30 mg/ml to 120 mg/ml. In *Stevia* leaves extract MICs 60 mg/ml ethyl acetate and 60 mg/ml chloroform, the bacterial inhibition zone against four *Lactobacillus* species, appeared slightly larger.

Research by Tiwari et al. (2018) has been carried out to compare the efficacy of *Stevia* leaves extract in 1% aqueous suspension, in 5% alcohol, and 6% both combinations against *Streptococcus mutans* and *Lactobacillus acidophilus*. Tests were carried out to determine the average minimum inhibitory concentration (MIC) through the broth dilution method and the average minimum bactericidal concentration (MBC) through the agar plate sub culture streaking method at various concentrations for the three types of *Stevia* leaves extract. The average MIC value of *Stevia* leaves extract in 1% aqueous suspension against *Streptococcus mutans* and *Lactobacillus acidophilus* appeared to be significantly better ($p<0.05$) which was 0.83 g/200 ml and 0.66 g/200 ml, respectively, compared to the MIC value of *Stevia* leaves extract in 5% alcohol which was 4.16 g/200 ml and 3.3 g/200 ml and compared to the MIC value 6% combination of the two extracts, which was 5 µg/200 ml and 5 µg/200 ml, sequentially. This study concluded that the inhibitory effect of *Stevia* leaves extract in 1% aqueous suspension of against *Streptococcus mutans* and *Lactobacillus acidophilus* was better than *Stevia* leaves extract in 5% alcohol and 6% combination of both extracts. However, there is still a lag from the results of this study because MBC values cannot be observed in *Stevia* leaves extract in 1% aqueous suspension and it is likely to need to increase concentrations to be able to observe the MBC ratio.

On previous study done by Ajagannanavar et al. (2014) compared the antibacterial efficacy of *Stevia rebaudiana Bertoni* leaves extract in aqueous solvents and alcohol (ethanol) solvents versus chlorhexidine against *Streptococcus mutans* and *Lactobacillus acidophilus* at various concentrations. The test of determining the inhibitory zone of bacteria against *Streptococcus mutans* and *Lactobacillus acidophilus* was carried out using the Agar disk diffusion method and the determination of the

minimum inhibitory concentration (MIC) using the serial broth dilution method. The MIC value of *Stevia rebaudiana Bertoni* leaves extract in an aqueous solvent against *Lactobacillus acidophilus* is 50% and 25% against *Streptococcus mutans.* The MIC value of *Stevia rebaudiana Bertoni* leaves extract in alcohol solvents (ethanol) against *Lactobacillus acidophilus* was 6.25% and 12.5% against *Streptococcus mutans*. The antibacterial activity of *Stevia rebaudiana Bertoni* leaves extract in an aqueous solvent against *Lactobacillus acidophilus* is 10.8 mm, while *Stevia rebaudiana Bertoni* leaves extract in alcohol solvent (ethanol) is 12.3 mm, and chlorhexidine as a positive control group is 13.2 mm. The average bacterial inhibition zone of *Stevia rebaudiana Bertoni* leaves extract in water solvent against *Streptococcus mutans* was 22.8 mm, while *Stevia rebaudiana Bertoni* leaves extract in alcohol solvent (ethanol) was 24.7 mm, and chlorhexidine as a positive control group was 26.5 mm. This study concluded that the effect of inhibiting bacterial growth from *Stevia rebaudiana Bertoni* leaves extract in alcohol solvents (ethanol) against *Lactobacillus acidophilus* and *Streptococcus mutans* was better than *Stevia rebaudiana Bertoni* leaves extract in aqueous solvent but lower than chlorhexidine.

Discussion

According to the findings of a study conducted by Usha et al. (2017) both 0.5% aqueous extract of *Stevia* leaves and 0.12% chlorhexidine mouthwash were effective in reducing the cariogenic microbial (*S.mutans* and *Lactobacilli*) count. The result is consistent with the previous study done by Gamboa & Chaves (2012), which evaluated the antibacterial activity of *Stevia rebaudiana Bertoni* leaves extract against cariogenic bacteria in vitro, one of which is *Lactobacillus acidophilus.* In the study done by Usha et al (2017) an aqueous extract of *Stevia* leaves was planned to be used as a mouthwash for patient safety. Although Usha et al (2017) found that 10^5 CFU/ml of *S.mutans* and *Lactobacilli* in saliva is considered low caries index, long-term clinical studies are required to prove its efficacy, similar to that of chlorhexidine as a broad-spectrum antimicrobial agent.

In a study done by Gamboa & Chaves (2012), the inhibition zone of *Stevia* leaves extract against bacteria *Lactobacillus acidophilus* ATCC 4365 in hexane, methanol, ethanol, ethyl acetate, and chloroform were respectively 13.6 mm, 13.0 mm, 14.0 mm, 15.0 mm, and 17.3 mm. The inhibition zones of the 5 extracts were slightly higher for the 4 *Lactobacillus* strains than for the 12 *Streptococcus* strains, primarily in the 60 mg/ml ethyl acetate and 60 mg/ml chloroform extracts, indicating that they are the most susceptible microorganisms. Their increased susceptibility to the various extracts could be attributed to the presence of active substances in *Stevia rebaudiana Bertoni* leaves extract or to active metabolites that are most soluble and act as antibacterial substances in these solvent systems. that can easily penetrate the bacteria and cause more damage (Gamboa & Chaves, 2012; Mohammadi-Sichani, 2012).

The reason why the mean inhibition rates were higher with alcoholic (ethanol) extract of *Stevia* leaves against *Lactobacillus acidophilus* than in the aqueous form in the study by Ajagannanavar et al. (2014) is unknown. However, the ethanolic extract of *Stevia rebaudiana Bertoni* showed better inhibitory results than the aqueous extract, which could be attributed to better dissolving capacity in alcohol, better bioavailability (thus increasing bioactivity), and the polarity of the antibacterial compounds, which allows the compounds to be extracted more easily by organic solvents. The limitation of this study was that it could not have been conducted with other group of 70% ethyl alcohol to state that it was the effect of *Stevia* alone that inhibited *Lactobacillus acidophilus* and *Streptococcus mutans* and not alcohol (Ajagannanavar et al., 2014) In contrast to this study, Tiwari et al. (2018) found that an aqueous suspension of *Stevia rebaudiana Bertoni* outperformed inhibitory result compare to its alcoholic extract and their combination, possibly due to the method of preparation of the suspension, which avoided the extraction process, that preserved the active components and anti-oxidants such as tannins, xanthine (theobromine and caffeine), and flavonoids in stevioside.

Stevia rebaudiana Bertoni leaves extract has been scientifically proven to have antibacterial activity against *Lactobacillus acidophilus* in a variety of solvents. These could be attributed to bioactive compounds found in *Stevia* leaves extract. Gupta E et al. (2017) discovered the presence of phenols as the most abundant bioactive constituents or phytochemicals in methanol and ethanolic extracts of *Stevia rebaudiana Bertoni,* followed by phytosterols, tannins, saponins, glycosides, and flavonoids. The preliminary analysis of water and acetone extract conducted by Moselhy et al (2016) showed that acetone extract contains more phenolic and flavonoids than aqueous extract. The total phenolic content of the aqueous and acetone extracts was 30 and 85 mg gallic/gm, respectively. While total flavonoids were discovered to be 60 mg and 80 mg/gm, respectively. It was discovered that the antibacterial activity of acetone extract differed in terms of growth inhibition against selected five bacteria species. The presence of a high flavonoid content could explain the antibacterial activity. The inhibition zone diameter (mm) of the acetone extract revealed a variable inhibitory effect on bacteria at different concentrations. The analysis of gas chromatography and mass spectroscopy in this study revealed that monoterpene and indole are the main components of the essential oil of *Stevia* leaves extract (Moselhy et al., 2016). Preliminary phytochemical screening of different extracts of *Stevia rebaudiana Bertoni* by Siddique et al. (2014) revealed that alkaloids and steroids were the most abundant compounds in the *Stevia rebaudiana Bertoni* leaves extract, followed by tannins, saponins, and flavonoids.

The presence of these bioactive constituents or phytochemicals in the extract of *Stevia rebaudiana Bertoni* leaves from those studies provides antimicrobial property. The presence of bioactive components in these extracts generally inhibits microorganism growth and metabolism and is quantified by determining the minimum bactericidal activity and minimum inhibitory concentration (Gupta et al., 2017).

These medicinally bioactive components have antimicrobial activity via various mechanisms. Tannins inhibit the synthesis of bacterial cell walls by forming irreversible complexes with proline-rich protein. Saponins can cause protein and enzyme leakage from bacterial cells. Terpenoids are responsible for the dissolution of microorganism cell walls by weakening the membranous tissue. Flavanoids, which have been discovered to be effective antimicrobial substances against a wide range of microorganisms, can complex with extracellular and soluble proteins, as well as bacterial cell walls. Steroids are also known for their bacterial activity, which is specifically associated with membrane lipids and causes leakage from liposomes (Mujeeb et al., 2014). Through lysis activities of the bacterial cell wall, alkaloid compounds can inhibit bacterial cell wall synthesis. Furthermore, alkaloid compounds can interfere with the formation of peptidoglycan constituents in bacterial cells, resulting in bacterial cell wall layer failure (Hastuty, 2019).

In addition, the presence of steviol glycosides in *Stevia* leaf extract may inhibit the growth of cariogenic bacteria (Wölwer-Rieck, 2012). This is consistent with the findings of an in vitro study conducted by Brambilla et al. (2014), who discovered that *Stevia rebaudiana Bertoni* leaves extract, which contained stevioside and rebaudioside A, did not support the growth of cariogenic bacteria, including *Streptococcus mutans.*

More research is required to determine the most potent bioactive component of *Stevia rebaudiana Bertoni* leaves extract was tested against the cariogenic bacterial *Lactobacillus acidophilus*, as well as its antibacterial activity against a variety of microorganisms known as a cause of dental caries.

Conclusion

Stevia rebaudiana Bertoni leaves extract has the potential to inhibit the growth of the cariogenic bacteria *Lactobacillus acidophilus*, hence can be used as a natural alternative antibacterial agent or natural remedy to prevent dental caries.

Acknowledgment

The author would like to acknowledge the support of the Department of Oral Biology, Faculty of Dentistry, University of Prof.Dr.Moestopo(B) for the publication of this paper.

References

Ajagannanavar, S., Al-Kheraif, A., AlS ayed, M. A. E., Battur, H., Shamarao, S., & Tikare, S. (2014). Effect of aqueous and alcoholic Stevia (*Stevia rebaudiana*) extracts against Streptococcus mutans and Lactobacillus acidophilus in comparison to chlorhexidine: An in vitro study. *Journal of International Society of Preventive and Community Dentistry*, *4*(5), S116-21. https://doi.org/10.4103/2231-0762.146215

Brambilla, E., Cagetti, M. G., Ionescu, A., Campus, G., & Lingström, P. (2014). An in vitro and in vivo comparison of the effect of stevia rebaudiana extracts on different caries-related variables: A randomized controlled trial pilot study. *Caries Research*, *48*(1), 19–23. https://doi.org/10.1159/000351650

Chughtai, M. F. J., Pasha, I., Zahoor, T., Khaliq, A., Ahsan, S., Wu, Z., Nadeem, M., Mehmood, T., Amir, R. M., Yasmin, I., Liaqat, A., & Tanweer, S. (2020). Nutritional and therapeutic perspectives of Stevia rebaudiana as emerging sweetener; a way forward for sweetener industry. *CYTA - Journal of Food*, *18*(1), 164–177. https://doi.org/10.1080/19476337.2020.1721562

Contreras, M. S. (2013). Anticariogenic properties and effects on periodontal structures of Stevia rebaudiana Bertoni. Narrative review. *Journal of Oral Research*, *2*(3), 158–166. https://doi.org/10.17126/joralres.2013.034

Cura, F., Palmieri, A., Girardi, A., Martinelli, M., Scapoli, L., & Carinci, F. (2012). Lab-Test 4: Dental caries and bacteriological analysis. *Dental Research Journal*, *9*(2), S139-41. Doi:10.4103/1735-3327.109723

Das, K. (2013). Wound healing potential of aqueous crude extract of stevia rebaudiana in mice. *Revista Brasileira de Farmacognosia*, *23*(2), 351-357. https://doi.org/10.1590/S0102-695X2013005000011

Elashtokhy, M. M. A., & Taha, H. S. A. (2017). Molecular and microbiological assesment of Stevia rebaudiana Bertoni leaf extracts for anti-bacterial and anti-mutagenic activities. *Zagazig Journal of Agricultural Research*, *44*(5), 1683–1692. https://doi.org/10.21608/zjar.2017.52238

Gamboa, F., & Chaves, M. (2012). Antimicrobial potential of extracts from Stevia rebaudiana leaves against bacteria of importance in dental caries. *Acta Odontológica Latinoamericana: AOL*, *25*(2), 171–175.

Gupta, E., Purwar, S., Sundaram, S., & Rai, G. K. (2013). Nutritional and therapeutic values of Stevia rebaudiana: A review. *Journal of Medicinal Plants Research*, *7*(46), 3343–3353. https://doi.org/10.5897/JMPR2013.5276

Gupta, E., Vajpayee, G., Purwar, S., Shakyawar, S., Alok, S., Shanthy, A., & Sundaram. (2017). Phytochemical screening and in-vitro studies of antioxidant and antimicrobial activity of extracts of dried stevia rebaudiana leaves. *International Journal of Pharmaceutical Sciences and Research*, *8*(8), 3354–3360. https://doi.org/10.13040/IJPSR.0975-8232.8(8).3354-60

Gupta, R., Ingle, N. A., Kaur, N., Yadav, P., Ingle, E., & Charania, Z. (2015). Ayurveda in dentistry: A review. *Journal of International Oral Health: JIOH*, *7*(8), 141–143.

Hastuty, A. (2019). Antibiofilm and antimicrobial activities of papaya (*Carica papaya* L.) and stevia (Stevia rebaudiana Bertoni) leaf extracts against three biofilm-forming bacteria. *Journal of Microbial Systematics and Biotechnology*, *1*(1), 19–29. https://doi.org/10.37604/jmsb.v1i1.18

Ibrahem, E. S., Ragheb, E. M., Yousef, F. M., & Abdel-Aziz, Budour, A., & Alghamdi, M. F. (2020). Nutritional value, cytotoxic and antimicrobial activities of *Stevia rebaudiana* Leaf Extracts. *J Biochem Tech*, *11*(12), 108–115.

James, P., Worthington, H. v., Parnell, C., Harding, M., Lamont, T., Cheung, A., Whelton, H., & Riley, P. (2017). Chlorhexidine mouthrinse as an adjunctive treatment for gingival health. *Cochrane Database of Systematic Reviews*, *2017*(3), CD008676. https://doi.org/10.1002/14651858.CD008676.pub2

Jurášková, D., Ribeiro, S. C., & Silva, C. C. G. (2022). Exopolysaccharides produced by lactic acid bacteria: From biosynthesis to health-promoting properties. *Foods*, *11*(2). https://doi.org/10.3390/foods11020156

Kesehatan, B. P. dan P., & Indonesia, K. K. R. (2018). Laporan Nasional Riskesdas 2018. In *Kementerian Kesehatan Indonesia*, 10.

Khiraoui, A., Hasib, A., al Faiz, C., Amchra, F., Bakha, M., & Boulli, A. (2017). *Stevia rebaudiana* bertoni (Honey Leaf): A magnificent natural bio-sweetener, biochemical composition, nutritional and therapeutic values. *Journal of Natural Sciences Research*, *7*(14), 75–85.

Lemus-Mondaca, R., Vega-Gálvez, A., Zura-Bravo, L., & Kong, A. H. (2012). Stevia rebaudiana Bertoni, source of a high-potency natural sweetener: A comprehensive review on the biochemical, nutritional and functional aspects. In *Food Chemistry*, *13* (3), 1121-1132. https://doi.org/10.1016/j.foodchem.2011.11.140

Mohammadi-Sichani, M. (2012). Effect of different extracts of Stevia rebaudiana leaves on Streptococcus mutans growth. *Journal of Medicinal Plants Research*, *6*(32), 4731-4734. https://doi.org/10.5897/jmpr11.1622

Moselhy, S. S., Ghoneim, M. A., & Khan, J. A. (2016). *In Vitro and In Vivo evaluation of antimicrobial and antioxidant potential of Stevia extract*. *13*, 18–21. https://doi.org/10,21010/ajtcam.v13i6.4

Mujeeb, F., Bajpai, P., & Pathak, N. (2014). Phytochemical evaluation, antimicrobial activity, and determination of bioactive components from leaves of aegle marmelos. *BioMed Research International*, *2014*. https://doi.org/10.1155/2014/497606

Nagappan, N., & John, J. (2012). Antimicrobial Efficacy of Herbal and Chlorhexidine Mouth rinse - A systematic review. *IOSR Journal of Dental and Medical Sciences*, *2*(4), 5–10. https://doi.org/10.9790/0853-0240510

Pitts, N. B., Zero, D. T., Marsh, P. D., Ekstrand, K., Weintraub, J. A., Ramos-Gomez, F., Tagami, J., Twetman, S., Tsakos, G., & Ismail, A. (2017). Dental caries. *Nature Reviews Disease Primers*, 25(3), 17030. https://doi.org/10.1038/nrdp.2017.30

Rathee, M., & Sapra, A. (2020). *Dental Caries - PMID: 31869163*. In book: StatPearls Knowledge BasePublisher: StatPearls Publishing

Rezaei-Soufi, L., Raedi, S., Alikhani, M. Y., Vahdatinia, F., Farazyani, A., Hosseini, S. M., & Jazaeri, M. (2016). Comparison the effect of stevia extract with glucose and fructose on dental enamel caries formation. *Journal of Chemical and Pharmaceutical Sciences*, *9*(2), 685–689.

Samaranayake, L. (2018). *Essential microbiology for dentistry*. elsevier.

Shinde, M. R., & Winnier, J. (2020a). Comparative evaluation of Stevia and Xylitol chewing gum on salivary Streptococcus mutans count-A pilot study. *Journal of Clinical and Experimental Dentistry*, *12*(6), e568–e573. https://doi.org/10.4317/jced.55720

Shinde, M. R., & Winnier, J. (2020b). Health Benefits and Application of *Stevia rebaudiana* Bertoni in Dentistry. *Journal of Drug Delivery and Therapeutics*, *10*(4-s), 271–274. https://doi.org/10.22270/jddt.v10i4-s.4285

Siddique, A. B., Rahman, S. M. M., Hossain, M. A., & Rashid, M. A. (2014). Phytochemical screening and comparative antimicrobial potential of different extracts of *Stevia rebaudiana* Bertoni leaves. *Asian Pacific Journal of Tropical Disease*, *4*(4), 275–280. https://doi.org/10.1016/S2222-1808(14)60572-7

Sreekumar, S., & Hegde, V. K. (2018). Comparative evaluation of antibacterial effect of three commercially available herbal products against streptococcus mutans: An In vitro Study. *Journal of Indian Association of Public Health Dentistry*, *16*(1), 75–78. https://doi.org/10.4103/jiaphd.jiaphd_131_17

Tiwari, B. S., Ankola, A. v., Sankeshwari, R. M., Bolmal, U., & Kashyap, B. R. (2018). Comparison of antibacterial efficacy of aqueous suspension, alcoholic extract and their combination of *Stevia rebaudiana* against two cariogenic organisms- an in-vitro study. *International Journal of Life-Sciences Scientific Research*, *4*(4), 1946–1951. https://doi.org/10.21276/ijlssr.2018.4.4.13

Usha, C., Ramarao, S., John, B. M., & Babu, M. E. (2017). Anticariogenicity of *Stevia rebaudiana* extract when used as a mouthwash in high caries risk patients: Randomized controlled clinical trial. *World Journal of Dentistry*, *8*(5), 364–369. https://doi.org/10.5005/jp-journals-10015-1466

WHO. (2022). *Oral health*. March 15. 2022. http://www.who.int/news-room/fact-sheets/detail/oral-health

Wölwer-Rieck, U. (2012). The leaves of Stevia rebaudiana (Bertoni), their constituents and the analyses thereof: A review. In *Journal of Agricultural and Food Chemistry*, 60 (4), 886-895. https://doi.org/10.1021/jf2044907

Yadav K, P. S. A. (2016). A review of dental caries. *Asian Journal of Biomed Pharm Sci. 2016,* 73–80. https://doi.org/10.15272/ajbps.v6i53.773

Yadav, K., & Prakash, S. (2017). Dental caries: A microbiological approach. *Journal of Clinical Infectious Diseases & Practice*, *02*(01), 1–15. https://doi.org/10.4172/2476-213x.1000118

Yildiz-Ozturk, E., Nalbantsoy, A., Tag, O., & Yesil-Celiktas, O. (2015). A comparative study on extraction processes of Stevia rebaudiana leaves with emphasis on antioxidant, cytotoxic and nitric oxide inhibition activities. *Industrial Crops and Products*, *77*, 961–971. https://doi.org/10.1016/j.indcrop.2015.10.010