Int. J. Odontostomat.,
19(4):404-410, 2025.

Effects of the Use of Hydroalcoholic Solution of *Syzygium Aromaticum* on the Prevalence of *Porphyromonas gingivalis*: An *in vitro* Study

Efecto del Uso de la Solución Hidroalcohólica de *Syzygium Aromaticum* Sobre la Prevalencia de Porphyromonas Gingivalis: Un Estudio *in vitro*

Juan Pablo Aragon-Larota[1]; Rubi Patricia Caicedo-Ferro[1]; Jesús Alejandro Arenas Fernández-Dávila[1]; Annushka Malpartida-Caviedes[1] & Giovanna Gutiérrez-Gayoso[2]

ARAGON-LAROTA, J. P.; CAICEDO-FERRO, R. B.; FERNÁNDEZ-DÁVILA, J. A. A.; MALPARTIDA-CAVIEDES, A. & GUTIÉRREZ-GAYOSO, G. Effects of the use of hydroalcoholic solution of *Syzygium aromaticum* on the prevalence of *Porphyromonas gingivalis*: An *in vitro* Study. *Int. J. Odontostomat.,19(4)*:404-410, 2025.

ABSTRACT: Over the past few years, periodontal infections have increased, contributing to the spread of multidrug resistant pathogens and negatively impacting oral health. The aim of this study was to evaluate the antibacterial effect of a hydroalcoholic solution of *Syzygium aromaticum* at different concentrations against *Porphyromonas gingivalis* (*P. gingivalis*) ATCC 33277. An *in vitro* experimental design was used, consisting of 45 Petri dishes inoculated with the *P. gingivalis* ATCC 33277 strain. These were divided into three groups of 15 plates each, corresponding to *Syzygium aromaticum* hydroalcoholic solution concentrations of 25 %, 50 %, and 75 %. The antibacterial effect was assessed using the Kirby-Bauer agar disc diffusion method. Incubations were performed at 35°C for 18, 24, and 48 h to measure the diameter of the inhibition zones. A significant antibacterial effect of *Syzygium aromaticum* against *P. gingivalis* ATCC 33277 was observed. The highest inhibitory activity was recorded at 25 %, 50 %, and 75 % concentrations after 48 h of incubation. Overall, *Syzygium aromaticum* essential oils emerge as effective agents demonstrating substantial antibacterial activity against *P. gingivalis*.

KEY WORDS: Antibacterial effect, hydroalcoholic solution, *Syzygium aromaticum*, clove, *P. gingivalis*.

INTRODUCTION

Treating bacterial diseases remains a major clinical challenge. Antibiotic resistance has emerged as a global public health concern due to its profound impact on human health and the global economy. In recent years, human infections caused by multidrug-resistant pathogens have increased markedly, with a particularly significant impact on oral health, further underscoring the urgency of this problema (Ginting *et al*., 2021; Maggini *et al*., 2024; Shehabeldine *et al*., 2024).

Oral health is a fundamental component of overall health and well being, given its potential to exert systemic, multi organ effects. Evidence demonstrates a direct association between oral conditions and coronary heart disease, cerebrovascular disorders, pulmonary complications, and adverse obstetric outcomes. This relationship is particularly critical in patients with diabetes, who require heightened clinical attention (Fiorillo *et al*., 2024; Song *et al*., 2024).

Among the most significant complications affecting the oral cavity, periodontal disease stands out as an infectious inflammatory condition initiated by components of the subgingival biofilm that colonize the gingival sulcus and progressively damage the periodontal supporting tissues. If left untreated, it can ultimately lead to tooth loss and contribute to the deterioration of overall systemic health. Moreover, it is one of the most common inflammatory disorders of the oral cavity (Díaz-Zúñiga *et al*., 2012) and is recognized as the 6 most prevalent disease worldwide (Paranagama *et al*., 2020).

[1] Universidad Andina del Cusco, Department of Stomatology, Cusco, Perú.
[2] Escuela Profesional de Estomatología, Segunda Especialidad, Universidad Privada San Juan Bautista, Lima, Perú.

Received: 2025-04-14 Accepted: 2025-08-24

Periodontitis can be caused by *P. gingivalis*, a gram-negative anaerobic bacterium that feeds on gingival crevicular fluid and is characterized by its ability to exchange chromosomal DNA between different strains through conjugation and natural competition. It possesses virulence factors such as cysteine proteinases (gingipains), hemagglutinins, lipopolysaccharides, and fimbriae, which facilitate colonization and support its growth and persistence within the gingival sulcus (Ramos-Perfecto *et al*., 2011; Cardozo *et al*., 2015).

Currently, natural resources provide a substantial contribution to human health due to their diverse pharmacotherapeutic properties. For this reason, it is essential to investigate their pharmacognosy and chemical composition, as such knowledge is fundamental for overcoming the limitations and adverse effects that may arise from conventional drug therapies(Cardozo *et al*., 2015; Prashar *et al*., 2021).

Syzygium aromaticum, commonly known as clove, is a medicinal plant belonging to the Myrtaceae family. Native to the Maluku Islands in Indonesia, it exhibits notable antimicrobial properties and requires a tropical climate for optimal growth. The plant is characterized by its lanceolate leaves and flowers with white to pink petals (Maggini *et al*., 2024; Cortés-Rojas *et al*., 2014; Goetz, 2021). Its chemical composition includes approximately 14–21 % b-caryophyllene and 10–13 % tannins, as well as various phenols and sesquiterpenes. Among these, phenylpropanoids and eugenol responsible for its distinctive aroma are considered the most significant bioactive constituents. Clove has been associated with antioxidant, hypotensive, analgesic, broad-spectrum antibacterial, antifungal, and anti-inflammatory activities, supporting its potential applications within the oral cavity (Rodríguez *et al*., 2014; Alanazi *et al*., 2022; Afrendi *et al*., 2023; Haro-González *et al*., 2021). In addition, it is non-toxic and biodegradable, and its use can exert a bacteriostatic effect due to its substantial inhibitory activity on biofilm formation (Kacániová *et al*., 2021; Kiki, 2023).

The aim of this study was to evaluate the antibacterial activity of different concentrations of a hydroalcoholic *Syzygium aromaticum* extract against *P. gingivalis* ATCC 33277.

MATERIAL AND METHOD

No human or animal subjects were involved in this study; therefore, ethical approval was not required. The evaluation of the antibacterial activity of the hydroalcoholic *Syzygium aromaticum* solution was conducted at Meding Laboratories in Cusco, Peru, over an eight-month period between October 2023 and May 2024.

A total of 45 Petri dishes containing *P. gingivalis* derived from the ATCC® 33277™ strain were used in this study. The samples were distributed into three experimental groups: Group A (15 dishes exposed to a 25 % concentration), Group B (15 dishes exposed to a 50 % concentration), and Group C (15 dishes exposed to a 75 % concentration). The bacterial cultures were obtained from the Microbiologics® laboratory collection (Catalog No. 0912K), provided in the KWIK-STIK™ format, classified under biosafety level 2, and designated for microbial identification through culture-based methods. All bacterial cultures were maintained on anaerobic blood agar and incubated at 35 °C under anaerobic conditions.

Five kilograms of *Syzygium aromaticum* buds were collected through conventional harvesting with the assistance of a professional botanist. The plant material was transported to the MC Quimicalab laboratory, where it underwent a selection process based on predefined quality criteria. Only mature buds that retained their characteristic color and odor and showed no evidence of deterioration due to mechanical damage or biological contamination were included for subsequent extraction procedures.

Syzygium aromaticum essential oil was extracted using the Kjeldahl steam distillation method (Fig. 1A). The distillate was subsequently collected in a separation funnel, where phase separation occurred (Fig. 1B–C). Following extraction, the condensate was transferred into test tubes and centrifuged for 5 min to facilitate the separation of the essential oil from residual aqueous components. The isolated oil was then stored in 20 mL amber glass bottles under refrigeration to preserve its physicochemical properties (Fig. 1D). In addition, hydroalcoholic *Syzygium aromaticum* solutions were prepared at different concentrations, as illustrated in Figure 2, for subsequent evaluation of their antibacterial activity.

Activation of the *P. gingivalis* strain. Prior to inspecting the KWIK-STIK® package and while maintaining room temperature conditions, the detachable portion of the label was removed. With the primary culture plate prepared, the ampoule located at the top of the KWIK-STIK® device was carefully crushed to release the hydration fluid. The unit was

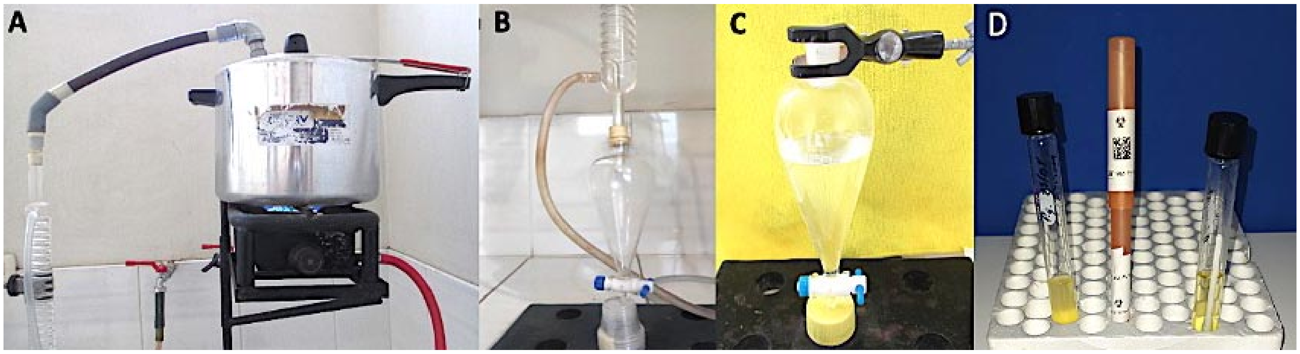

Fig. 1. (A) Obtaining *Syzygium aromaticum* essential oil, done using the Kjeldahl method, (B, C) oil extraction by descent and (D) oil separation with other liquids. To obtain *Syzygium aromaticum* hydroalcoholic solution, 96 % ethanol with a chemical dilution formula was used.

Fig. 2. *Syzygium aromaticum* hydroalcoholic solution at different concentrations.

then held in a vertical position and gently tapped against a firm surface to ensure complete passage of the fluid through the shaft toward the lower compartment, where the inoculating microsphere is contained.

A sterile swab was thoroughly saturated with the hydrated material and subsequently transferred onto the prepared agar medium. The primary culture plates were then inoculated by gently streaking one third of the plate using a sterile loop, facilitating the proper isolation of bacterial colonies under temperature and atmospheric conditions suitable for *P. gingivalis* (Fig. 3).

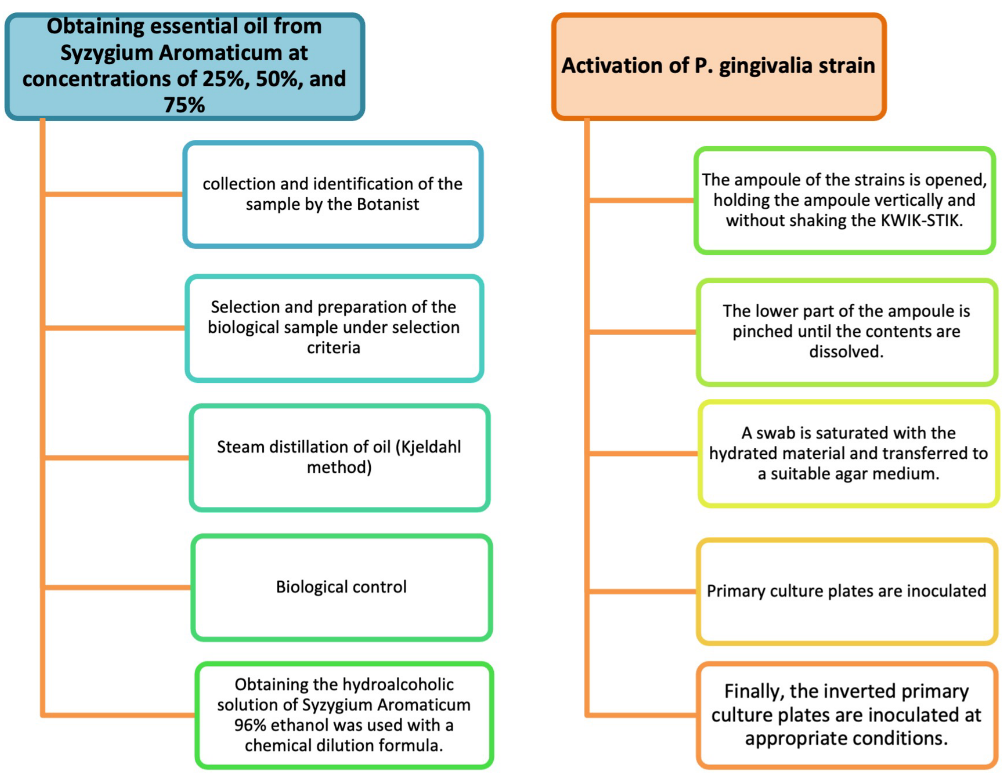

Fig. 3. Flowchart of the procedures.

Preparation of culture media for sensitivity. Filter paper discs measuring 6 mm in diameter and 2 mm in thickness were sterilized in an-autoclave and subsequently immersed in the hydroalcoholic *Syzygium aromaticum* solution at concentrations of 25 %, 50 %, and 75 %. The discs were allowed to soak for 3 to 4 minutes to ensure adequate saturation (Fig. 4).

Fig. 4. Preparation of culture media for sensitivity.

The antibacterial activity of the *Syzygium aromaticum* hydroalcoholic solutions at 25 %, 50 %, and 75 % was then assessed against *P. gingivalis* ATCC 33277 to determine their inhibitory effect under controlled laboratory conditions.

Once the microorganism was activated, the filter paper discs impregnated with the hydroalcoholic *Syzygium aromaticum* solutions were inoculated onto Petri dishes containing blood agar medium. The discs corresponding to each concentration were then carefully placed on the agar surface previously seeded with *P. gingivalis*, ensuring proper contact to allow diffusion of the bioactive components (Fig. 5).

Inhibition halos were measured at 18, 24, and 48 h to qualitatively assess the *in vitro* antibacterial activity according to the diameter of microbial growth inhibition. Measurements were interpreted following the Duraffour scale (Fig. 6). For data collection, direct observation techniques were employed, using a precision vernier micrometer to quantify the antibacterial effect produced by the essential oil.

Data analysis. Once the data were recorded in the registration and control matrix containing the research variables and their corresponding indicators, they were entered into a database and processed using SPSS version 26.

A one-way ANOVA was performed for the bivariate quantitative statistical analysis to evaluate mean differences across the study groups. Contingency tables were constructed to examine associations between categorical variables, and the chi-square test was applied to determine the degree of correlation.

Fig. 5. Inoculation of the microorganism *P. gingivalis* in Petri dishes containing blood agar medium.

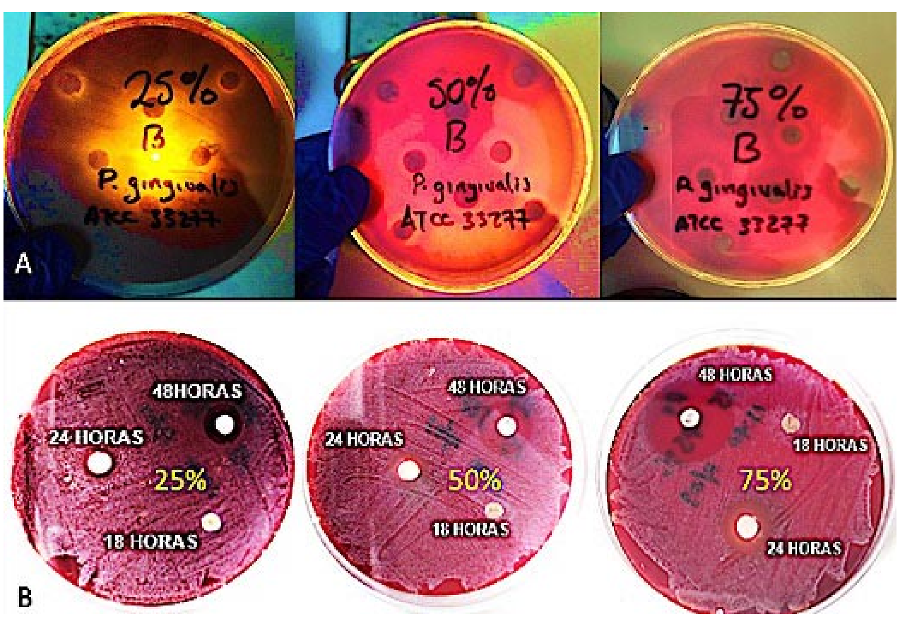

Fig. 6. Antibacterial effect by measuring the inhibition halos at 18, 24 and 48 hours at different concentrations of *Syzygium aromaticum* hydroalcoholic solution.

RESULTS

Table I presents the *in vitro* antibacterial activity of the hydroalcoholic solution of *Syzygium aromaticum* at different concentrations against *P. gingivalis*. At 18 h, the mean inhibition halo measured 8.5 ± 0.82 mm at 25 %, 10.64 ± 0.91 mm at 50 %, and 12.34 ± 0.91 mm at 75 %. At 24 h, the inhibition zones were 8.3 ± 0.81 mm, 10.2 ± 0.83 mm, and 12.5 ± 0.76 mm for concentrations of 25 %, 50 %, and 75 %, respectively. At 48 h, the halos measured 7.10 ± 0.89 mm at 25 %, 8.9 ± 0.55 mm at 50 %, and 10.84 ± 0.46 mm at 75 %. Across all time points, an increase in inhibition halo diameter was observed as the concentration of the extract increased. According to the one-way ANOVA test, these differences in mean values were statistically significant (p = 0.00).

Table II presents the antibacterial efficacy of the hydroalcoholic solution of *Syzygium aromaticum* against *P. gingivalis* at 18, 24, and 48 hours, demonstrating sensitivity at concentrations of 25 %, 50 %, and 75 %. According to Kendall's Tau-C statistical test, the associations between concentration and antibacterial response were significant (p < 0.05). The results indicate a progressive increase in antibacterial activity with higher concentrations of the extract, as reflected in the Duraffourd scale classifications. This association remained statistically significant (p = 0.001), confirming that *Syzygium aromaticum* exhibits a stronger antibacterial effect at 25 %, 50 %, and 75 % concentrations, particularly at 48 h.

Table I. *In vitro* antibacterial effect of different concentrations of *Syzygium aromaticum* hydroalcoholic solution against *P. gingivalis*.

Syzygium Aromaticum hydroalcoholic solution		N	Media	Standard deviation	95 % confidence for the mean		Min.	Max	Anova
					Lower limit	Upper limit			
At 18 hours	25 %	15	8.587	.8280	8.128	9.045	7.1	10.0	F:26.70 P=0.00
	50 %	15	10.640	.9171	10.132	11.148	9.3	12.6	
	75 %	15	10.640	.9171	10.132	11.148	9.3	12.6	
	Total	45	9.956	1.3083	9.563	10.349	7.1	12.6	
At 24 hours	25 %	15	8.307	.8119	7.857	8.756	7.0	10.0	F:102.62 P=0.00
	50 %	15	10.273	.8336	9.812	10.735	8.9	12.3	
	75 %	15	12.513	.7671	12.089	12.938	10.9	13.9	
	Total	45	10.364	1.9075	9.791	10.938	7.0	13.9	
At 48 hours	25 %	15	7.107	.8964	6.610	7.603	6.0	9.3	F:117.75 P=0.00
	50 %	15	8.987	.5579	8.678	9.296	8.0	10.0	
	75 %	15	10.840	.4657	10.582	11.098	10.2	11.8	
	Total	45	8.978	1.6732	8.475	9.480	6.0	11.8	

Table II. *In vitro* antibacterial effect at different concentrations of *Syzygium aromaticum* hydroalcoholic solution against *P. gingivalis* according to the Duraffourd scale.

***Syzygium aromaticum* Hydroalcoholic solution**	**Duraffour scale**	Concentration 25 %	50 %	75 %	**Total**	**Kendall's Tauc statistic test**
		f	f	f	f	
At 6 p.m.	Null	5	-	-	5	t=0.296 p=0.009
	Sensitive	10	15	15	40	
	Very sensitive	-	-	-	-	
	Highly sensitive	-	-	-	-	
	Total	15	15	15	45	
At 24 hours	Null	7	-	-	7	t=0.415 p=0.001
	Sensitive	8	15	15	38	
	Very sensitive	-	-	-	-	
	Highly sensitive	-	-	-	-	
	Total	15	15	15	45	
After 48 hours	Null	13	1	-	14	t=0.770 p=0.000
	Sensitive	2	14	15	31	
	Very sensitive	-	-	-	-	
	Highly sensitive	-	-	-	-	
	Total	15	15	15	45	

DISCUSSION

Periodontal disease is a multifactorial condition characterized by infection and inflammation of the periodontal tissues caused by periodontopathogenic microorganisms, among which *P. gingivalis* is recognized as a primary etiologic agent. The findings of this study demonstrate that the hydroalcoholic solution of *Syzygium aromaticum* exhibits a measurable natural antibacterial inhibitory effect against *P. gingivalis*, supporting its potential relevance as an adjunctive antimicrobial agent in periodontal therapy.

Haro-González *et al*. (2021) reported that clove essential oil exhibits a broad range of bioactive properties relevant to human health, including potent insecticidal, antimicrobial, anti-inflammatory, wound-healing, antiviral, antioxidant, and even anticancer activities. These findings align with the results of the present study, which demonstrate a clear antibacterial effect against *P. gingivalis*, thereby expanding the potential applications of *Syzygium aromaticum* in the prevention and control of oral diseases. Likewise, the present results are consistent with the work of Kiki *et al*. (2023), who confirmed both the antioxidant and antibacterial activities of clove oil.

Its antibacterial effect against *P. gingivalis* was further demonstrated in a comparative study by Vaish *et al*. (2012) who evaluated the *in vitro* efficacy of herbal mouthwashes including clove-based formulations in inhibiting periodontal pathogenic microorganisms relative to 0.2 % chlorhexidine. Their findings supported the use of these natural preparations as effective adjuncts for improving and maintaining oral health.

These findings are attributed to the presence of clove and other bioactive natural components, which appear to interact synergistically to enhance the antimicrobial effect. The authors concluded that these herbal mouthwashes demonstrated plaque-control efficacy comparable to that of chlorhexidine. These observations align closely with the results of the present study, which likewise demonstrated a significant inhibitory effect of the hydroalcoholic solution of *Syzygium aromaticum* against *P. gingivalis*.

Its effectiveness against *P. gingivalis* has also been documented by Katariya *et al*. (2023) and Sreenivasan *et al*. (2020), who reported similar results in their *in vitro* evaluations of herbal toothpastes containing clove. Both studies demonstrated significant antibacterial activity against periodontal pathogens associated with periodontitis. The authors concluded that clove-based dentifrices may serve as adjunctive therapeutic agents in the management of periodontal diseases and recommended their use according to the patient's clinical condition. These findings are consistent with the results obtained in the present study.

Finally, the results of this study align with the findings reported by Magmoud *et al*. (2021), who demonstrated that clove-derived compounds represent a promising alternative for managing periodontal diseases in patients with antibiotic resistance due to their notable antibacterial activity. In accordance with their conclusions, the present study supports recommending the use of *Syzygium aromaticum* based formulations for the treatment and control of bacterial infections, particularly those caused by *P. gingivalis*.

CONCLUSION

Syzygium aromaticum (clove) essential oil exhibits robust antibacterial activity against *Porphyromonas gingivalis*, as demonstrated by the inhibition zone diameter measured in accordance with the Duraffour scale. These findings support its potential application as a bioactive agent for limiting the proliferation of *P. gingivalis*, a major pathogen associated with periodontal disease and related systemic conditions.

ACKNOWLEDGMENTS. We extend our gratitude to MEDING Laboratory in Cusco.

ARAGON-LAROTA, J. P.; CAICEDO-FERRO, R. B.; FERNÁNDEZ-DÁVILA, J. A. A.; MALPARTIDA-CAVIEDES, A. & GUTIÉRREZ-GAYOSO, G. Efecto del uso de la solución hidroalcohólica de *Syzygium aromaticum* sobre la prevalencia de *Porphyromonas gingivalis*: Un estudio *in vitro*. *Int. J. Odontostomat., 19(4)*:404-410, 2025.

RESUMEN: En los últimos años, se ha observado un incremento en las infecciones periodontales, lo que ha contribuido a la propagación de patógenos multirresistentes y ha afectado negativamente la salud oral. El objetivo de este estudio fue evaluar el efecto antibacteriano de una solución hidroalcohólica de *Syzygium aromaticum* en diferentes concentraciones contra *Porphyromonas gingivalis* (*P. gingivalis*) ATCC 33277. Se llevó a cabo un diseño experimental *in vitro*, compuesto por 45 cajas Petri inoculadas con la cepa *P. gingivalis* ATCC 33277. Estas se dividieron en tres grupos de 15 cajas cada uno, correspondientes a concentraciones del 25 %, 50 % y 75 % de la solución hidroalcohólica de *Syzygium aromaticum*. El efecto antibacteriano se evaluó mediante el método de difusión en agar con disco de Kirby–Bauer. Las incubaciones se realizaron a 35 °C durante 18, 24 y 48 h para medir el diámetro de los halos de inhibición. Se observó un efecto antibacteriano significativo de *Syzygium aromaticum* contra *P. gingivalis* ATCC 33277. La mayor actividad inhibidora se registró en las concentraciones del 25 %, 50 % y 75 % después de 48 h de incubación. En conjunto, los aceites esenciales de *Syzygium aromaticum* emergen como agentes efectivos, demostrando una actividad antibacteriana sustancial contra *P. gingivalis*.

PALABRAS CLAVE: Efecto antibacteriano, solución hidroalcohólica, *Syzygium aromaticum*, clavo, *P. gingivalis*.

REFERENCES

Afrendi, E.; Prastya, M. E.; Astuti, R. I.; Wahyuni, W. T. & Batubara, I. Bioactivity of the ethanol extract of clove (*Syzygium aromaticum*) as antitoxin. *Int. J. Food Sci., 2023*:3245210, 2023.

Alanazi, A. K.; Alqasmi, M. H.; Alrouji, M.; Kuriri, F. A.; Almuhanna, Y.; Joseph, B. & Asad, M. Antibacterial activity of *Syzygium aromaticum* (clove) bud oil and its interaction with imipenem in controlling wound infections in rats caused by methicillin-resistant *Staphylococcus aureus*. *Molecules, 27(23)*:8551, 2022.

Orrego-Cardozo, M.; Parra-Gil, M. A.; Salgado-Morales, Y. P.; Muñoz-Guarín, E. & Fandiño-Henao, V. *Porphyromonas gingivalis* y enfermedades sistémicas. *CES Odontol., 28(1)*:57-73, 2015.

Cortés-Rojas, D. F.; de Souza, C. R. F. & Oliveira, W. P. Clove (*Syzygium aromaticum*): A precious spice. *Asian Pac. J. Trop. Biomed., 4(2)*:90-6, 2014.

Díaz-Zúñiga, J.; Yáñez Figueroa, J.; Melgar Rodríguez, S.; Álvarez Rivas, C.; Rojas Lagos, C. & Vernal Astudillo, R. Virulencia y variabilidad de *Porphyromonas gingivalis* y *Aggregatibacter actinomycetemcomitans* y su asociación a la periodontitis. Rev. Clin. Periodoncia Implantol. *Rehabil. Oral, 5(1)*:40-5, 2012.

Fiorillo, L. Oral health: The first step to well-being. *Medicina (Kaunas), 55(10)*:676, 2019.

Ginting, E. V.; Retnaningrum, E. & Widiasih, D. A. Antibacterial activity of clove (*Syzygium aromaticum*) and cinnamon (Cinnamomum burmannii) essential oil against extended-spectrum b-lactamase-producing bacteria. *Vet. World, 14(8)*:2206-11, 2021.

Goetz, P. *Syzygium aromaticum* (L.), Giroflier. *Phytotherapie, 19(1)*:55-59, 2021.

Haro-González, J. N.; Castillo-Herrera, G. A.; Martínez-Velázquez, M. & Espinosa-Andrews, H. Clove essential oil (*Syzygium aromaticum* L. Myrtaceae): Extraction, chemical composition, food applications, and essential bioactivity for human health. *Molecules, 26(21)*:6387, 2021.

Kacániová, M.; Galovicová, L.; Borotová, P.; Valková, V.; Dúranová, H.; Kowalczewski, P. ; Said-Al Ahl, H. A. H.; Hikal, W. M.; Vukic, M.; Savitskaya, T.; Grinshpan, D. & Vukovic, N. L. Chemical composition, *in vitro* and *in situ* antimicrobial and antibiofilm activities of *Syzygium aromaticum* (clove) essential oil. *Plants, 10(10)*:2185, 2021.

Katariya, M.; Singh, J.; Sirdesai, A. & Bandyopadhyay, P. *In vitro* assessment of babool extract, mint and clove oil containing toothpaste on gingivitis-causing bacteria. J. *Adv. Microbiol. Res., 4(1)*:128-33, 2023.

Kiki, M. J. *In vitro* antiviral potential, antioxidant, and chemical composition of clove (*Syzygium aromaticum*) essential oil. *Molecules, 28(6)*:2421, 2023.

Maggini, V.; Semenzato, G.; Gallo, E.; Nunziata, A.; Fani, R. & Firenzuoli, F. Antimicrobial activity of *Syzygium aromaticum* essential oil in human health treatment. *Molecules, 29(5)*:999, 2024.

Mahmoud, A.; Afifi, M. M.; El Shenawy, F.; Salem, W. & Elesawy, B. H. *Syzygium aromaticum* extracts as potential antibacterial inhibitors against clinical isolates of *Acinetobacter baumannii*: An in-silico-supported in-vitro study. *Antibiot., 10(9)*:1062, 2021.

Paranagama, M. P.; Piyarathne, N. S.; Nandasena, T. L.; Jayatilake, S.; Navaratne, A.; Galhena, B. P.; Williams, S.; Rajapakse, J. & Kita, K. The *Porphyromonas gingivalis* inhibitory effects, antioxidant effects, and the safety of a Sri Lankan traditional betel quid: An *in vitro* study. *BMC Complement. Med. Ther., 20(1)*:259, 2020.

Ramos-Perfecto, D.; Moromi-Nakata, H. & Martínez-Cadillo, E. *Porphyromonas gingivalis*: patógeno predominante en la periodontitis crónica. *Odontol. Sanmarquina, 14(1)*:34-8, 2011.

Prashar, D. & Jasra, K. Pharmacognostic, phytochemical and therapeutic overview of three allied herbs used in dentistry. *Asian J. Res. Pharm. Sci., 11(2)*:121-5, 2021.

Rodríguez, O.; Sánchez-Casas, R.; Verde-Star, M.; Núñez, M.; Ríos, R. & Chávez, A. Obtaining the essential oil of *Syzygium aromaticum*, identification of eugenol and its effect on *Streptococcus mutans*. *J. Oral Res., 3(4)*:218-24, 2014.

Shehabeldine, A. M.; Doghish, A. S.; El-Dakroury, W. A.; Hassanin, M. M. H.; Al-Askar, A. A.; Abd Elgawad, H. & Hashem, A. H. Antimicrobial, antibiofilm, and anticancer activities of *Syzygium aromaticum* essential oil nanoemulsion. *Molecules, 28(15)*:5812, 2023.

Sreenivasan PK, Kakarla VVP, Sharda S, Setty Y. The effects of a novel herbal toothpaste on salivary lactate dehydrogenase as a measure of cellular integrity. *Clin Oral Investig. 25(5)*:3021-30, 2021.

Song, W. P.; Bo, X. W.; Dou, H. X.; Fan, Q. & Wang, H. Association between periodontal disease and coronary heart disease: A bibliometric analysis. *Heliyon, 10(7)*:28325, 2024.

Vaish, S.; Ahuja, S.; Dodwad, V. & Parkash, H. Comparative evaluation of 0.2% chlorhexidine versus herbal oral rinse on plaque-induced gingivitis. *J. Indian Assoc. Public Health Dent., 10(19)*:55, 2012.

Corresponding author:
Giovanna Gutiérrez-Gayoso
Escuela Profesional de Estomatología
Segunda Especialidad
Universidad Privada San Juan Bautista
Lima
PERÚ

E-mail: giovanna.gutierrez@upsjb.edu.pe

https://orcid.org/0000-0002-2007-0407