JRSSEM 2025, Vol. 05, No. 05, December
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

In-vitro Study on the Effectiveness of Coconut Shell Liquid Smoke Gel on Cleaning Smear Layer and Debris in Root Canal Treatment

Linda Novelgia Setiawan , Roselyn Avrillia, Tresnandya Pradipta*
Universitas Prima Indonesia, Indonesia
Email: lindanovelgiasetiawan@unprimdn.ac.id*, roselynavrillia@unprimdn.ac.id*, tresnandyaadip@gmail.com*

Smear layer and debris are major challenges in successful root canal treatment because they obstruct dentinal tubules and reduce penetration of irrigants and intracanal medicaments. Sodium hypochlorite (NaOCl) 5.25% is used; however, it has limited smear layer removal ability and may induce cytotoxic effects on periapical tissues. Coconut shell liquid smoke (CS-LS) contains phenolic compounds, carbonyls, and organic acids with antibacterial and chelating properties, indicating potential as an irrigant. This study aimed to evaluate the effectiveness of CS-LS gel in removing smear layer and debris in the apical third of the root canal. This experimental study employed a post-test only control group design. Twenty-four single-rooted premolars were randomly allocated into four groups (n=6): 5.25% NaOCl, saline solution, CS-LS gel, and 100% CS-LS. Root canal preparation was performed up to a #25 K-file, followed by irrigation according to the assigned treatment. Specimens were examined using scanning electron microscopy at 5000× magnification. Smear layer and debris were assessed using Hülsmann's scoring system. Statistical analysis using the Kruskal–Wallis test showed significant differences among groups for smear layer and debris scores ($p=0.001$). The CS-LS gel and CS-LS demonstrated lower smear layer and debris scores (1.50 ± 0.548 and 2.00 ± 0.632) (1.83 ± 0.408; and 2.00 ± 0.632) than 5.25% NaOCl (4.00 ± 0.632 and 4.50 ± 0.548) and saline (3.25 ± 0.957 and 3.50 ± 0.577). Mann–Whitney analysis showed significantly lower scores for CS-LS gel compared with NaOCl 5.25% and saline ($p<0.05$). CS-LS gel was effective on cleaning smear layer and debris in the apical third of the root canal.

Keywords: Smear layer; debris; coconut shell liquid smoke; gel; root canal treatment.

INTRODUCTION

Root canal treatment (RCT) is a clinical procedure performed to eliminate bacterial infection within the root canal system and to preserve the function of the affected tooth (Jemima Br Surbakti et al., 2022). The success of this treatment depends on adequate cleaning and shaping of the root canal, which involves the use of endodontic instruments, irrigation solutions, and intracanal medicaments. However, due to the complex anatomy of the root canal system, mechanical instrumentation alone is insufficient to remove debris and microorganisms from all areas of the canal, particularly in the apical region (Awawdeh et al., 2018). Consequently, irrigation plays a critical role in achieving effective root canal disinfection (Kusumawardhani et al., 2019).

One of the major challenges during root canal preparation is the formation of smear layer and debris on the canal walls. Smear layer is an irregular layer, approximately 1–5 μm thick, composed of organic and inorganic materials produced during mechanical

instrumentation (Permatasari & Ekiyo, 2023). The presence of smear layer may obstruct dentinal tubules, reduce the penetration of irrigants and intracanal medicaments, and compromise the sealing ability of root canal filling materials. Therefore, effective removal of smear layer and debris is considered an important factor for successful root canal treatment (Permatasari & Ekiyo, 2023).

Sodium hypochlorite (NaOCl) at concentrations ranging from 0.5% to 5.25% is the most commonly used irrigating solution in endodontic practice due to its ability to dissolve organic tissue and its broad antimicrobial activity (Youssef et al., 2020). Despite these advantages, NaOCl has limited effectiveness in removing the inorganic components of the smear layer and has been reported to be cytotoxic and corrosive to vital tissues. In addition, higher concentrations or combination with other solutions are often required to enhance its smear layer removal capability, which may increase the risk of adverse effects (Mahardika, Kristanti, et al., 2022).

Various alternative irrigating agents have been investigated to overcome the limitations of NaOCl. Ethylenediaminetetraacetic acid (EDTA) is widely used as a chelating agent to remove the inorganic component of the smear layer, while mixtures such as tetracycline isomer, acid, and detergent (MTAD) have also been introduced. However, previous studies have shown that the effectiveness of these agents in completely eliminating smear layer and debris, particularly in the apical third of the root canal, remains limited. To date, no single irrigating solution has been demonstrated to fully remove smear layer and debris under all conditions (Permatasari & Ekiyo, 2023).

Indonesia generates a substantial amount of organic waste, including coconut shell waste (*Cocos nucifera*), which is difficult to decompose naturally despite being classified as organic material (Zebua et al., 2023). The utilization of coconut shell waste to produce liquid smoke has been reported as an economical and environmentally friendly approach (Mulyawanti et al., 2019). Liquid smoke is a bioactive compound obtained through the condensation of vapor produced during the pyrolysis of biomass at temperatures of approximately 400°C. It contains various chemical constituents, including organic acids, carbonyl compounds, and phenolic derivatives (Purwantisari et al., 2023; Nahla et al., 2021). Phenolic compounds and organic acids in liquid smoke have been reported to possess antibacterial and antioxidant properties, suggesting potential application in dental treatment (Imaniar et al., 2019).

The formulation of irrigating agents in gel form has been proposed to improve stability, prolong contact time, and reduce evaporation during application (Diki Wahyudi et al., 2022). Sodium carboxymethylcellulose (Na-CMC) is commonly used as a gelling agent due to its ability to form stable gel formulations at various concentrations (Hastuty et al., 2018). The use of a gel-based irrigant may enhance interaction between the active compounds and the root canal walls, particularly in the apical region.

Scanning Electron Microscopy (SEM) is a widely used method for evaluating the cleanliness of root canal walls, as it allows high-resolution visualization of dentin surfaces and dentinal tubules at the micro- and nanoscale. SEM analysis enables qualitative assessment of smear layer and debris removal and has been extensively applied in endodontic research to evaluate the effectiveness of irrigation materials (Mahardika et al., 2022).

MATERIALS AND METHODS

This study was an in vitro experimental laboratory research using a post-test only control group design, conducted from April to July 2025 at the Integrated Laboratory of Universitas Sumatera Utara and the Integrated Laboratory of the Faculty of Medicine, Dentistry, and Health Sciences, Universitas Prima Indonesia. A total of 24 extracted human single-rooted maxillary and mandibular premolars with fully formed apices and standardized root lengths of 15 mm were selected. Teeth with fractures, root caries, cracks, or previous endodontic treatment were excluded. The sample size was determined using the Federer formula, and the specimens were randomly allocated into four groups (n = 6): 5.25% sodium hypochlorite (NaOCl), saline solution, coconut shell liquid smoke gel (CS-LS gel), and 100% coconut shell liquid smoke (CS-LS).

All teeth were decoronated at the cemento-enamel junction using a low-speed diamond disc. Working length was determined by inserting a #10 K-file until visible at the apical foramen, and root canal preparation was performed using a manual step-back technique up to a #25 K-file. Irrigation was carried out during instrumentation with 10 mL of the assigned solution using a 30-gauge irrigation needle, followed by final irrigation with 3 mL of saline solution.

The CS-LS gel was prepared using sodium carboxymethyl cellulose (Na-CMC) as a gelling agent, dissolved in heated distilled water (70°C) until a homogeneous gel was obtained. Coconut shell liquid smoke extract was then added and homogenized using a magnetic stirrer, with propylene glycol and glycerin incorporated to improve stability and consistency. The gel was stored in sterile containers at room temperature prior to use.

After irrigation, the specimens were split longitudinally, dehydrated, and examined under a scanning electron microscope (Hitachi TM-3030, Japan) at 5000× magnification, 30 kV accelerating voltage, and a 12 mm working distance. Smear layer and debris were evaluated in the coronal, middle, and apical thirds using Hülsmann's scoring system by two blinded and calibrated examiners.

Statistical analysis was performed using SPSS version 24. Inter-examiner reliability was assessed with the Kappa test. Data normality and homogeneity were analyzed using the Shapiro–Wilk and Levene tests, respectively. As the data were not normally distributed, comparisons among groups were conducted using the Kruskal–Wallis test followed by the Mann–Whitney post hoc test, with a significance level set at $p < 0.05$.

RESULTS AND DISCUSSION

Smear Layer

Average *Smear Layer Score*

Based on Table 3.1, the observation results were obtained that the average smear layer score in one-third of the root canal after the administration of.

Table 1 Average *Smear Layer Score*

Groups	Layer smear *score*						
	Sample						$\bar{x} \pm SD$
	1	2	3	4	5	6	
NaOCl 5,25%	4	4	3	5	4	4	4,00±0,632
Saline	4	4	3	2			3,25±0,957
Gel CS-LS	2	1	2	1	2	1	1,50±0,548
CS-LS 100%	2	2	2	2	3	1	2,00±0,632

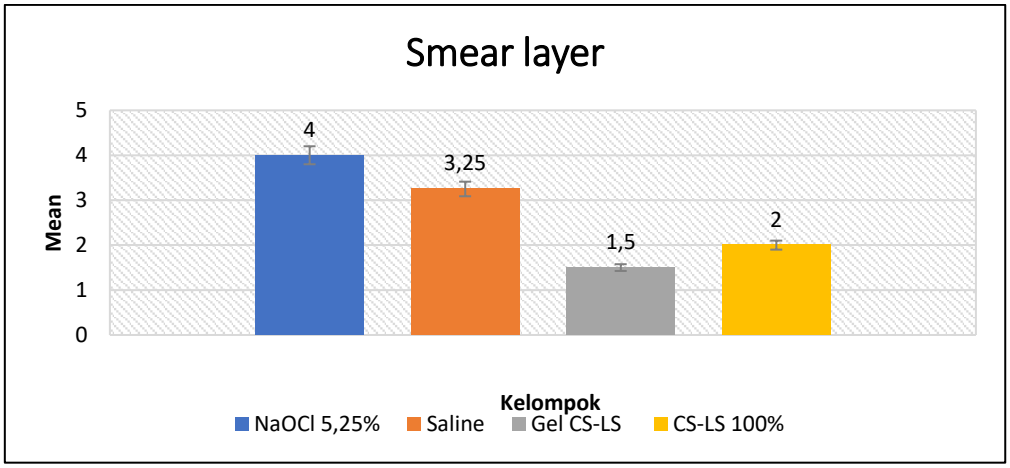

Figure 1 Average *Smear Layer Score*

Normality and Homogeneity *Test Results of Smear Layer*

Based on Table 3.2, the results of *the Shapiro-Wilik* normality test and the homogeneity *of the Levene Test* can be stated that the distributed data are abnormal (p<0.05) and homogeneous (p>0.05). Therefore, the data analysis used in this study is *Kruskal-Wallis* and *Mann-Whitney*.

Table 2 Normality and Homogeneity *Test Results of Smear Layer*

Groups	Normalitas *Shapiro-Wilk*		Homogenitas *Levene Test*	
	p-value	Remarks	*p-value*	Remarks
NaOCl 5,25%	0,001	Abnormal	0,407	homogeneous
Saline	0,272	Normal		
Gel CS-LS	0,004	Abnormal		
CS-LS 100%	0,101	Normal		

Kruskal-Wallis Smear Layer Test Results

The Kruskal-Wallis *statistical test* aims to determine the effectiveness of coconut shell liquid smoke gel against the cleaning of *the smear layer* in root canal treatment. Based on Table 3.3, the results of this statistical test can be stated that there is a significant difference in *layer smear* scores between all groups (p=0.002; p<0.05). Therefore, the results of this test mean that there is an effectiveness of coconut shell liquid smoke gel in cleaning the *smear layer* on one-third of the root canal.

Table 3. *Kruskal-Wallis Smear Layer Test Results*

Groups	$\bar{x} \pm SD$	*p-value*
NaOCl 5,25%	4,00±0,632	0,002*
Saline	3,25±0,957	
Gel CS-LS	1,50±0,548	
CS-LS 100%	2,00±0,632	

*Signifikan

Mann-Whitney Smear Layer Test Results

The Mann-Whitney *statistical test* aimed to determine the significant difference in *the layer smear* score between two different groups after the administration of coconut shell liquid smoke gel in root canal treatment. Based on Table 3.4, the results of this statistical test can be stated that there is *a significant difference in layer smear* score between the 5.25% NaOCl group with CS-LS gel and 100% CS-LS, as well as between the saline group with CS-LS gel (p<0.05). The difference in *layer smear* scores between the saline group and 100% CS-LS,

between the CS-LS gel and 100% CS-LS, and between the 5.25% NaOCl and saline was not significant (p>0.05). Thus, it can be stated that 100% CS-LS and CS-LS gels have a better ability compared to 5.25% NaOCl in cleaning *the smear layer* in one-third of the root canal.

Table .4 *Mann-Whitney Smear Layer Test Results*

Groups		*p-value*
NaOCl 5,25%	Saline	0,185
	Gel CS-LS	0,003*
	CS-LS 100%	0,004*
Saline	Gel CS-LS	0,019*
	CS-LS 100%	0,052
Gel CS-LS	CS-LS 100%	0,171

Debris

Average Debris Score

Based on Table 3.5, the observation results were obtained that the average debris score in one-third of the root canal after the administration of.

Table 5 Average Debris Score

Groups	Skor debris						
	Sample						$\bar{x} \pm SD$
	1	2	3	4	5	6	
NaOCl 5,25%	5	4	4	5	5	4	4,50±0,548
Saline	4	4	3	3			3,50±0,577
Gel CS-LS	2	2	2	1	2	2	1,83±0,408
CS-LS 100%	2	2	2	2	3	1	2,00±0,632

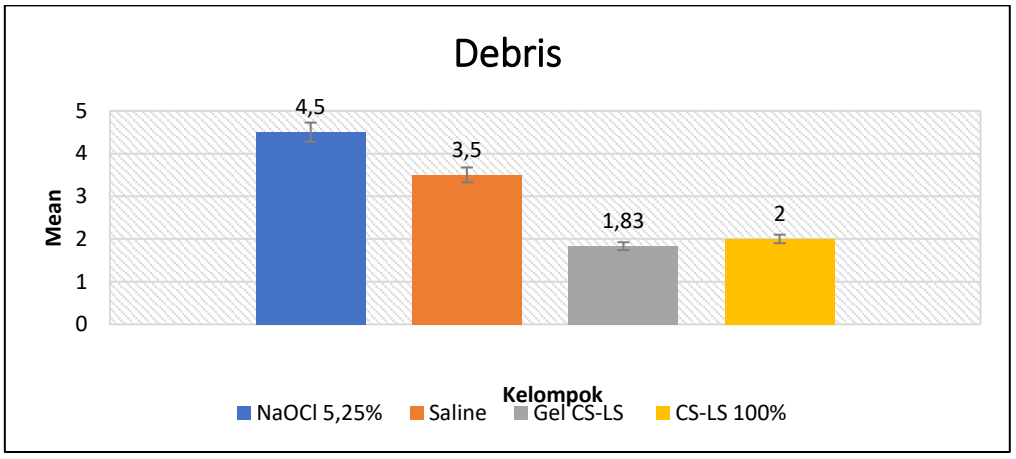

Figure 2 Average Debris Score

Results of Debris Normality and Homogeneity Test

Based on Table 3.6, the results of *the Shapiro-Wilik normality test* and the homogeneity of *the Levene Test* can be stated that the distributed data are abnormal (p<0.05) and homogeneous (p>0.05). Therefore, the data analysis used in this study is *Kruskal-Wallis* and *Mann-Whitney*.

Table 6 Results of Debris Normality and Homogeneity Test

Groups	Normalitas *Shapiro-Wilk*		Homogenitas *Levene Test*	
	p-value	Remarks	*p-value*	Remarks
NaOCl 5,25%	0,004	Abnormal	0,532	homogeneous
Saline	0,024	Abnormal		
Gel CS-LS	0,000	Abnormal		
CS-LS 100%	0,101	Normal		

Kruskal-Wallis *Debris* Test Results

The Kruskal-Wallis *statistical test* aims to determine the effectiveness of coconut shell liquid smoke gel against debris cleaning in root canal treatment. Based on Table 3.7, the results of this statistical test can be stated that there is a significant difference in debris score between all groups (p=0.002; p<0.05). Therefore, the results of this test mean that there is an effectiveness of coconut shell liquid smoke gel in cleaning debris in one-third of the root canal.

Table 7 *Kruskal-Wallis* Debris Test Results

Groups	$\bar{x} \pm SD$	*p-value*
NaOCl 5,25%	4,50±0,548	0,001*
Saline	3,50±0,577	
Gel CS-LS	1,83±0,408	
CS-LS 100%	2,00±0,632	

*Signifikan

Mann-Whitney *Debris* Test Results

The Mann-Whitney *statistical test* aimed to find out the significant difference in debris scores between two different groups after the administration of coconut shell liquid smoke gel on root canal treatment. Based on Table 3.8, the results of this statistical test can be stated that there is a significant difference in debris score between the 5.25% NaOCl group with CS-LS, 100% CS-LS gel, and saline, as well as between the saline group with 100% CS-LS and CS-LS gel (p<0.05). The difference in debris score between the CS-LS gel group and 100% CS-LS was not significant (p>0.05). Thus, this result can be stated that 100% CS-LS and CS-LS gels have a better ability compared to NaOCl 5.25% in cleaning debris in one-third of the root canal.

Table 8 *Mann-Whitney* Debris Test Results

Groups		*p-value*
NaOCl 5,25%	Saline	0,037*
	Gel CS-LS	0,002*
	CS-LS 100%	0,003*
Saline	Gel CS-LS	0,006*
	CS-LS 100%	0,014*
Gel CS-LS	CS-LS 100%	0,598

Discussion

The removal of smear layer and debris is an important factor in root canal treatment, as their presence may interfere with the penetration of irrigants and intracanal medicaments and affect the adaptation of root canal sealers (Maulidiyah et al., 2021; Permatasari & Ekiyo, 2023). Therefore, the evaluation of alternative irrigating agents with adequate cleaning ability remains relevant.

In this study, coconut shell liquid smoke gel (CS-LS gel) and 100% coconut shell liquid smoke showed lower smear layer and debris scores in the apical third of the root canal compared to 5.25% sodium hypochlorite (NaOCl) and saline solution. The Kruskal–Wallis test indicated statistically significant differences among groups ($p < 0.05$), suggesting that CS-LS-based irrigants demonstrated better cleaning performance under the experimental conditions of this in vitro study. However, these findings should be interpreted within the limitations of laboratory settings.

The observed cleaning effect of CS-LS may be related to its chemical composition, particularly the presence of organic acids such as acetic acid and other carboxylic acids. These

compounds have been reported to exhibit chelating properties that can bind calcium ions from hydroxyapatite, potentially facilitating partial removal of the inorganic components of the smear layer (Setianingrum et al., 2017; Maulidiyah et al., 2021). The acidic pH range of coconut shell liquid smoke reported in previous studies may contribute to this effect, especially in the apical third where mechanical instrumentation is less effective (Mulyawanti et al., 2019).

In addition to organic acids, coconut shell liquid smoke contains phenolic compounds that have been associated with antibacterial activity in previous studies (Nosartika et al., 2021; Setiawan et al., 2025). Although antimicrobial properties were not evaluated in the present study, the removal of smear layer alone may facilitate better penetration of intracanal medicaments. Therefore, the potential antimicrobial contribution of CS-LS should be interpreted as supportive evidence rather than a direct outcome of this research.

The gel formulation of CS-LS may have influenced its performance by increasing viscosity and contact time with the root canal walls. Increased viscosity has been suggested to enhance retention within the canal and improve interaction with dentin surfaces, which may support smear layer and debris reduction (Kim et al., 2023). Nevertheless, the absence of a direct comparison of contact time or penetration depth limits definitive conclusions regarding the specific contribution of the gel formulation.

The results also showed that 5.25% NaOCl exhibited limited effectiveness in removing smear layer and debris. This finding is consistent with previous studies indicating that NaOCl primarily dissolves organic tissue and has limited ability to remove inorganic components of the smear layer (Mahardika et al., 2022; Permatasari & Ekiyo, 2023). Furthermore, concerns related to the cytotoxicity and potential effects of NaOCl on dentin structure have been reported in the literature, particularly at higher concentrations (Youssef et al., 2020; Cai et al., 2023), although these aspects were not assessed in this study.

Saline solution demonstrated moderate cleaning ability, which may be explained by its flushing action and relatively low surface tension. However, saline does not possess chelating or antibacterial properties, and therefore its role as an irrigating solution is considered limited (Mahardika et al., 2022).

Several limitations should be considered when interpreting the findings of this study. The in vitro design does not fully represent clinical conditions, and factors such as tissue response, fluid dynamics, and long-term effects on dentin were not evaluated. Consequently, the results of this study should not be directly extrapolated to clinical practice. Further studies, including in vivo investigations and biocompatibility assessments, are required to clarify the safety, optimal concentration, and potential clinical role of CS-LS gel as a root canal irrigant.

CONCLUSION

Based on the results of the study, it can be concluded that the results of the SEM test analysis show that CS-LS gel is effective on cleaning *the smear layer* and debris in the apical third of the root canal.

Some of the suggestions that can be given in this study are to determine the impact of the use of CS-LS gel on the strength of dentin in root canal treatment and in-vivo studies to determine the safe dose of CS LS gel use in root canal treatment.

REFERENCES

Astria, N., Subiyanto, A., & Mooduto, L. (2017). Daya Bunuh dan Daya Hambat Antimikrobial Chlorhexidine 2% dan Povidone iodine 1% sebagai Medikamen Saluran Akar terhadap Enterococcus faecalis. *Conservative Dentistry Journal*, *7*(1), 12–17.

Awawdeh, L., Jamleh, A., & Al Beitawi, M. (2018). The antifungal effect of propolis endodontic irrigant with three other irrigation solutions in presence and absence of smear layer: An in vitro study. *Iranian Endodontic Journal*, *13*(2), 234–239. https://doi.org/10.22037/iej.v13i2.19227

Cai, C., Chen, X., Li, Y., & Jiang, Q. (2023). Advances in the Role of Sodium Hypochlorite Irrigant in Chemical Preparation of Root Canal Treatment. *Hindawi BioMed Research International*, *2023*, 1–17. https://doi.org/https://doi.org/10.1155/2023/8858283

Diki Wahyudi, M., Syahrina, F., Carabelly, A. N., Puspitasari, D., Wasiaturrahmah, Y., Patologi, D., Dan, O., Fakultas, M., & Gigi, K. (2022). FORMULASI DAN UJI STABLITAS FISIK GEL EKSTRAKBATANG PISANG MAULI (Musa acuminata). *Dentin Jurnal Kedokteran Gigi*, *2022*(3), 161–165.

Djalil, J. P., Salimi, Y. K., Iyabu, H., Isa, I., Bialangi, N., Mohamad, E., Kimia, P. S., Matematika, F., Gorontalo, U. N., Prof, J., Bj, I., Moutong, D., & Bolango, K. B. (2024). Karakteristik Kimia dan Organoleptik Asap Cair Tempurung Kelapa dalam Menurunkan Cemaran Logam Timbal (pB) pada Ikan Cakalang (Katsuwonus pelamis). *Jambura Fish Processing Journal*, *6*(1), 52–65. https://doi.org/https://doi.org/10.37905/jfpj.v6i1.21715

Hassan, H., Zaazou, M., Sadony, D., & Mohamed, T. (2025). Effect of Photodynamic Therapy on Enterococcus faecalis and Candida albicans compared to diode laser activated nanoparticle herbal irrigants. *Laser Innovations for Research and Applications*, *2*(2), 1–34.

Hastuty, H. S. B., Purba, P. N., & Nurfadillah, E. (2018). UJI STABILITAS FISIK FORMULASI SEDIAAN GEL EKSTRAK DAUN KETEPENG CINA (Cassia alata L.) DENGAN GELLING AGENT CMC-NA TERHADAP Staphylococcus aureus ATCC 230840. *Gema Kesehatan*, *10*(1), 22–27. https://doi.org/10.47539/gk.v10i1.5

Hutami, O. S., & Muryani, A. (2020). Perawatan Saluran Akar (PSA) Satu Kali Kunjungan pada Gigi Molar Pertama Bawah Kanan dengan Restorasi Endocrown Resin Komposit. *Jurnal Kedokteran Gigi Universitas Padjadjaran*, *32*(December), 54–63. https://doi.org/10.24198/jkg.v32i2.18040

Imaniar, A. C., Vidyahayati, I. L., Wibisono, G., Ciptaningtyas, V. R., & Pulpa, G. (2019). Pengaruh Pemberian Asap Cair Pada Berbagai Konsentrasi Terhadap Pertumbuhan Enterococcus Faecalis Penyebab Gangren Pulpa. *Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro)*, *7*(2), 424–432.

Jemima Br Surbakti, A., Mozartha, M., & Bellinda, M. (2022). THE EFFECT OF 20% CURCUMA LONGA EXTRACT ON SMEAR LAYER CLEANING IN THE APICAL THIRD OF THE ROOT CANAL. *Jurnal Kedokteran Gigi Universitas Baiturrahmah*, *9*(2), 220–228.

Kim, H., Park, S., Park, S., Hwang, Y., Yu, M., & Min, K. (2023). Efficacy of Flowable Gel-type EDTA at Removing the Smear Layer and Inorganic Debris under Manual Dynamic Activation. *Journal of Endodontics*, *39*(7), 910–914.

https://doi.org/10.1016/j.joen.2013.04.018

Kusumawardhani, T., Sukaton, S., & Sudirman, A. (2019). PERBEDAAN KHASIAT ANTIBAKTERI BAHAN IRIGASI LARUTAN PROPOLIS DAN SODIUM HYPOCHLORITE TERHADAP BAKTERI Streptococcus viridans. *Conservative Dentistry Journal*, *8*(1), 42. https://doi.org/10.20473/cdj.v8i1.2018.42-48

Mahardika, C., Kristanti, Y., & Rinastiti, M. (2022). The Effect Sodium Hypochlorite 2, 5% and Sodium Thiosulphate as Irrigation on the Cleanliness of the Apical Third Root. *Odonto: Dental Journal*, *9*(1), 81–87.

Mahardika, C., Rinastiti, M., Kristanti, Y., Gigi, D. K., Kedokteran, F., Universitas, G., & Mada, G. (2022). The Effect Sodium Hypochlorite 2,5% and Sodium Thiosulphate as Irrigation on the Cleanliness of the Apical Third Root. *ODONTO : Dental Journal*, *9*(1), 81–87.

Maulidiyah, D. D., Lestari, S., Nugroho, R., & Aju, D. W. (2021). Efektivitas Air Perasan Pulpa Kakao 50 % dalam Membersihkan Smear Layer pada Dinding Saluran Akar Gigi. *Jurnal Kedokteran Gigi Universitas Padjadjaran*, *33*(3), 2. https://doi.org/10.24198/jkg.v33i3.34435

Mulyawanti, I., Kailaku, S. I., Syah, A. N. A., & Risfaheri. (2019). Chemical identification of coconut shell liquid smoke. *IOP Conference Series: Earth and Environmental Science*, *309*(1). https://doi.org/10.1088/1755-1315/309/1/012020

Nahla, N., Lestari, E. S., & Hardini, N. (2021). The Effect of Various Concentrations of Liquid Smoke with Time Differences on the Viability of Candida albicans. *Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro)*, *10*(2), 161–165. https://doi.org/10.14710/dmj.v10i2.30112

Nosartika, I., Hardini, N., & Prihatiningsih, T. (2021). In Vitro Antimicrobial Activity of Coconut Shell Liquid Smoke Against Candida albicans and Lactobacillus acidophilus Attributing to Endodontic Treatment Failure. *Diponegoro Medical Journal*, *10*(1), 35–40.

Permatasari, R., & Ekiyo, E. (2023). Potensi Chitosan Sebagai Bahan Irigasi Dalam Pembersihan Smear Layer Saluran Akar. *Andalas Dental Journal*, *11*(2), 61–73. https://doi.org/10.25077/adj.v11i2.231

Purwantisari, S., Sari, D. M. S. P., Risnanda, M. A., Khanifah, N. N., Amatullah, L. H., & Mahardhika, W. A. (2023). Potensi Asap Cair Tempurung Kelapa Sebagai Antijamur Fusarium Foetens, Fusarium Moniliforme, Dan Colletotrichum Capsici. *Jurnal Penelitian Hasil Hutan*, *41*(2), 69–78. https://doi.org/10.55981/jphh.2023.998

Rahmahwati, D., & Cahyani. (2022). Perawatan Saluran Akar Multivisit dengan Teknik Step Back pada Incisivus Lateral (Laporan Kasus). *JIKG (Jurnal Ilmu Kedokteran Gigi)*, *5*(2), 1–6.

Setianingrum, I. D., Suardita, K., Subiyanto, A., & Wahjuningrum, D. A. (2017). Perbedaan Daya Pembersih Kavitas Saponin Ekstrak Kulit Manggis (Garcinia mangostana Linn) 0,78% dan Asam Sitrat 6%. *Conservative Dentistry Journal*, *7*(1), 6–11.

Setiawan, L. N., Li, W., & Citta Kartika, D. (2025). Studi In-Vitro Uji Stabilitas dan Efektivitas Gel Asap Cair Tempurung Kelapa Terhadap Candida Albicans dan Enterococcus Faecalis Pada Saluran Akar Gigi. *COMSERVA : Jurnal Penelitian Dan Pengabdian Masyarakat*, *4*(11), 3884–3894. https://doi.org/10.59141/comserva.v4i11.2978

Swastawati, F., Riyadi, P., Mulyono, M., Nugraheni, A., Muniroh, M., & Hidayati, A. (2022). Effectiveness of Liquid Smoke as a Source of Acetic Acid in Lowering Heavy Metals Levels in Blood Cockle (Anadara granosa). *IOP Conf. Series: Earth and Environmental Science 1036*, 1–10. https://doi.org/10.1088/1755-1315/1036/1/012010

Youssef, A. R., Alturkistani, E., Muharrij, I., Alsrehi, L., Shafei, N., Alzahrani, N., & Alqahtani, M. (2020). Effects of chlorhexidine, ethylenediaminetetraacetic acid, and sodium hypochlorite on cell viability of human gingival fibroblasts in vitro. *Saudi Endodontic Journal*, *10*(3), 234–239. https://doi.org/10.4103/sej.sej_149_19

Zebua, N. F., Yulia, R., & Zulkarnain, N. (2023). Pembuatan Sediaan Gel Anti Acne dari Asap Cair Tempurung Kelapa Berbasis Galaktomanan dengan Bakteri Staphylococcus aureus. *Journal of Pharmaceutical and Health Research*, *4*(3), 371–378. https://doi.org/10.47065/jharma.v4i3.4219