Jurnal Riset Kesehatan, 13 (2), 2024, 160 - 168

DOI: 10.31983/jrk.v13i2.12240

Jurnal Riset Kesehatan

http://ejournal.poltekkes-smg.ac.id/ojs/index.php/jrk

FORMULATION AND STABILITY OF GEL TOOTHPASTE WITH SUNGKAI LEAF (*PERONEMA CANESCENS JACK*) EXTRACT AND NA-CMC GELLING AGENT

Halimatussa'diyah [a*] ; Rini Wahyuni[b] ; Karin Tika Fitria[c]

[a,b] Departement of Pharmacy, Politeknik Kesehatan Kementerian Kesehatan Jambi ; Jl. H. Agus Salim no 23 ; Jambi 36128 ; Indonesia
[c] Departement of Dental Health ; Politeknik Kesehatan Kementerian Kesehatan Jambi ; Jl. H. Agus Salim no 9 ; Jambi 36128 ; Indonesia

Abstract

The Sungkai leaf (*Peronema canescens Jack*), which is rich in alkaloids, flavonoids, tannins, and phenolics, has long been used as a natural immune booster, particularly during the pandemic. With increasing concerns over the health risks of fluoride, such as dental fluorosis and systemic toxicity, the demand for natural alternatives in oral care has risen. This study aimed to formulate and evaluate the physical stability of a gel toothpaste containing Sungkai leaf extract by examining the effects of varying concentrations of Na-CMC (Sodium Carboxymethyl Cellulose) as a gelling agent. Using an experimental one-shot case study design, the physical stability of different concentrations of NaCMC (3%, 4%, 5%, and 6%) was assessed. Stability testing was performed on 5 sample formulations per concentration**.** The tests included organoleptic properties, homogeneity, pH, foam height, and viscosity over four weeks. The results showed that all formulations met the Indonesian National Standard (SNI No.12-3524-1995), with semi-solid consistency, distinctive Sungkai odor, and slightly bitter taste. The average pH ranged from 6.42 to 6.84, the foam heights were stable, and the viscosity increased with higher Na-CMC concentrations, confirming the stability of the formulation. These findings suggest that natural Sungkai leaf-based toothpaste could provide a promising alternative to traditional fluoride-based products, particularly in markets concerned about chemical ingredients in oral care products.

Keywords: *Sungkai Leaf Extract; Toothpaste; Gelling Agent; Na-CMC*

1. Introduction

Oral and dental health are essential components of overall physical health, as they have a direct impact on general wellness (World Health Organization, 2023). Toothpaste, commonly paired with a toothbrush to clean reachable tooth surfaces, includes both active and additional ingredients that serve specific roles. Among these, fluoride and triclosan are frequently found (Nicita et al., 2023)However, fluoride, when used at high concentrations, can result in adverse effects such as fluorosis or weakened enamel(Casaglia et al., 2021; Whelton et al., 2019). Dental fluorosis can cause superficial cavities that promote plaque buildup and lead to tooth decay(García-Escobar et al., 2022). As concerns about these risks grow, there is an increasing demand for natural alternatives in oral care.

Consequently, there is growing interest in using essential oils and herbal extracts as antibacterial ingredients in toothpastes. This approach resonates with the "Back to Nature" movement and the increasing popularity of traditional remedies (Demir et al., 2021; Patel, 2019).

Maintaining oral hygiene by brushing teeth is one of the key factors that can prevent

*) Corresponding Author (Halimatussa'diyah)
E-mail: halimadarnis@poltekkesjambi.ac.id

DOI: 10.31983/jrk.v13i2.12240

oral diseases such as caries and periodontal disease(Rahatina et al., 2023). Toothpaste with anti-plaque and antimicrobial activities is essential to prevent the growth of plaque-forming microorganisms (Alleh & Iyevhobu, 2022; Hwang et al., 2016). The primary microorganism causing cavities is *Streptococcus mutans*, which is found in the early stages of plaque formation. This microorganism can produce acids that can demineralize dental tissue (Qudeimat et al., 2021; Sivapathasundharam & Raghu, 2020).

The addition of herbal ingredients to toothpastes is expected to inhibit plaque formation, which is a significant dental health issue. Furthermore, herbal ingredients are safer owing to their fewer side effects and easy availability of raw materials in Indonesia. The use of herbal ingredients in the form of toothpaste provides a modern and convenient application(Janakiram et al., 2020).

An example of an herbal ingredient is the extract of sungkai leaves, which are abundant in the Jambi region and are known to contain secondary metabolites, such as alkaloids, flavonoids, and tannins. Flavonoids, for example, act as antibacterial agents by forming complexes with extracellular proteins that disrupt the bacterial cell membrane integrity. Similarly, tannins, a group of polyphenols, exhibit antibacterial activity by contracting bacterial cell walls, disrupting cell permeability, and ultimately inhibiting cell growth and causing cell death (Halimatussa'diyah et al., 2024).

Jambi is one of the main producers of sungkai leaves, providing an opportunity to explore the commercial potential of this local plant by developing it into a marketable product for the community. According to Basic Health Research results from 2013, dental and oral health issues among Indonesians reached 25.9%, increasing to 57.6% in 2018 (Kementrian Kesehatan RI, 2018). These data indicate an increasing prevalence of dental problems among Indonesians. The challenges faced by Indonesia relate to poor dental and oral health, which begins in childhood and persists into adolescence and adulthood. More than 70% of the population experience dental caries. This classification highlights the widespread nature of poor oral health in Indonesia, which affects individuals across all age groups. The indicators of this issue are clearly seen in the high prevalence of dental caries, as reported in the 2023 Indonesian Health Survey, with 78.3% of children aged 3-4 years being affected, and a slightly lower but still significant prevalence of 58.3% in individuals over 12 years of age (Kementerian Kesehatan RI, 2023).

Sungkai leaf has long been a part of traditional Indonesian medicine, prized for its natural healing properties, especially in boosting immunity. Traditionally, the Jambi community uses only boiled sungkai leaves to maintain body stamina(Dillasamola et al., 2022). Research has shown that sungkai leaves are also effective as antibacterial agents against *Streptococcus mutans*, the bacterium responsible for dental caries. This effectiveness was confirmed in a previous study, which showed that Sungkai leaf extract toothpaste could inhibit *Streptococcus mutans* at a concentration of 25% Sungkai leaf extract with an inhibition zone of 38.5 mm, which is classified as very strong (Halimatussa'diyah et al., 2024). With the increasing demand for natural and herbal-based health products in Indonesia, driven by consumer concerns over the risks of synthetic chemicals, Sungkai emerges as a culturally relevant and commercially viable ingredient for developing natural toothpaste products.

Sodium Carboxymethyl Cellulose (NaCMC) is a cellulose derivative that serves as a thickener, stabilizer, and viscosity enhancer (Dillasamola et al., 2021). NaCMC helps to create a smooth, gel-like texture in toothpaste, providing the right consistency for easy dispensing and spreading during brushing. It also helps suspend other ingredients, such as abrasives and active components, ensuring that they remain uniformly distributed in the paste. Additionally, NaCMC contributes to the overall stability of the product by preventing the separation of ingredients and maintaining moisture balance, which extends the shelf life of the toothpaste(Sofyan, 2017).

While herbal alternatives to fluoride-based toothpastes are gaining popularity, there is limited research on the specific benefits of Sungkai leaf (*Peronema canescens Jack*) as an ingredient in oral care products. Based on these findings, researchers intend to create toothpastes containing natural antibacterial active ingredients from Sungkai leaf extract. This study aimed to formulate and assess the physical stability of a gel toothpaste containing Sungkai leaf extract (***Peronema canescens Jack***) by evaluating the effects of different concentrations of **Na-CMC** as a gelling agent on the consistency, texture, and stability of the preparation.

DOI: 10.31983/jrk.v13i2.12240

2. Method

The research was conducted experimentally using the one-shot case study design at the Pharmacy Technology Laboratory and the Phytochemistry and Microbiology Laboratory of Poltekkes Kemenkes Jambi, Pharmacy Department. This study has received approval from the Ethics Committee of Poltekkes Kemenkes Jambi. In this study, fresh sungkai (*Paronema canescens Jack*) leaves were dried, ground into powder, and sieved using a mesh 100 sieve. The extraction was conducted using the maceration method with 96% ethanol, chosen for its semi-polar properties, allowing the extraction of both polar and slightly non-polar compounds, such as flavonoids, tannins, and saponins. The mixture was stirred three times daily for five days, then filtered using a flannel cloth. The filtrate was concentrated using a rotary vacuum evaporator at 60°C and then thickened in a water bath.

Chemical tests revealed that the extract contained tannins, flavonoids, and saponins. Tannins were confirmed by a dark green color after adding FeCl3, whereas flavonoids were indicated by an orange color after adding magnesium and HCl, suggesting the presence of flavanone-type flavonoids. Finally, the herbal toothpaste was prepared by combining the extract with a gel base made from Na CMC, TEA (Triethanolamine), Nipagin, Tween 80, glycerin, and Aquadest. The formulation of the Sungkai Leaf Extract (*Peronema canescens Jack*) toothpaste is presented in Table 1. Variations in Na-CMC concentration (3%, 4%, 5%, and 6%) were tested, along with formulation and physical stability tests, including organoleptic, homogeneity, pH, foam height, and viscosity tests.

Table 1. Formulation of the Sungkai Leaf Extract (*Peronema canescens Jack*) Toothpaste

Ingredient	function	Formulation			
		F1(%)	F2(%)	F3(%)	F4(%)
Sungkai Leaf Extract	Active Ingredient	15	15	15	15
Na-CMC	Paste Base	3	4	5	6
Tween 80	Co-Solvent	1	1	1	1
Glycerin	Sweetener	1	1	1	1
Nipagin	Preservative	1	1	1	1
TEA	Stabilizer	1	1	1	1
Aqua ad	Solvent	100	100	100	100

Organoleptic Evaluation

This evaluation includes a visual examination of the color, texture, and smell of each toothpaste formula stored at room temperature(Oluwasina et al., 2023).

Homogeneity

A small amount of toothpaste from each formula was applied to a glass slide and covered with cover glass. The samples were then observed for the presence of coarse particles or any signs of inhomogeneity, which were recorded. A well-homogenized formulation should exhibit no air bubbles, clumps, separated particles, or visible foreign matter. This test was conducted over four weeks(Nurjannah et al., 2018).

pH Test

The pH test was performed by dipping the electrode of a pH meter into each formula, waiting for the pH meter display to stabilize. This test was conducted over a four-week period(Berto et al., 2019).

Viscosity and Flow Properties Test

Viscosity tests were performed using a Brookfield viscometer. The formulation was placed in a 250 mL beaker and the spindle was lowered into the preparation to a set limit(Kornaeva et al., 2023).

DOI: 10.31983/jrk.v13i2.12240

Foam Height Test

For this test, 1 g of the gel toothpaste containing Sungkai leaf extract was placed in a 50 mL measuring cylinder and dissolved in 10 mL of distilled water. The measuring cylinder was then capped and shaken five times, after which the height of the foam formed was observed(Wahidin et al., 2021).

3. Result and Discussion

Based on the conducted research, the drying loss of Sungkai leaf simplicia involved drying 3000 g of Sungkai leaves to 450 g, resulting in a 15% yield. The extract yield obtained from 450 g of simplicia powder was 105 ml, equivalent to 23.3%. Identification of Secondary metabolite of the extract is shown in table 2. Sungkai (Paronema canescens Jack) is a wild plant that does not require special care and is commonly found in forests, gardens, and yards. Sungkai are classified as a woody plant type with a diameter of 60 cm and can grow to a height of 20-30 cm.

Table 2. Identification of Secondary metabolite of the extract

Variable	Reagent	Result	Picture
Phenol	$FeCl_3$	(+) black	
Terpenoid	vanillin + H_2SO_4 (p)	(+) greenish black	
Alcaloids	dragendorf	(+) dark terracotta	
	bourchardat	(+) brown	
Saponin	Hot water (shake vertically)	(+)Stable foam formed and lasted for 5 minutes	
Flavonoid	Magnesium powder + HCl (heat), after cooling, add 5 drops of amyl alcohol	(+) a red color formed, extending to the middle layer	

DOI: 10.31983/jrk.v13i2.12240

Variable	Reagent	Result	Picture
Tanin	$FeCl_3$	(+) greenish black	

The trunk of the sungkai is gray or brownish with small grooves, shallow ridges, and small, thin flakes. It has pinnate compound leaves that are odd numbered and paired with pointed leaf tips. The flowers are arranged in panicles and the fruit is small. Its shallow roots could not withstand a lack of oxygen for more than ten days. Sungkai belongs to the Verbenaceae family and is traditionally used as a remedy for colds, as a dewormer, for toothache prevention, as a mixture in bathwater for women who have just given birth, and as a fever reducer(Fareez et al., 2020; Maigoda et al., 2022).

Table 3. Result of Organoleptic test

Organoleptic	Formulation	Week of Observation			
		I	II	III	IV
Stucture	F1	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)
	F2	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)
	F3	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)
	F4	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)	Semi Solid (gel)
Colour	F1	Deep moss green	Deep moss green	Deep moss green	Deep moss green
	F2	Less deep moss green	Less deep moss green	Less deep moss green	Less deep moss green
	F3	Less deep moss green	Less deep moss green	Less deep moss green	Less deep moss green
	F4	Moss green	Moss green	Moss green	Moss green
Aroma	F1	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf
	F2	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf
	F3	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf
	F4	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf	typical sungkai leaf
Taste	F1	bitter	Less bitter	Less bitter	Less bitter
	F2	bitter	Less bitter	Less bitter	Less bitter
	F3	bitter	Less bitter	Less bitter	Less bitter
	F4	bitter	Less bitter	Less bitter	Less bitter

Sungkai leaves contain several secondary metabolites such as alkaloids, flavonoids, and tannins. The flavonoid group acts as an antibacterial agent by forming complex compounds with extracellular proteins, which disrupt the integrity of bacterial cell membranes. Tannins are part of the polyphenol group with antibacterial activity; their mechanism of action involves contracting the bacterial cell wall and disrupting cell permeability, which inhibits growth and leads to cell death. Alkaloids also exhibit antibacterial properties(Dillasamola et al., 2021; Helina & Ahmad Roni, 2021).

The results of the organoleptic test in Table 3 showed that the aroma of all three formulas had a distinct scent in the sungkai leaf extract. There were differences in the color of the preparations, with Formula 1 (F1) having a deep moss green color, Formula 2 (F2) a slightly lighter moss green, and Formulas 3 (F3) and 4 (F4) regular moss green. The consistency of gel toothpaste increased from F1 to F4. The taste of all formulas was slightly bitter, with the characteristic smell of the sungkai leaf extract. Based on these results, improvements are needed in the taste of toothpaste, as most children prefer toothpaste with a sweet, fruity, minty flavor, white or red color, and a pleasant fragrance (Choudhari et al., 2020).

Table 4. Result of the pH test

Week	Formulation	pH			Parameter
		P1	P2	P3	
1	F1	6.80	6.81	6.83	SNI No.12-3524-1995 (4,5 – 10,5)
	F2	6.64	6.65	6.63	
	F3	6.57	6.56	6.54	
	F4	6.37	6.35	6.36	
2	F1	6.84	6.85	6.86	
	F2	6.67	6.68	6.66	
	F3	6.53	6.52	6.51	
	F4	6.41	6.40	6.38	
3	F1	6.82	6.88	6.87	
	F2	6.59	6.58	6.57	
	F3	6.47	6.46	6.45	
	F4	6.43	6.47	6.46	
4	F1	6.82	6.83	6.84	
	F2	6.61	6.62	6.60	
	F3	6.50	6.48	6.48	
	F4	6.47	6.46	6.42	

The results of the four formulas over four weeks were homogeneous, with no visible air bubbles, lumps, or separated particles (SNI-12-3524-1995). This indicated that the ingredients in the formula were evenly mixed, and no significant phase separation occurred. The use of TEA as a stabilizer functioned effectively, ensuring that the preparation remained homogeneous and stable throughout the study period(Aisyah, 2021).

The pH of the toothpaste shown in Table 4 obtained fell within the range set by SNI (12-3524-1995), where the pH standard for toothpaste is 4.5-10.5. The pH value of Formula 2 (F2) was lower than that of Formula 1 (F1), likely due to the addition of Sodium Carboxymethyl Cellulose (Na-CMC), which has a pH range of 6.0-8.5 and is stable between pH 2-10, and is water-soluble (Ismail et al., 2010). The different concentrations of Na-CMC used in the toothpaste formulations affected the pH of each formula. Additionally, the Sungkai leaf extract, which is the main ingredient in this gel toothpaste, has a pH of 4-5.2, indicating its acidic nature. The pH decreased in formulas F3 and F4, as shown by the average pH measurements: F1 = 6.84, F2 = 6.63, F3 = 6.51, and F4 = 6.42. The pH of this toothpaste is still considered safe because the critical pH threshold for the occurrence of demineralization and caries is less than 5.5 (Kidd, 2015).

Table 5. Result of the viscosity test

Week	Formulation	Viscosity (centipoise)	Parameter
1	F1	25.980	SNI viscosity standard for toothpaste No.12-3524-1995 (20.000-50.000 cPs)
	F2	26.980	
	F3	27.880	
	F4	28.800	
2	F1	25.680	
	F2	26.780	
	F3	27.800	
	F4	28.680	
3	F1	25.560	
	F2	26.500	
	F3	27.660	
	F4	28.680	
4	F1	25.560	
	F2	26.500	
	F3	27.500	
	F4	28.600	

The Sungkai leaf extract toothpaste formulas all met the standard viscosity values. The average viscosity for Formula 1 (F1) was 25,705 cps, for Formula 2 (F2) 26,690 cps, for Formula 3 (F3) 27,710 cps, and for Formula 4 (F4) 28,690 cps, showing an increase in viscosity across the formulas. According to SNI 12-3524-1995, the standard viscosity value for toothpaste is 20,000-50,000 cps, indicating that all formulas fall within an acceptable range, as can be seen in Table 5

Table 6. Foam Height Test

Formulation	Foam Height (cm)			Parameter
	P1	P2	P3	
F1	6.80	6.81	6.83	No standard of foam height in toothpaste
F2	6.64	6.65	6.63	
F3	6.57	6.56	6.54	
F4	6.37	6.35	6.36	

The foam height produced by the four formulas in Table 6, ranged from 1.5 cm to 2.4 cm. Foam height measurements indicated the presence of a detergent to generate the foam. There is no specific foam height requirement for toothpaste products, as they are primarily associated with consumer preferences for aesthetic reasons. The higher the viscosity, the more difficult it is for surfactants to be released from the compound. The addition of triethanolamine (TEA) in the formulation serves as an alkalizing agent proportional to carbomer 940, which is used to increase the viscosity of the toothpaste. As the toothpaste viscosity increases, it becomes more difficult for water to penetrate and interact with the foaming agent, resulting in a lower foam height(Aisyah, 2021).

Foams provide a sensory experience that many consumers associate with cleanliness. It makes brushing more enjoyable, especially for children, and gives the feeling that toothpaste is spreading effectively throughout the mouth. Foams assist in loosening food particles and plaque from the teeth and gums, making them easier to remove during brushing(Achmad & Hartono, 2016; Maharani & Hersoelistyorini, 2009; Yi & Xu, 2022).

4. Conclusion and Suggestion

Based on the results of this study, it can be concluded that all four formulas meet the physical quality requirements for toothpaste (organoleptic test, homogeneity, pH, foam height, and viscosity). This formulation can be developed into a herbal toothpaste product suitable for public use.

5. References

Achmad, H., & Hartono, R. (2016). Studies of toothpaste detergent and non detergent composition to growth of plaque and saliva secretion: The study was conducted to students of Inpres …. *Int J Sci Res*.

Aisyah, Y. (2021). Formulation Of Hand Antiseptic Gel from Betel Leaf (Piper Betle L.) Extract with the Addition of Triethanolamine (TEA) Stabilizer. *JFP Jurnal Ilmiah Mahasiswa Pertanian*, *6*(4).

Alleh, A. O., & Iyevhobu, K. O. (2022). Effect of Toothpaste on Oral Microbial Flora. *International Journal of Research Publications*, *100*(1). https://doi.org/10.47119/ijrp1001001520223115

Berto, L. A., Lauener, A., Carvalho, T. S., Lussi, A., & Eick, S. (2019). In Vitro Effects of Arginine-Containing Toothpastes on Cariogenic Biofilms. *Oral Health & Preventive Dentistry*. https://doi.org/10.3290/j.ohpd.a42684

Casaglia, A., Cassini, M. A., Condò, R., Iaculli, F., & Cerroni, L. (2021). Dietary fluoride intake by children: When to use a fluoride toothpaste? *International Journal of Environmental Research and Public Health*, *18*(11). https://doi.org/10.3390/ijerph18115791

Choudhari, S., Gurunathan, D., & Kanthaswamy, A. (2020). Children's perspective on color, smell and flavor of toothpaste. In *Indian Journal of Dental Research* (Vol. 31, Issue 3). https://doi.org/10.4103/ijdr.IJDR_363_18

Demir, S., Keskin, G., Akal, N., & Zer, Y. (2021). Antimicrobial effect of natural kinds of toothpaste on oral pathogenic bacteria. *Journal of Infection in Developing Countries*, *15*(10). https://doi.org/10.3855/jidc.14966

Dillasamola, D., Aldi, Y., Wahyuni, F. S., Rita, R. S., Dachriyanus, Umar, S., & Rivai, H. (2021). Study of Sungkai (Peronema canescens, Jack) leaf extract activity as an immunostimulators with in vivo and

DOI: 10.31983/jrk.v13i2.12240

in vitro methods. *Pharmacognosy Journal*, *13*(6), 1397–1407. https://doi.org/10.5530/PJ.2021.13.177

Dillasamola, D., Syofyan, Almahdy, Rachmaini, F., Yultri, M., Larisa, H., Gustia, E., Diliarosta, S., & Oktomalioputri, B. (2022). Immunostimulant Effect of Peronema canescens. Jack Leaves Extract and Propolis in Male White Mice. *Proceedings of the 2nd International Conference on Contemporary Science and Clinical Pharmacy 2021 (ICCSCP 2021)*, *40*(Iccscp), 62–67. https://doi.org/10.2991/ahsr.k.211105.038

Fareez, K., Halim, K., Jalani, K. J., Fadzillah Mohsin, H., & Wahab, I. A. (2020). Original Research Article Phytochemical Screening of Peronema Canescens Jack. *International Journal of Pharmaceuticals, Nutraceuticals and Cosmetic Science*, *1*, 7–15. https://doi.org/10.24191/IJPNaCS.v1.02

García-Escobar, T. M., Valdivia-Gandur, I., Astudillo-Rozas, W., Aceituno-Antezana, O., Yamadala, B., Lozano de Luaces, V., Chimenos-Küstner, E., & Manzanares-Céspedes, M. C. (2022). Moderate and Severe Dental Fluorosis in the Rural Population of Anantapur, India: Change in Their Biological Susceptibility? *International Journal of Environmental Research and Public Health*, *19*(18). https://doi.org/10.3390/ijerph191811293

Halimatussa'diyah, H., Wahyuni, R., & Fitria, K. T. (2024). Formulation of Gel Toothpaste With Sungkai Leaf Extract (Peronema Canescens Jack) Against The Antibacterial Activity of Streptococcus Mutans. *JDHT Journal of Dental Hygiene and Therapy*, *5*(1), 87–91. https://doi.org/10.36082/jdht.v5i1.1551

Helina, M., & Ahmad Roni, K. (2021). Sungkai Leaf Extract (Peronema Canescens Jack) As Antibacterial Agent in Wound Dressing. *Turkish Online Journal of Qualitative Inquiry (TOJQI)*, *12*(9), 3975–3981.

Hwang, D. G., Na, S. R., Cho, H. J., Kim, S. J., Kim, H. E., & ... (2016). Toothpaste development trend analysis-composition. *Korean J Oral Maxillofac ….*

Janakiram, C., Venkitachalam, R., Fontelo, P., Iafolla, T. J., & Dye, B. A. (2020). Effectiveness of herbal oral care products in reducing dental plaque & gingivitis - a systematic review and meta-analysis. *BMC Complementary Medicine and Therapies*, *20*(1), 43. https://doi.org/10.1186/S12906-020-2812-1

Kementerian Kesehatan RI. (2023). *Laporan Tematik Survei kesehatan Indonesia (SKI) Tahun 2023*.

Kementrian Kesehatan RI. (2018). Laporan Riskesdas 2018 Nasional. In *Kementerian Kesehatan Republik Indonesia* (pp. 146–379).

Kidd, E. A. (2015). *Essentials of Dental Caries* (3rd ed.). Oxford University Press.

Kornaeva, E. P., Stebakov, I. N., Kornaev, A. V., Dremin, V. V., Popov, S. G., & Vinokurov, A. Y. (2023). A method to measure non-Newtonian fluids viscosity using inertial viscometer with a computer vision system. *International Journal of Mechanical Sciences*, *242*. https://doi.org/10.1016/j.ijmecsci.2022.107967

Maharani, E. T., & Hersoelistyorini, W. (2009). Analisis kadar detergent anionik pada sediaan pasta gigi anak-anak. *Jurnal Kesehatan Universitas Muhammadiyah Semarang*, *2*(2).

Maigoda, T., Judiono, J., Purkon, D. B., Haerussana, A. N. E. M., & Mulyo, G. P. E. (2022). Evaluation of Peronema canescens Leaves Extract: Fourier Transform Infrared Analysis, Total Phenolic and Flavonoid Content, Antioxidant Capacity, and Radical Scavenger Activity. *Open Access Macedonian Journal of Medical Sciences*, *10*(A), 117–124. https://doi.org/10.3889/oamjms.2022.8221

Nicita, F., D'Amico, C., Minervini, G., Cervino, G., & Fiorillo, L. (2023). Toothpaste Consumption: Implications for Health and Sustainability in Oral Care. *European Journal of General Dentistry*, *12*(3), 183–188. https://doi.org/10.1055/s-0043-1776320

Nurjannah, W., Yusriadi, & Nugrahani, A. W. (2018). Uji Aktivitas Antibakteri Formula Pasta Gigi Ekstrak Batang Karui (Harrisonia Perforata Merr .) Terhadap Bakteri Streptococcus Mutans. *Uji Aktivitas Antibakterial Formula Pasta Gigi Ekstrak Batang Karui*, *12*(2).

Oluwasina, O. O., Idris, S. O., Ogidi, C. O., & Igbe, F. O. (2023). Production of herbal toothpaste: Physical, organoleptic, phyto-compound, and antimicrobial properties. *Heliyon*, *9*(3). https://doi.org/10.1016/j.heliyon.2023.e13892

Patel, K. (2019). "Natural" Toothpaste. *British Dental Journal*, *226*(12), 911–912. https://doi.org/10.1038/s41415-019-0478-1

Qudeimat, M. A., Alyahya, A., Karched, M., Behbehani, J., & Salako, N. O. (2021). Dental plaque microbiota profiles of children with caries-free and caries-active dentition. *Journal of Dentistry*, *104*(November 2020), 103539. https://doi.org/10.1016/j.jdent.2020.103539

Rahatina, V. E. F., Hadisaputro, S., & Setyawan S, H. (2023). Risk Factors for Dental Caries in Elementary School Children Aged 6-12 in Indonesia (Systematic Literatur Review). *Jurnal Riset Kesehatan*, *12*(2), 130–142. https://doi.org/10.31983/jrk.v12i2.9988

DOI: 10.31983/jrk.v13i2.12240

Sivapathasundharam, B., & Raghu, A. R. (2020). Dental caries. *Shafer's Textbook of Oral …*. https://books.google.com/books?hl=en%5C&lr=%5C&id=xbzyDwAAQBAJ%5C&oi=fnd%5C&pg=PA369%5C&dq=caries%5C&ots=7vYmNe5-RC%5C&sig=Nl9vvoXOw-eRwIC-SMhOgreO4Z0

Sofyan, V. (2017). *Penggunaan Na-CMC (gelling agent) dalam Sediaan Pasta Gigi Ekstrak Kayu Siwak (Salvadora persica) dan Ekstrak Daun Sirih Merah (Piper crocatum)*. http://repository.ump.ac.id/4772/

Wahidin, Farid, A. M., & Firmansyah. (2021). Formulasi dan Uji Stabilitas Pasta Gigi Cangkang Telur Ayam Ras (Gallus sp) Dengan Variasi Konsentrasi Na.CMC. *Fito Medicine: Journal Pharmacy and Sciences*, *12*(2).

Whelton, H. P., Spencer, A. J., Do, L. G., & ... (2019). Fluoride revolution and dental caries: evolution of policies for global use. *Journal of Dental …*. https://doi.org/10.1177/0022034519843495

World Health Organization. (2023). Global oral report Towards universal health coverage for oral health by 2030 Regional summary of the Western Pacific Region. In *World Health Organization*. https://iris.who.int/bitstream/handle/10665/364538/9789240061484-eng.pdf?sequence=1

Yi, R., & Xu, C. (2022). Experimental study on dense foam toothpaste. *China Surfactant Detergent and Cosmetics*, *52*(11). https://doi.org/10.3969/j.issn.1001-1803.2022.11.010