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Virgin Coconut Oil as a Biomaterial of Choice in Periodontitis Therapy Through PDGF Expression

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Abstract

Objective: Coconut is a natural commodity produced in large quantities in Indonesia. Utilizing coconut to produce Virgin Coconut Oil (VCO) offers a potential alternative biomaterial that can be safely and widely used as a substitute for chemical treatments in managing periodontitis. Platelet-derived growth factor (PDGF) is one of the most extensively studied growth factors in periodontics and plays a crucial role in promoting the regeneration of bone, cementum, and periodontal ligaments. This study aims to evaluate the effect of VCO gel on periodontal regeneration in periodontitis by analyzing PDGF expression as a key tissue healing growth factor. **Methods**: This research is an experimental laboratory study using a post-test only control group design. The primary ingredient, virgin coconut oil, is derived from processing coconut into oil and further refined to achieve a gel consistency. *Porphyromonas gingivalis* bacteria were induced into the gingival soft tissue of Wistar rats. The sample group was divided into three groups based on the type of treatment administered. Observations were conducted on days 7 and 21, followed by immunohistochemical examination of tissue preparations to observe PDGF expression in Wistar rat tissues. **Results**: The study showed an increase in PDGF expression in the sample group. The elevated PDGF levels indicate the effectiveness of VCO gel in promoting the healing of periodontitis, as demonstrated by the expression of tissue healing markers associated with growth factors that emerge when the gel is applied. **Conclusion**: Virgin coconut oil gel can be considered an alternative treatment for bacteria- induced periodontitis due to its positive effect on tissue healing markers, making it a widely applicable option.

Keywords: Virgin Coconut Oil, PDGF, Periodontitis.

Introduction

Periodontitis is a chronic inflammatory disease triggered by various factors, especially due to the accumulation of dental plaque or biofilm. This disease is characterized by gradual damage to the supporting tissues of the teeth, such as the periodontal ligament and alveolar bone. The occurrence of periodontitis involves a complex interaction between specific pathogenic bacteria, the body's immune response, and environmental factors. In Indonesia, periodontal disease ranks second after caries with a prevalence of 96.58%. Several studies have shown that dental and oral problems, including periodontitis, reach 23.5%, and in the 25-34 age group, 47.40% of individuals have calculus. Overall, the prevalence of periodontal disease

in Indonesia in all age groups reaches 96.58%. (Kwon, Lamster and Levin, 2021)(Rohmawati and Santik, 2019)

Data from the National Health and Nutrition Survey in the United States in 2009-2014 revealed that periodontitis affects about 42% of adults, and 7.8% of them suffer from chronic conditions. This fact shows that almost half of adults in the US (aged 30 years and above) still have to struggle with this problem. At the global level, an estimated 11% of the world's population suffers from severe periodontitis, affecting 743 million people. In addition to the need for more intensive prevention promotion, biomaterial-based therapeutic approaches also need to be evaluated in depth. (Kwon, Lamster and Levin, 2021)

The main cause of periodontal disease is bacteria that can damage the supporting tissues of the teeth directly or indirectly. Most cases of periodontitis can be treated by cleaning the bacterial mass and calculus in the subgingival environment through scaling and root planing procedures. P. gingivalis is one of 700 species of bacteria in the oral cavity which is a Gram-negative, anaerobic, and rod-shaped bacteria. P. gingivalis plays a role in the formation of chronic periodontitis by damaging the commensal bacterial community, thereby worsening the condition of dysbiosis. Several studies have shown that P. gingivalis is able to survive in organs other than the oral cavity. (Shaddox and Walker, 2010)(Mei *et al.*, 2020)

Periodontitis in the supporting tissues of the teeth is characterized by infiltration of inflammatory cells caused by toxic products from bacteria that damage the epithelial structure and periodontal tissues. These toxic products come from the periodontopathogenic bacteria P. gingivalis. Regeneration of periodontal structures lost due to periodontal disease is a complex biological process regulated by interactions between cells and growth factors. Neovascularization is needed to provide nutrients to the wound area and help maintain granulation tissue. Activated platelets at the wound edge release growth factors such as PDGF, TGF-α, and EGF. (Harefa *et al.*, 2022)(Sehar *et al.*, 2020)

Platelet-Derived Growth Factor (PDGF) is a growth factor that has been widely studied in clinical periodontics for local soft tissue and bone damage, first discovered to play a role in the regeneration of bone, cementum, and periodontal ligament. Various in vitro and in vivo studies have shown that PDGF is a very effective chemotactic and mitogenic factor for gingival and periodontal ligament fibroblasts, cementoblasts, and osteoblasts. (Nevins *et al.*, 2013)(Kaigler *et al.*, 2011)

Biological materials that have the potential as alternative therapies to control disease processes and damage due to chronic inflammatory pathology are still in the research stage. Virgin Coconut Oil (VCO) contains medium chain fatty acids that are easily digested and

oxidized by the body, so they do not cause fat accumulation. VCO also has a very high antioxidant content, such as tocopherol and beta-carotene, which play an important role in preventing premature aging and maintaining body vitality. The main components of VCO consist of about 90% saturated fatty acids and 10% unsaturated fatty acids, with lauric acid dominating the saturated fatty acids. VCO contains about 53% lauric acid and 7% capric acid, both of which are medium chain fatty acids known as Medium Chain Fatty Acid (MCFA). VCO is different from ordinary coconut oil because it contains more biologically active components such as vitamins and polyphenols. (Harefa *et al.*, 2022)(Garzón *et al.*, 2022)(Hayatullina *et al.*, 2012)

Based on this background, the researcher intends to identify the effectiveness of Virgin Coconut Oil (VCO) on the expression of Platelet-Derived Growth Factor (PDGF) as one of the growth factors involved in the regeneration process.

Methods

This study is a laboratory experimental study with a post-test only control group research design. The study began with the manufacture of VCO preparations at the Biology Laboratory of Makassar State University. Experimental research on experimental animals was conducted at the Docpet Makassar Animal Clinic. All stages of this study refer to the ethics published by the Health Research Ethics Commission of the Hasanuddin University Dental and Oral Hospital with No. 0141 / PL.09 / KEPK FKG-RSGM UNHAS / 2023. Virgin Coconut Oil is made from pure coconut processed using conventional methods without heating and additional chemicals to form pure coconut oil. The next stage is the manufacture of VCO Gel using 1% NaCMC , 300 ml of distilled water, and other ingredients that are mixed until homogeneous using a homogenizer. The research subjects used were Rattus Norvegicus rats or Wistar rats that had previously been adapted until ready to be treated. The inclusion criteria for subjects included a body weight of 200-250 grams of experimental animals, an age of around 6-8 months, male gender, and normal behavior and activity. The exclusion criteria were if there was a 10% weight loss after the adaptation period.

Wistar rats were induced using periodontopathogenic bacteria P. gingivalis and silk ligatures were inserted to modulate the occurrence of periodontitis in the anterior area of the lower jaw. Wistar rats were divided into three groups that were given different treatments. Each group was given Scaling and Root Planing (SRP) therapy, but in group two VCO gel was applied, and in group three metronidazole gel was applied. Group one as a negative control was only given SRP. On the 7th and 21st days, tissue sacrification and bone density examination

were performed on Wistar samples. Each sample underwent a two-dimensional radiographic examination to compare bone density at the two observation times. Tissue sacrification was performed after each Wistar rat was euthanized to facilitate tissue sampling.

Each tissue was then formed into a slide preparation to be examined through Immunohistochemistry to read PDGF expression. The data obtained were then tested for normality using the Kolmogorov-Smirnov Test and tested for homogeneity using the Levene Test. Differences in PDGF expression in each group were analyzed using the One-Way Anova Test.

Results

The research design used was a post-test only control group. In the initial stage of the study, the process of making VCO from fresh coconuts was carried out which were previously processed into pure coconut oil or Virgin Coconut Oil, this stage was carried out in the Biology Laboratory of the Faculty of Mathematics and Natural Sciences, Hasanuddin University. After obtaining VCO, the next stage was the stage of making VCO Gel by mixing ingredients that were able to change the consistency of the oil into a gel form at a measured VCO concentration.

The experimental animals that had been prepared were then kept and adapted at the Makassar Docpet Animal Clinic, the selection of experimental animals followed the inclusion and exclusion criteria that had been determined at the beginning of the study. After all sample criteria were met, p.gingivalis bacteria were then induced in experimental animals to induce periodontitis. Periodontitis was then observed on the seventh day after induction in experimental animals by observing the clinical condition of the rat's gingiva. Symptoms of periodontitis that appear are reddish gums, increased pocket depth, and swelling of the gums.

Treatment is given to each sample group according to the type of intervention. Action intervention is given once every three days. Until the 7th and 21st days all samples are sacrified. The sacrified tissue is then stored in a pot containing formalin and then labeled with a marker based on the sample group.

Table I. Comparison of PDGF expression in each sample group.

Sample Group	**PDGF**		**P Value**
	Mean	SD	
SRP	4.80	1.62	0.000
SRP + Gel VCO	9.90	2.42	
SRP + Gel Metronidazole	7.50	1.58	

Anova Test ; * p< 0.005 = significant

Table 2. Comparison Table of PDGF Expression at monitoring time on Day-7 and Day-21

Marker	Monitoring Time			
	Day 7		Day 21	
	Mean	SD	Mean	SD
PDGF	6.27	2.37	8.53	2.83
P value	0.024		0.001*	

T Independen test ; *p<0.005

Table 3. Comparison of PDGF expression at monitoring time on day 7 and day 21 in each sample group.

Sample Group	Monitoring Time				P Value
	Day 7		Day 21		
	Mean	SD	Mean	SD	
SRP	3.80	1.30	5.80	1.30	0.042
SRP + Gel VCO	8.40	1.82	11.40	2.07	0.041
SRP + Gel Metroni-dazole	6.60	1.14	8.40	1.52	0.067

T Indepent Test : * p< 0.005 = significant

In table 1 the results of statistical examination show a comparison table of PDGF expression between the three research groups, from the statistical results showing a comparison of PDGF expression statistically significant in all sample groups with a p value <0.005. In the statistical analysis of the comparison of PDGF expression in the three research groups, the p value was obtained at 0.0000 which indicates a significant value.

The study was conducted in two observation periods, namely 7 and 21 days. Comparison of PDGF expression values observed at two monitoring times showed that PDGF expression on the 7th day obtained an average PDGF value of 6.27 with a p value = 0.024, while monitoring PDGF expression on the 21st day obtained a PDGF value of 8.53 with a p value =

0.001. Statistically, Table 2 shows that PDGF on the 7th day is not significant because the p value> 0.005. On the 21st day showed a statistically significant PDGF expression with a p value = 0.0001.

Table 4. Advanced Test Table Comparison of PDGF expression at the 7th day of monitoring with the LSD Post Hoct Test.

Group Sample	PDGF		
	SRP	SRP + Gel VCO	SRP + Gel Metronidazole
SRP		0.000	0.010
SRP + Gel VCO			0.073
SRP + Gel Metronida-zole			

*LSD Test

Table 3 shows a comparison of PDGF expression at the 7th and 21st day of monitoring in each sample group, this table shows the average value of PDGF expression in each group until at different monitoring times. In the negative control group that was only given SRP, the average value of PDGF expression on the 7th day was 3.80 and the average value of PDGF expression on the 21st day in the negative control group was 5.80 with a p value = 0.042, meaning that the comparison of PDGF expression on the 7th day and the 21st day in the negative control group was statistically significant.

The positive control group is a sample group that was given SRP + Metronidazole gel, from table 3 it can be seen that the PDGF expression in this group on the 7th day of monitoring had an average value of 6.60 while on the 21st day the average value was 8.40, with a p value = 0.067, p value> 0.05, so that the PDGF expression in this group at the two monitoring times did not show a statistically significant number.

The treatment group is a group that received SRP + Gel VCO treatment, table 3 shows the average value of PDGF expression on the 7th day in this group, which is 8.40, while on the 21st day the average value of PDGF expression is 11.40 with a p value = 0.041 which means PDGF expression in the treatment group at two monitoring times is statistically significant.

Table 4 also shows the highest PDGF expression obtained in the sample group that received SRP + Gel VCO treatment, compared to other sample groups and the comparison value of PDGF expression also shows a statistically significant value.

Table 5. Advanced Test Table Comparison of PDGF and IGF expression at the 21st day of monitoring with the LSD Post Hoct Test.

Kelompok Sampel	**PDGF**		
	SRP	SRP + Gel VCO	SRP + Gel Metronidazole
SRP		0.000	0.029
SRP + Gel VCO			0.015
SRP + Gel Metronidazole			

*LSD Test

Table 4 shows a comparison of PDGF expression on day 7 using the LSD Post Hoc Test where this statistical test is a follow-up test used to compare two treatment groups. Table 4 shows a significant comparison of PDGF expression between the treatment group and the negative control group and the positive control group compared to the negative control group and the treatment group.

Similar to table 4, table 5 also uses the Post Hoc LSD follow-up test to compare PDGF expression in two sample groups on the 21st day of observation. From table 5, it was found that PDGF expression between the treatment group and the negative control group was statistically significant, as well as between the positive control group and the negative control group and the negative control group and the treatment group.

The results of the statistical analysis in several tables above are then entered into a bar chart. Figure 1 shows a bar chart comparing PDGF expression in the three sample groups. From the picture, it can be seen that the highest PDGF expression value was obtained in the treatment group (SRP + VCO) both at the observation time of day 7 and day 21. Figure 2 shows a bar chart comparing PDGF expression in three sample groups. From figure 2, it is the same as figure 1, the highest PDGF expression was found in the treatment group and the lowest was found in the sample group that only received SRP.

Figure 1. Bar diagram of PDGF expression in three treatment groups.

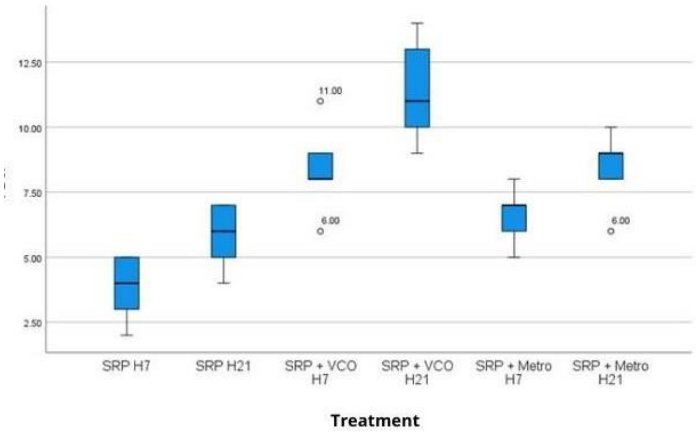
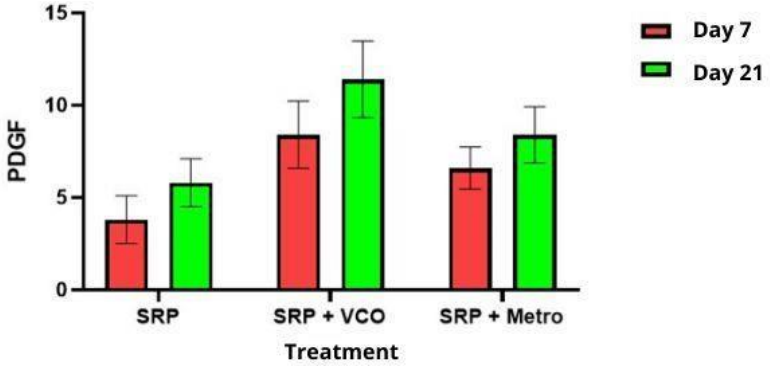


Figure 2. Bar chart of PDGF expression in three treatment groups



The tissue was then processed to make a preparation in the Anatomical Pathology Laboratory of the Unhas Teaching Hospital. After that, PDGF expression examination was carried out through Immunohistochemistry examination in the Biomolecular Biochemistry Laboratory, Faculty of Medicine, Brawijaya University. The PDGF expression image from the results of the Immunohistochemistry examination can be seen in Figure 3 dan 4.

The Immunohistochemistry examination carried out by the Biomolecular Biochemistry Laboratory, Faculty of Medicine, Brawijaya University obtained the results of the PDGF expression analysis reading and then continued with Biostatistical Analysis

Figure 3. Immunohistochemical examination results of PDGF expression in the three experimental groups on day 7. A. Immunohistochemical image of the negative control group, B. Treatment group, and C. Positive control group.

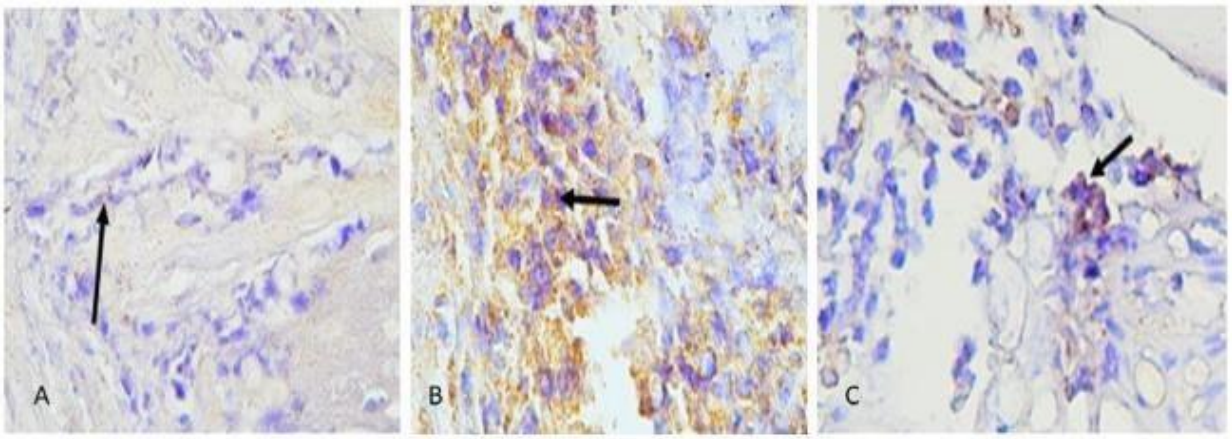
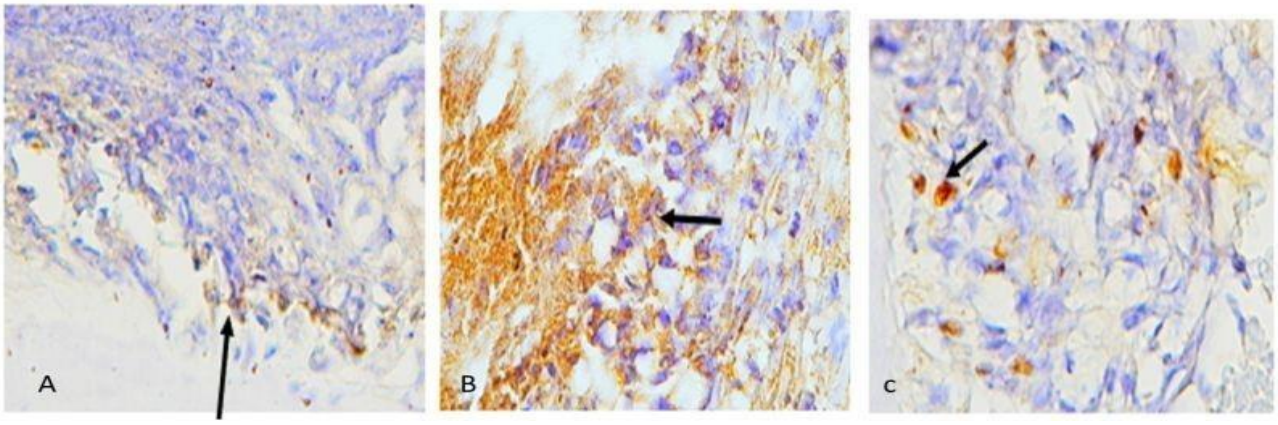


Figure 4. Immunohistochemical examination results of PDGF expression in the three experimental groups on day 21. A. Immunohistochemical image of the negative control group, B. Treatment group, and C. Positive control group.



Discussions

The periodontium consists of four main components: gingiva, periodontal ligament, cementum, and alveolar bone Optimal periodontal function is achieved through structural integrity and the interaction between its components. Periodontal disease involves a complex dynamic interaction between specific pathogenic bacteria, individual susceptibility, and risk factors. Epidemiological surveys have shown that more than 50% of the adult population worldwide suffers from periodontal disease. In addition, the incidence of periodontal disease

increases with age, with the prevalence rate increasing significantly over the previous period in the 10-year period from 2005 to 2015. In recent years, periodontitis has also been shown to be closely associated with systemic diseases. (Fiorellini *et al.*, 2020)(Nanci and DD Bosshardt -, 2006)(Kwon, Lamster and Levin, 2021)(Liu *et al.*, 2019)(Xiong *et al.*, 2023)

The success of periodontal treatment depends on the ability to recognize, identify, and eliminate key factors that are determinants of effective prophylaxis. Gingivitis precedes periodontitis, but not all cases of gingivitis progress to periodontitis. In gingivitis, the inflammatory lesion is limited to the gingiva; while in periodontitis, the inflammatory process extends to affect the periodontal ligament and alveolar bone. One of these inflammatory changes is the destruction of the periodontal ligament fibers, resulting in loss of clinical attachment and resorption of the alveolar bone. Periodontal infection is a mixed infection with a very complex microbiota, making it difficult to distinguish between secondary causes and true pathogens. (Mihaela *et al.*, 2019)(Newman *et al.*, 2019)(Bathla and Damle, 2017)(Lang and Lindhe, 2015)

The general principles of tissue regeneration are also relevant in periodontal wound healing. This healing procedure involves various types of cells, extracellular matrix, cytokines, and growth factors. In the proliferative phase, there are four processes that occur simultaneously, namely fibroplasia (the entry of fibroblasts that produce extracellular matrix), angiogenesis (formation of new blood vessels in the wound area), re-epithelialization (restore the epithelial barrier), and tissue contraction to shrink the wound area. On the third to fourth day of healing, fibroblasts begin to appear in the wound area and their number will peak between the seventh and 14th days. These fibroblasts are responsible for synthesizing collagen that is activated by PDGF, bFGF, TGF-β, IL-1, and TNF. Epithelialization begins with the migration of intact epithelial cells from the wound edge until the migrating cells meet and form a new basement membrane. This process is driven by EGF and TGF-α produced by platelets and macrophages. (Cho *et al.*, 2021)(Weinreb and Nemcovsky, 2015)(Ather and Harding, 2009)

Similar to fibroblasts, endothelial cells, and keratinocytes, in periodontal wounds, osteoblast and fibroblast populations derived from the periodontal ligament and gingival connective tissue direct the secretion of growth factors, so that wound healing enters the cell proliferation and repair/matrix formation phase. Several growth factors play an important role in regulating keratinocyte proliferation during the wound healing process. The main growth factors include epidermal growth factor, transforming growth factor, heparin-binding epidermal growth factor, and keratinocyte growth factor . (Susin *et al.*, 2015)(Aukhil, 2000)

Polypeptide growth factors are a group of natural biological mediators that regulate key cellular events in tissue repair. Platelet-Derived Growth Factor (PDGF) is the most widely studied growth factor in periodontics. PDGF is a protein that is naturally found in abundant amounts in the bone matrix. PDGF receptor signaling has been reported to play a critical role in regulating cell proliferation and migration, including osteoblasts and fibroblasts. Nister et al.'s study showed that PDGF-AA has no chemotactic activity or ability to stimulate reorganization in human fibroblasts, while PDGF-BB has been reported to stimulate proliferation of osteoblasts and fibroblasts. (Thakare *et al.*, 2013)(Javed *et al.*, 2011)

Biomaterials play an important role and make great contributions to medical science, including periodontal medicine. In recent decades, various innovations such as nanoparticles, hydrogels, films, and fibers have been developed for periodontal drug delivery, and many biocompatible materials are used as fillers or scaffolds for periodontal tissue regeneration. These therapies aim to reduce symptoms and prevent disease progression, but cannot completely restore the attachment of periodontal tissue to the original teeth and periodontal tissue. Therefore, the development of alternative regenerative strategies is essential to restore the structure and function of periodontal tissues in periodontitis patients. (Luan *et al.*, 2023)(Liang, Luan and Liu, 2020)

To achieve successful periodontal treatment, it is important to integrate various material methods such as essential oils, scaffolds, lasers, photodynamic therapy, stem cells, anabolic agents, immunomodulators, colloidal silver nanoparticles, as well as prebiotics and probiotics. Coconut oil, which is one of the main agricultural commodities in Indonesia, Medium chain saturated fatty acids and their derivatives (such as monoglycerides) have been shown to be effective in destroying various types of bacteria by damaging their lipid membranes. (Radu *et al.*, 2024)(Ripari *et al.*, 2020)

Lauric acid and monolaurin interact with certain functional groups on the cell membrane and can cause damage to these cells. In general, the potential of VCO as a healthy food is driven by the antimicrobial properties of lauric acid and monolaurin. Polyphenols are abundant dietary micronutrients and protect cells from damage due to oxidative stress. Several phenols have been identified in coconut oil, such as protocatechuic acid, vanillic acid, caffeic acid, ferulic acid, and p-coumaric acid. Marina et al. (2017) found a 7% higher phenolic content in virgin coconut oil compared to processed coconut oil. The highest amount of polyphenols was found in fermented virgin coconut oil, while the lowest amount was found in processed coconut oil. (Nitbani *et al.*, 2022)(Peedikayil *et al.*, 2021)

Recent studies have shown that Virgin Coconut Oil (VCO) accelerates wound healing time and provides the highest healing effect on chemical burns in Rattus Norvegicus. Periodontitis can damage soft and hard tissues in the oral cavity, which is largely due to the high concentration of medium-chain saturated fatty acids, such as lauric acid and capric acid. These fatty acids facilitate penetration through the skin barrier, thereby increasing fibroblast proliferation, new blood vessel formation, and accelerating the epithelialization process. VCO also increases collagen levels, which strengthens its role in accelerating wound healing. Several studies have shown that VCO and its hydrogenated variants increase the expression of wound healing-related proteins, such as MMP-9, PDGF-BB, and TGF-β. (Thahir *et al.*, 2021)(ARMAN *et al.*, 2024)

The role of Platelet-Derived Growth Factor (PDGF) in the regeneration of periodontal ligament and cementum, as well as in cell migration, differentiation, and proliferation is one of the prerequisites for successful wound healing. This study used experimental animals Rattus norvegicus that had been induced by P. gingivalis bacteria to see PDGF expression in the application of Virgin Coconut Oil (VCO). The use of animals for scientific purposes has been recorded in the book Corpun Hippocraticum (±400 BC). At that time, the animals used were animals that could be obtained around the area. Since ancient times, humans have tried to understand the causes of diseases and find ways to cure them. Laboratory animals used for dental research vary widely, but the most widely used include rats (Rattus norvegicus), mice (Mus musculus), cotton rats (Sigmodon hispidus), and hamsters (Mesocricetus auratus).(Salasia and Mangkoewidjojo, 2021)

Table 1 shows the results of statistical examination showing a comparison table of PDGF expression between the three research groups, with statistical results showing a statistically significant comparison of PDGF expression in all sample groups with a p value <0.005. In the statistical analysis of the comparison of PDGF expression in the three research groups, the p value obtained was 0.0000 which showed a significant value. The amount of PDGF expression was greater in the treatment group than the positive control group and the negative group, with a significant biostatistical significance value at p <0.05. These results are in line with research conducted by Imelda et al., who conducted an experiment on the application of VCO to burns in rabbits, the results showed increased healing of skin tissue on days 3, 7, and 15. This is considered because VCO has various biological and pharmacological activities, including anti-inflammatory, antibiotic, and antioxidant properties. VCO contains the main compound in the form of flavonoids which have anti-inflammatory and antioxidant effects. This antioxidant

effect is seen from its flavonoid content, namely the presence of caffeic acid phenyl ester. (Jian *et al.,* 2022)(Imelda *et al.,* 2020)

Table 2 shows a comparison of PDGF expression at the monitoring time of day 7 and day 21, where a significant increase in PDGF expression was seen on day 21, which is the proliferation phase of tissue healing. In detail, the early phase of hemostasis begins with blood vessel constriction and fibrin clot formation immediately after injury. Proinflammatory cytokines and growth factors such as TGF, PDGF, FGF, and EGF are released by the blood clot and surrounding wound tissue. After bleeding stops, inflammatory cells migrate to the wound (chemotaxis) and initiate the inflammatory phase, which is characterized by gradual infiltration of neutrophils, macrophages, and lymphocytes. Neutrophils play an important role in clearing microorganisms and cell debris from the wound, but they also produce compounds such as proteases and reactive oxygen species (ROS), which can cause additional damage. Table 3 shows the highest PDGF expression in the sample group that received SRP + VCO Gel treatment, compared to other sample groups, and the comparative value of PDGF expression also showed a statistically significant value. Table 4 and Table 5 show the comparison of PDGF expression on day 7 using the Post Hoc LSD Test, which is a follow-up test to compare two treatment groups. Table 4 shows a significant comparison of PDGF expression between the treatment group and the negative control group, as well as the positive control group compared to the negative control group and the treatment group. In another experiment involving hydrogels with flavonoid glycosides, there was a decrease in wound area over a period of 4 to 16 days. The formulation to accelerate wound closure was started on the 4th day. Therefore, flavonoids play an important role in healing bone disorders, which is one of the obstacles in clinical therapy. This study was evaluated in 44-week-old rats that were kept in groups of eight and given different doses of flavonoids. The therapeutic activity was found to be directly related to the higher dose, which was 100 mg/kg per day, which is the optimal dose to provide successful treatment for bone damage. Flavonoids can initiate osteoblast differentiation, thereby promoting angiogenesis and indirectly reflecting proliferative activity. (Zulkefli *et al.*, 2023)

The results of this study indicate that VCO gel is effective in increasing PDGF expression, which has the potential to accelerate wound healing in periodontitis. There are still some limitations in this study and further testing is needed to obtain the right effective dose of VCO Gel.

Conclusion

Virgin coconut oil gel can be used as an alternative material of bacteria-induced periodontitis that can be widely utilized because of its effect on tissue healing markers.

Conflict of interest

The authors confirm that this article content has no conflict of interest.

References

Arman, E. *Et Al.* (2024) 'Combined Effect Of Topical Application Of Virgin Coconut Oil (Vco) And Black Cumin Oil (Nigella Sativa) On The Upregulation Of', *International Journal Of Applied Pharmaceutics* , 16(1), Pp. 35–40.

Ather, S. And Harding, K.G. (2009) 'Wound Management And Dressings', *Advanced Textiles For Wound Care: A Volume In Woodhead Publishing Series In Textiles*, Pp. 3–19. Doi:10.1533/9781845696306.1.3.

Aukhil, I. (2000) 'Biology Of Wound Healing', *Periodontology 2000*, 22, Pp. 44–50.

Bathla, S. And Damle, S.G. (2017) *Textbook Of Periodontics*. 1st Edn.

Cho, Y.D. *Et Al.* (2021) 'Periodontal Wound Healing And Tissue Regeneration: A Narrative Review', *Pharmaceuticals (Basel, Switzerland)*, 14(5), Pp. 1–17. Doi:10.3390/Ph14050456.

Fiorellini, J.P. *Et Al.* (2020) 'Anatomy Of Periodontium', In *Biomarkers In Periodontal Health And Disease*. Springer International Publishing, Pp. 1–7. Doi:10.1007/978-3-030-37317-7_1.

Garzón, H. *Et Al.* (2022) 'Biomaterials Used For Periodontal Disease Treatment: Focusing On Immunomodulatory Properties', *International Journal Of Biomaterials*, 2022, Pp. 1–8. Doi:10.1155/2022/7693793.

Harefa, A. *Et Al.* (2022) 'Potential Of Lauric Acid, Miristic Acid And Combination Gel As Inhibiting The Growth Of Porphyromonas Gingivalis Bacteria In Gingivitis', *Ijisrt.Com*, 13(3), Pp. 1827–1836.

Hayatullina, Z. *Et Al.* (2012) 'Virgin Coconut Oil Supplementation Prevents Bone Loss In Osteoporosis Rat Model', *Evidence-Based Complementary And Alternative Medicine : Ecam*, 2012, Pp. 1–8. Doi:10.1155/2012/237236.

Imelda *Et Al.* (2020) 'An Experiment Of Virgin Coconut Oil Treatments For Burn Incidence On Rabbits', *Mecnit 2020 - International Conference On Mechanical, Electronics, Computer, And Industrial Technology*, Pp. 386–389. Doi:10.1109/Mecnit48290.2020.9166605.

Javed, F. *Et Al.* (2011) 'Significance Of The Platelet-Derived Growth Factor In Periodontal Tissue Regeneration', *Archives Of Oral Biology*, 56(12), Pp. 1476–1484. Doi:10.1016/J.Archoralbio.2011.06.020.

Jian, K. *Et Al.* (2022) 'Pdgf-Bb-Derived Supramolecular Hydrogel For Promoting Skin Wound Healing', *Journal Of Nanobiotechnology*, 20(1), Pp. 1–9. Doi:10.1186/S12951-022-01390-0/Figures/4.

Kaigler, D. *Et Al.* (2011) 'Platelet-Derived Growth Factor Applications In Periodontal And Peri-Implant Bone Regeneration', *Expert Opinion On Biological Therapy*, 11(3), Pp. 375–385. Doi:10.1517/14712598.2011.554814.

Kwon, T.H., Lamster, I.B. And Levin, L. (2021) 'Current Concepts In The Management Of Periodontitis', *International Dental Journal*, 71(6), Pp. 462–476. Doi:10.1111/Idj.12630.

Lang, N.P. And Lindhe, J. (2015) 'Clinical Periodontology And Implant Dentistry, 2 Volume Set - Google Buku', In Holmstrup, P. And Jontell, M. (Eds) *Clinical Periodontology And Implant Dentistry*. 6th Edn. Wiley, Pp. 339–376.

Liang, Y., Luan, X. And Liu, X. (2020) 'Recent Advances In Periodontal Regeneration: A Biomaterial Perspective', *Bioactive Materials*, 5(2), Pp. 297–308. Doi:10.1016/J.Bioactmat.2020.02.012.

Liu, J. *Et Al.* (2019) 'Periodontal Bone-Ligament-Cementum Regeneration Via Scaffolds And Stem Cells', *Cells*, 8(6), Pp. 1–24. Doi:10.3390/Cells8060537.

Luan, J. *Et Al.* (2023) 'Functional Biomaterials For Comprehensive Periodontitis Therapy', *Acta Pharmaceutica Sinica B*, 13(6), Pp. 2310–2333. Doi:10.1016/J.Apsb.2022.10.026.

Mei, F. *Et Al.* (2020) 'Porphyromonas Gingivalis And Its Systemic Impact: Current Status', *Pathogens 2020, Vol. 9, Page 944*, 9(11), P. 967. Doi:10.3390/Pathogens9110944.

Mihaela, M. *Et Al.* (2019) 'Assessment Of Local Risk Factors In The Etiology And Evolution Of Periodontal Diseases', *Romanian Journal Of Oral Rehabilitation*, 11(3), Pp. 115–122.

Nanci, A. And Dd Bosshardt - (2006) 'Structure Of Periodontal Tissues In Health And Disease', *Periodontology2000*, 40, Pp. 11–28.

Nevins, M. *Et Al.* (2013) 'Platelet-Derived Growth Factor Promotes Periodontal Regeneration In Localized Osseous Defects: 36-Month Extension Results From A Randomized, Controlled, Double-Masked Clinical Trial', *Journal Of Periodontology*, 84(4), P. 464. Doi:10.1902/Jop.2012.120141.

Newman, M.G. *Et Al.* (2019) *Clinical Periodontology*. 11th Edn. Elsevier Wordmark.

Nitbani, F.O. *Et Al.* (2022) 'Antimicrobial Properties Of Lauric Acid And Monolaurin In Virgin Coconut Oil: A Review', *Chembioeng Reviews*, 9(5), Pp. 442–461. Doi:10.1002/Cben.202100050.

Peedikayil, F.C. *Et Al.* (2021) 'Perceptions And Efficacy Of Oral Rinsing With Two Types Of Coconut Oil: A Comparative Study', *Cord*, 37, Pp. 45–51. Doi:10.37833/Cord.V37i.438.

Radu, C.M. *Et Al.* (2024) 'Exploring The Efficacy Of Novel Therapeutic Strategies For Periodontitis: A Literature Review', *Life 2024, Vol. 14, Page 468*, 14(4), Pp. 1–16. Doi:10.3390/Life14040468.

Ripari, F. *Et Al.* (2020) 'The Role Of Coconut Oil In Treating Patients Affected By Plaque-Induced Gingivitis: A Pilot Study', *European Journal Of Dentistry*, 14(4), Pp. 558–565. Doi:10.1055/S-0040-1714194/Id/Jr_29/Bib.

Rohmawati, N. And Santik, Y.D.P. (2019) 'Status Penyakit Periodontal Pada Pria Perokok Dewasa', *Health, Higeia Journal Of Public Development, Research And*, 3(2), Pp. 286–297.

Salasia, S.I.O. And Mangkoewidjojo, S. (2021) *Hewan Laboratorium Dalam Penelitian Biomedis*. Gadjah Mada University Press.

Sehar, K. *Et Al.* (2020) 'Periodontal Growth Factors In Wound Healing', *Saudi Journal Of Oral And Dental Research*, Pp. 327–335. Doi:10.36348/Sjodr.2020.V05i07.006.

Shaddox, L.M. And Walker, C.B. (2010) 'Treating Chronic Periodontitis: Current Status, Challenges, And Future Directions', *Clinical, Cosmetic And Investigational Dentistry*, 2, Pp. 79–91.

Susin, C. *Et Al.* (2015) 'Wound Healing Following Surgical And Regenerative Periodontal Therapy', *Periodontology 2000*, 68(1), Pp. 83–98. Doi:10.1111/Prd.12057.

Thahir, H. *Et Al.* (2021) 'The Effectiveness Of Natural Virgin Coconut Oil In Periodontal Tissue Regeneration', *Annals Of The Romanian Society For Cell Biology*, 25(6), Pp. 4364–4375.

Thakare, K. *Et Al.* (2013) 'Periodontal Regeneration Using Platelet-Derived Growth Factor In Infrabony Defects: A Series Of Three Cases', *Case Reports In Dentistry*, 2013, Pp. 1–4. Doi:10.1155/2013/849823.

Weinreb, M. And Nemcovsky, C.E. (2015) 'In Vitro Models For Evaluation Of Periodontal Wound Healing/Regeneration', *Periodontology 2000*, 68(1), Pp. 41–54. Doi:10.1111/Prd.12079.

Xiong, K. *Et Al.* (2023) 'Research On The Association Between Periodontitis And Copd', *International Journal Of Copd*, 18, Pp. 1937–1948. Doi:10.2147/Copd.S425172.

Zulkefli, N. *Et Al.* (2023) 'Flavonoids As Potential Wound-Healing Molecules: Emphasis On Pathways Perspective', *International Journal Of Molecular Sciences 2023, Vol. 24, Page 4607*, 24(5), Pp. 1–29. Doi:10.3390/Ijms24054607.