MORINGA PLANT (*Moringa oleifera*) EXTRACT AS AN ALTERNATIVE AGENT FOR ROOT CANAL MEDICATION A LITERATURE REVIEW

Thesis

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DEPARTMENT OF CONSERVATIVE DENTISTRY

FACULTY OF DENTISTRY

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THESIS

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iii

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iv

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Hereby declare that the thesis titled "Moringa Plant (*Moringa oleifera*) Extract as An Alternative Agent for Root Canal Medication" is my own original work, and no plagiarism has been done in its writing. Any citations in this thesis have been given due acknowledgements and have their sources quoted and listed. I am willing to carry out the proper process in accordance with the applicable laws and regulations if it turns out that this thesis is partly or entirely plagiarized from other works.

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PREFACE

بِسْمِ اللهِ الرَّحْمٰنِ الرَّحِيْمِ

All praise and gratitude to Allah SWT for all His blessings and guidance so that the author can complete the writing and preparation of the thesis titled "Moringa Plant (*Moringa oleifera*) Extract as An Alternative Agent for Root Canal Medication." This thesis was written as a requirement for the completion of studies in achieving a bachelor's degree in dentistry at the Faculty of Dentistry, Hasanuddin University. Salawat and greetings are also extended to the great Prophet Muhammad SAW as an example who leads people from a dark path to a path of knowledge.

The author acknowledges that the writing of this thesis would not be possible without the support of many parties. In this opportunity, the author would like to express her gratitude and respects to the author's parents, **drg. Bustamin B Taba, MARS** and **Mulfahida, S. Sos**, for it is their prayers and their blessings, as well as their love and patience in providing both material and moral support so that this thesis can be completed.

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The author is fully aware that this thesis is still far from perfection, because perfection belongs to Allah alone. Therefore, the author apologizes if there are errors in the writing of this thesis. The author appreciates criticism and suggestions for the improvement of similar writing in the future. The author hopes that this thesis can be useful and can be of positive value for all parties who need it.

Makassar, 22 Agustus 2022

Author

ABSTRAK

MAHIRAH MUKHBITAH BUSTAMIN: Ekstrak Tanaman Kelor (*Moringa oleifera*) Sebagai Alternatif Agen Medikasi Saluran Akar. Suatu Kajian Pustaka.
(Dibimbing oleh Juni Jekti Nugroho)

Latar Belakang: medikasi saluran akar merupakan tahapan pada perawatan saluran akar dengan pemberian larutan irigasi dan *dressing* saluran akar. Larutan irigasi yang paling umum digunakan adalah natrium hipoklorit (NaOCl) dan *ethylendiaminetetraacitic acid* (EDTA), sedangkan *dressing* saluran akar yang sering digunakan yaitu kalsium hidroksida ($Ca(OH)_2$). Berdasarkan pertimbangan keterbatasan dari bahan sintetis maka dilakukan beberapa penelitian pada tanaman kelor. Tanaman kelor salah satu yang potensial sebagai alternatif agen medikasi karena mengandung senyawa glikosinolat dan isotiosionat yang bersifat sebagai antibakteri, metabolik sekunder seperti flavonoid, alkaloid dan tanin yang memiliki sifat antibakteri dan saponin yang bersifat sebagai pembersih. **Tujuan:** mengetahui potensi ekstrak tanaman kelor (*Moringa oleifera*) sebagai alternatif agen medikasi saluran akar. **Metode:** desain penulisan ini adalah kajian pustaka. **Kesimpulan:** berdasarkan penelitian yang telah ada dapat disimpulkan sementara bahwa tanaman kelor (*Moringa oleifera*) memiliki potensi sebagai alternatif agen medikasi saluran akar.

Kata Kunci: larutan irigasi, *dressing* saluran akar, tanaman kelor

ABSTRACT

MAHIRAH MUKHBITAH BUSTAMIN: Moringa Plant (*Moringa oleifera*) Extract as An Alternative Agent for Root Canal Medication. A Literature Review.
(Supervised by Juni Jekti Nugroho)

Background: root canal medication is an important step in root canal treatment, comprised of irrigation and dressing of the root canal. The most commonly used irrigation solutions are sodium hypochlorite (NaOCl) and ethylendiaminetetraacetic acid (EDTA). Meanwhile, the most commonly used root canal dressing is calcium hydroxide ($Ca(OH)_2$). Based on the limitations of the synthetic materials used, several studies have been conducted on the Moringa plant as an alternative to the materials. Moringa plant have the potential to be an alternative agent due to its glycosinolates and isothiosionates contents that act as antibacterial agents, its secondary metabolites such as flavonoids, alkaloids, and tannin that also act as antibacterial agents, and its saponin contents that acts as cleanser. **Objective:** to analyze the potential of Moringa plant extract (*Moringa oleifera*) as an alternative agent for root canal medication. **Methods:** this thesis is a literature review. **Conclusion:** Based on existing studies, it can be temporarily concluded that the Moringa plant has the potential to be an alternative agent for root canal medication.

Key Words: irrigation solution, root canal dressing, moringa plant

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

1.1. Background

Root canal medication is a step in step in root canal treatment in which irrigation solution and dressing is applied to the canal. The medication is done to optimize the cleaning and disinfection processes on the root canal.[1,2] The irrigation solution is used as cleanser with the purpose to eliminate debris, as well as a tissue solvent, lubricant, and an antimicrobial agent.[3] The most commonly used irrigation solution is sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA). NaOCl solutions could dissolve organic tissues. However, it could also potentially irritate the vital periapical tissues, cause unpleasant smell, have high toxicity, worsen modulus elasticity and dentin flexibility, and be ineffective in removing the smear layer.[4] The EDTA solution, as a chelator agent, could dissolve inorganic tissues, but could also cause erosion on the root canal walls.[5,6] This step of medication could be optimized by applying root canal dressing to eliminate microorganisms and to prevent inflammation.

Calcium hydroxide ($Ca(OH)_2$) is the most commonly used solution for root canal dressing, used for its antibacterial properties, as well as its ability to reduce exudates on the periapical.[7] However, previous researches has shown that the active action period of calcium hydroxide is limited to a few days. The application of this dressing on the walls of the root canal could cause changes

to the physical properties of the dentin, and thus increases the risk of root fracture.[8,9] Considering the limitations of said synthetic materials, multiple studies have been done to research natural materials as an alternative for root canal medication agent.

Currently, multiple researches are developing natural alternative materials, especially herbal materials. The Moringa plant (*Moringa oleifera*) is one of many natural materials researched in the field of endodontics. The plant contains glycosinolates and isothiosionates, which have antibacterial properties; secondary metabolites, for example, flavonoids, alkaloids, and tannin, which also have antibacterial properties; and saponins, which acts as cleansers.[10] Its leaves contain high concentration of calcium, around 3,65%, that provides a remineralization effect.[11] Research done by Nugroho *et al* (2021) shows that 5% of the ethanol extract of Moringa leaves is effective against the *Enterococcus faecalis* bacteria that is known as a bacteria that is resistant to root canal treatment.[10]

Based on the description above, the author has done a literature review regarding previous researches on the Moringa plant (*Moringa oleifera*) and the development of further researches on the Moringa plant as an alternative for root canal medication agent.

1.2. Formulation of the Problem

Based on the background of the problem that has been described, the problem is formulated as follows:

What is the potential of Moringa plant (*Moringa oleifera*) extract as an alternative for root canal medication material?

1.3. Objectives of Thesis

General Objective

To know the potential of Moringa plant extract (*Moringa oleifera*) as an alternative material to root canal medication.

Specific Objective

To compare multiple researches on the potential of Moringa plant extract (*Moringa oleifera*) as an alternative agent to root canal medication.

1.4. Benefits of Thesis

General Benefits

It is hoped that this literature review can provide insight about the potential of Moringa plant extract (*Moringa oleifera*) as an alternative root canal medication material.

Specific Benefits

It is hoped that this literature review can be used as a basis for further research on the potential of Moringa plant extract (*Moringa oleifera*) as an alternative root canal medication material.

CHAPTER II

LITERATURE REVIEW

2.1. Root Canal Medication

Medication is an important step in the success of root canal treatment. Root canal irrigation could eliminate microorganisms and prevent recontamination after treatment. To optimize the medication step, root canal dressing is also done to remove any remaining microorganisms on the root canal.[12,13] NaOCl and EDTA are two of the most common material used for irrigation and $Ca(OH)_2$ is the most common material for root canal dressing.

2.2. Irrigation Solutions

The irrigation of root canal has an important role in endodontic treatment, as it is done to eliminate bacteria, dissolve organic and inorganic tissues, and lubricate the root canal for further treatment. Irrigation solutions is ideal if it does not irritate the vital periapical tissues, does not weaken the structure of the tooth, and is nontoxic. However, by the time of the writing of this thesis, there has not been a single ideal irrigation solution, and therefore, irrigating the root canal requires the use of a combination of several irrigation solutions.[3,10]

The influencing factors in the effectivity of an irrigation solution in irrigating a root canal are its concentration and volume, the anatomy and diameter of the root canal, the technique used in irrigation, and the temperature of the solution as well as contact duration with the tissue.[3] A few examples of

the most used irrigation solutions are sodium hypochlorite (NaOCl) and Ethylenediaminetetraacetic acid (EDTA).

2.2.1. Sodium Hypochlorite (NaOCl)

Sodium hypochlorite or NaOCl is one of the most used irrigation solutions in the field of endodontics, since it has a wide range antibacterial properties and has the ability to dissolve organic tissues, such as necrotic tissues, remaining pulp tissues, and collagen.[12,14] NaOCl is formed in a reaction between Na^+ and OCl^- that also forms hypochlorite acid (HOCl). This creates NaOCl as an organic tissues solvent through saponification that will help in releasing debris from the root canal. [5]

The natural low viscosity of NaOCl allows for easier access inside the root canal, with the highest concentration of said solution used is around 0,5% - 5,25%.[13] The effectivity of NaOCl can be increased by heating the solution until the effects of the solution and antibacterial properties has increased significantly.[15]

Even though NaOCl is one of the most used irrigation solutions, it has several drawbacks, such as cytotoxicity during extrusion on the periapical that causes pain, unpleasant smell and taste, and inflammation to the patient.[15] Another drawback of NaOCl application as an irrigation solution is a decrease in adhesive strength of dentin, caused by the property of NaOCl which is removing collagens on the surface of the dentin, that will inhibit the formation of hybrid layers that is needed to achieve dentin-adhesive bonding.[16]

2.2.2. Ethylenediaminetetraacetic acid (EDTA)

Ethylenediaminetetraacetic acid (EDTA) is a polymonocarboxilate acid that is colorless and is used as a chelator agent.[16] Chelator agents were first introduced in endodontics by Nygaard Østby in 1957 as a medication agent for calcified root canal.[3] EDTA is used as a supplement to NaOCl that could only dissolve organic tissues, since EDTA is able to dissolve inorganic tissues, such as hydroxyapatite.[12,14] EDTA is also able to soften micro dentin inside the root canal, that will allow for easier step in instrumentation.[17] The effectivity of EDTA on dentin relies on the concentration of the solution used and the duration of the application on the dentin.[13] The most common concentration of EDTA used as an irrigation solution is around 17%.[12]

The EDTA solution works by reacting with the calcium ions in dentin, forming calcium chelates that could dissolve.[16] Ethylenediaminetetraacetic acid has limited antibacterial effects that is caused by cation chelation outside the outer membrane of bacteria. To increase the antibacterial effects of EDTA, NaOCl is used together with EDTA.[17] The irrigation step commonly uses 17% of EDTA for 1 minute, followed by 2,5% of NaOCl.[17]

2.3. Root Canal Dressing

Root canal dressing is used for sterilization between endodontic treatments. The purpose of root canal dressing application is to ease pain between treatments, to act as an antibacterial agent, and to prevent recontamination in the root canal.[8, 9] Root canal dressing is ideally able to penetrate into the dentinal

tubules while maintaining its concentration, so that it can still eliminate bacteria that are still present in the root canal.[13] One of the examples of the most used root canal dressing is calcium hydroxide.

2.3.1. Calcium Hydroxide ($Ca(OH)_2$)

Calcium hydroxide ($Ca(OH)_2$) is a strong base in a form of a white, odorless powder, with a pH of 12,5-12,8. Calcium hydroxide was first introduced into dentistry by Herman (1920), and has been developed in its use in endodontics since.[18] Calcium hydroxide is used as root canal dressing that is applied between treatments as an antibacterial and anti-inflammation agent.[19]

The antibacterial effect of calcium hydroxide works within 7 days, attributing that to its high pH level. After its application on the root canal, $Ca(OH)_2$ will release hydroxyl ion through the dentinal tubules, rising the pH level of the root canal and therefore eliminating most of the pathogens found within the root canal.[7] The usage of calcium hydroxide as dressing for the root canal could promote healing of inflamed periapical tissue. This is due to the biocompability of calcium hydroxide.[7,18]

Besides having antibacterial and anti-inflammation effects, calcium hydroxide also has other influences on dentin strength. The fracture resistance of dentin at the root is significantly reduced within 6 months. However, even with this limitation, this material is still being used as the main dressing material in endodontic treatment.[19]

2.4. Moringa Plant (*Moringa oleifera*)

Moringa oleifera is a plant with a tree that is always leafy, with a height of 10 - 12 m, and has a straight and elongated stem growing branching with a rough and woody surface. The skin of the Moringa plant is pale gray or brown in color with a smooth or finely wrinkled texture.[20] The flower of Moringa plant is triangle-shaped, with white yellowish color, and has a green midrib hood. Moringa pods, measuring 20-60 cm, are green when young and will turn brown. The seeds of said plant are round-shaped and dark brown in color.[21] The Moringa leaves are 2-3 double pinnate compound leaves with scattered positions, oval-shaped leaves with pointed, blunt, and grooved ends. Moringa leaf color depends on the age of the plant with dark green, light green, or yellowish green.[22]

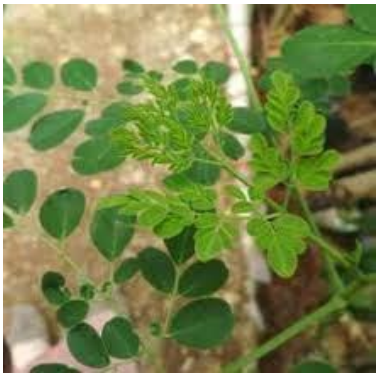

Image 1: Tanaman Kelor. **Source**: Dani B, Etnobotani tanaman kelor (*Moringa oleifera Lam.*) di desa Kedungbulus Gembong Pati. Al-Hayat: Journal of Biology and Applied Biology, 2019. p. 49.

This plant has multiple benefits and is widely recognized nationally and internationally. In Indonesia, the use of Moringa plant includes food source,

medicine, cosmetic ingredients, to use in traditional cultural rituals.[21] Besides that, societies in Asia and Africa have used Moringa plant as a supplement for nursing mothers and children in their developing stage, since the entirety of this plant has high nutritional value.[20]

Moringa plant contains beta-carotene, thiamine, riboflavin, niacin, calcium, iron, phosphorus, magnesium, zinc, and vitamin C. In addition, Moringa plants can function as antimicrobial, antifungal, antihypertensive, antihyperglycemic, antitumor, anticancer, and anti-inflammatory agent. This is due to the content of ascorbic acid, tannins, flavonoids, saponins, phenols, and carotenoids.[20,21]

2.4.1. Antibacterial Effect

Hijar *et al* (2018) did research on the methanol extract of *Moringa oleifera*, comparing it with 2% chlorhexidine in vitro. The result shows that the antibacterial effects of Moringa plants toward *Enterococcus faecalis* within the first 24 to 48 hours, which proves that Moringa plants, compared to chlorhexidine, has higher antibacterial effect.[23] Another research by Sopandani (2020) uses 25%, 50%, 75%, and 100% of Moringa leaves extract, with results showing that 75% and 100% of said extract is effective in eliminating *E. faecalis*, which is the same as using 5,25% of NaOCl.[24] Research done by Rochyani (2020) showed that the same extract at 20%, 40%, 60% and 80% contains antibacterial compounds that inhibits the growth of *E. faecalis* bacteria.[25]

Research on the usage of nanoparticle paste of Moringa leaves (*Moringa oleifera*) was done by Nugroho (2022) with 1% and 2,5% concentration on the *Enterococcus faecalis* bacteria. This research used the Kirby-Bauer method, which is a diffusion method with disc paper. The test groups used were aquadest (negative control), 1% and 2,5% Moringa leaf nanoparticle paste, and calcium hydroxide (positive control). Based on the results of the different zones of inhibition against *E. faecalis*, it was shown that the entire test group when compared to the negative control did not have the same antibacterial effect. In contrast to the test group, Moringa leaf paste 2,5% showed the same results with calcium hydroxide. This study proves that Moringa leaf nanoparticle paste is quite effective as an antibacterial agent, with higher concentration resulting in better antibacterial effect.[26]

Another study by Gasri (2021) is done to study the antibacterial effectivity of Moringa nanoparticle paste against *E. faecalis*. This research also used the Kirby-Bauer method with aquadest (negative control), Moringa leaf nanoparticle paste, and calcium hydroxide (positive control). The results of the research on the inhibition zone value of Moringa leaf nanoparticle paste and calcium hydroxide showed different results where the antibacterial power of Moringa leaf paste was 7,60 ± 1,16 mm (5-10 mm) included in the category of moderate inhibition zone, compared to calcium hydroxide which had inhibition zone was strong category with a value of 10,88 ± 0,79. This research proves that Moringa leaf nanoparticle paste is effective in inhibiting the growth of

E. faecalis bacteria and has potential as a natural material used for root canal dressings.[27]

Antibacterial effects were also reported in Nugroho's (2021) study on the inhibition of the ethanol extract of Moringa leaf (*Moringa oleifera*) against *Enterococcus faecalis* bacteria. The results showed that the bacterial inhibition of the 5% concentration of Moringa leaf ethanol extract was strong. This was the same as if using concentrations of 10%, 20%, 40%, and 80%. This result is a fact that the ethanolic extract of Moringa leaves is effective as an antimicrobial agent due to the content of phytochemicals, namely saponins, flavonoids and alkaloids.[10] The antibacterial effect of saponin compounds is to limit the permeability of the bacterial cell wall. The function of flavonoid compounds is to form complex compounds with proteins so that protein denaturation occurs which causes disruption of the physiological function of bacteria. Tannin compounds can inhibit the synthesis of cell wall-forming proteins, causing bacterial death. Meanwhile, the antibacterial mechanism of alkaloid compounds interferes with the constituent components in bacterial cells, causing cell death.[24]

2.4.2. Anti-inflammation Effect

Research conducted by Amin *et al* (2021) on white rats showed an anti-inflammatory effect of *Moringa oleifera* seed extract. Tannin compounds contained in the extract can eliminate free radicals, reactive oxygen, improve wound healing, form blood capillaries and activate fibroblasts. Another

compound, namely saponins, helps the formation of fibroblasts and collagen. It is proven that Moringa seed extract is effective in wound healing in white rat gingiva, indicated by an increase in collagen thickness. Research compared with aspirin which has an anti-inflammatory effect but does not have antibacterial and antioxidant content so that the thickness of collagen is lower than Moringa seed extract. This study concluded that Moringa seed extract has potential as an anti-inflammatory agent.[28]

Nurul *et al* (2020) reported their study on the Moringa plant as an anti-inflammatory in the oral cavity. Research shows Moringa plant extracts reduce inflammatory cytokines and reduce clinically apparent inflammatory symptoms. The flavonoid content of Moringa plants inhibits the secretion of arachidonic acid and lysosomal enzymes in the endothelium thereby inhibiting proliferation and inflammatory processes. Another fact shows that the anti-inflammatory effect of 200mg/kgBW ethanolic extract of Moringa leaves is better than 100mg/kgBW and 150mg/kgBW in white rats, although it is still lower than diclofenac sodium. This evidence can be used as a reference that Moringa plant extract can be used as an alternative material in the treatment of gingivitis and periodontitis.[29]

Another research done by Sahrakary *et al* (2017) on the reduced inflammatory cytokines in rat periodontal tissues. This study used *Moringa oleifera* extract at a dose of 500mg/kg compared to indomethacin at a dose of 5mg/kg. The results showed that *Moringa oleifera* extract reduced the production of inflammatory cytokines, namely interleukin-1beta (IL-1β) and

tumor necrosis factor alpha (TNF-α), which are the main cytokines in the development of periodontitis. The two data did not show a significant difference. It was concluded that the use of indomethacin could be replaced with *Moringa oleifera* extract in periodontitis conditions.[30]

2.4.3. Cytotoxic Effect

Nararya *et al* (2015) researched the toxicity effects of Moringa leaf extract (*Moringa oleifera*) at concentrations of 3,125%, 1,625%, 0,812% and 0,406% on gingival fibroblast cells. The toxicity test used enzymatic test method (calorimetry) with MTT (Methyl Tiazolydiphenyl Tetrabromide) assay reagent. The results showed the percentage of living cells with these concentrations were 103,8%, 103%, 101%, and 100%, respectively. Research proves that at this concentration, Moringa leaf extract is non-toxic and can be used as an alternative material in dentistry.[31]

Another study conducted by Nugroho *et al* (2021) regarding the cytotoxicity of 5% concentration of Moringa leaf ethanol extract on fibroblast cell culture with a ratio of 2,5% NaOCl and 2% chlorhexidine. The results showed that 5% ethanol extract of Moringa leaves and 2% chlorhexidine were in the moderate cytotoxic category, in contrast to 2,5% NaOCl which was in the strong cytotoxic category. This condition is caused by glycosinolate compounds which basically do not have toxic properties but can form isothiocyanate toxic compounds. Although Moringa leaf extract showed

moderate toxic effects, its potential as an alternative to root canal irrigation could be considered because its toxicity level was below 2,5% NaOCl.[10]

Gulzar *et al* (2021) conducted a study with Moringa leaf extract and calcium hydroxide on periodontal ligament fibroblast cells. The concentration for Moringa leaf extract varied, namely 25 g/ml, 50 g/ml, 75 g/ml, 100 g/ml with cell viability results 94,8%, 89,8%, 84,4%, 76,8%, while 5mg/ml of calcium hydroxide has a viability of 27,1%. The results of the study concluded that Moringa leaf extract with a concentration of 25 g/ml had low toxicity and had potential as an alternative to root canal medicaments.[32]

2.4.4. Antioxidant Effect

Antioxidants are molecules that could inhibit the oxidation of other molecules that can be used to prevent tissue damage caused by free radicals. Some compounds that have good antioxidants are ascorbic acid, α-tocopherol, and proanthocyanidine. Several studies on natural materials have been carried out to determine the antioxidant effect in endodontics such as increasing dentin bond strength after internal bleaching treatment and to increase the effect of hydraulic seal in resin sealer bonding system in root canal obturation.[33,34] Another natural material that is also a good antioxidant is *Moringa oleifera.*

Aji (2020) stated that *Moringa oleifera* contains molecules that can inhibit free radicals such as phenolic compounds, nitrogen and vitamins that have antioxidant activity. The content of phenolics as antioxidants in Moringa leaves is able to neutralize the oxidation reaction of free radicals that will affect

cell structure and cause disease. Other phenolic compounds have the role of reducing free radicals. The flavonoids in Moringa leaves play a role in the process of inhibiting bleeding so as to accelerate wound healing and as an antiscorbute.[35]

A study by Ali *et al* (2020) investigated antioxidant activity using *n-hexane* extract and formulated it as a hydrogel for Moringa seeds. Research proved that Moringa seeds showed the highest antioxidant activity at a concentration of 160 g/ml with an IC50 (inhibition concentration 50) value of 162,4 compared to 96,24 of ascorbic acid.[36]

Mohanty *et al* (2020) wrote that the high phenolic content in *Moringa oleifera* acts as an antioxidant in stabilizing free radicals produced by cells by accepting electrons. Moringa seeds contain *myricetin* which is higher in antioxidants than α-tocopherol. In addition, Moringa leaf extract is able to increase antioxidant enzymes and inhibit lipid peroxidation. This study reports that *Moringa oleifera* can be used as an alternative mouthwash because of its antioxidant effect, it can work as an accelerator in healing wounds on the oral mucosa thereby improving oral health.[37]

2.4.5. Chelator Agent Effect

Utami (2021) did a study on the change of structure and erosion on dentin after the application of Moringa leaf extract as an alternative chelator agent. The study used samples of aquadest solution, 17% EDTA solution, and 3% and 10% concentration Moringa leaf extract solution. *Moringa oleifera*

extract is able to bind Ca^{2+} ions on the root canal dentin. This activity is related to the phenolic compounds of *Moringa oleifera* leaves, namely flavonoids and vitamins (ascorbic acid) including quercetin and kaempferol. This compound is a functional group that is able to bind minerals, one of which is calcium. In this study, the amount of Ca^{2+} dentin of the root canal showed results in 3% Moringa leaf extract of 1,193%, 10% Moringa leaf extract by 0,976% and 17% EDTA solution of 1,274%. This amount of calcium indicates that Moringa leaf extract naturally reacts with calcium ions. The chemical matrix in the form of a phenolic compound function group contained in Moringa leaf extract can affect the balance and bind calcium ions to the structure of dentin complex molecules. Moringa leaf phenolic compounds have negatively charged molecules that produce class action on multivalent cations, such as calcium, magnesium, and iron. The results also showed Moringa leaf extract at 3%, 10% and EDTA 17% was able to remove the peritubular layer and dentin intratubular (smear layer) covering the dentinal tubules.[38]

Research on the viability of *Moringa oleifera* as an alternative to irrigation materials combined or not combined with chlorhexidine showed that *Moringa oleifera* is able to remove residual debris was conducted by Khallaf (2020). this activity is similar to the use of NaOCl and chlorhexidine. Based on the scanning electron microscope (SEM) image on the middle third and apical root canal irrigated with *Moringa oleifera* shows little debris on the root canal wall. It is related to the effects of *Moringa oleifera* as a chelator agent, which has also been proven by Zaroual *et al* (2014).[39]

In another study by Wahyuni (2021) regarding the evaluation of the depth of penetration of Moringa leaf extract (*Moringa oleifera*) to find out the ability to clean organic and inorganic tissues when preparing root canals, the study used Moringa leaf extract with concentrations of 3% and 10% and used a solution of aquadest and NaOCl of 2,5% as a control. The results showed the penetration of Moringa leaf extract (*Moringa oleifera*) 3% as far as 732,97μm while the concentration of 10% as far as 521,54 μm, seen the penetration ability of the two solutions is different because the low viscosity can be penetrated deeper in the tubule dentin root canal. The 2,5% NaOCl solution has a penetration ability as far as 702,57μm but Moringa leaf extract (*Moringa oleifera*) is 3% better, since it has saponin content that works as an emulgator and surfactant, thus is better at lowering the surface tension of the root canal wall and dissolving the organic and inorganic tissues of the root canal.[40]

Putri (2021) studied the cleanliness of the dentin smear layer of the root canal using a solution of Moringa leaf nanoparticles with a concentration of 2,5% and 5% and EDTA 17%. A 2,5% solution of Moringa leaf nanoparticles (*Moringa oleifera*) showed a yield of 1,85 with an open dentin tubule and a slight smear layer. Unlike the 5% Moringa leaf nanoparticle solution with a yield of 2,50 shows dentin tubules that are not all open because there is still a smear layer, not much different from the use of EDTA solution 17% with a result of 2,38 which shows dentin tubules that are open but there are still many smear layers. In fact, this study proves that Moringa leaf nanoparticle solution (*Moringa oleifera*) is 2,5% better at cleaning smear layers compared to EDTA

17%, while Moringa leaf nanoparticle solution (*Moringa oleifera*) 5% is still effective in cleaning smear layer although not better than EDTA 17%.[41]

2.4.6. Remineralization Effect

Khallaf *et al* (2020), in their research, proved that *Moringa oleifera* leaf extract as a single accompaniment or combined with chlorhexidine (CHX) is effective in removing debris at 1/3 apical root canal, and is just as effective as NaOCl activity.[39]

The ability to remove smear layer of Moringa leaf extract at 2,5%, 5% and EDTA at 17% is also proven by Pasino (2018). This study showed the number of smear layers is different with the application of different irrigation solutions on the walls of the root canal. The smear layer image on Moringa leaf extract application is 5% very little compared to Moringa leaf extract 2,5%. In the application of EDTA solution at 17% indicates a slight smear layer and the application of 2,5% NaOCl solution indicates a smear layer covering the root canal wall. The results of this study proved that Moringa leaf extracts of 2,5% and 5% have the same ability as EDTA solution of 17% and better than NaOCl solution 2,5%.[42]

Another study was also conducted by Tonglo (2021) on the micro hardness of dentin root canal using ethanol extract of Moringa leaves (*Moringa oleifera*) with concentrations of 3% and 10% and NaOCl 2,5%. Research shows the micro hardness values of dentin in Moringa leaf extract solutions of 3%, 10%, and NaOCl 2,5% respectively are 26,13 VHN, 26,16 VHN and 20,70

VHN. This proves that there is an increase in the micro hardness of dentin root canal in the application of Moringa leaf ethanol extract solution (*Moringa oleifera*) compared to NaOCl, due to the content of *proanthocyanidine* in Moringa leaves that can maintain the mechanical properties of dentin. NaOCl 2,5% as a proteolytic agent dissolves organic tissue, affecting the mechanical properties of dentin.[43]

Research by Anas *et al* (2021) on the effectiveness of *Moringa oleifera* paste in increasing calcium levels of human teeth, showed higher levels of dental calcium in the application of Moringa leaf paste (*Moringa oleifera*) compared to CPP-ACP. This is because Moringa leaves have high calcium levels. Calcium and phosphate ions are essential minerals for the remineralization process. The results of this study concluded that Moringa leaf paste (*Moringa oleifera*) can be developed as a remineralizer ingredient.[44]