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A STUDY ON THE EFFECTIVENESS OF GOJI BERRY EXTRACT (LYCIUM BARBARUM L.) IN INCREASING COLLAGEN FIBER DENSITY FOLLOWING TOOTH EXTRACTION IN WISTAR RATS (RATTUS NORVEGICUS)

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ABSTRACT

Background: Tooth extraction initiates wound healing through inflammatory, proliferative, and remodelling phases, with collagen density serving as an important indicator of healing quality. Goji berry (*Lycium barbarum* L.) contains bioactive compounds, including polysaccharides, flavonoids, alkaloids, saponins, and tannins, which may promote fibroblast proliferation and collagen synthesis, supporting its potential to enhance post-extraction socket healing. **Purpose:** To evaluate the effectiveness of Goji berry extract gel at concentrations of 15%, 30%, and 55% on collagen fiber density in Wistar rat sockets subsequent to dental extraction. **Methods:** This research was an in vivo laboratory experimental study, single blind, utilizing a post-test only control group design. Thirty male Wistar rats were separated into five groups: negative control, positive control (Povidone Iodine), and Goji berry extract gel at concentrations of 15%, 30%, and 55%. Gel was applied topically twice daily for 14 days. Tissue samples were collected on days 3, 5, 7, and 14 for histopathological examination using an inverted phase contrast microscope at 400x magnification. Data were analyzed using One-Way ANOVA and Post-Hoc Duncan test. **Results:** Goji berry gel groups showed higher collagen density compared to both control groups across all observation days. Significant differences were found on days 5, 7, and 14 ($p < 0.05$), with the 30% and 55% groups showing the highest collagen density values of 643.82 μm and 699.91 μm on day 14, respectively. **Conclusion:** Goji berry extract gel significantly increases collagen fiber density in Wistar rat sockets after tooth extraction, with 55% as the optimal concentration.

Keywords: Collagen; Goji berry; Tooth extraction; Wistar rats; Wound healing

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INTRODUCTION

Oral health constitutes a fundamental component of holistic well-being, significantly influencing an individual's overall quality of life. Data derived from the World Health Organization (WHO) indicates that oral diseases impact approximately 3.5 billion individuals globally, with dental caries recognized as the predominant condition necessitating tooth extraction.^{1,2} In Indonesia, the 2018 Riset Kesehatan Dasar (Riskesdas) documented a prevalence rate of dental and oral health issues at 57.6%, with tooth extraction being among the most frequently conducted procedures in dental care establishments.^{3,4} Given that the mouth and teeth play a vital role and are an integral part of the human body, teeth serve not only a functional purpose but also have aesthetic value.⁵

Tooth extraction represents a surgical intervention aimed at the removal of a tooth from its alveolar bone socket. This procedure is considered ideal when it can be performed painlessly, minimizes trauma to the surrounding tissues, and ensures optimal post-operative wound healing.⁶ The process of wound healing within the oral cavity transpires at an accelerated rate and comprises three interrelated stages: the inflammatory phase, the proliferative phase, and the remodeling phase. One method for monitoring the wound healing process involves the assessment of collagen fiber density. Collagen density is a key parameter used to evaluate the progression of wound healing, particularly during the remodeling phase. The collagen that is synthesized functions to establish connective tissue that firmly binds the edges of the wound together and enhances the adhesion between new tissues, thereby strengthening the area undergoing healing.⁷

Collagen is a protein that is prevalent in the extracellular matrix of connective tissues throughout the organism, constituting approximately 25–30% of the total protein content of the body. Collagen is instrumental in the development of new tissue and the regeneration of alveolar bone in the socket region by facilitating fibroblast proliferation and the production of growth factors which aid in the formation of new blood vessels (angiogenesis) and the re-epithelialization process.⁸ In addition, collagen also helps improve the tensile strength of the wound, allowing the wound to heal completely.⁹ Thus, efforts to increase collagen fiber density during the proliferation phase are a key strategy for accelerating post-extraction wound healing.

Currently, a great deal of research is being conducted on natural substances to support the wound healing process.¹⁰ Halim et al.¹¹ the findings revealed that the gel derived from senggani leaf extract significantly enhanced the proliferation of fibroblasts and the density of collagen fibers in the socket after extraction. Ermawati et al.¹² It also highlights the potency of Robusta coffee bean extract gel in boosting the density of collagen fibers post-gingivectomy. Similar to Goji berries (*Lycium barbarum*), both Senggani leaves and Robusta coffee beans share key bioactive compounds, particularly flavonoids and phenolic acids, which are known to promote wound healing through anti-inflammatory, antioxidant mechanisms that stimulate fibroblast proliferation and collagen synthesis. However, studies on the effects of Goji berries (*Lycium barbarum* L.) on collagen fiber density specifically in the context of post-tooth-extraction wound healing remain very limited. Given that the Goji berry (*Lycium barbarum* L.) is a medicinal plant that is gaining popularity due to its antioxidant content, which can increase antioxidant levels in the body and help reduce oxidative stress¹³.

Goji berries (*Lycium barbarum* L.) represent the fruit derived from a shrub belonging to the Solanaceae family, which have been utilized for several centuries within the realm of traditional Chinese medicine. These berries are known as a superfood because they are rich in bioactive compounds, particularly *Lycium barbarum* polysaccharides (LBP), flavonoids, carotenoids, and phenolic acids.¹⁴ These compounds work synergistically to neutralize free radicals and reactive oxygen species (ROS) formed as a result of neutrophil and macrophage activation during the inflammatory phase.^{15,16} In the context of wound healing following tooth extraction, flavonoids, particularly, assume a critical function in attenuating the synthesis of pro-inflammatory cytokines such as IL-1 and TNF- α , modulating the effects of TGF- β 1 which facilitates the proliferation of fibroblasts and restricting the enzymatic activity of matrix metalloproteinase (MMP) enzymes that degrade collagen. LBP has been empirically shown in controlled laboratory investigations to augment the production of type I collagen in osteoblasts and significantly foster cellular differentiation, thereby supporting alveolar bone healing after tooth extraction.^{17,18}

Based on the preceding discourse, there exists a robust scientific foundation for the prospective use of goji berries as a therapeutic agent in enhancing collagen fiber density throughout the wound healing process after tooth extraction. Consequently, this investigation was conducted to test the effectiveness of Goji berry extract with the aim of evaluating the efficacy of Goji berry extract gel to determine which extract is effective in increasing collagen fiber density following tooth extraction in vivo in Wistar rats.

MATERIALS AND METHODS

This research was an in vivo laboratory experimental investigation, executed as a single-blind trial employing a post-test only control group format. The subjects were healthy male Wistar rats (*Rattus norvegicus*), aged 2–3 months and weighing 150–200 g. Inclusion criteria were clinically healthy rats with no signs of systemic disease, while exclusion criteria included rats that were sick, injured, or exhibited abnormal behavior during the study. The goji berries (*Lycium barbarum* L.) used in this study were obtained from a specified source and processed through cleaning, drying, and extraction procedures; berries that showed signs of

contamination or deterioration were not used in the extraction process. A total of 30 rats were split into 5 groups ($n = 6$ rats for each group), including the negative control group (untreated), the positive control group (Povidone Iodine), the three treatment groups receiving 15%, 30%, and 55% goji berry extract gel. The gel was formulated using Na-CMC as the base, and the stated concentrations (15%, 30%, and 55%) represent the proportion of goji berry extract incorporated into the gel formulation relative to the total composition.

The subject of this study was the Goji berry (*Lycium barbarum* L.), obtained from the Lautan Timur Chinese Pharmacy, Jl. Mt. Haryono, North Sumatra. The Goji berries first underwent a species identification test at the Herbarium Laboratory of the University of North Sumatra to ensure that the species used was *Lycium barbarum* L. This research was granted approval by Komite Etik Penelitian Kesehatan (KEPK) of Prima Indonesia University under number 042/KEPK/UNPRI/X/2025.

Production and Preparation of Goji Berry Extracts and Gels

The research methodology commenced with the procurement of Goji berries (*Lycium barbarum* L.) from the Lautan Timur Chinese Pharmacy located on Jl. Mt. Haryono, North Sumatra, which were subsequently subjected to taxonomical identification analyses at the Herbarium Laboratory of the University of North Sumatra to validate the taxonomic classification of the species in question. Following this, the Goji berries underwent a thorough washing, cleaning, draining, and drying process in an oven maintained at 40°C, after which they were processed into a fine powder utilizing a blender. The extract was generated employing the maceration technique, wherein 250–500 grams of the dried powder were introduced into a glass container and amalgamated with 2–4 liters of 96% ethanol. This mixture was allowed to rest for a period ranging from 5 to 10 days, with intermittent stirring, while being shielded from light to avert the degradation of active compounds. Upon the conclusion of the maceration phase, the resultant mixture was subjected to filtration to separate the liquid extract from the solid residues, followed by the concentration of the liquid employing a rotary evaporator or a water bath maintained at a temperature not exceeding 50°C until a viscous extract was obtained. A gel was formulated by dissolving 0.5 grams of sodium carboxymethyl cellulose (Na-CMC) in distilled water, which was subsequently heated on a hot plate while being stirred until a homogeneous gel was achieved.

Phytochemical Analyses for Goji Berry

Phytochemical analyses were performed to detect the presence of active compounds such as flavonoids, alkaloids, saponins, and tannins using standard qualitative methods. Flavonoids were identified using the Shinoda test, indicated by a reddish or orange coloration; alkaloids were detected using Mayer's or Dragendorff's reagent, indicated by the formation of a precipitate; saponins were confirmed by the frothing test through the formation of stable foam; and tannins were identified using ferric chloride, indicated by a dark blue or greenish-black coloration.

Procedures for Laboratory Animals

Prior to treatment, male Wistar rats were acclimatised for one week to a 12-hour light-dark cycle and were provided with pellet feed and drinking water ad libitum. Extraction of the lower incisors was performed under intraperitoneal anaesthesia with ketamine 100 mg/1 ml at a dose of 20–40 mg/kg body weight to eliminate pain and ensure the rats remained immobile during the procedure. Extraction was carried out using a sharp excavator or a special sterile extractor, taking care to avoid injury to surrounding tissue and ensuring the entire tooth was removed without any root remnants. Goji berry extract gel was applied topically to the extraction socket using a 5 cc syringe or cotton bud according to the treatment group concentration, this study, collagen density was assessed based on the average diameter (thickness) of collagen fibers (μm) rather than fiber count. This method was chosen because collagen maturation is better reflected by increased fiber thickness and organization. The extract was incorporated into a Na-CMC gel base and mixed until a homogeneous semi-solid dispersion was achieved. Na-CMC acts as a hydrophilic polymer that forms a gel matrix, in which the extract is dispersed rather than completely dissolved, ensuring uniform distribution without phase separation.¹⁹ Application started immediately after extraction, twice daily for 14 consecutive days.

Sampling and Histopathological Examination

Tissue samples were collected at intervals on days 3, 5, 7 and 14 to assess the effect of Goji berry extract on wound healing. Following sampling, the mice were humanely euthanised using a high dose of ketamine anaesthetic in accordance with ethical standards for laboratory animals. The collected jaw tissue samples were then fixed, dehydrated using graded alcohol, cleared, and infiltrated into liquid paraffin before undergoing embedding. The paraffin blocks were sectioned using a microtome at a thickness of 5 μm , placed in a water

bath, incubated on a hot plate, and stained with haematoxylin and eosin. Histopathological observations were performed using a single-blind technique with an inverted phase-contrast microscope at 400x magnification to measure collagen fibre density. Histopathological analysis and quantification of collagen fibres were performed by the principal investigator (the author), who has been trained in histological assessment. To minimise subjective bias, measurements were performed repeatedly and duplicated twice. In addition, an experienced histological analyst supervised the procedures to ensure accuracy and consistency. Collagen fibre density was quantified using digital image analysis with ImageJ. Microscopic images (400x magnification) were captured and analysed by measuring the average diameter (thickness) of collagen fibres (μm) across several fields of view^{20,21}. The average value of these measurements was used to represent collagen density.

Data Analysis

Following data collection, the Shapiro-Wilk test was conducted to assess normality. Data normality was assessed using the Shapiro–Wilk test, followed by Levene’s test to evaluate homogeneity of variance. Based on these results, either a one-way ANOVA test with post hoc Tukey analysis was performed for normally distributed and homogeneous data, or a Kruskal–Wallis test was used for non-normally distributed data to determine differences among treatment groups.

RESULTS

The outcomes of phytochemical screening to determine the bioactive compounds present in Goji berry (*Lycium barbarum*) gel indicate that the gel contains alkaloids, flavonoids, saponins, tannins and terpenoids. This indicates that Goji berries (*Lycium barbarum*) predominantly contain polyphenolic compounds such as flavonoids, terpenoids, tannins and alkaloids.

Table 1. Phytochemical Screening Results of Goji Berry Gel

Metabolite	Résultats	Description
Alkaloid	Positif	+
Flavonoid	Positif	+
Saponin	Positif	+
Tanim	Positif	+
Steroid	Negatif	-
Terepenoid	Positif	+

Description: + : Contains a group of secondary metabolites
 - : Does not contain secondary metabolites

Table 2. Average collagen density diameter (μm) on days 3, 5, 7, and 14 in rats following tooth extraction.

Research Group	Day			
	Day 3	Day 5	Day 7	Day 14
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Negative Control	205.22 $\pm$ 84.06	234.66 $\pm$ 61.46	258.01 $\pm$ 62.30	286.72 $\pm$ 136.61
Positive Control	257.75 $\pm$ 76.86	278.97 $\pm$ 74.98	341.82 $\pm$ 61.78	303.59 $\pm$ 105.93
Goji Berry Gel 15%	320.60 $\pm$ 111.15	401.92 $\pm$ 111.70	527.33 $\pm$ 320.62	429.83 $\pm$ 106.20
Goji Berry Gel 30%	321.33 $\pm$ 108.23	515.37 $\pm$ 243.75	626.12 $\pm$ 234.91	643.82 $\pm$ 199.41
Goji Berry Gel 55%	376.11 $\pm$ 96.35	519.29 $\pm$ 92.92	676.23 $\pm$ 292.03	699.91 $\pm$ 219.70

The highest collagen density diameter on day 3 was observed in the 55% Goji berry gel group (376.11 μm), while the lowest was recorded in the negative control group (205.22 μm). On day 5, the 55% Goji berry gel group again showed the highest collagen density (519.29 μm), and the negative control group showed the lowest (234.66 μm). The same pattern was observed on days 7 and 14, where the 55% Goji berry gel group recorded the highest values of 676.23 μm and 699.91 μm , respectively, while the negative control group recorded the lowest values of 258.01 μm and 286.72 μm .

Histopathological examination revealed that the collagen fibres appeared thick, dense and regularly arranged, with a more intense blue staining in the Goji berry gel group, whilst the negative control group showed collagen fibres that appeared thin, sparse and irregularly arranged (Figure 1 and Figure 2). On day 3, collagen density values across all groups were relatively similar, indicating that acute inflammation was still

ongoing around the socket tissue, degrading collagen components. An increase in collagen density began to appear on day 5 across all groups, with the most pronounced increase observed in the 30% and 55% Goji berry gel groups. The highest collagen density was recorded on day 7, where the Goji berry gel groups exhibited thicker and more densely packed collagen fibres compared to both control groups. By day 14, the 30% and 55% Goji berry gel groups continued to show a consistently increasing collagen density, with a homogeneous and intense blue colour indicating the deposition of nearly mature collagen extracellular matrix and the ongoing process of tissue remodelling. The positive control group (Povidone Iodine) showed moderate collagen density, greater than the negative control yet less than all the Goji berry gel groups.

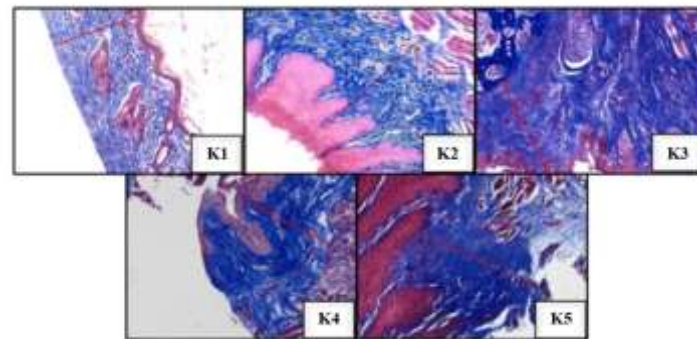


Figure 1. Collagen histology in rat alveolar bone tissue on day 7 following tooth extraction.

Note: K1 = Negative control (tooth extraction only); K2 = Positive control (treatment with povidone-iodine); K3, K4 and K5 = Treatment with Goji berry gel at concentrations of 15%, 30% and 55%.

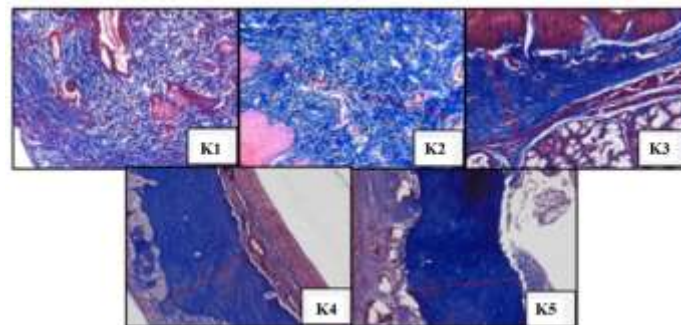


Figure 2. Collagen histology in rat alveolar bone tissue on day 14 following tooth extraction.

Note: K1 = Negative control (tooth extraction only); K2 = Positive control (treatment with povidone-iodine); K3, K4 and K5 = Treatment with Goji berry gel at concentrations of 15%, 30% and 55%.

The outcomes of the Shapiro-Wilk normality test and Levene's test of homogeneity demonstrated that all data exhibited a normal distribution and homogeneity ($p > 0.05$); consequently, the analysis was conducted utilizing a one-way ANOVA in conjunction with Duncan's post-hoc test. The findings from the One-Way ANOVA revealed no statistically significant differences among the groups on day 3 ($p = 0.09$), whereas significant differences were observed on days 5, 7, and 14 ($p < 0.05$). The results of Duncan's Post-Hoc test are delineated in Table 3.

Table 3. Results of Duncan's post-hoc test for mean collagen density (μm) on days 5, 7 and 14.

Day	Research Group				
	Negative Control	Positive Control	Goji Berry Gel 15%	Goji Berry Gel 30%	Goji Berry Gel 55%
Day 5	234,66 ^a	278,97 ^a	401,92 ^a	515,37 ^b	515,29 ^b
Day 7	258,01 ^a	341,82 ^{ab}	527,33 ^{abc}	626,12 ^{bc}	676,23 ^c
Day 14	286,72 ^a	303,59 ^a	429,83 ^a	643,82 ^b	699,91 ^b

Note: Different letters within the same column signify a statistically significant difference ($p < 0.05$; Duncan's multiple range test).

According to the findings of Duncan's post-hoc test, the 30% and 55% Goji berry gel groups exhibited statistically significant differences when compared to the negative control, positive control, and 15% Goji berry gel groups on days 5 and 14. On day 7, the negative control group differed significantly from the 30% and 55% Goji berry gel groups, whilst the positive control and 15% Goji berry gel groups showed no significant

differences. These results demonstrate that the administration of 30% and 55% Goji berry gel consistently exerts a significant effect on increasing collagen density in the alveolar socket tissue following tooth extraction in rats.

DISCUSSION

Goji berry (*Lycium barbarum* L.) extract gel has been shown to increase collagen density in the alveolar tissue of rats following tooth extraction, as demonstrated by histopathological observations and statistical analysis. This is supported by phytochemical screening results showing that Goji berries contain bioactive compounds such as flavonoids, alkaloids, saponins, tannins, and triterpenoids, which have the potential to increase collagen deposition in wound tissue.

The mechanism by which Goji berry gel increases collagen density begins with the acute inflammatory phase following tooth extraction, triggered via the nuclear factor kappa beta (NF- κ B) pathway, during which macrophages and neutrophils infiltrate the socket tissue and phagocytose residual matrix and bacteria.²² This effect is primarily mediated by bioactive compounds in goji berries, particularly *Lycium barbarum* polysaccharides (LBP), flavonoids, and phenolic compounds.²³ The flavonoids and phenolic compounds in Goji berry gel subsequently reduce the production of pro-inflammatory cytokines and collagenase, whilst modulating signalling pathways that support fibroblast proliferation and activity. Granulation cells then secrete growth factors such as TGF- β 1, PDGF, TNF, and IL-1, which play a role in stimulating fibroblast formation to synthesise collagen. Flavonoids also act as antioxidants that inhibit Matrix Metalloproteinases (MMPs), ensuring that the collagen that has formed does not degrade rapidly and that the density of the collagen tissue in the wound area is maintained.^{22,24}

On day 3 post-extraction, collagen density values across all groups were relatively similar and showed no significant difference ($p=0.09$), indicating that the tissue was still in the acute inflammatory phase, dominated by neutrophil and macrophage infiltration, meaning that the proliferation phase had not yet progressed optimally. An increase in collagen density began to appear on day 5, marking the onset of early collagen deposition and the formation of a temporary extracellular matrix scaffold. The peak of the proliferation phase occurred between days 7 and 14, during which collagen synthesis increased significantly and the structure of the socket-filling tissue began to form. By day 14, collagen consolidation occurs alongside a transition from type III collagen to type I collagen, as evidenced histologically by a more homogeneous and intense blue staining in the group treated with Goji berry gel.

The outcomes of Duncan's post-hoc test indicated that the 30% and 55% Goji berry gel groups significantly differed from both the negative and positive control groups on days 5, 7, and 14 ($p<0.05$), whilst the 15% Goji berry gel group did not show any significant difference from either control group. This suggests that the 15% concentration does not yet demonstrate efficacy in enhancing collagen density in comparison to the 30% and 55% concentrations. The content of *Lycium barbarum* polysaccharides (LBP) at higher concentrations promotes a consistent increase in collagen density, in line with the statement Zhang et al. (2019)¹⁸ that LBP can increase the expression of type I collagen (COL1A1) and stimulate osteoblast differentiation. The positive control group (Povidone Iodine) showed moderate collagen density, higher than the negative control but lower than all Goji berry gel groups, indicating that Povidone Iodine tends to act as an inflammatory modulator with a neutral effect on collagen deposition depending on its concentration.

This study is limited by the use of an animal model and a semi-quantitative histopathological assessment, which may not fully represent clinical outcomes in humans. Therefore, the findings and analysis of this study lead to the conclusion that the application of Goji berry (*Lycium barbarum* L.) extract gel notably enhances collagen fibre density in the alveolar tissue of rats post tooth extraction, with the most effective concentration identified in the 55% Goji berry gel group.

REFERENCES

1. Kurniamy CS, Ramlis R, Rustandi H. Relationship Between Tooth Brushing Behaviour And Cariogenic Food Consumption Habits With Dental Caries Incidence Dental Caries In SD Negeri 50 Bengkulu City Year 2024. *Student Scientific Journal*. 2025;3(2):145-154.
2. World Health Organization. Oral Health. World Health Organization. 2022.
3. Nanda LM, Endriani R, Anggraini D, Prakoso AT, Rafni E. Hubungan karies gigi dengan kualitas hidup pada anak usia Sekolah Dasar: studi cross-sectional. *Jurnal Kedokteran Gigi Universitas Padjadjaran*. 2025;37(3):320-326.
4. Balitbangkes RI. *Laporan Riskesdas 2018 Nasional*. 2018.

5. Dewi CD, Syamsudin E, Hadikrishna I. Karakteristik pasien dan diagnosis pencabutan gigi pada pasien di klinik eksodontia RSGM Universitas Padjadjaran Characteristics patient and indications of tooth extraction of patients at the exodontia clinic Padjadjaran University Dental Hospital. *Jurnal Kedokteran Gigi Universitas Padjadjaran*. 2022;34(2):152-158.
6. Sudiasih NL, Dewi NPDC. Tooth Extraction Management Using the Open Method Extraction Technique for the Maxillary First Molar. *Interdental Jurnal Kedokteran Gigi (IJKG)*. 2025;21(3):514-519.
7. Ermawati T, Harmono H, Kartikasari D. Effectiveness of robusta coffee bean extract gel on collagen fibers density in post-gingivectomy wound healing. *Odonto Dent J*. 2021;8:9.
8. Yu J, Yan Y, Zhang L, et al. A comprehensive review of goji berry processing and utilization. *Food Sci Nutr*. 2023;11(12):7445-7457.
9. Pascawinata A. *Preservasi Tulang Alveolar Pasca Pencabutan Gigi: Dasar, Penerapan Dan Pengembangan*. Deepublish; 2025.
10. Oktalevia A, Purnamasari R. *Menggali Manfaat Ekstrak Berbagai Tanaman Untuk Kesehatan Gigi Dan Mulut*. CV. Gita Lentera; 2025.
11. Halim S, Girsang E, Ehrich IN, Napiah A. Effectivity of gel ethanolic extract of senggani leaves (*Melastoma candidum* D. Don) in increasing the number of fibroblast cells and thickness of collagen fibers against socket wound after tooth extraction on male white rats. *Eff Gel Ethanolic Extr Senggani Leaves (Melastoma candidum D Don) Increasing Number Fibroblast Cells Thick Collagen Fibers Against Socket Wound after Tooth Extr Male White Rats*. 2019;60:159-173.
12. Ermawati T, Harmono H, Kartikasari D. Effectiveness of robusta coffee bean extract gel on collagen fibers density in post-gingivectomy wound healing. *Odonto Dent J*. 2021;8:9.
13. Anggraeni W, Ekawati ER, Santoso SD, Al Batati N. Antibacterail Activity Goji Berry Extract Against *Staphylococcus Aureus* and *Streptococcus Pyogenes*. *Jurnal SainHealth*. 2025;9(2):76-83.
14. Shi X, Wang X, Zheng Y, Fu L. Advances in the study of bioactive compounds and nutraceutical properties of goji berry (*Lycium barbarum* L.). *Applied Sciences*. 2024;15(1):262.
15. Rangi R. POTENTIAL AND BENEFITS OF SIJENTIKFRUIT (*Baccaurea polyneura*) AS A FUNCTIONAL FOOD FOR HEALTH. *Jurnal Teknologi Pangan dan Ilmu Pertanian (JIPANG)*. 2025;7(01):28-33.
16. Giri IMDS, Wardani IGA, Suen NMD. Peran metabolit sekunder tumbuhan dalam pembentukan kolagen pada kulit tikus yang mengalami luka bakar. *Usadha*. 2021;1(1).
17. Shi X, Wang X, Zheng Y, Fu L. Advances in the study of bioactive compounds and nutraceutical properties of goji berry (*Lycium barbarum* L.). *Applied Sciences*. 2024;15(1):262.
18. Zhang H, Zheng L, Yuan Z. *Lycium barbarum* polysaccharides promoted proliferation and differentiation in osteoblasts. *J Cell Biochem*. 2019;120(4):5018-5023.
19. Chandra D, Rahmah R. Uji fisikokimia sediaan emulsi, gel, emulgel ekstrak etanol goji berry (*Lycium barbarum* l.). *MEDFARM: Jurnal Farmasi dan Kesehatan*. 2022;11(2):219-228.
20. Rosenbaum AJ, Wicker JF, Dines JS, et al. Histologic stages of healing correlate with restoration of tensile strength in a model of experimental tendon repair. *HSS Journal®*. 2010;6(2):164-170.
21. SAM ADP. Analysis of Procollagen Type I N-Terminal Peptide (PINP), Procollagen Type III N-Terminal Peptide (PIIINP), and Histopathology in Rat Achilles Tendon (*Rattus Norvegicus*). Universitas Hasanuddin; 2025.
22. Yang T, Hu Y, Yan Y, et al. Characterization and evaluation of antioxidant and anti-inflammatory activities of flavonoids from the fruits of *Lycium barbarum*. *Foods*. 2022;11(3):306.
23. Shi X, Wang X, Zheng Y, Fu L. Advances in the study of bioactive compounds and nutraceutical properties of goji berry (*Lycium barbarum* L.). *Applied Sciences*. 2024;15(1):262.
24. Qing C. The molecular biology in wound healing & non-healing wound. *Chinese Journal of Traumatology*. 2017;20(04):189-193.