

Original Research Article

Preparation of *Moringa oleifera* gel for the treatment of second-degree burns in a diabetic rat model

Elis Anggeria, Chrismis Novalinda Ginting*, Tiarnida Nababan

Faculty of Nursing and Midwifery, Universitas Prima Indonesia, Medan, Indonesia

*For correspondence: **Email:** chrismis@unprimdn.ac.id

Sent for review: 5 December 2025

Revised accepted: 19 March 2026

Abstract

Purpose: To determine the effectiveness of *Moringa oleifera* leaf extract in a gel preparation for treating second-degree burns in diabetic rat models.

Method: The animals were divided into five groups labelled placebo, Bioplacenton®, and test preparations of 5, 10, and 15 % concentrations, respectively. Diabetes mellitus was first induced using intraperitoneal streptozotocin at a dose of 30 mg/kg BW and confirmed on the 3rd day; then, second-degree burns were made on the backs of the animals. The 96 % ethanolic extract of mature *Moringa oleifera* was made into a gel. The placebo, Bioplacenton and gel preparations were then applied to the wounds of their labelled models. Wound healing was assessed through the healing rate based on the percentage decrease in wound diameter on the day of observation compared to the wound diameter the day after the wound was made.

Results: There were statistically significant differences in wound healing rates among the groups (Bioplacenton, Placebo, 5, 10, and 15 %) treated with *Moringa* leaf gel on the 3rd, 6th, and 9th day ($p < 0.05$). There was no significant difference in healing rate among the 5 groups on the 12th and 14th day ($p > 0.05$). The average healing of second-degree burns occurred on the 14th day.

Conclusion: *Moringa* leaves in gel preparations at 5, 10, and 15 % accelerate the healing process of second-degree burns in diabetic rat model.

Keywords: Extract, *Moringa* leaves, Gel, Burns, Degree II

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited.

Tropical Journal of Pharmaceutical Research is indexed by Scopus, Chemical Abstracts, Embase, Index Copernicus, EBSCO, African Index Medicus, JournalSeek, Directory of Open Access Journals (DOAJ), African Journal Online, Bioline International, Open-J-Gate and Pharmacy Abstracts

INTRODUCTION

Diabetes mellitus (DM) is a chronic condition characterized by insufficient insulin production by the pancreas or the body's inability to use the insulin produced adequately [1]. By 2045, diabetes cases are projected to surge to 783 million, accompanied by a corresponding increase in the burden of care [2]. Unfortunately, this condition is often underdiagnosed in low-and-middle-income countries in Africa, the Western Pacific, and Southeast Asia [2]. Diabetes in Indonesia is also projected to

increase from 18.69 million cases in 2020 to 40.7 million cases in 2045. This figure represents an increase from 9.19 to 16.09 %. If appropriate interventions are implemented, this prevalence will decrease [3].

Untreated Diabetes mellitus results in a variety of complications, including the obstruction of microvascular blood vessels, such as retinopathy and nephropathy, and macrovascular diseases, such as coronary artery disease and blood vessels in the extremities [4]. Type 2 DM is a chronic metabolic disorder characterized by

insulin resistance and a relative deficiency in insulin secretion, resulting in persistent hyperglycemia. It is the most common form of diabetes and is strongly associated with lifestyle factors such as unhealthy dietary patterns, physical inactivity, obesity, and tobacco use [1]. People with DM typically experience significantly slower wound healing compared to individuals without diabetes. In people with diabetes, physiological mechanisms of hemostasis, inflammation, proliferation, and remodeling, and cellular processes are impaired, which leads to chronic, non-healing wounds and serious complications such as infection or ulcers [5].

Treatment of DM requires comprehensive wound care, including debridement and cleansing, as well as topical antibiotic administration. Burns and their management are important medical issues. Loss of the skin's physical barrier function facilitates microbial penetration and lead to infection [6]. Second-degree burns are the most common type of burn in clinical practice and are difficult to treat. Particular attention is paid to the fact that formulating a clinical management plan presents significant challenges. Second-degree burns often exhibit dynamic changes in the early post-burn period, which are not only determined by their pathophysiological characteristics but also closely related to wound interventions and other factors. Timely and rational pre-hospital first aid and appropriate wound care after hospital admission are crucial in preventing wound deepening [7].

Moringa oleifera Lam. (Family: Moringaceae) is a tropical deciduous tree, originating in India, widely planted in Asia, Africa, and Central America. Its leaves, roots, and seeds are used as food, and its active components have various pharmacological functions, including antioxidant, anti-inflammatory, anti-diabetic, lipid-lowering, anticancer, and antibacterial properties [8]. Ethanolic extract of mature *Moringa oleifera* leaves influences the catalytic activity of paraoxonase - 1 and catalase enzymes to compensate for changes triggered by diabetes in rats. [9]. The gel dosage form is one of the best choices for optimizing the antioxidant activity of *Moringa* leaves [10].

Several scientific studies have reported phytochemical tests of *Moringa* leaves in powder, cream, ointment, and gel forms. *Moringa* leaves extract possesses numerous therapeutic benefits, including antioxidant, anticancer, antidiabetic, and antimicrobial properties. Despite the known pharmacological properties of *Moringa oleifera*, there is limited evidence regarding its effectiveness in topical gel formulations for the

treatment of burn wounds under diabetic conditions. The purpose of this study is to investigate the effectiveness of *Moringa oleifera* leaf extract in gel preparations for healing second-degree burns in a diabetes mellitus model in rats.

EXPERIMENTAL

Materials

Moringa oleifera leaf extract, 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical, and glycine, vitamin C (Sigma - Aldrich, USA). Sodium-carboxymethyl cellulose (CMC - Na), propylene glycol, methylparaben, methanol, 96 % ethanol, hydrochloric acid (HCl), ammonia, chloroform, sulfuric acid (H₂SO₄), Dragendorff's reagent, ferric chloride (FeCl₃), potassium ferricyanide K₃(Fe(CN)₆) and sodium chloride (NaCl), Merck, Germany.

Plant preparation

Mature *Moringa oleifera* leaves were collected locally. Botanical identification and authentication were performed by a botanist at the Faculty of Medicine, Dentistry, and Health Sciences (FKKGIK) at Universitas Prima Indonesia (UNPRI). A voucher specimen was deposited in the institutional herbarium under voucher number (MO - 021/2024) for future reference.

Extraction

The dried *Moringa oleifera* leaves were ground into a fine powder using a blender. A total of 1,000 g of dried leaf powder was macerated in a single stage using 7 L of 96 % ethanol for 5 days with daily stirring at room temperature. The mixture was then filtered to obtain the filtrate. The solution was evaporated using a rotary evaporator and thickened in a water bath at a temperature of 70 °C. The *Moringa* leaf extract was then semi-dried in the open air and heated in an oven at 50 - 60 °C until completely dry.

Animal

The study consisted of 25 male white rats (*Rattus norvegicus*), aged 2 - 3 months and weighing 120 - 200 g, obtained from a certified laboratory animal breeding facility. The rats were housed in standard polypropylene cages under controlled environmental conditions (temperature 22 - 25 °C, relative humidity 50 - 60 %, and a 12 - hour light/dark cycle). All animals were acclimatized for 7 days. Rats were provided with standard laboratory pellet diet and unlimited access to drinking water. All rats were induced

with diabetes mellitus by a single intraperitoneal injection of streptozotocin (STZ) at 30 mg/kg body weight (BW). Fasting blood glucose (FBG) levels were measured on the third day after streptozotocin (STZ) injection. Before blood sampling, the rats were fasted for 8 - 12 hours with free access to drinking water. Blood samples were taken from the tail vein, and glucose levels were measured using a portable glucometer and glucose test strips. Rats with fasting blood glucose levels ≥ 126 mg/dL were considered diabetic [11].

Ethical approval

Ethical approval was obtained from the Health Research Ethics Committee (*Komisi Etik Penelitian Kesehatan, KEPK*) of Universitas Prima Indonesia, Medan, Indonesia (approval no. 021/KEPK/UNPRI/XII/2023).

Body weight (BW) and Blood glucose level (BGL) determination

Body weight was recorded using a digital analytical balance, while blood glucose levels were measured before treatment as described in the protocol. The test preparation used to heal diabetes mellitus burns in this study was *Moringa* leaf ethanol extract in gel preparation. *M. oleifera* leaves.

Phytochemical test

The presence of various phytochemical constituents such as alkaloids, flavonoids, saponins, tannins and triterpenoids was determined by following standard procedures [11].

Antioxidant activity

This assay was performed using a standard DPPH radical scavenging method. Two milligrams of the sample extract was mixed with 2 mL of a methanol solution containing 100 ppm DPPH (1,1-diphenyl-2-picrylhydrazyl). The solution was diluted to obtain four concentrations (10, 20, 30, and 40 ppm) for calibration.

DPPH solution preparation

The DPPH at different concentrations of 40 ppm and up to 100 ppm was prepared. The mixture was stirred and left in a dark room for 30 minutes. The comparison was observed with a standard vitamin C solution. Next, measurements were performed using a spectrophotometer at an absorbance wavelength of 517 nm. The blank used is methanol. The magnitude of the activity

of the antioxidant compound is then calculated. The percent inhibition of DPPH was calculated using Eq 1.

$$\text{Inhibition (\%)} = \{(A_{\text{blank}} - A_{\text{sample}}) / A_{\text{blank}}\} 100 \dots\dots (1)$$

Where: A_{blank} = absorbance of the DPPH solution with methanol (blank); A_{sample} = absorbance of the DPPH solution with the sample or extract.

Gel formulation

The gel preparations had varying concentrations of *Moringa* leaf extract, namely, 5, 10, and 15 %. A total of 50 mL of distilled water was heated to 80 °C, CMC - Na was added until it expanded and formed a base, then methylparaben and propylparaben, which were dissolved in hot water, and mixed with a blend of propylene glycol, and extract of *Moringa* leaves, until homogeneous and distilled water was added.

Animal grouping and handling

Animals were randomly divided into five groups, with five rats in each group. Wound measurements were performed by an investigator blinded to the treatment groups. Group I served as the negative control and consisted of diabetic burn-induced rats treated with the gel base (placebo). Group II served as the positive control and consisted of diabetic burn-induced rats treated with Bioplacenton® gel. Group III consisted of diabetic burn-induced rats treated with a topical gel containing 5 % ethanolic extract of *Moringa oleifera* leaves. Group IV consisted of diabetic burn-induced rats treated with a topical gel containing 10 % ethanolic extract of *Moringa oleifera* leaves. Group V consisted of diabetic burn-induced rats treated with a topical gel containing 15 % ethanolic extract of *Moringa oleifera* leaves. Observations were made on days 3, 6, 9, 12, and 14, and the wound was measured with a caliper. Rats had their hair shaved on the upper back. Next, the diabetic rats were anesthetized using 0.12 mL of ketamine intramuscularly (IM), then a special circular metal plate, 2 cm x 2 cm in diameter, heated to 100 °C, was attached to the rats' upper back area for 30 seconds. Burns are considered circular; therefore, the circle, divided into several radial lines, depicts the direction of wound diameter measurement from several sides. Wound diameter was measured in four main directions (e.g., vertical, horizontal, and two diagonals) and was calculated using Eq 2.

$$D \text{ (mm)} = (d_1 + d_2 + d_3 + d_4) / 4 \dots\dots\dots (2)$$

Where: d: Wound diameter on the day of observation.

Wound healing determination

The percentage of wound healing (W) was calculated based on the reduction in wound diameter using Eq 3.

$$W (\%) = \{(d_1^2 - d_2^2) / d_1^2\} 100 \dots\dots\dots (3)$$

d1: Wound diameter the day after wound 1 was made, d2: Wound diameter on the day of observation

Data analysis

The data were analyzed univariately descriptively on healing second-degree burns in diabetic rats. Data were analyzed using the Statistical Package for the Social Sciences software. The normality of the data distribution was assessed using the Shapiro–Wilk test, while the homogeneity of variances among groups was evaluated using Levene's test. Data that were normally distributed and homogeneous were further analyzed using one-way analysis of variance (ANOVA), followed by an appropriate post hoc test to identify differences between groups. A *p*-value of < 0.05 was considered statistically significant.

RESULTS

Phytochemical contents

Results for phytochemical screening showed that alkaloid, flavonoid, saponin, tannin, and triterpenoid/steroid compounds were positive, meaning they were present in the extract (Table 1).

Table 1: Phytochemical screening results of ethanolic extract of *Moringa oleifera* leaves

Phytochemical compound	Description
Alkaloids	Brown precipitate
Flavonoids	Reddish - brown solution
Saponins	Stable foam
Tannins	Dark blue solution
Triterpenoids / Steroids	Greenish solution

Antioxidant activity test

The results of the antioxidant activity of *Moringa* leaf extract at concentrations of 10 ppm, 20 ppm, 30 ppm, and 40 ppm in triplicate showed average results of 58, 58, 36, and 41 %, respectively, while the antioxidant activity of vitamin C was 51, 48, 57, and 54 %, respectively.

Wound healing activity of *Moringa oleifera* leaf extract in gel

Fasting blood glucose levels (FBG) measured before streptozotocin (STZ) administration were < 126 mg/dL, indicating that the rats were not diabetic. After STZ administration, fasting blood glucose levels increased to > 126 mg/dL, confirming the successful induction of diabetes mellitus. The study results showed that burn wounds were closed in rats given *Moringa* leaf extract in a gel preparation. Closure rate of burn wounds in rats given the ethanol extract gel concentration of *Moringa* leaves in group 3 (5 %) was faster than in group 5 (15 %) and the negative control/placebo. The results show that *Moringa* leaves in gel preparation of 5 % and 10 % concentrations cause burn wounds in rats to close more quickly than in rats not given treatment (Table 2).

DISCUSSION

The plant material used in this study was mature *Moringa oleifera* leaves. Extraction is the process of separating a substance based on its solubility difference in two immiscible liquids, usually water and another organic solvent. The chemical composition of natural products is identified by a low content of active components and a complex composition. This process facilitates subsequent work in purification, analysis, and separation. Second-degree burns are superficial partial thickness burns (IIA) and deep partial thickness burns (IIB) [12]. A second-degree burn, or superficial partial-thickness burn, impacts the upper layer of the dermis. Blisters are prevalent and may remain unbroken during the initial assessment. After unroofing the blister, the exposed wound bed appears uniformly red or pink and exhibits blanching upon application of pressure. These burns are excruciating. Recovery generally occurs within 2 to 3 weeks with no scarring [13].

There were differences in healing rate among groups (Bioplacenton, Placebo, 5 %, 10 %, and 15 %) on the 3rd, 6th, and 9th day, with *p* < 0.05; however, there were no differences in healing rate on the 12th and 14th day. The results show that *Moringa* leaves in gel preparations at concentrations of 5, 10, and 15 % speed up the healing process of second-degree burns. The most significant outcome for the healing results for second-degree burns occurred on the 14th day at a concentration of 15 % of *Moringa* leaf gel. The lack of significant differences in wound healing rates between groups on days 12 and 14 may be due to the late proliferative and early remodeling phases. At this stage, re-

epithelialization is largely complete. Bioactive compounds in *Moringa oleifera* modulate inflammation, increase fibroblast proliferation,

and promote collagen synthesis, contributing to accelerated early-phase healing [14].

Table 2: Healing rate of Grade II burns in diabetic rats (n = 5)

Days	Treatment	Mean $\pm$ SD (mm)	P-value
3rd-day wound	Bioplacenton	17.62 $\pm$ 0.75	0.000
	Placebo	20.50 $\pm$ 0.78	
	5 %	17.50 $\pm$ 0.81	
	10 %	18.32 $\pm$ 0.93	
	15 %	17.60 $\pm$ 1.14	
6th-day wound	Bioplacenton	15.46 $\pm$ 0.82	0.000
	Placebo	21.34 $\pm$ 2.31	
	5 %	16.58 $\pm$ 0.80	
	10 %	16.98 $\pm$ 0.71	
	15 %	15.22 $\pm$ 1.49	
9th-day wound	Bioplacenton	13.70 $\pm$ 1.38	0.003
	Placebo	19.34 $\pm$ 3.55	
	5 %	15.94 $\pm$ 1.41	
	10 %	14.80 $\pm$ 1.67	
	15 %	14.92 $\pm$ 1.13	
12th-day wound	Bioplacenton	10.86 $\pm$ 6.25	0.092
	Placebo	19.58 $\pm$ 4.87	
	5 %	11.76 $\pm$ 6.66	
	10 %	9.20 $\pm$ 8.63	
	15 %	7.64 $\pm$ 6.97	
14th-day wound	Bioplacenton	8.16 $\pm$ 4.86	0.093
	Placebo	15.04 $\pm$ 3.50	
	5 %	8.12 $\pm$ 4.79	
	10 %	6.92 $\pm$ 6.74	
	15 %	6.16 $\pm$ 5.63	

Moringa leaves contain many bioactive substances such as minerals, vitamins, and phytochemicals, making them a valuable source of active ingredients for health products. Microparticles that have been developed and filled with *Moringa oleifera* extract are an essential ingredient for wound healing [8]. *Moringa oleifera* (MO) is a tree belonging to the *Moringaceae* family originating from South Asia [8]. Al-Ghanayem *et al* showed that *M. oleifera* extract had antioxidant properties [15]. Rubio-Sanz *et al* [14] demonstrated that *Moringa oleifera* leaves contain high concentrations of several nutrients, such as calcium, potassium, and iron, compared to other *Moringa* species, such as *M. stenopetala* and *M. peregrina*. In addition, the presence of various bioactive compounds, including β - β -carotene (provitamin A), ascorbate (vitamin C), and glutathione (primarily functioning as antioxidants), as well as chlorogenic acid with anticancer properties and quercetin with antioxidant, anticancer, and antidiabetic activities, has been well documented [14]. *Moringa* leaf extracts have demonstrated antidiabetic and anti-inflammatory effects in experimental models, including reductions in insulin resistance, glucose levels, and pro-inflammatory cytokines such as TNF- α [15]. *Moringa* leaves lower indices of liver functioning in hyperglycemic situations. The flavonoid group

among the bioactive elements in the leaves is important in blood glucose level maintenance. Flavonoids' antioxidant qualities allow one to stop liver damage, leading to higher circulation of liver enzyme release. The extract also slows the formation of cancer tissue [14]. *Moringa* leaf extract formulations induce the expression of the vascular endothelial growth factor (VEGF) and gene expression of Transforming Growth Factor (TGF - β 1) and promote increased tissue proliferation in the wound area. The efficacy of *M. oleifera* extract was less evident in treating *P. aeruginosa* - contaminated wounds in diabetic rats, indicating variable impact depending on the infecting pathogen [16]. The gel form is determined to be suitable for use [17].

CONCLUSION

Moringa oleifera leaf ethanol extract contains polyphenols, flavonols, and alkaloids. This extract possesses antioxidant, anti-inflammatory, antidiabetic, and antibacterial properties. The results show that *Moringa* leaves in gel preparations at concentrations of 5, 10, and 15 % accelerates the healing process of second-degree burns in a rat model. The most significant healing results for second-degree burns were observed on the 14th day, using a 15% *Moringa* leaf extract gel.

DECLARATIONS

Acknowledgment/Funding

We would like to express our profound appreciation to Universitas Prima Indonesia for granting authorization and facilitating the conduct of this research. We also appreciate the Faculty of Medicine, Dentistry, and Health Sciences (FKKGIK) at Universitas Prima Indonesia (UNPRI), which contributed to the completion of this study. We are also grateful for the constructive comments and feedback from reviewers on this manuscript.

Ethical clearance

This study protocol was reviewed and approved by the Health Research Ethics Committee (KEPK) of Universitas Prima Indonesia, Medan, Indonesia. Ethical approval was granted under approval number 021/KEPK/UNPRI/XII/2023.

Use of Artificial intelligence/Large language models

We also declare that we did not use Generative artificial intelligence (AI) and AI-assisted technologies in writing the manuscript.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

No conflict of interest is associated with this work.

Contribution of authors

We declare that this work was done by the author(s) named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors.

REFERENCES

1. World Health Organization. Diabetes 2024. <https://www.who.int/news-room/fact-sheets/detail/diabetes>.
2. Hossain MJ, Al-Mamun M, Islam MR. Diabetes mellitus, the fastest-growing global public health concern: Early detection should be focused. *Health Sci Rep* 2024; 7: e2004–e2004. <https://doi.org/10.1002/hsr2.2004>.
3. Wahidin M, Achadi A, Besral B, Kosen S, Nadjib M, Nurwahyuni A, Ronoatmodjo S, Rahajeng E, Pane M, Kusuma D. Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. *Sci Rep* 2024; 14: 5424. <https://doi.org/10.1038/s41598-024-54563-2>.
4. Abu-Kamar MK, Abu-Qamar AA. Factors associated with uncontrolled diabetes mellitus among diabetic patients in Jordan: A cross-sectional study. *Trop J Pharm Res* 2025; 24: 1299–304. <https://doi.org/10.4314/tjpr.v24i10.10>.
5. Dasari N, Jiang BSAA, Skochdopole A, Chung J, Reece EM, Vorstenbosch J, Winocour S. Updates in diabetic wound healing, inflammation, and scarring. *Semin Plast Surg* 2021; 35: 153–158. <https://doi.org/10.1055/s-0041-1731460>.
6. Żwierzeło W, Piorun K, Skórka-Majewicz M, Maruszewska A, Antoniewski J, Gutowska I. Burns: Classification, pathophysiology, and treatment: A review. *Int J Mol Sci* 2023; 24: 3749. <https://doi.org/10.3390/ijms24043749>.
7. Ji S, Xiao S, Xia Z. Consensus on the treatment of second-degree burn wounds (2024 edition). *Burns Trauma* 2024; 12: 1–36. <https://doi.org/10.1093/burnst/tkad061>.
8. Cao J, Shi T, Wang H, Zhu F, Wang J, Wang Y, Cao F, Su E. Moringa oleifera leaf protein: Extraction, characteristics and applications. *Journal of Food Composition and Analysis* 2023; 119: 105234. <https://doi.org/10.1016/j.jfca.2023.105234>.
9. Sierra-Campos E, Valdez-Solana M, Avitia-Domínguez C, Campos-Almazán M, Flores-Molina I, García-Arenas G, Téllez-Valencia A. Effects of Moringa oleifera leaf extract on diabetes-induced alterations in paraoxonase 1 and catalase in rats analyzed through progress kinetic and blind docking. *Antioxidants* 2020; 9: 840. <https://doi.org/10.3390/antiox9090840>.
10. Barros MC, Silva VCS, Silva AGB, Silva Neto JC, Maux JML, Santos PÉM, Oliveira WA, Coelho LCB, Fernandes MP, Oliveira AM, et al. Antioxidant activity and chemoprotective effect of Moringa oleifera Lam. leaf infusion against methotrexate-induced damage in rats. *Toxicol Rep* 2025; 14: 102000. <https://doi.org/10.1016/j.toxrep.2025.102000>.
11. Rumanti RM, Nainggolan M, Harahap U. Phytochemical screening and antidiabetic activity of different leaf extracts from Lotus (Nelumbo nucifera Gaertn.) in streptozotocin-induced mice. *Asian J Pharm Clin Res* 2017; 10(12): 190–192. doi:10.22159/ajpcr.2017.v10i12.20888.
12. Markiewicz-Gospodarek A, Koziol M, Tobiasz M, Baj J, Radzikowska-Büchner E, Przekora A. Burn wound healing: Clinical complications, medical care, treatment, and dressing types: The current state of knowledge for clinical practice. *Int J Environ Res Public Health* 2022; 19: 1338. <https://doi.org/10.3390/ijerph19031338>.
13. Warby R, Maani CV. Burn classification. *StatPearls* 2023. <https://pubmed.ncbi.nlm.nih.gov/30969595/>.

14. Rubio-Sanz L, Dorca-Fornell C, Fornos M, Navarro-León E, Jaizme-Vega MC. Phytochemical characterization of *Moringa oleifera* leaves. *Herba Polonica* 2021; 67. <https://doi.org/10.2478/hepo-2021-0019>.
15. Al-Ghanayem AA, Alhussaini MS, Asad M, Joseph B. *Moringa oleifera* leaf extract promotes healing of infected wounds in diabetic rats: Evidence of antimicrobial, antioxidant and proliferative properties. *Pharmaceuticals (Basel)* 2022; 15: 528. <https://doi.org/10.3390/ph15050528>.
16. Siahaan SCPT, Santoso B, Widjiati. Effectiveness of *Moringa oleifera* leaves on TNF- α expression, insulin levels, glucose levels and follicle count in *Rattus norvegicus* PCOS model. *Diabetes, Metabolic Syndrome Obesity* 2022; 15: 3255–3270. <https://doi.org/10.2147/DMSO.S385492>.
17. Pagano C, Perioli L, Baiocchi C, Bartoccini A, Beccari T, Blasi F, Calarco P, Ceccarini MR, Cossignani L, di Michele A, et al. Preparation and characterization of polymeric microparticles loaded with *Moringa oleifera* leaf extract for exuding wound treatment. *Int J Pharm* 2020; 587: 119700. <https://doi.org/10.1016/j.ijpharm.2020.119700>.