

The therapeutic role of goat milk supplementation in burn wound healing

Abstract

Background: Burn injuries require optimal nutritional and systemic support for effective healing. Goat milk contains bioactive nutrients that may enhance tissue repair.

Objective: To evaluate the impact of goat milk supplementation on burn wound healing in hospitalized patients.

Methods: This experimental study enrolled 62 burn patients (Gorontalo and Manado) from August 2023 to January 2025. Participants received 250 mL of commercially available pure goat milk daily for seven consecutive days. Wound healing was assessed every two days using the Bates-Jensen Wound Assessment Tool. Nutritional composition of goat milk was documented. Ethical clearance was obtained (EC/89617/07/2023).

Results: Accelerated epithelialization was observed in 58/62 (93.5%) patients by Day 7. Mean BWAT scores improved significantly from 38 ± 4 to 26 ± 3 ($p < 0.01$). Goat milk's proteins, medium-chain triglycerides, immunoglobulins, lactoferrin, zinc, and selenium are hypothesized to enhance collagen synthesis and modulate inflammatory pathways.

Conclusion: Goat milk supplementation appears to expedite burn wound healing and may be integrated into nutritional protocols for burn care.

Keywords: goat milk, burn injury, wound healing, bioactive compounds, experimental study

Volume 11 Issue 3 - 2025

Agussalim

Parepare School of Nursing, Makassar Health Polytechnic, Indonesia

Correspondence: Agussalim, MSN, DNS, Parepare School of Nursing, Makassar Health Polytechnic, Jalan Laupe, Parepare City, South Sulawesi Province, Indonesia, Tel +6281342273044

Received: September 24, 2025 | **Published:** November 4 2025

Introduction

Burn injuries represent one of the most severe and complex forms of trauma, with far-reaching physiological and psychological consequences. These injuries often result in prolonged hospitalization, elevated metabolic demands, immunosuppression, electrolyte imbalances, and a heightened susceptibility to infection due to the disruption of the skin's protective barrier.¹ Beyond the immediate tissue damage, burn wounds initiate a systemic inflammatory response syndrome (sirs), leading to catabolism of lean body mass and impaired wound healing if nutritional support is inadequate. Thus, effective wound management must extend beyond topical care and surgical intervention to include comprehensive nutritional therapy tailored to the body's regenerative needs.²

Central to tissue repair is the synthesis of collagen, a triple-helical structural protein that forms the backbone of granulation tissue and scar matrix. Collagen production depends heavily on the availability of specific amino acids—particularly proline, glycine, and hydroxyproline—as well as cofactors like vitamin c, zinc, and iron, which are required for post-translational modifications. Similarly, immune competence during the wound healing phase is reliant on adequate levels of micronutrients such as selenium and vitamin a, which modulate cytokine release, enhance lymphocyte function, and reduce oxidative damage at the cellular level.

In this context, goat milk emerges as a promising, naturally available nutritional intervention widely consumed in traditional societies and prized for its bioavailability and digestibility, goat milk contains a rich spectrum of macronutrients and micronutrients that collectively support cellular regeneration.³ Its protein fraction includes casein and whey proteins, which upon digestion release bioactive peptides known to promote tissue growth, stimulate insulin-like growth factor-1 (igf-1), and enhance angiogenesis. These peptides are absorbed through

the intestinal epithelium and transported via the portal circulation to the wound site, where they can influence fibroblast proliferation and extracellular matrix remodeling.

Moreover, the fat content of goat milk is predominantly composed of medium-chain fatty acids (mcfas), such as caprylic (c8), capric (c10), and lauric acid (c12), which bypass conventional lymphatic transport and are rapidly metabolized by hepatic mitochondria into ketone bodies. These ketones serve as alternative energy substrates for rapidly dividing cells at the wound margin, thus enhancing metabolic efficiency and sparing glucose for immune and reparative functions. Additionally, MCFAS possess inherent antimicrobial properties that may reduce the local microbial load on burn surfaces.⁴

Trace elements such as zinc, selenium, and magnesium present in goat milk play irreplaceable roles in enzymatic pathways essential for wound repair. Zinc acts as a catalytic component of DNA and RNA polymerases, supporting keratinocyte proliferation and epithelialization, while selenium is a vital cofactor in glutathione peroxidase, a key antioxidant enzyme that neutralizes reactive oxygen species generated during inflammation. Vitamin a, another key micronutrient in goat milk, regulates gene expression involved in cell differentiation and collagen cross-linking, crucial for restoring the structural integrity of dermal tissue.

Despite its long-standing traditional use in convalescence and its well-characterized nutritional profile, the scientific literature remains limited in quantifying the effects of goat milk on clinical wound healing outcomes in burn patients. This study aims to address that gap by empirically evaluating the therapeutic potential of goat milk as an adjunctive intervention in hospitalized individuals with thermal injuries. By integrating humanistic care with molecular understanding, the study aspires not only to validate a culturally resonant remedy but also to illuminate the mechanistic pathways through which goat milk may modulate systemic healing responses.

Methods

This experimental study recruited a total of 62 adult patients (aged 18–60 years) diagnosed with second-degree or superficial third-degree burns, admitted consecutively to two government referral hospitals in Gorontalo and Manado, Indonesia, between August 2023 and January 2025. The selection criteria aimed to ensure homogeneity of subjects and minimize confounding factors that could affect the natural course of wound healing. Patients with known allergies to cow or goat milk, severe systemic comorbidities (e.g., uncontrolled diabetes mellitus, autoimmune diseases, malignancies), or gastrointestinal intolerance (such as lactase deficiency or inflammatory bowel disease) were excluded to avoid adverse interactions with the nutritional intervention and to maintain safety and scientific rigor.

Following informed consent and baseline clinical evaluation, participants received 250 ml of pasteurized, commercially available pure goat milk administered orally each morning for seven consecutive days during their inpatient care. This intervention was conducted in conjunction with standardized burn management protocols, including wound dressing, fluid resuscitation, analgesia, infection control, and physiotherapy, as per institutional guidelines.

The nutritional composition of the goat milk was meticulously documented and standardized for each participant. Per 100 ml, the milk contained:

- i Protein: 3.6 g, primarily casein and whey proteins, which upon enzymatic digestion yield bioactive peptides that act as substrates for fibroblast proliferation and collagen matrix assembly.
- ii Fat: 4.2 g, of which approximately 55% comprised medium-chain triglycerides (MCTS) such as caprylic (c8), capric (c10), and lauric acid (c12), which are rapidly hydrolyzed and oxidized in the liver to provide immediate ATP for cellular repair mechanisms.
- iii Carbohydrates: 4.5 g, predominantly in the form of lactose, serving as a primary energy source and contributing to the absorption of calcium and magnesium in the small intestine.
- iv Micronutrients included calcium (134 mg), phosphorus (111 mg), and magnesium (14 mg), all essential for intracellular signaling and cell membrane stabilization.
- v Zinc (0.3 mg) and selenium (2 µg), which act as catalytic cofactors for zinc-dependent matrix metalloproteinase and selenium-based glutathione peroxidases, respectively, both essential for redox homeostasis and wound remodeling.
- vi Vitamin A (57 µg), a fat-soluble retinoid involved in regulating keratinocyte gene expression, epithelial differentiation, and immune modulation at the wound site.

The presence of bioactive proteins such as lactoferrin and immunoglobulins was also notable, contributing to mucosal immunity, iron regulation, and suppression of pathogenic bacterial growth within the wound bed.

To objectively quantify the wound healing trajectory, clinical evaluations were performed on days 1, 3, 5, and 7 using the bates-Jensen wound assessment tool (BWAT). This validated instrument scores multiple wound parameters including size, depth, edges, exudate type and amount, granulation tissue, and epithelialization, with lower scores indicating improved healing. The BWAT allowed for sensitive temporal tracking of wound progression in response **TO THE NUTRITIONAL INTERVENTION** in addition to BWAT

scores, secondary clinical outcomes were meticulously recorded by trained wound care nurses. These included the presence and maturation of granulation tissue (indicating angiogenesis and matrix deposition), volume and consistency of exudate (as a marker of inflammation or infection), and erythema around the wound margins (serving as an indirect measure of immune activity and vascular response). Photographic documentation and measurement standardization were used to enhance reliability.

All collected data were subjected to statistical analysis using paired t-tests, comparing wound healing indices over time within each subject. The level of statistical significance was pre-set at $\alpha = 0.05$. Missing data were handled using last-observation-carried-forward (LOCF) techniques to preserve analytical consistency. The study was powered to detect clinically meaningful differences in BWAT scores over the 7-day period with >80% power at the given alpha level.

This rigorous methodological design, integrating clinical wound observation with nutritional biochemistry, was crafted to explore not only the empirical efficacy of goat milk in enhancing tissue repair but also to open pathways for understanding its molecular underpinnings as a potential adjunct therapy in modern burn management.

Results

All 62 patients successfully completed the 7-day intervention protocol without experiencing any adverse reactions, allergic responses, or gastrointestinal disturbances, underscoring the excellent biocompatibility, hypoallergenic profile, and digestive tolerability of goat milk in the context of acute clinical care. This complete adherence rate not only indicates the biological safety of the intervention but also reflects the cultural acceptability and psychological comfort derived from the use of a familiar and traditionally endorsed nutritional supplement. The absence of attrition or dropout suggests that goat milk was well-received both physically and emotionally, facilitating a sense of therapeutic trust and compliance during hospitalization.

Quantitative assessment of wound healing using the bates-jensen wound assessment tool (BWAT) provided robust clinical data that affirmed the efficacy of the intervention. A statistically significant decline in mean BWAT scores was observed, from 38 ± 4 on day 1 to 26 ± 3 on day 7 ($p < 0.01$), indicating a substantial shift in wound healing dynamics. This decline reflects not merely numerical improvement but a multidimensional restoration of wound architecture, encompassing reductions in wound depth, necrotic tissue, undermining, and exudate, alongside improvements in granulation, epithelial migration, and tissue color. The overall reduction in BWAT score signifies not only faster recovery but also more orderly and biologically efficient tissue remodeling, which is critical in burn care where time-to-heal directly influences infection risk and scarring severity (Table 1).

Table 1 Progression of BWAT scores from day 1 to day 7

Day	Mean BWAT Score \pm SD	Epithelialization (%)
Day 1	38 \pm 4	0%
Day 3	32 \pm 3.5	42%
Day 5	28 \pm 3	74%
Day 7	26 \pm 3	93.50%

By day 7, epithelialization was clinically evident in 93.5% of patients, a critical milestone in the wound repair process. Epithelial closure serves as the biological completion of tissue regeneration, restoring barrier function and protecting the wound from microbial invasion, dehydration, and mechanical injury. This high epithelialization rate within a one-week period is notable for

patients with second-degree and superficial third-degree burns, whose baseline wounds were characterized by substantial dermal damage and inflammatory exudate. The process was accompanied by marked increases in granulation tissue formation, a reflection of healthy angiogenesis and fibroblast activity, and notable reductions in erythema and wound exudate volume, both of which are indicative of subsiding inflammation and stabilization of the local wound environment (Table 2).

Table 2 Clinical indicators of healing observed during intervention

Indicator	Day 1	Day 5	Day 7
Granulation Tissue (%)	18%	68%	92%
Erythema (Mean Area in cm ²)	12.5	7.2	3.4
Exudate Volume (mL)	22	13	5
Infection Incidence	0	0	0

Throughout the study duration, no wound infections were recorded, a finding of both clinical and public health importance. Infections in burn wounds often lead to sepsis, prolonged hospital stays, and greater costs of care. The absence of infectious complications here may be attributed in part to the immune-modulatory and antimicrobial properties of components in goat milk—such as lactoferrin, immunoglobulins, and bioavailable zinc—which may have contributed to systemic resistance and local microbial control, although further studies are needed to delineate this mechanism. Importantly, no gastrointestinal complaints such as bloating, nausea, or intolerance were reported by any participant, confirming that goat milk was not only effective but also well-tolerated as a nutritional adjunct.

Collectively, these outcomes validate the hypothesis that goat milk supplementation is a safe, acceptable, and clinically effective nutritional intervention in the management of burn wounds. The consistency of clinical improvement across multiple objective markers supports the integrative potential of goat milk in modern nursing care—where biological efficacy must harmonize with patient-centered approaches to nutrition and healing.

Discussion

Daily supplementation with goat milk demonstrably accelerated burn wound healing, as reflected by significant and measurable reductions in **BWAT** scores over the one-week intervention. The rapid improvement in wound status can be attributed to the synergistic biochemical actions of several bioactive constituents inherent in goat milk. These components interact at the cellular and molecular level to support and enhance the three critical overlapping phases of wound healing: inflammation, proliferation, and remodeling.⁵

First, the protein matrix in goat milk—composed primarily of casein and whey fractions—yields a high concentration of essential amino acids upon digestion. These include glycine, proline, lysine, and hydroxyproline precursors, which are indispensable for the biosynthesis of type i and type iii collagen fibers—major structural elements of the extracellular matrix in healing dermal tissue.⁶ Beyond their structural roles, these amino acids also modulate cell signaling pathways that influence fibroblast proliferation, myofibroblast contraction, and angiogenesis, essential processes for wound granulation and contraction.

The fat content, rich in medium-chain triglycerides (**MCTS**), undergoes rapid hydrolysis by pancreatic lipases and is absorbed directly into the portal vein. These fatty acids—particularly caprylic (c8), capric (c10), and lauric (c12) acids—are rapidly oxidized in

hepatic mitochondria to generate atp, bypassing the carnitine shuttle required **FOR LONG-CHAIN FATTY ACIDS**⁷ The increased energy availability at the cellular level supports heightened metabolic demands during tissue regeneration. In addition, **MCTS** may exert epigenetic effects on inflammatory gene expression through modulation of nuclear transcription factors such as nf- κ b and ppar- γ , thereby attenuating excessive inflammatory responses common in burn wounds.

Lactoferrin, a multifunctional iron-binding glycoprotein present in goat milk, contributes both antimicrobial and anti-inflammatory properties. By sequestering free iron, it limits bacterial proliferation and biofilm formation at the wound site, a key factor in **PREVENTING SECONDARY INFECTION**.⁸ Simultaneously, Lactoferrin modulates cytokine production, promoting anti-inflammatory interleukins (e.g., il-10) while down regulating pro-inflammatory mediators such as tnf- α and il-6. These effects stabilize the inflammatory phase and prepare the wound microenvironment for effective tissue remodeling.

Immunoglobulins (primarily igg and secretory iga) play a pivotal role in enhancing mucosal and **SYSTEMIC IMMUNE FUNCTION**.⁹ These immunoglobulins bind to pathogenic antigens, activate complement cascades, and facilitate phagocytic clearance by neutrophils and macrophages. Their presence may contribute to the infection-free course observed in all patients during the study, reinforcing their role in innate immune surveillance at epithelial barriers.

Trace elements such as zinc and selenium further underpin antioxidant and reparative processes. Zinc acts as a catalytic center in over 300 metalloenzymes, including DNA and RNA polymerases, and matrix metalloproteinase (**MMPS**), which are crucial for keratinocyte migration and **EXTRACELLULAR MATRIX TURNOVER**.¹⁰ Selenium, incorporated into selenoproteins like glutathione peroxidase, neutralizes reactive oxygen species generated during the inflammatory cascade, thereby reducing oxidative cellular injury and lipid **PEROXIDATION IN NEWLY FORMING TISSUE**.¹¹ Both elements work in tandem to preserve cellular redox balance and protect rapidly dividing cells at the wound site.

Vitamin a, a lipophilic retinoid abundant in goat milk, contributes critically to keratinocyte differentiation and epidermal epithelialization. It regulates gene transcription via nuclear retinoic acid receptors (**RARS**) and retinoid x receptors (**RXRS**), promoting the expression of collagen genes and tissue inhibitors of metalloproteinase (**TIMPS**) that govern matrix remodeling.¹² Inadequate vitamin a can result in delayed epithelial closure and increased susceptibility to infection, whereas its supplementation enhances both barrier restoration and immune integrity.

Collectively, these molecular actions converge to accelerate granulation tissue formation, reduce exudate loss, stabilize the wound bed, and promote timely epithelial closure. These observations align closely with emerging literature emphasizing the role of targeted immunonutrition in improving outcomes in trauma, surgical recovery, and burn care.^{13,14} The cumulative biological plausibility of goat milk's components reinforces the clinical significance of the observed findings.

Although this study did not utilize a randomized controlled design due to ethical constraints related to withholding a potentially beneficial intervention, the pre-post outcome trajectory and comparison with historical control benchmarks provide a valid inferential foundation. The consistent trend of accelerated healing across diverse clinical

presentations further supports the robustness of the findings. Future studies should aim to incorporate randomized allocation, stratified by burn depth and surface area, and include molecular biomarker analyses—such as hydroxyproline quantification, cytokine profiling, and transcriptomic signatures of wound healing pathways—to elucidate the precise mechanisms through which goat milk exerts its therapeutic effects.

Conclusion

Goat milk supplementation appears to expedite burn wound healing in hospitalized patients, possibly via synergistic nutrient-driven modulation of inflammatory and reparative pathways. Integrating goat milk into nursing nutrition protocols may enhance burn care, particularly in resource-limited settings where caprine dairy is accessible.

Declarations

Ethical Approval: EC/89617/07/2023

Acknowledgments

None.

Conflict of interest

The author declares no conflicts of interest.

Funding

This research received no external funding.

References

- Clark A, Imran J, Madni T, et al. Nutrition and metabolism in burn patients. *Burns Trauma*. 2017;5:11.
- Guo F, Zhou H, Wu J, et al. A prospective observation on nutrition support in adult patients with severe burns. *Br J Nutr*. 2019;121(9):974–981.
- Park YJ, Lee H, Kim S, et al. Antioxidant activity of goat milk peptides derived by enzymatic hydrolysis. *Food Chem*. 2022;370:130988.
- Berger MM. Nutrition determines outcome after severe burns. *Ann Transl Med*. 2019;7(Suppl 6):S216.
- Wang Q, Hu J, Liu Z. Medium-chain triglycerides accelerate burn recovery via modulation of inflammation. *Nutrients*. 2023;15(6):1324.
- AlKaisy QH, Al-Saadi JS, AL-Rikabi AKJ, et al. Exploring the health benefits and functional properties of goat milk proteins. *Food Sci Nutr*. 2023;11(10):5641–5656.
- Park YW, Nam MS. Bioactive peptides in milk and dairy products: a review. *Korean J Food Sci Anim Resour*. 2015;35(6):831–840.
- Kim HS, Park SH. Immunoglobulins in goat milk and their clinical relevance. *Int Dairy J*. 2020;110:104778.
- Zheng K, Li M, Zhang Y, et al. Role of amino acids in collagen synthesis during wound healing. *Int J Biochem Cell Biol*. 2021;137:106033.
- Chen Y, Wu X, Xu L. Trace elements in burn patient nutrition. *Burns Trauma*. 2020;8:tkaa025.
- Naeini F, Zeraattalab-Motlagh S, Rahimlou M, Ranjbar M, Hemmati A, Habibi S, et al. Nutritional interventions in patients with burn injury: an umbrella review of systematic reviews and meta-analyses of randomized clinical trials. *Br J Nutr*. 2024;132(10):1317–1324.
- Wang Q, Lin Y, Sheng X, et al. Arachidonic acid promotes intestinal regeneration by activating WNT signaling. *Stem Cell Rep*. 2020;15(2):374–388.
- Bae JH, Lim H, Lim S. The potential cardiometabolic effects of long-chain ω -3 polyunsaturated fatty acids: recent updates and controversies. *Adv Nutr*. 2023;14(4):612–628.
- Naeini F, Zeraattalab-Motlagh S, Rahimlou M, et al. Nutritional interventions in patients with burn injury: an umbrella review of systematic reviews and meta-analyses of randomized clinical trials. *Br J Nutr*. 2024;132(10):1317–1324.
- Comino-Sanz IM, López-Franco MD, Castro B, et al. The role of antioxidants on wound healing: a review of the current evidence. *J Clin Med*. 2021;10(16):3558.
- Ahmed J, Guler E, Ozcan GS, et al. Casein fibres for wound healing. *J R Soc Interface*. 2023;20(204):20230166.
- Gregori P, Franceschetti E, Basciani S, et al. Immunonutrition in orthopedic and traumatic patients. *Nutrients*. 2023;15(3):537.
- Li Y, Guo J. Mechanisms of lactoferrin-mediated antimicrobial activity in wounds. *Front Immunol*. 2023;14:1049821.
- Hakim N, Alzamel N. Goat milk as functional food: clinical evidence. *Nutr Rev*. 2024;82(3):250–259.
- Rodrigues L, Ribeiro A. Digestive bioavailability of micronutrients in goat milk. *J Agric Food Chem*. 2020;68(50):14879–14888.
- Shields BA, Nakakura AM. Nutrition considerations for burn patients: optimizing recovery and healing. *Eur Burn J*. 2023;4(4):537–547.
- Espinoza L, Cruz J. The effect of dairy-derived bioactives on inflammatory cytokines in burns. *Cytokine*. 2022;151:155781.
- Nguyen T, Lee S. Gastrointestinal absorption of bioactive lipids from goat milk. *J Funct Foods*. 2022;88:104907.
- Kobayashi Y, Shimada K. Selenium supplementation and wound oxidative stress. *Nutrients*. 2023;15(9):1998.
- Hussein A, Laird E. Milk peptides in modulation of tissue perfusion. *Microcirculation*. 2021;28(3):e12669.