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"Wound Healing Spray with Camel Milk Protein Anti-microbial and Skin Regenerative Properties"

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ABSTRACT:
Using proteins from camel milk, which are renowned for their antibacterial and skin regenerative properties, this study aims to create a wound healing spray. To maintain the stability of the proteins and make the formulation skin friendly, it was made in a sterile isotonic buffer. Excellent antibacterial action against major wound infections and improved cell development with quicker wound closure were demonstrated in lab experiments. The spray continued to be nontoxic, stable, and collagen-producing. These results imply that camel milk protein spray may be a secure and practical choice for accelerated wound healing; nevertheless, more in vivo research is required.

KEYWORDS: Camel milk protein, wound healing, antimicrobial, collagen, spray formulation.

I. OVERVIEW:

Injury recovery is a complex, multistage procedure that's marked by communication between several cell types, such as fibroblasts, immune cells, and keratinocytes. Growth factors, chemokines, and cytokines are among the molecular regulators that control this complex coordination.[1] Milk from camels has unique biological qualities since i contains a lot of health- promoting biologically active compounds. Additionally, milk bioactive compounds are highly sought-after because of their natural source and low toxicity. These compounds are used to treat skin conditions, boost immunity, and combat cancer.

Milk from camels has long been employed in conventional medicine to treat animal bites, purulent skin lesions, and wounds that are difficult to heal. [2] Because they keep skin moist, protect it, and calm it down, and anti-aging, impacts Dairy products are becoming more and more being used in skin care treatments to aid chronic wound healing, speed up the healing of tissue and reduce inflammatory lesions. [3] Diabetes, poor nutrition, and recurrent injuries are a few conditions that significantly hinder the healing process of wounds. About Lifestyle diseases kill 40 million people every year, which is nearly 70% of all deaths in the world. These diseases include, among others, cancer, diabetes, obesity, and cardiovascular disorders. Approximately 25% of Poland's 2 million+ diabetics are unaware that they have the disease. It is anticipated that the number of diabetics in our nation would increase over the next 15 to 20 years. Notably, people with diabetes have a 12–25% lifetime risk of growing an ulcer, and their chances of amputation are 30–40 times higher than those of non-diabetics. Moreover, diabetic people have poor wound healing. Therefore, it is crucial to look for natural medicine items that will help patients achieve better health outcomes, both from a clinical and socioeconomic standpoint. Wide-ranging physiological and metabolic alterations may transpire, contingent on the extent of the injury and its magnitude, leading to problems in the healing process and a reduction in the patients' immunity. [4] Wounds primarily injected with polybacterial germs that exhibit high resistance to antimicrobial treatments are known as diabetic foot. [5] In this regard, the milk of sheep and camels may be ideal since it contains broad variety of a bioactive substances that are beneficial to the body and can be used to make hydrogel dressings.

Phases of wound healing:

Early wound cleansing and defence are regulated by inflammatory cells.[6] Fibroblasts start making collagen during the stage of proliferation, which aids in the formation of granulation tissue, which promotes the creation of new tissue.[7] Long-term tensile strength is increased during the maturation phase by collagen remodeling. [8]

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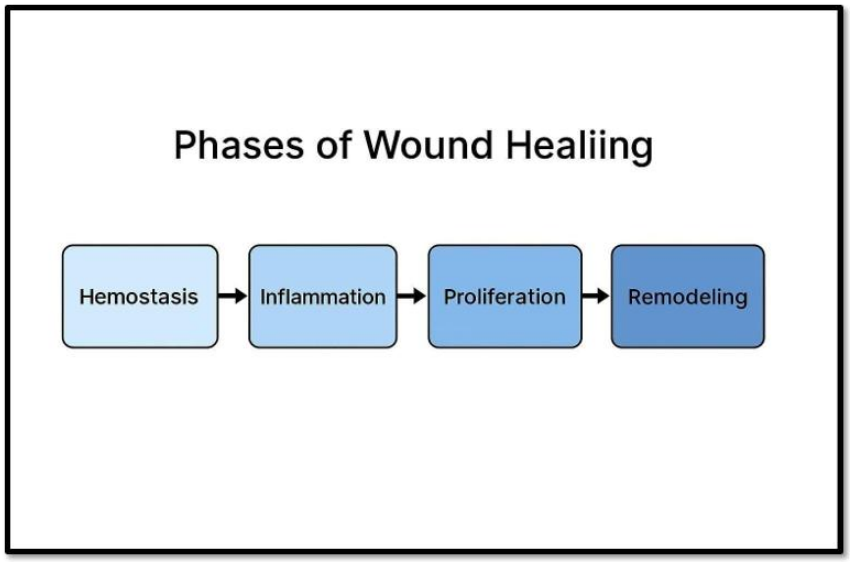

Figure no. 1: Phases of wound healing.

Camel's milk composition:

Milk nutrient is added to mice's diets to speed up the healing of diabetic sores.[9] Milk proteins, which include lactoferrin (LF), lactalbumin, and other components, may help diabetics repair wounds by controlling blood sugar, oxidative stress, inflammation, and growth factors. [10,11] According to research, camel milk's whey proteins help diabetic wounds heal by controlling the expression of the cell death receptor mRNA and TNF-α.[12] Additionally, Whey proteins in camel milk help being diabetic rats repair damages by lowering oxidative stress and modifying ranges of β-defensin and cytokines that encourage inflammation. [13] Additionally, Camel milk is diabetic-preventing, medicinal, and sterilising. qualities due to its high content of fatty acids, peptides, LF, and zinc. [14] Camel's milk is less allergenic since it lacks β-lactoglobulin, but it does contain additional whey proteins, including antibodies and lactate.[15] Glycoprotein lactoferrin is capable of binding two ferric ions. Its concentration in camel's milk varies between 0.02 and 2.1 g/L. It possesses immunomodulatory, anticancer, antibacterial, and anti- inflammatory properties. [16]

The content of Lysozyme, another milk antibacterial ingredient, in camel's milk is approximately 150 µg/L, which is more than that of cow's milk (70 µg/L).Whey proteins which are primarily responsible for newborns' passive immunity are called immunoglobulins (IgG).IgG predominates in camel's milk as an immunoglobulin. It is released in colostrum at a concentration of about 100 g/L, but during lactation, it quickly drops to less than 10 g/L.

Inclusion of lactoferrin, lysozyme, lactoperoxidase, hydrogen peroxide, and immunoglobulins gives camel's milk antiviral and antibacterial qualities. These substances have the ability to inhibit both Gram-positive and Gram-negative bacteria, including Escherichia coli, Listeria monocytogenes, and Staphylococcus aureus. In comparison to cow's milk, camel milk has a more concentration of antimicrobial components. On the other hand, milk loses all of its health benefits after 30 minutes at 100 °C. Additionally, camel's milk's whey proteins strengthen the anti-rotavirus properties to manage non-bacterial gastroenteritis.

86–89% of camel milk is water, which aids in staying hydrated in hot weather. [17] The fat content of camel milk is between 2.9 to 5.4%, with tiny fat globules that enhance digestion.[18]

Isotonic buffer function:

keeps the osmotic equilibrium stable to avoid irritating or damaging cells. Maintains a steady pH (7.2–7.4) for the protection of skin and proteins. Keeps proteins from becoming denaturated and increases their stability. Spraying it on wounds eases discomfort and lessens stinging.

Supports the overall stability of the formulation and the efficacy of the preservative.

Advantages of wound healing spray:

Keeps bioactive proteins safe: mild treatment keeps immunoglobulins, growth factors, and lactoferrin intact.

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Sanitary and non-contact; lowers the chance of infection.
Maintaining moisture and providing even coverage helps wounds heal more quickly. It cools and soothes the wound and has anti-inflammatory properties.
Accurate dose and less waste yield a steady quantity.
Has improved penetration into tiny spaces and can reach uneven surfaces. Convenient & painless – easy, comfortable, and encourages patient compliance.

Antimicrobial effect of camel milk:

Investigating the antibacterial characteristics of camel milk proteins and their hydrolysates is scarce. Gram-positive bacteria include Listeria monocytogenes, Bacillus cereus, and Staphylococcus aureus. Gram-negative bacteria include Escherichia coli. microorganisms were tested for antibacterial activity in the digested sample after camel caseins were enzymatically broken down.[19] The alkalise-produced casein hydrolysate had the best action that stops (17.93

± 0.82) opposed to E. coli found that the antibacterial activities against E. Coli were enhanced by the enzymatic degradation of milk proteins from camels and cattle. The antibacterial qualities of camel milk whey nutrient hydrolysates must be thoroughly investigated utilising various proteolytic enzymes and experimental setups, and tested both in vitro and in vivo against a variety of pathogenic microbes. Numerous parameters, including structural variety, load, hydrophobicity, and specific amino acid composition, affected the bioactive peptides' antibacterial activity. [20,21] Milk protein hydrolysates and peptides were evaluated for their antibacterial ability in vitro by identifying the sequence of peptide that subsequently synthesised and examined antibacterial property's ability against bacterial strains.[22] Interleukin-22 (IL-22), which is essential for the initial stages of wound healing, is produced by a variety of immune cell types. Damage-induced reactions cause the expression of IL-22, which in turn promotes pro-inflammatory gene expression, cell migration, and proliferation, ultimately leading to tissue regeneration. [23,24]

Lactoferin:
Because camel milk lactoferrin can bind iron, bacteria cannot use iron to proliferate. Additionally, it damages bacterial membranes and suppresses pathogens like Listeria monocytogenes, Staphylococcus aureus, and E. coli. [25]

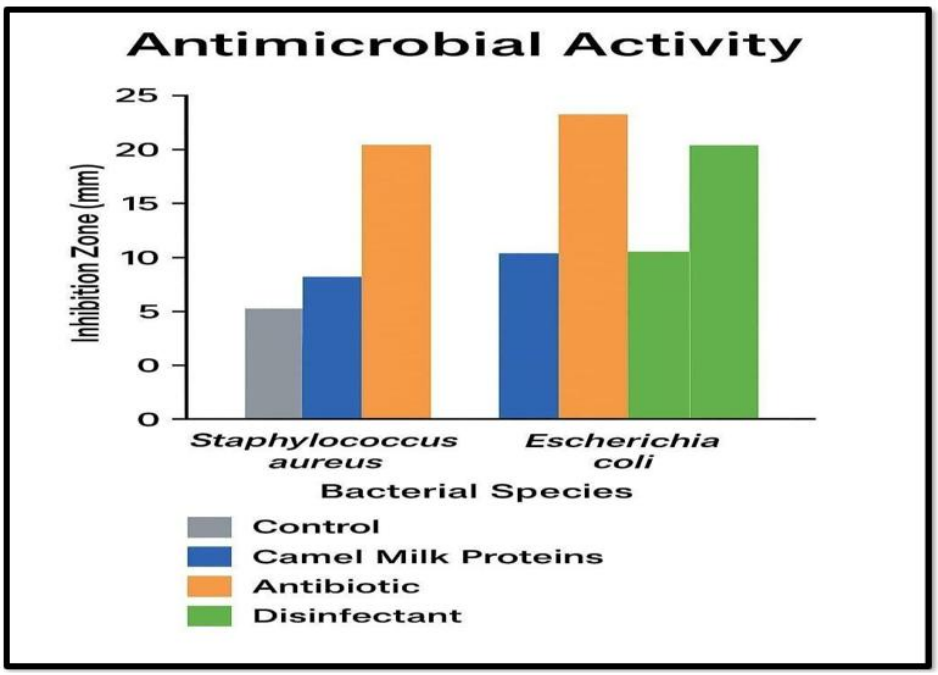

Figure no. 2: Anti-microbial Activity

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Skin Regenerative properties:

LF is a glycoprotein that aids in numerous biological functions linked to tissue regeneration and wound repair. It has anti-inflammatory properties, directly stimulates granulation tissue development, increases collagen and hyaluronan synthesis, and stimulates fibroblast and keratinocyte migration and proliferation.[26] The presence of many bacteria in the damaged tissue is among the most significant aspects impeding skin wound recovery in diabetics.[27]

Camels have antibacterial, antioxidant, and antidiabetic qualities as a result. [28] The authors note that the remarkable ability to cure wounds might be attributed to camel milk's antibacterial properties.[29] Used bioactive milk proteins like LF to produce bioactive scaffolds that promote skin regeneration.[30] Human keratinocytes (HaCaT) and healthy human dermal fibroblasts were employed to measure biological activity in vitro, and the results revealed markedly improved cell proliferation .]Studies have demonstrated that adding milk bioactive ingredients boosts the scaffolds' biological activity and enables deep skin tissue regeneration.

[31] Furthermore it improves skin absorption resulting in deep mosturization and improved barrier repair this element work together to make camel milk good for hydration skin renewal and general skin health. [32]

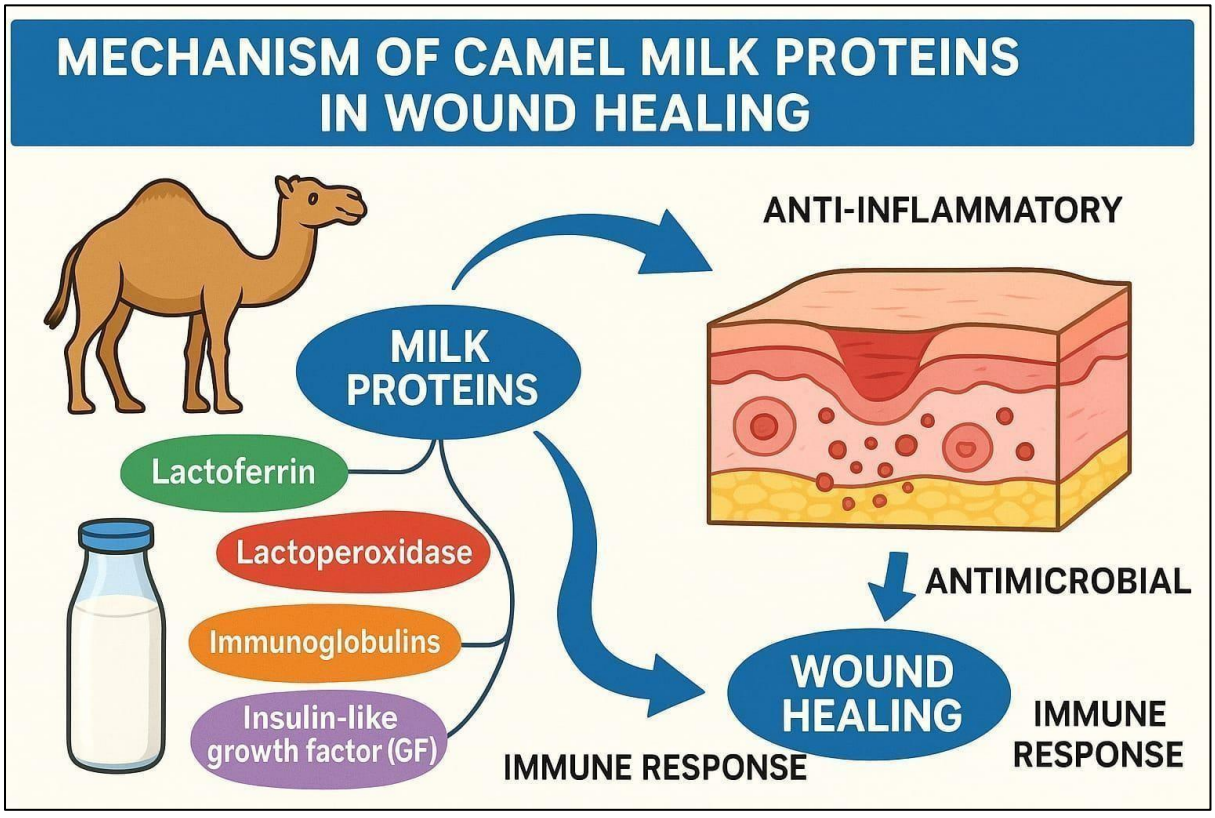

Figure no. 3: Mechanism of Camel Milk Protein in Wound Healing

Advantages over conventional use:

Milk contains biologically active chemicals and substances that are essential for proper growth and immune protection. Antibacterial, anticarcinogenic, antioxidant among the many beneficial nutritional and therapeutic properties of camel's milk are its anti-hypertensive and anti-diabetic properties.[33] The inclusion of hydrogen peroxide, lysozyme, Immunoglobulins, lactoperoxidase, and also lactoferrin gives camel milk antiviral and antibacterial qualities. These substances have the ability to suppress the infection of the bacteria Staphylococcus and other Gram-positive and Gram-negative bacteria.[34] Conventional wound care typically consists of chemical-based ointments, lotions, or antibiotics. Although their primary aim is infection management and basic healing, prolonged usage may result in skin irritation, delayed healing, or resistance. The natural, bioactive substitute provided by camel milk spray,

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however, in contrast, is abundant within proteins, enzymes, and immunological factors that accelerate healing, have antibacterial properties, and encourage skin regeneration without causing negative side effects.

II. Limitations:

Estimating the function of using inflammation-regulating biomaterials in the recovery of wounds due to diabetes has advanced significantly, but there are still a number of constraints that need be taken into account for further research.

For instance, more thorough clinical studies are necessary to confirm the safety and effectiveness of biomaterials for diabetic wound healing, which is one of the research's major obstacles. Additionally, it is imperative to do thorough study to enhance the current prospective biomaterials for diabetic wound healing, especially with regard to their mechanical qualities, biocompatibility, and capacity to effectively regulate inflammation

There are technological and legal barriers to converting laboratory research results into clinical applications, which calls for interdisciplinary cooperation and expedited procedures. To guarantee patient safety and effectiveness, successful translation thus requires navigating regulatory restrictions in addition to addressing scalability, repeatability, and cost-effectiveness issues.

III. Future directions :

To improve wound healing and tissue regeneration, future research will examine innovative medication delivery methods or bioactive compounds. Since the protein corona influences how they modulate their influence on biology, inflammatory responses, and targetability as delivery systems, targeted delivery systems like nanoparticles might be particularly beneficial in this situation. [35] Additionally, tailored treatment plans based on the unique traits of each patient and the kind of wound they have indicated a possible path towards optimisation. For example, by supplying customised dosage and physical qualities based on the patient's clinical needs as well as the nature and features of the wound, 3D-printed dressing materials provide patients with wounds with individualised therapy.[36] Although there are many preclinical studies on , Bioactive compounds and biomaterials that modulate inflammation for the repair of diabetic wounds more investigations and clinical studies are necessary. reships between academia, business, and medical professionals are required to fully realise the possibility of these cutting- edge treatments for diabetes people with long-term wounds. [37]

IV. Conclusion :

Researchers and physicians can create focused strategies to hasten healing and reduce complications by comprehending the complex interactions between immune cells, cytokines and molecular pathway that contribute to pathogenesis of diabetic wound.

Health promoting compound such as lactoferrin, zinc, bioactive peptides and mono and poly unsaturated fatty acids as well as peptides are abundant in camels milk.The main benefit of these bioactive peptides are that they are antioxidant, antimicrobial, angiotensin converting enzyme(ACE) inhibitors, antidiabetic and anticholesterol .

Although fundamental research has shed light on the mechanism behind diabetic wound healing, it is still difficult to use these discoveries in clinical settings. There aren't many clinical trials looking into biomaterial based treatments for diabetic wound which emphasizes the requirements for additional clinical data to backup their efficiency and security. However the results of clinical trials to date have been encouraging, suggesting that inflammation modulating biomaterials may help control diabetic wound. To maximize these treatments and fulfill the unmet requirements in diabetic wound management.

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