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Recent Advancement and Therapeutic Potential of Phytoconstituents for Management of Diabetic Wound Healing

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ABSTARCT

Diabetic wounds represent a critical complication of diabetes mellitus, characterized by chronic inflammation, impaired angiogenesis, oxidative stress, microbial infection, and delayed tissue regeneration. In recent years, phyto-constituents have gained significant attention as potential therapeutic agents for the management of diabetic wounds due to their multifaceted pharmacological activities and favorable safety profiles. Recent advancements highlight the role of plant-derived bioactives such as curcumin, quercetin, and flavonoids in modulating key wound-healing pathways including inflammation, angiogenesis, collagen synthesis, and oxidative stress regulation. Emerging evidence demonstrates that these phyto-constituents exert their therapeutic effects through modulation of molecular signaling pathways such as NF-κB, VEGF, TGF-β, PI3K/Akt, and matrix metalloproteinases, thereby promoting fibroblast proliferation, keratinocyte migration, neovascularization, and extracellular matrix remodeling. Furthermore, recent advancements in nanotechnology-based delivery systems, including liposomes, nanoparticles, nano-emulsions, and hydrogels, have significantly enhanced the bioavailability, stability, and targeted delivery of phyto-constituents at the wound site.

Keywords: Diabetic wounds, phyto-constituents, nanotechnology-based delivery systems,hydrogel system.

I. INTRODUCTION

Diabetes mellitus is a metabolic disorder characterised by hyperglycaemia which predisposes sufferers to chronic complications affecting several organs of the body, including the eye, blood vessels, kidneys and the nerves. It can have a significant impact on wound healing. In patients who have had a non-traumatic amputation, over 50% have diabetes and in a high number of cases the amputation was preceded by an ulcer or non healing wound. Intermittent claudication, absent pedal pulses and ischaemic gangrene are more prevalent in people with diabetes and diabetic foot ulcers affect up to 25% of all diabetics, which should make prevention of wounds and good wound care in diabetic patients a high priority in today's health care system. Diabetes delays the healing process leading to a non-healing wound including various complications with associated psychiatric stress and depression. These complications consist of functional limitations, difficulty in walking, and infection like cellulitis, abscess, osteomyelitis, gangrene, and septicaemia. Impairment of healing in diabetic patients is familiar but the link between patho-physiology and impaired wound healing in diabetes is still an unknown etiology. The healing process necessitates collaboration between inflammatory cells and biochemical mediators stimulated by various factors. However, alteration of the cellular and biochemical factors and activities have been implicated in the failure of wound healing in diabetics.

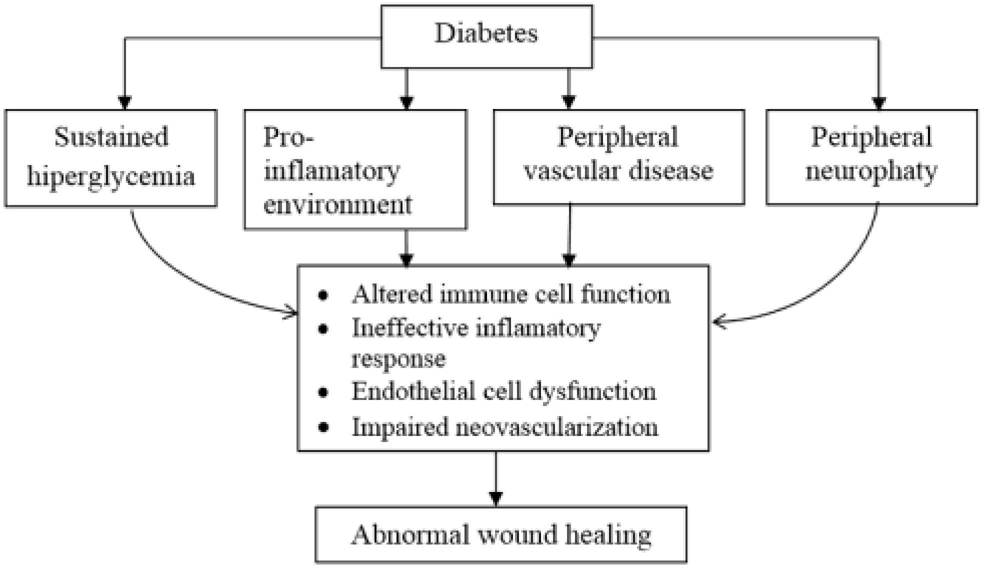

Fig. 1F-1.Wound Healing Disorder in Diabetes

II. DIABETIC WOUND

Diabetes is an endocrine and metabolic disease with high incidence. Delayed wound healing is a major complication, which impairs the quality of patients' life. The majority view is that changes of vascular basement membrane in tissues, down-regulation of collagen expression,disorder in immune response exacerbate pain and wound healing dis-orders. In addition, accumulation of advanced glycation end products and hyperglycemia could cause damage to peripheral blood vessels and micro-vessels, and inhibit the expression of various neuro-trophic and vascular factors. Several physiological factors are decreased,such as proliferation of fibroblasts, growth factors, keratinocytes, angiogenesis and collagen deposition, which are associated with poor therapy effect of diabetic wounds. Hence, it is urgent to explore anew therapeutic treatment of diabetic wound healing.

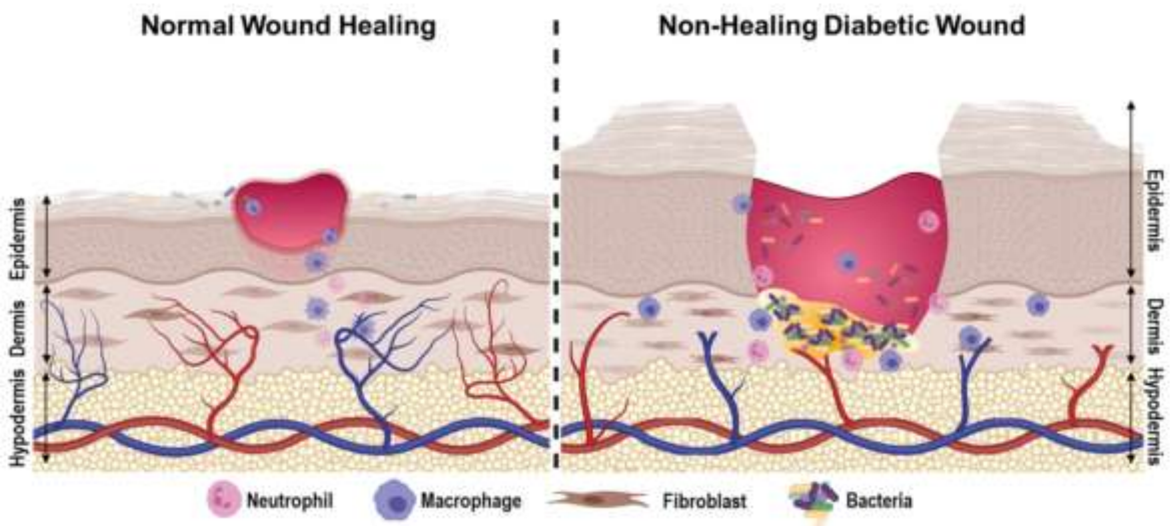

Fig. 1F-2.Wound Healing mechanism in Normal and Diabetic Wounds

III. TYPES OF DIABETIC WOUNDS

External diabetic wounds are dangerous because they usually go unnoticed. Most diabetics have peripheral neuropathy, a condition of damaged or diseased nerves affecting sensation. With peripheral neuropathy, a person may not feel a cut and thus proper treatment can be delayed potentially resulting in further complications. Internal diabetic wounds are those such as ulcers, ingrown toenails or calluses. These types of wounds can be examined to affect the skin and tissue surrounding the wound increasing the risk of infection.

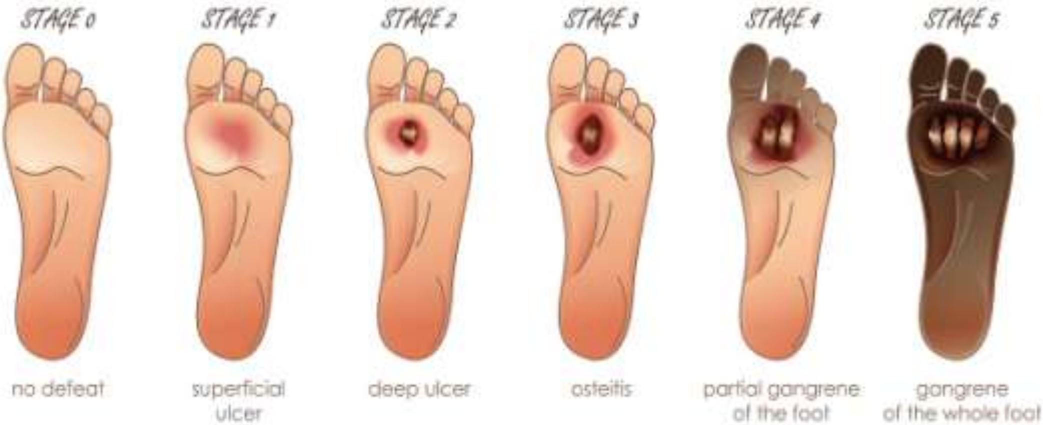

Fig. 1F-3 External and Internal Stages of Diabetic Wound

IV. REASON OF DIABETIC WOUND:

High blood sugarblood sugar is more than just a number on your glucose meter. It plays a part in your energy level, medical needs and your body's ability to heal injuries.buthigh glucose levels disturb the micro-environment of your arteries, and when out of balance, your blood vessels can stiffen and narrow at an accelerated rate. This reduction in blood flow lowers the amount of oxygen and nutrients your cells need to function properly. If the cells responsible for wound healing aren't functioning optimally, in severe cases,wound become gangrenous and require ans amputation, **Neuropathy**Diabetes and high blood sugar can cause nerve damage called diabetic neuropathy. Neuropathy causes tingling and numbness, which will make it harder to feel if you're injured. Hyperglycemia produces oxidative stress on nerve cells and leads to neuropathy, **Reduced immune system function**Person have diabetes, body produces enzymes and hormones that make your immune system less effective. This can lead to infections that may cause diabetic wounds to take longer to heal and require medical attention.

V. PATHOPHYSIOLOGY OF DIABETIC WOUND HEALING

Hyperglycemia can lead to non-enzymatic glycation of collagen and other proteins and to the formation of advanced glycation end products (AGE). These end products reduce the solubility of the extracellular matrix and perpetuate the inflammatory alterations observed in diabetes, **Chronic Inflammation** diabetes is characterized by a chronic low-grade inflammatory state and by a prolonged inflammatory response after injury that is detrimental to wound closure. Patients with diabetes, irrespective of their risk for developing foot ulcers, have been found to have an increased number of inflammatory cells in the dermis and around vessels, **Hypoxia** oxygen supply is essential for cell metabolism and energy production. Poor tissue perfusion and oxygen supply due to microvascular and macrovascular disease create a hypoxic wound and impair the healing process.

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Hypoxia prolongs injury by increasing the levels of free oxygen radicals. Chronic hyperglycemiainduced inflammation further increases oxidative stress and delays wound healing, **Impaired Angiogenesis and Vasculogenesis** angiogenesis and vasculogenesis have been also described to be impaired in the non-healing diabetic wound. EPCs are reduced in patients with diabetes at risk of foot ulceration and in patients with active diabetic foot ulcers Hyperglycemia and chronic inflammation are considered the main causes of EPC dysfunction and impaired EPC recruitment from the bone marrow in diabetes, **Impaired Neuropeptide Signaling** peripheral nerve fibers of the skin are stimulated immediately after injury and release several neuropeptides into the microenvironment of the wound. Neuropeptides such as substance P, neuropeptide Y (NPY) and calcitonin gene-related peptide (CGRP) influence mast cells, endothelial cells, fibroblasts, and keratinocytes, and are involved in vasoregulation and angiogenesis [32–34]. The expression of these neuropeptides has been found to be reduced in diabetes. In addition, their altered expression and function could lead to the impaired healing observed in diabetic wounds, **Microvascular and Macrovascular Dysfunction**peripheral arterial disease impairs wound healing by affecting macrocirculation and blood flow to the lower limbs. In addition, diabetic neuropathy has been also found to be associated with changes in the microcirculation.

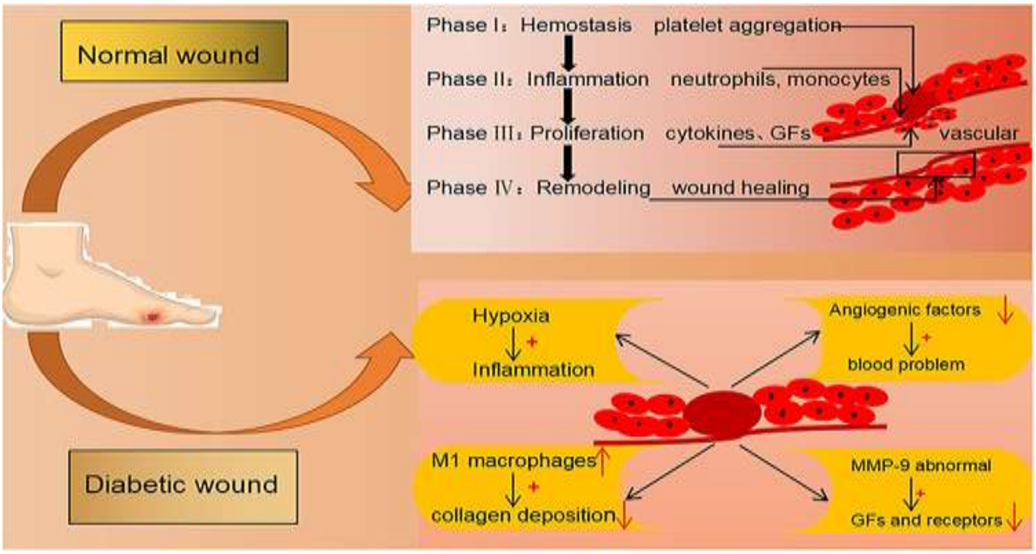

Fig. 1F-4 Healing process of diabetic wounds and normal wounds

VI. PHYTOCHONSTITUENTS FUNCTION AND CLASSIFICATION

Phytoconstituents are naturally occurring bioactive chemical compounds found in plants that are responsible for their medicinal and therapeutic properties. They are mainly secondary metabolites produced by plants for protection against environmental stress, pathogens, and herbivores. phytoconstituents exhibit a wide range of pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and wound-healing effects. Common classes include alkaloids, flavonoids, phenolics, terpenoids, glycosides, and saponins. Due to their multi-targeted action and relatively low toxicity, phytoconstituents play a vital role in herbal medicine and modern drug development, especially in the management of chronic diseases like diabetic wounds, Diabetic wounds are characterized by prolonged inflammation, oxidative stress, impaired angiogenesis, reduced collagen synthesis, and high susceptibility to infection. phytoconstituents play a crucial role in diabetic wound healing by targeting these pathological factors through multiple mechanisms, Anti-inflammatory- inhibit pro-inflammatory mediators (TNF-α, IL-1β, IL-6) and suppress NF-κB signaling, helping to resolve chronic inflammation such as Curcumin, Resveratrol, Antioxidant Function- They neutralize reactive oxygen species (ROS) and enhance endogenous antioxidant enzymes, protecting tissues from oxidative damagesuch as Quercetin, Catechins, Angiogenic- Certain phytoconstituents stimulate neovascularization by upregulating VEGF and nitric oxide pathways, improving oxygen and nutrient supply to wounds such as Asiaticoside, Ginsenosides, Collagen Synthesis and ECM Remodeling- They promote fibroblast proliferation, collagen deposition, and regulate matrix metalloproteinases (MMPs), enhancing wound strength such as Aloe vera polysaccharides,tannins, Antimicrobial-Many phytoconstituents exhibit antibacterial and antifungal activities, reducing infection and biofilm formation in diabetic wound such as Terpenoids, Alkaloids. Classification of Phytoconstituents: Anti-inflammatory-(Curcumin,Quercetin), Antioxidant-(Phenolicacids),Flavonoids-(Gallicacid, Catechin), Angiogenic-(Asiaticoside, Ginsenosides), Collagen-(Tannins), Polysaccharides-(Aloe vera), ProanthocyanidinsAntimicrobial –(Berberine, Thymol), Antidiabetic-(Gymnemic acid, Diosgenin).

VII. EFFECTS OF PHYTOCONSTITUENTS IN THE DIABETIC WOUND HEALING

Anti-inflammatory EffectPhytoconstituents suppress prolonged inflammation by inhibiting pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 and by down-regulating NF-κB signaling. This helps in transitioning the wound from the inflammatory to the proliferative phase,Antioxidant Effect,Hyperglycemia leads to excessive generate of reactive oxygen species (ROS), which delays wound repair. Flavonoids and phenolic compounds scavenge free radicals and enhance endogenous antioxidant enzymes (SOD, catalase, glutathione), thereby protecting cells involved in healing, Enhancement of Angiogenesis,Certain phytoconstituents stimulate neovascularization by up-regulating angiogenic factors such as VEGF and nitric oxide, improving blood supply, oxygenation, and nutrient delivery to the wound site, Promotion of Collagen Synthesis and ECM Remodeling,Phytoconstituents enhance fibroblast proliferation and collagen deposition while regulating matrix metalloproteinases (MMPs), resulting in improved extracellular matrix remodeling and increased tensile strength of healed tissue, Antimicrobial Effect

Many plant-derived compounds exhibit broad-spectrum antimicrobial activity, reducing microbial load and preventing infection and biofilm formation, which are major contributors to delayed diabetic wound healing, Acceleration of Re-epithelializationby stimulating keratinocyte migration and proliferation, phytoconstituents promote faster wound contraction and epithelial layer restoration, Glycemic Regulation.Some phytoconstituents exhibit antihyperglycemic effects by improving insulin sensitivity and glucose metabolism, indirectly supporting wound healing by maintaining a favorable systemic environment such as**Quercetin:**Quercetin is considered to be one of the most studied flavonoids. The flavonoid quercetin is derived from the amino acid, phenylalanine. Quercetin is mainly produced via the phenylpropanoid pathway it has several bioactivities, including antidiabetic, anti-inflammatory, and antioxidant effects. In the context of wound healing, NF-kB upregulates the inflammatory response by promoting the expression of various proinflammatory cytokines (TNF-α, IL-β) and chemokines. These molecules initiate the process of tissue repair by recruiting the immune cells at the injury site. In addition, it also plays a critical role in differentiation and proliferation of cells during the proliferative stage of wound healing It has been reported that it promotes the migration of fibroblasts and the development and formation of new blood vessels, which are highly important for tissue regeneration. The role of NF-kB is not limited to this stage of wound healing; it also has effects in the remodeling stage, upregulating the production of collagen and extracellular matrix, which ultimately supports and strengthens newly developed tissue.

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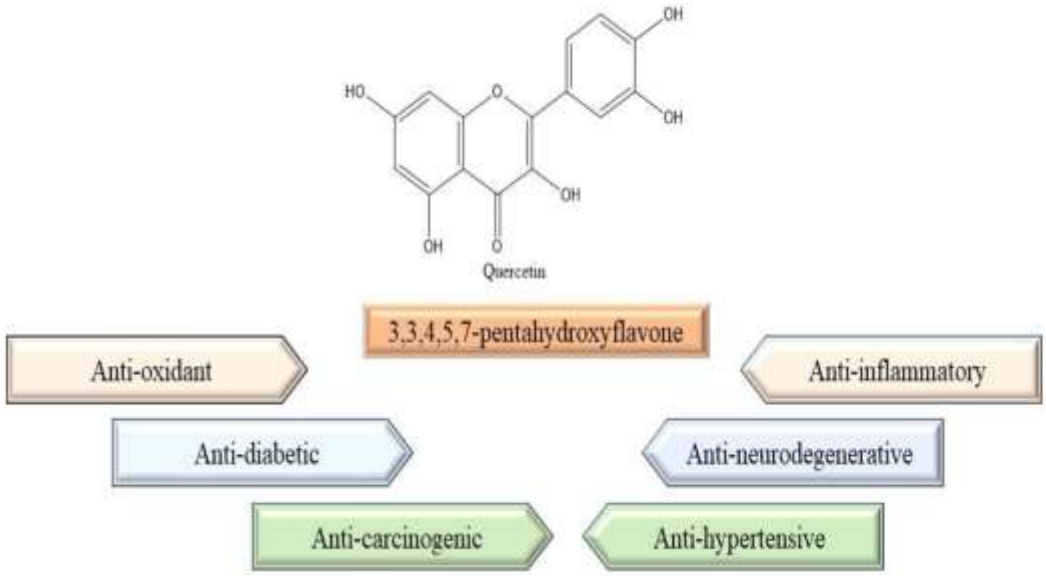
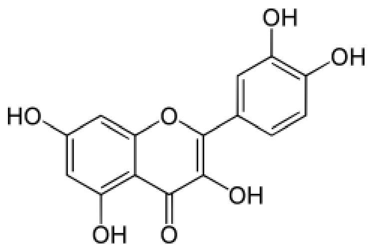


Figure 1F-7. Various pharmacological action of Quercetin

The signaling experiment of their research exhibited treatment using this molecule hindered MAPK without activating NFκB. QCN treatment ameliorated the process of impairment healing in I/R lesions by preventing MAPK pathway, In the present study, investigated whether quercetin enhances wound healing hyperglycemic reduction of the inflammatory process and an increase in markers involved in oxidative stress, angiogenesis, formation of granulation tissue, and extracellular matrix remodelling.

VIII. PHYSICOCHEMICAL PROPERTIES OF QUERCETIN:

Chemical Structure	
Molecular formula	**$C_{15}H_{10}O_7$**
IUPAC Name	**3,3′,4′,5,7-Pentahydroxyflavone**
Molar mass	**302.236 g/mol**
Color/form	**yellow crystalline powder**[1]
Solubility	**Practically insoluble in water; soluble in aqueous alkaline solutions**
Density	**1.799 g/cm^3**
Melting point	**316 °C (601 °F; 589 K)**

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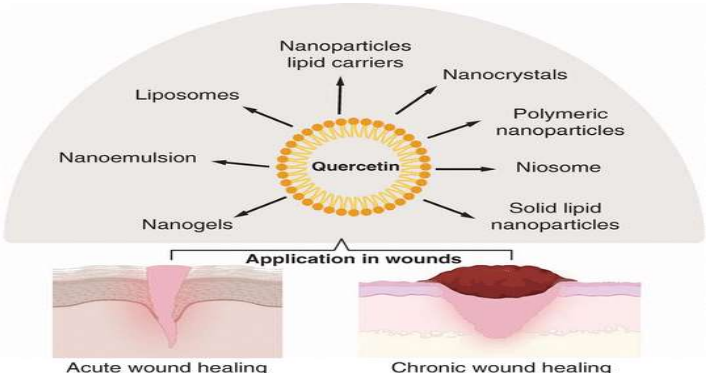

Figure 1F8. Various Quercetin based novel delivery system used for wound

IX. MECHANISM OF ACTION

Among the natural polyhydroxy flavonoids, quercetin has strong antioxidant and anti-inflammatory properties to regulate oxidative stress and inflammation, which delay the wound healing process. It has been shown that quercetin can promote the wound healing process by modulating inflammatory cells and increasing fibroblast proliferation while decreasing immune cell infiltration, fibrosis and scar formation, and creating changes in signaling in fibrosis-associated signaling pathways. A previous report revealed that quercetin accelerated diabetic wound repair by inhibiting inflammatory reactions via modulating macrophage polarization. In addition, quercetin was shown to accelerate cutaneous wound healing in rats by modulating inflammatory and anti-inflammatory cytokines, angiogenic growth factors and antioxidant systems, which might be responsible for the efficient proliferation of cells and increase collagen deposition. Quercetin has role in angiogenesis and proliferation of epithelial cells and fibroblasts. So, it was hypothesized that exogenous application of quercetin could be beneficial in wound healing. In present study, experimentally-wounded male rats were equally divided into four groups.

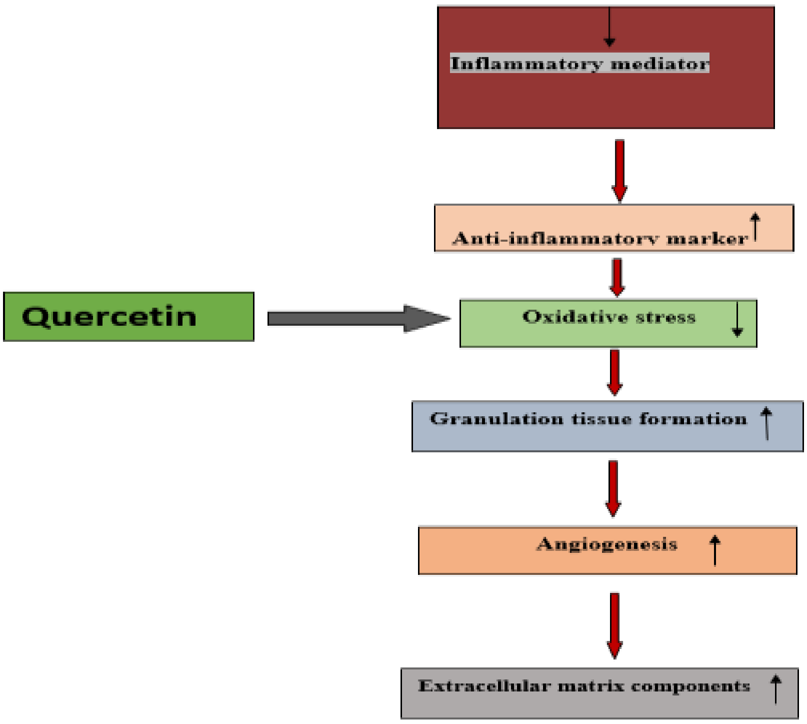

Figure 1F9. Mode of action of Quercetin

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X. TREATMENT OF DIABETIC WOUND HEALING

Diabetic wounds, particularly diabetic foot ulcers, are chronic and difficult to heal due to impaired circulation, neuropathy, prolonged inflammation, oxidative stress, and high risk of infection. Effective treatment requires a multidisciplinary and stepwise approach combining conventional therapy with advanced treatment modalities. Glycemic Control:Strict control of blood glucose levels is fundamental for wound healing. Optimal glycemic management improves immune function, reduces oxidative stress, and enhances tissue repair,wound Cleaning and Debridement:Regular surgical, enzymatic, or autolytic debridement removes necrotic tissue and reduces microbial load,Infection Management:Use of topical and systemic antibiotics based on culture and sensitivity,Antiseptic dressings help prevent biofilm formation,moist wound Environment:Maintaining adequate moisture using hydrogels, hydrocolloids, alginates, and foam dressings enhances epithelial cell migration and reduces healing time,offloading Pressure:Use of specialized footwear, total contact casts, or orthotic devices to reduce pressure on the wound area. advanced Wound Dressings:Antimicrobial dressings (silver, iodine),Growth factor–impregnated dressings,nano-based dressings (liposomes, nanoparticles, hydrogels),Growth Factors and Biological Therapies:Platelet-derived growth factor (PDGF),Platelet-rich plasma (PRP),Phytoconstituent-Based Therapy:Plant-derived bioactives with antioxidant, anti-inflammatory, antimicrobial, and angiogenic properties,Examples: Curcumin, Aloe vera, Asiaticoside,Often incorporated into hydrogels or nano-carriers for improved efficacy.oxygen Therapy:Hyperbaric oxygen therapy (HBOT) enhances oxygen supply to hypoxic wound tissue, promoting angiogenesis and bacterial killing,Surgical Interventions:Skin grafting,Flap surgery,Amputation (in severe cases).

XI. CONCLUSION

Recent advancements in phytoconstituent-based therapies have highlighted their significant therapeutic potential in the management of diabetic wounds, a condition characterized by chronic inflammation, oxidative stress, impaired angiogenesis, and delayed tissue regeneration. Phytoconstituents derived from medicinal plants exhibit multifunctional pharmacological actions, including antioxidant, anti-inflammatory, antimicrobial, angiogenic, and collagen-promoting effects, which collectively address the complex pathophysiology of diabetic wound healing. Advances in drug delivery technologies, particularly nanotechnology-based systems such as nanoparticles, liposomes, nano-emulsions, and hydrogel matrices, have markedly improved the stability, bioavailability, and targeted delivery of phytoconstituents at the wound site. These innovations enhance local drug retention, promote sustained release, and minimize systemic toxicity, thereby translating traditional herbal bioactives into clinically relevant therapeutics. Despite promising preclinical and emerging clinical evidence, challenges related to standardization, scalability, and regulatory approval remain. Nevertheless, the integration of phytoconstituents with advanced delivery platforms represents a safe, effective, and sustainable therapeutic strategy for diabetic wound management, offering a strong foundation for future translational research and clinical application.

REFERENCES

[1]. Lucetti, D.L., Lucetti, E.C.P., Bandeira, M.A.M., Veras, H.N.H., et al., (2010). Anti-inflammatory effects and possible mechanism of action of lupeol acetate isolated from Himatanthusdrasticus (Mart.) Plumel. J Inflamm (Lond). 7: 60.
[2]. Priyanka, K., Kosurua, R.I., Sharma, R.P., Singh, S. (2017). Assessment of pharmacokinetic parameters of lupeol in Ficus religiosa L. extract after oral administration of suspension and solid lipid nanoparticles to Wistar rats. J Drug Del Sci Tech, 41, 58-67.
[3]. Kangsamaksin, T., Chaithongyot, S., Wootthichairangsan, C., Hanchaina, R., Tangshewinsirikul, C., Svasti, J. (2017). Lupeol and stigmasterol suppress tumor angiogenesis and inhibit cholangiocarcinoma growth in mice via downregulation of tumor necrosis factor-α. PLoS ONE 12(12): -0189628.
[4]. Vidya, L. lenin, M., Varalakshmi, P. (2002). Evaluation of the effect of triterpenes on urinary risk factor of stone formation in pyridoxine deficient hyperoxaluric rats. Phytother Res. 16, 514-18.
[5]. Tchimene, M.K., Nwaehujor, C.O., Ezenwali, M., Okoli, C.C. et al., (2016). Free Radical Scavenging Activity of

Lupeol Isolated from the Methanol Leaf Extract of Cratevaadansonii Oliv. (Capparidaceae). Int JPharmacogPhytochem Res, 8(3); 419-426.

[6]. Saleem, M. (2009). Lupeol, a novel anti-inflammatory and anti-cancer dietary triterpenes. Cancer Letters 285,109–115.

[7]. Gallo, M.B.C., Sarachine, M.J. (2009). Biological activites of lupeol. Int. J. Biomed. Pharama. Sci. 3, 1, 46-66.

[8]. Andrikopoulos, N.K., Kallora, A.C., Assimopoulou, A.N., Papapeorgiou, V.P. (2003). Biological activity of some naturally occurring resins, gums and pigments against in vitro LDL oxidation. Phytother Res. 17, 501-07.

[9]. Flekhter, O.B., Karachurina, L.T., Nigmatullina, V.V., Baltina, L.A., Zarudii, F.S. et al. (2000). The synthesis and hepatoprotective activity of ester of lupine group triterpenoids. Rus. J Bioorg Chm. 26, 192-200.

[10]. Patel, S., Srivastava, S., Singh, M.R., Singh, D. (2018). Preparation and optimization of chitosan-gelatin films for sustained delivery of lupeol for wound healing. Int J Biol Macromol. 107(Pt B): 1888-1897.

[11]. Gupta, R., Sharma, A.K., Sharma, M.C., Dobhal, M.P., Gupta, R.S. (2012). Evaluation of antidiabetic and antioxidant potential of lupeol in experimental hyperglycaemia. Natural Product Res, 26, 12, 1125-1129.

[12]. Siddique, H.R., Saleem, M. (2011). Beneficial health effects of lupeol triterpene: a review of preclinical studies. Life Sci. 88(7-8):285-93.

[13]. Suksamrarn, T. Tanachatchairatana, S. Kanokmedhakul. (2003). Antiplasmodial triterpenes from twigs of Gardenia saxatills. J Ethnopharmacol. 88, 275-77.

[14]. Burgess JL, Wyant WA, Abdo Abujamra B, Kirsner RS, Jozic I. Diabetic wound-healing science. Medicina. 2021 Oct 8;57(10):1072.

[15]. Sharp A, Clark J. Diabetes and its impact on wound healing.

[16]. Hanefeld M, Duetting E, Bramlage P. Cardiac implications of hypoglycaemia in patients with diabetes–a systematic review. Cardiovascular diabetology. 2013 Dec;12:1-1.

[17]. Beckman JA, Goldfine AB, Gordon MB, Garrett LA, Keaney Jr JF, Creager MA. Oral antioxidant therapy improves endothelial function in Type 1 but not Type 2 diabetes mellitus. American Journal of Physiology-Heart and Circulatory Physiology. 2003 Dec;285(6):H2392-8.

[18]. Azhar A, Basheer M, Abdelgawad MS, Roshdi H, Kamel MF. Prevalence of peripheral arterial disease in diabetic foot ulcer patients and its impact in limb salvage. The International Journal of Lower Extremity Wounds. 2021 Jun 18:15347346211027063.

[19]. Jangde R, Singh D. Preparation and optimization of quercetin-loaded liposomes for wound healing, using response surface methodology. Artificial cells, nanomedicine, and biotechnology. 2016 Feb 17;44(2):635-41.

[20]. Begum MY, Sudhakar M, Abbulu K. Flurbiprofen-loaded stealth liposomes: studies on the development, characterization, pharmacokinetics, and biodistribution. Journal of Young Pharmacists. 2012 Oct 1;4(4):209-19.

[21]. Majtan, J., Bohova, J., Garcia-Villalba, R., Tomas-Barberan, F.A., Madakova, Z., Majtan, T., Majtan, V. and Klaudiny, J., 2013. Fir honeydew honey flavonoids inhibit TNF-α-induced MMP-9 expression in human keratinocytes: a new action of honey in wound healing. Archives of dermatological research, 305, pp.619-627.

[22]. Lucetti DL, Lucetti EC, Bandeira MA, Veras HN, Silva AH, Leal LK, Lopes AA, Alves VC, Silva GS, Brito GA, Viana GB. Anti-inflammatory effects and possible mechanism of action of lupeol acetate isolated from Himatanthusdrasticus (Mart.) Plumel. Journal of Inflammation. 2010 Dec;7(1):1-1.

[23]. Hatahet, T., Morille, M., Hommoss, A., Devoisselle, J.M., Müller, R.H. and Bégu, S., 2016. Quercetin topical application, from conventional dosage forms to nanodosage forms. European Journal of Pharmaceutics and Biopharmaceutics, 108, pp.41-53.

[24]. Sharma A, Sharma US. Liposomes in drug delivery: progress and limitations. International journal of pharmaceutics. 1997 Aug 26;154(2):123-40.

[25]. Riaz M. Liposomes preparation methods. Pakistan journal of pharmaceutical sciences. 1996 Jan 1;9(1):65-77.
[26]. Peppas NA, Hilt JZ, Khademhosseini A, Langer R. Hydrogels in biology and medicine: from molecular principles to bionanotechnology. Advanced materials. 2006 Jun 6;18(11):1345-60.
[27]. Peppas NA, Bures P, Leobandung WS, Ichikawa H. Hydrogels in pharmaceutical formulations. European journal of pharmaceutics and biopharmaceutics. 2000 Jul 3;50(1):27-46.
[28]. Duckworth C, Fisher JF, Carter SA, Newman CL, Cogburn C, Nesbit RR, Wray CH. Tissue penetration of clindamycin in diabetic foot infections. Journal of Antimicrobial Chemotherapy. 1993 Apr 1;31(4):581-4.
[29]. Broussard CL. Hyperbaric oxygenation and wound healing. Journal of vascular Nursing. 2004 Jun 1;22(2):42-8.
[30]. Kant V, Jangir BL, Nigam A, Kumar V, Sharma S. Dose regulated cutaneous wound healing potential of quercetin in male rats. Wound Medicine. 2017 Dec 1;19:82-7.
[31]. Yadav, P., Singh, M., Vinayagam, R. and Shukla, P., 2025. Therapies and Delivery Systems for Diabetic Wound Care: Current Insights and Future Pathways. Frontiers in Pharmacology, 16, p.1628252.