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Review Article

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Solanum Nigrum and Its Therapeutic Applications in Oral Mucosal Lesions: A Review

Dr. Chandrakala[1], Dr. Lakshminrusiman[2], Dr. Sowmiya[3], Rathinagokul K.[4*], Ramyasri T.[5] and Rochanaa S. K. S.[6]

[1]*Professor & Head of the Department, Department of Oral Medicine and Radiology, RVS Dental College and Hospital, Coimbatore, India.*
[2]*Reader, Department of Oral Medicine and Radiology, RVS Dental College and Hospital, Coimbatore, India.*
[3]*Senior Lecturer, Department of Oral Medicine and Radiology, RVS Dental College and Hospital, Coimbatore, India.*
[4,5,6]*Undergraduate Scholar, Department of Oral Medicine and Radiology, RVS Dental College and Hospital, Coimbatore, India.*

Email: drckshekar@gmail.com, dr.nrusimhan@gmail.com, sowmiyajaisankar2@gmail.com, rathinagokul2003@gmail.com[*]*, ramya130802@gmail.com, rochanaakannan555@gmail.com*

Abstract: *Oral mucosal lesions represent a wide range of pathological conditions affecting the lining of the oral cavity. These lesions may develop due to trauma, infections, immune-mediated disorders, nutritional deficiencies, systemic diseases, or adverse drug reactions. Common examples include recurrent aphthous ulcers, oral mucositis, leukoplakia, oral lichen planus, and oral candidiasis. Such conditions often cause pain, inflammation, ulceration, and discomfort that can significantly interfere with normal oral functions such as mastication, speech, and swallowing. Conventional treatment strategies for oral mucosal lesions usually involve the use of corticosteroids, antimicrobial agents, analgesics, and antifungal drugs. Although these treatments may provide symptomatic relief, long-term use can lead to undesirable side effects and the possibility of drug resistance. Medicinal plants have gained increasing importance in recent years due to their therapeutic properties and relatively fewer adverse effects. Solanum nigrum, commonly known as black nightshade, is a medicinal herb widely used in traditional systems of medicine such as Ayurveda and Siddha. The plant contains several bioactive compounds including steroidal alkaloids, flavonoids, glycosides, tannins, and phenolic compounds that contribute to its pharmacological properties. Studies have demonstrated that extracts of Solanum nigrum possess antimicrobial, anti-inflammatory, antioxidant, immunomodulatory, and wound-healing activities. These biological effects may play an important role in the prevention and management of oral mucosal lesions by reducing inflammation, inhibiting microbial growth, and promoting tissue regeneration. The present review aims to discuss the etiology, classification, and clinical manifestations of oral mucosal lesions while highlighting the phytochemical composition and pharmacological mechanisms through which Solanum nigrum may contribute to their management.*

Keywords: *Oral Mucosal Lesions, Solanum Nigrum, Phytochemicals, Anti-inflammatory Activity, Antimicrobial Effects, Wound Healing, Herbal Medicine, Oral Health.*

INTRODUCTION

The oral cavity is lined by a specialized mucosal tissue that functions as a protective barrier against microbial invasion, mechanical injury, and chemical irritants. The integrity of this mucosal lining is essential for maintaining oral health and supporting physiological functions such as mastication, swallowing, and speech. However, a variety of local and systemic factors may disrupt this protective barrier and lead to the development of oral mucosal lesions [1]. Oral mucosal lesions are frequently encountered in dental practice and may present in different forms such as ulcers, plaques, vesicles, nodules, or erythematous patches. These lesions may occur in any region of the oral cavity including the tongue, buccal mucosa, gingiva, palate, and lips. Some lesions are benign and self-limiting, whereas others may represent potentially malignant disorders requiring careful evaluation and management [2].

The prevalence of oral mucosal lesions varies among populations depending on lifestyle habits, environmental factors, and systemic health conditions. Tobacco use, alcohol consumption, nutritional deficiencies, and poor oral hygiene are considered major risk factors. In addition, certain systemic diseases and immunological disorders may predispose individuals to mucosal abnormalities [3].

Conventional treatment modalities mainly focus on controlling inflammation, preventing infection, and promoting tissue healing. However, the limitations associated with synthetic drugs have stimulated interest in herbal medicines that offer therapeutic benefits with fewer side effects. Among the various medicinal plants studied for their pharmacological properties, Solanum nigrum has gained considerable attention due to its wide range of biological activities [4].

ORAL MUCOSAL LESIONS

Oral mucosal lesions refer to abnormal changes affecting the mucous membrane lining the oral cavity. These lesions may involve alterations in color, texture, thickness, or structural integrity of the mucosal tissues. They may occur as localized or generalized changes and can vary significantly in clinical presentation [5]. The oral mucosa consists of stratified squamous epithelium supported by connective tissue known as the lamina propria. This tissue structure provides mechanical protection and plays a role in immune defense. When the mucosal barrier is disrupted, inflammatory responses may occur, resulting in the development of lesions [5]. Clinically, oral mucosal lesions can be broadly categorized into several groups including ulcerative lesions, white lesions, red lesions, vesiculobullous lesions, and infectious lesions. Each category encompasses specific conditions with distinct etiological and pathological characteristics.

Ulcerative lesions involve loss of epithelial tissue and exposure of underlying connective tissue. Recurrent aphthous stomatitis is a common example of this type of lesion [6]. White lesions such as leukoplakia and oral lichen planus are characterized by keratinization or thickening of the mucosal epithelium [2]. Red lesions including erythroplakia often indicate epithelial atrophy and increased vascularity [7]. Vesiculobullous lesions are associated with blister formation and may occur in autoimmune disorders such as pemphigus vulgaris [3].

ETIOLOGY OF ORAL MUCOSAL LESIONS

The development of oral mucosal lesions is influenced by multiple etiological factors. Mechanical trauma is one of the most common causes of mucosal injury. Accidental biting of oral tissues, sharp dental restorations, and ill-fitting dentures can lead to irritation and

ulceration of the mucosa [8]. Microbial infections also contribute significantly to the occurrence of mucosal lesions. Bacterial, viral, and fungal pathogens can cause inflammatory reactions within the oral cavity. For example, oral candidiasis is caused by Candida albicans, whereas herpes simplex virus can produce vesicular lesions on the oral mucosa [8].

Nutritional deficiencies, particularly deficiencies of vitamin B12, folic acid, and iron, have been associated with recurrent aphthous ulcers and mucosal atrophy. These nutrients are essential for maintaining epithelial integrity and immune function [6]. Systemic diseases such as diabetes mellitus, gastrointestinal disorders, and autoimmune conditions may also predispose individuals to oral mucosal lesions. In many cases, oral lesions serve as early indicators of underlying systemic disorders [3]. Certain medications including chemotherapeutic agents, antibiotics, and immunosuppressive drugs may cause mucosal inflammation and ulceration as adverse effects. Oral mucositis is a common complication observed in patients undergoing cancer therapy [9][10].

BOTANICAL DESCRIPTION AND TRADITIONAL USES OF SOLANUM NIGRUM

Solanum nigrum, as shown in Figure 1, commonly referred to as black nightshade, is an annual herbaceous plant belonging to the family Solanaceae. The genus Solanum comprises a large group of flowering plants that includes economically and medicinally important species such as potato and eggplant. Solanum nigrum is widely distributed across tropical and subtropical regions of Asia, Africa, Europe, and parts of North America. The plant grows abundantly in fields, gardens, and roadside environments and is often considered a common weed in agricultural areas [11].

Figure 1: Shows Solanum Nigrum belonging to the family Solanaceae.

Morphologically, the plant typically grows to a height ranging from 30 to 70 centimeters and is characterized by erect or slightly spreading stems. The leaves are simple, ovate to elliptical in shape, and arranged alternately along the stem. They possess smooth or slightly wavy margins and are generally dark green in color. The flowers are small, white, and star-shaped with yellow stamens, usually appearing in clusters. The fruit is a small spherical berry that changes from green to dark purple or black upon maturation.

In traditional systems of medicine such as Ayurveda, Siddha, and traditional Chinese medicine, Solanum nigrum has been used for centuries in the treatment of various ailments. The plant has been reported to possess anti-inflammatory, hepatoprotective, antimicrobial, and analgesic properties. Traditional practitioners have used the leaves and berries of the plant to treat conditions such as skin diseases, ulcers, liver disorders, fever, and inflammatory conditions. In some cultures, decoctions prepared from the leaves are used to treat gastrointestinal disturbances Because of these diverse medicinal applications, Solanum nigrum has attracted

the attention of researchers investigating plant-based therapeutic agents for oral diseases. The presence of numerous biologically active compounds within the plant further supports its potential role in the management of oral mucosal lesions.

PHYTOCHEMICAL CONSTITUENTS OF SOLANUM NIGRUM

The medicinal properties of Solanum nigrum are primarily attributed to its rich and diverse phytochemical composition. Phytochemical analysis of the plant has revealed the presence of several classes of bioactive compounds including steroidal alkaloids, flavonoids, phenolic acids, glycosides, tannins, and saponins. These compounds contribute to the wide range of pharmacological activities exhibited by the plant [12].

Steroidal glycoalkaloids are among the most important bioactive constituents present in Solanum nigrum. These compounds include solanine, solasonine, and solamargine. Glycoalkaloids are nitrogen-containing secondary metabolites that are known for their antimicrobial and cytotoxic activities. Studies have shown that these compounds can interact with cell membranes and disrupt membrane integrity in microbial cells, thereby inhibiting their growth and proliferation.

Flavonoids represent another important group of phytochemicals found in Solanum nigrum. These compounds are well known for their antioxidant properties and their ability to scavenge free radicals. Oxidative stress plays a significant role in the pathogenesis of inflammatory diseases, including oral mucosal lesions. By neutralizing reactive oxygen species, flavonoids help protect cellular components from oxidative damage and promote tissue healing [13].

PHARMACOLOGICAL PROPERTIES OF SOLANUM NIGRUM

The pharmacological activities of Solanum nigrum have been extensively investigated in recent years due to the presence of numerous bioactive compounds within the plant. These biological activities include antimicrobial, anti-inflammatory, antioxidant, analgesic, hepatoprotective, and wound-healing properties. Such pharmacological actions are particularly relevant in the management of oral mucosal lesions, where inflammation, microbial infection, and tissue damage are common pathological features [14]. The antimicrobial activity of Solanum nigrum has been demonstrated against a variety of pathogenic microorganisms including bacteria and fungi. Extracts of the plant have shown inhibitory effects against several oral pathogens, which may contribute to the prevention of secondary infections in oral lesions. By limiting microbial proliferation, the plant may help maintain a healthy oral environment and support the healing process [12][20].

Anti-inflammatory activity represents another important therapeutic property of the plant. Inflammatory responses play a major role in the pathogenesis of many oral mucosal diseases. Studies have indicated that extracts of Solanum nigrum may suppress the production of inflammatory mediators such as prostaglandins and cytokines. This effect may help reduce swelling, pain, and erythema associated with mucosal lesions [13]. The antioxidant properties of Solanum nigrum are mainly attributed to the presence of flavonoids and phenolic compounds. These molecules have the ability to neutralize free radicals and prevent oxidative damage to cellular components. Oxidative stress is known to contribute to tissue injury and delayed wound healing in inflammatory conditions. Therefore, the antioxidant activity of the plant may promote tissue repair and regeneration in damaged oral mucosa [14].

Additionally, wound-healing activity has been reported in experimental studies involving extracts of Solanum nigrum. These studies suggest that the plant may stimulate collagen

synthesis, enhance epithelial regeneration, and improve the overall healing process. Such properties may be particularly beneficial in the management of ulcerative lesions within the oral cavity [15].

MECHANISM OF ACTION OF SOLANUM NIGRUM IN ORAL MUCOSAL LESIONS

The therapeutic potential of Solanum nigrum in oral mucosal lesions is largely related to the combined effects of its bioactive compounds. These compounds interact with multiple biological pathways that influence inflammation, microbial activity, oxidative stress, and tissue regeneration. One of the key mechanisms involves the inhibition of inflammatory mediators. Inflammatory cytokines such as interleukins and tumor necrosis factor are often elevated in oral mucosal diseases. Bioactive constituents present in Solanum nigrum may inhibit the production of these mediators, thereby reducing inflammation and tissue damage [13][18].

Another important mechanism is the antimicrobial action of the plant's glycoalkaloids and phenolic compounds. These molecules can interfere with microbial cell membranes and metabolic processes, ultimately leading to the destruction or inhibition of pathogenic microorganisms. Since microbial infection can aggravate oral lesions and delay healing, controlling microbial growth is essential for effective treatment [12][18]. The antioxidant activity of Solanum nigrum also plays a critical role in its therapeutic effects. Reactive oxygen species generated during inflammatory responses can damage cellular structures such as proteins, lipids, and DNA. Antioxidant compounds present in the plant help neutralize these reactive molecules, thereby protecting tissues from oxidative injury [14].

Furthermore, the plant has been reported to promote tissue regeneration through stimulation of fibroblast activity and collagen deposition. Collagen is an essential structural component of connective tissue and plays a vital role in wound healing. By enhancing collagen synthesis and epithelial cell proliferation, Solanum nigrum may accelerate the healing of ulcerative lesions in the oral cavity [15].

CLINICAL AND THERAPEUTIC APPLICATIONS OF SOLANUM NIGRUM IN DENTISTRY

The growing interest in herbal medicine has encouraged researchers to explore plant-based therapies for oral diseases. Solanum nigrum is considered a promising candidate due to its diverse pharmacological activities and long history of traditional medicinal use. Herbal preparations derived from the plant may be used as adjunctive treatments for various oral conditions [19]. One possible application involves the use of plant extracts in mouth rinses designed to control microbial growth within the oral cavity. Such herbal mouthwashes may help reduce the accumulation of pathogenic microorganisms on mucosal surfaces and dental plaque. This antimicrobial effect may help prevent secondary infections in oral ulcers and inflammatory lesions [18].

Topical formulations such as gels or ointments containing extracts of Solanum nigrum may also be useful in managing ulcerative conditions. When applied directly to affected areas, these preparations may provide localized anti-inflammatory and analgesic effects while promoting wound healing. This localized mode of delivery may increase the effectiveness of the therapeutic compounds while minimizing systemic exposure. Herbal toothpaste containing plant extracts may further contribute to oral health maintenance by reducing microbial load and preventing inflammatory conditions affecting the mucosa and gingiva. The incorporation of

medicinal plant extracts into dental products is gaining popularity because these agents may offer therapeutic benefits with minimal adverse effects [17].

SAFETY AND TOXICOLOGICAL CONSIDERATIONS

Although Solanum nigrum possesses several medicinal properties, it is important to consider potential safety concerns associated with its use. Certain parts of the plant contain glycoalkaloids such as solanine, which can produce toxic effects when consumed in excessive amounts. These compounds are naturally occurring secondary metabolites that function as protective agents for the plant against pests and pathogens [20]. Exposure to high concentrations of glycoalkaloids may cause symptoms such as nausea, vomiting, abdominal discomfort, and neurological disturbances. However, traditional medicinal practices often involve specific preparation techniques such as cooking, drying, or boiling, which help reduce the concentration of toxic compounds in the plant material. When used in appropriate doses and properly processed forms, Solanum nigrum is generally regarded as safe for medicinal use. In many traditional practices, the leaves and ripe berries are used after adequate preparation, while unripe berries and raw plant parts are usually avoided due to their higher glycoalkaloid content.

Modern pharmacological studies emphasize the importance of establishing standardized extraction procedures and dosage guidelines to ensure the safe and effective use of herbal medicines. Additional toxicological studies are required to determine optimal dosage and long-term safety in therapeutic applications related to oral healthcare [20].

FUTURE PERSPECTIVES AND RESEARCH DIRECTIONS

Despite the promising pharmacological properties of Solanum nigrum, further scientific research is required to fully understand its therapeutic potential in the management of oral mucosal lesions. Most existing studies have been conducted using in-vitro experiments or animal models. Although these studies provide valuable information regarding biological activity, clinical trials involving human participants are necessary to confirm the safety and effectiveness of the plant in dental applications [21].

Future research should focus on identifying and isolating the specific bioactive compounds responsible for the therapeutic effects of the plant. Understanding the molecular mechanisms through which these compounds act may facilitate the development of standardized herbal formulations [22][23]. Advancements in pharmaceutical technology may also enhance the delivery of plant-derived compounds to oral tissues. Novel drug-delivery systems such as bio-adhesive gels, nanoparticles, and controlled-release formulations may improve the bioavailability and retention of herbal extracts within the oral cavity [24][25]. Additionally, researchers may investigate potential synergistic effects between Solanum nigrum and other medicinal plants. Herbal combinations containing multiple plant extracts may produce enhanced therapeutic outcomes through complementary pharmacological actions.

CONCLUSION

Oral mucosal lesions represent a significant clinical concern because they can cause pain, discomfort, and impairment of normal oral functions. These lesions may arise from a variety of factors including trauma, infections, systemic diseases, and immune-mediated conditions. Conventional therapeutic approaches are often effective but may be associated with certain limitations such as adverse effects and recurrence. Medicinal plants have long been used as

alternative sources of therapeutic agents, and increasing attention has been directed toward their potential role in oral healthcare. Solanum nigrum is one such plant that has been widely utilized in traditional medicine for the treatment of inflammatory disorders and ulcers.

Scientific studies have demonstrated that the plant contains several bioactive compounds with antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. These pharmacological activities may contribute to the management of oral mucosal lesions by reducing inflammation, inhibiting microbial growth, and promoting tissue regeneration. Although preliminary research findings are encouraging, further clinical investigations are required to establish standardized formulations and therapeutic protocols. Integrating traditional medicinal knowledge with modern scientific research may lead to the development of novel plant-based therapies for the prevention and treatment of oral diseases.

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