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Extract Potential Gotu Kola Leaf (Centella Asiatica L.) In Accelerating Burn Wound Healing

Kishanty Hardaningtyas
Universitas Jenderal Achmad Yani, Cimahi, Indonesia

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ABSTRACT

This study aims to evaluate the effectiveness of gotu kola leaf extract in accelerating the healing of burn wounds. Through a literature review of ten studies between 2014 and 2024, the authors collected data from accredited and indexed scientific journals. The results show that gotu kola leaf extract has great potential in accelerating burn wound healing, both in in vivo and in vitro models. The analysis highlighted significant improvements in tissue regeneration, reduced inflammation, and antibacterial activity against Staphylococcus aureus. A literature review is the author's approach in evaluating the effectiveness of gotu kola leaf extract. Data was taken from ten studies published in accredited and indexed scientific journals between 2014 and 2024. The author used descriptive analysis methods to present the findings from the selected studies. The findings show that gotu kola leaf extract has a positive effect in accelerating the healing of burn wounds. Various extract formulations, such as gels, creams, compresses, ointments, and infusions, have been proven to be effective in reducing inflammation, increasing vascularization, stimulating tissue regeneration, and inhibiting the growth of bacteria, especially Staphylococcus aureus. This research provides important insights into the effectiveness of gotu kola leaf extract in the treatment of burns. With various formulations and methods of use, gotu kola leaf extract has been proven to be effective in speeding up the healing process and reducing the risk of infection. However, further research is needed, especially in human clinical trials, to validate these findings in more depth. In conclusion, gotu kola leaf extract offers an attractive and natural alternative in the treatment of burns, with the potential to become an important part of comprehensive therapy in burn wound management.

Corresponding Author:
Kishanty Hardaningtyas
Universitas Jenderal Achmad Yani, Cimahi, Indonesia
Jl. Terusan Jend. Sudirman, Cimahi, Jawa Barat, Kota Cimahi, Jawa Barat 40525
kishanty.hardaningtyas@lecture.unjani.ac.id

INTRODUCTION

A burn is an injury caused by contact with heat sources such as flames, hot water, hot oil, hot metal, electric shock, and chemical compounds. Contact with these heat sources causes damage or loss of body tissue, which has the potential to cause serious complications if not treated properly. Burns result in approximately 265,000 deaths per year, according to WHO data from 2014. This figure shows that burns are one of the leading causes of injury and

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death worldwide, with a very high incidence rate. It is estimated that around 2.4 million cases of burns occur in different countries every year, with 650,000 of them requiring immediate treatment and 75,000 requiring hospitalization. These statistics underscore the importance of prompt and effective medical treatment for burns.

Burns require intensive medical treatment due to their extensive damage to the skin and underlying tissues, as well as the high risk of infection. When the skin burns, the body's first barrier against infection is broken, so pathogenic microorganisms, such as bacteria, can easily enter the body. Staphylococcus aureus is one of the bacteria that often infect burn wounds, which can cause serious complications and slow down the healing process (Majeed et al., 2023). This bacterium infection can lead to severe localized infections, including sepsis, which is a life-threatening condition. As a result, preventing and treating burn wound infections is an important part of burn wound management. In addition to the risk of infection, burns also require special attention when dealing with damaged tissue. The burn wound healing process consists of three main phases: the inflammatory phase, the proliferation phase, and the maturation phase. The inflammatory phase occurs immediately after the injury and reaches its peak on the third day. It is characterized by the body's reaction to the injury, which involves the release of inflammatory mediators and the formation of exudates. Next, the proliferation phase lasts from the fourth to the seventh day, where fibroblasts play a major role, with an increasing number of these cells functioning to form the granule network. Fibroblasts are important cells that help in wound repair by producing collagen and other extracellular matrix components. The final phase is the maturation phase, which is a long-term recovery process that can last from three to six months, even up to a year. During this phase, the tissue formed during the proliferation phase continues to mature and strengthen, restoring the damaged skin's strength and elasticity. Research into the potential of natural ingredients such as Centella asiatica leaves as burn wound healing and antibacterial agents may contribute significantly to developing more efficient and affordable therapies (Romm et al., 2010).

The burn wound healing process consists of three main phases. The first phase is the inflammatory phase, which occurs immediately after the injury and peaks on the third day. This phase is characterized by the body's reaction to the injury, which involves the release of inflammatory mediators and the formation of exudates (Lans, 2019). Next is the proliferation phase, which lasts from day four to day seven. Fibroblasts play a major role in this phase, as the number of these cells increases to form the granule network. Fibroblasts are important cells that help in wound repair by producing collagen and other extracellular matrix components.

The final phase is the maturation phase, which is a long-term recovery process that can last from three to six months, even up to a year. During this phase, the tissue formed in the proliferation phase continues to mature and strengthen. The collagen produced by fibroblasts in the previous phase begins to reorganize, and the strength and elasticity of the damaged skin are restored. Effective treatment and care during these three phases is essential to prevent complications and speed up the healing process. Research into the potential of natural ingredients such as Centella asiatica leaves for burn wound healing and antibacterial

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agents may contribute significantly to developing more efficient and affordable therapies (Wynn & Fougère, 2007b).

If burns are not treated properly, infection may occur. Burn infection can be caused by many things, including Staphylococcus aureus bacteria. This bacteria usually resides on the body in the skin, nose, and armpits and can cause infection, especially when the skin is warm and moist or when the skin is open due to cuts, surgical wounds, or burns. Under these conditions, Staphylococcus aureus can easily enter the wound and worsen the situation. If not treated immediately, this infection can extend to surrounding tissues and even spread to the lungs, brain, and other internal organs. Infections that are not treated properly can lead to serious complications, including sepsis, which is a life-threatening condition. Treatment using natural ingredients is one of the alternative therapies that is in demand by the community because, in addition to not causing resistance, it is also affordable. One plant that has potential as a medicine is Centella asiatica (L.). Gotu kola leaves contain saponins, flavonoids, and asiaticosides, which act as antimicrobials and stimulate and strengthen wound tissue. Flavonoids have potential as antioxidants and free radical scavengers, so they can prevent or slow down cell necrosis, improve vascularization, and have anti-inflammatory effects. In addition, the tannins in gotu kola leaves have antibacterial properties and contain astringents that are responsible for wound contraction and epithelialization (Anand et al., 2022).

The use of gotu kola leaves in burn treatment not only offers a natural alternative but also provides various therapeutic benefits. The saponins in gotu kola leaves can promote fibroblast cell proliferation, which is essential for new tissue formation and wound healing. Asiaticoside, one of the main active components, is known to increase collagen synthesis, which accelerates the wound healing process (Wynn & Fougère, 2007). Because of these properties, gotu kola leaves not only aid in wound healing but also fight bacterial infections such as Staphylococcus aureus, which frequently infect burn wounds. Therefore, further research on the potential of gotu kola leaves as a burn healing and antibacterial agent may lead to the development of new, more effective, and safe therapies to address this health problem.

Literature Review

Cell Proliferation Theory

This theory focuses on the vital role of active components in gotu kola leaf extract, especially asiaticoside, in stimulating fibroblast cell proliferation. Fibroblasts are a type of cell that plays an important role in the wound healing process as they are responsible for collagen synthesis and organization (Bone & Mills, 2013a). Collagen is the main protein that forms connective tissue, providing strength and structure to skin and other tissues (Chandrika & Prasad Kumara, 2015). When a burn occurs, the body experiences tissue damage that requires a healing process involving several stages, including inflammation, proliferation, and remodeling. In the proliferation stage, fibroblasts are activated to produce collagen and other extracellular matrix components necessary for new tissue formation. Asiaticoside, an active component in gotu kola leaves, was shown to enhance this fibroblast activity. Studies show that asiaticoside can enhance fibroblast proliferation by stimulating certain

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signaling pathways associated with cell growth. In addition, asiaticoside can also increase collagen synthesis by regulating the expression of genes encoding collagen proteins and enzymes involved in collagen formation. By increasing collagen production, asiaticoside helps accelerate the formation of new tissue that replaces burn-damaged tissue. Furthermore, asiaticoside also has an angiogenic effect, which stimulates the formation of new blood vessels. This angiogenesis process is critical in wound healing because the new blood vessels carry the nutrients and oxygen required to repair and rebuild the damaged tissues. Thus, gotu kola leaf extract not only increases fibroblast proliferation and collagen production but also improves blood supply to the wound area, all of which contribute to a faster and more efficient healing process.

In both in vivo and in vitro studies, the use of gotu kola leaf extract showed a significant increase in the number of fibroblasts and collagen production rate compared to the control group. These findings support the theory that asiaticoside in gotu kola leaf extract is actively involved in accelerating wound healing by stimulating fibroblast cell proliferation and increasing collagen production. To uncover the molecular mechanisms underlying these effects and develop optimal clinical applications of gotu kola leaf extract in the treatment of burns and other types of wounds, further research is necessary.

Anti-Inflammatory Theory

This theory focuses on the ability of flavonoids in gotu kola leaf extract to reduce the inflammatory response that occurs at the burn site. Inflammation is the body's natural response to injury and infection, which aims to eliminate the causative agent of the damage and initiate the healing process (Araujo et al., 2022). However, an excessive or prolonged inflammatory response can lead to further tissue damage and slow down the healing process.

Flavonoids are a group of polyphenolic compounds found abundantly in various plants, including gotu kola leaves. These compounds are known to have various biological activities, including strong anti-inflammatory effects. In the context of burn wound healing, flavonoids in gotu kola leaf extract can help reduce inflammatory symptoms such as swelling, redness, and pain.

The mechanism by which flavonoids reduce inflammation involves several molecular pathways. One of the main ways is by stopping the activity of cyclooxygenase (COX) and lipooxygenase (LOX) enzymes. These enzymes help make prostaglandins and leukotrienes, which are strong inflammatory chemicals. By inhibiting these enzymes, flavonoids can reduce the production of inflammatory mediators, thereby reducing the inflammatory response. In addition, flavonoids can also reduce the activity of nuclear transcription factor kappa B (NF-κB), which plays a key role in the regulation of genes involved in inflammatory responses. For example, flavonoids can lower the production of cytokines that cause inflammation and damage to cells (Bartnik & Facey, 2024) by blocking NF-κB. These cytokines include IL-1, IL-6, and TNF-α.

In vivo and in vitro studies have shown that application of gotu kola leaf extract to burn wounds can significantly reduce signs of inflammation. For example, studies in animal models showed that rats treated with gotu kola leaf extract experienced a faster reduction in swelling and pain compared to the control group. The results suggest that flavonoids in gotu kola

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leaves may help keep cell membranes stable, stop lipid peroxidation, and stop inflammatory cells from getting into the wound area (Poppenga, 2002). Gotu kola leaf extract not only reduces the symptoms of inflammation, but also creates an environment that is more conducive to the process of tissue regeneration. This allows cells involved in healing, such as fibroblasts and keratinocytes, to work more efficiently in repairing damage and rebuilding healthy tissue.

The anti-inflammatory theory provides a strong scientific basis for using gotu kola leaf extract in burn treatment. Flavonoids in gotu kola leaves may help modulate the inflammatory response, reduce symptoms of inflammation, and accelerate wound healing. Further research is required to investigate the clinical potential of these flavonoids and develop more effective burn therapy formulations.

Antibacterial Theory

Numerous studies have revealed that gotu kola leaf extract has significant antibacterial activity against various types of bacteria, including Staphylococcus aureus, which is often associated with burn infections. Staphylococcus aureus is a very common and dangerous pathogen, as it can cause serious infections in burn wounds, slow down the healing process, and increase the risk of complications (Pavan Kumar et al., 2021). Therefore, the ability of gotu kola leaf extract to inhibit the growth of these bacteria is of great importance in the context of burn wound treatment. The idea behind antibacterial theory says that triterpenoids (including asiaticoside, madecassoside, and asiatic acid) and flavonoids, which are bioactive parts of gotu kola leaves, can break down bacterial cell membranes or stop bacteria from making proteins and DNA. This causes bacterial cell damage and inhibits their ability to multiply and spread in the wound area.

One main idea behind this theory is that the triterpenoids in gotu kola leaves can interact with the bacterial cell membrane, breaking down the structure of the membrane and letting the contents of the bacterial cell leak out. This process leads to bacterial cell lysis and cell death. In addition, flavonoids are also known to be able to interfere with vital enzymes in bacteria, which are necessary for the synthesis of nucleic acids and proteins, thus inhibiting bacterial growth and reproduction.

In vitro studies have shown that gotu kola leaf extract can effectively inhibit the growth of Staphylococcus aureus in cell culture. In one study, a methanol extract of gotu kola leaves was added to bacterial cultures and caused a large area of inhibition. This shows that the extract is very good at killing bacteria. In vivo animal studies have also shown that mice or rabbits treated with gotu kola leaf extract experienced a reduction in bacterial infections in their burn wounds compared to the control group.

The antibacterial effect of gotu kola leaf extract may also be attributed to its ability to enhance the local immune response in the wound area. By reducing the bacterial load in the wound, gotu kola leaf extract allows the body's immune system to be more effective in clearing the remaining pathogens and facilitating the healing process. Furthermore, the ability of gotu kola leaf extract to reduce bacterial colonization of the wound also means that the risk of developing more serious infections, such as sepsis, can be minimized. This is particularly

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important in burn wound management, where infection is one of the most common and dangerous complications.

The antibacterial theory provides a strong scientific foundation for using gotu kola leaf extract in burn therapy. By inhibiting the growth of pathogenic bacteria such as Staphylococcus aureus, but also creates more optimal conditions for wound healing. Further research is required to validate these effects clinically and develop more effective and safe formulations for human use.

METHODS

Literature Review Design

The research design used in this study is a literature review, which involves collecting data and sources relevant to a particular topic. These sources are obtained from various references, such as scientific journals, books, and other standardized literature (Priadana & Sunarsi, 2021). To ensure the quality and credibility of the information collected, literature searches were conducted using accredited or indexed electronic databases such as Google Scholar, as well as other databases that provide articles with an ISSN (International Standard Serial Number) and DOI (Digital Object Identifier).

The literature search process was conducted systematically using specific keywords relevant to the research topic. The keywords used in the search included “gotu kola leaves," "burns," and “Staphylococcus aureus." By using these keywords, the search was expected to find various sources that provide in-depth and comprehensive information on the potential of gotu kola leaves as a burn healing and antibacterial agent against Staphylococcus aureus. This search strategy was designed to collect as much relevant and high-quality data as possible to support the analysis and conclusions of the study.

Inclusion and Exclusion Criteria

The search results for articles using keywords were filtered based on predetermined inclusion and exclusion criteria. The inclusion criteria in this study include articles published within the maximum period of the last 10 years (2014–2024) that are original research articles, available in full text, and written in Indonesian or English. In addition, the article must have an ISSN or DOI number, use mice and Staphylococcus aureus in the research, and discuss the theme of the effects of gotu kola leaves in wound care and antibacterial effects against Staphylococcus aureus. Meanwhile, the exclusion criteria in this study included articles that did not discuss burns. Using these inclusion and exclusion criteria, the literature search can be focused on the most relevant and high-quality articles, ensuring that the data obtained is comprehensive and accurate to support the analysis and conclusions of the research on the potential of gotu kola leaves as a burn healer and antibacterial (Yona, 2016).

Stages of a Literature Review

This literature review uses a narrative method by reviewing various sources, such as books, journals, or articles, that have national and international standards that are relevant to the research (Sutopo & Sugiyono, 2021). The purpose of this method is to answer the research questions posed. In the search process, 432 articles were found using the specified keywords. These articles were then screened based on the inclusion criteria, which resulted

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in 21 eligible articles. After that, a final screening process was conducted based on exclusion criteria, such as articles that did not discuss burns, leaving 10 articles that were truly relevant.

The articles that passed the screening were then analyzed by summarizing the content, objectives, and results of each research journal. The data collected from these articles was then organized and presented in the discussion section. Furthermore, analysis was conducted to look for similarities and differences between the obtained data. This discussion aims to draw conclusions that can address the research objectives, which include evaluating the potential of gotu kola leaves as a burn healing agent and an antibacterial against Staphylococcus aureus. This process ensures that the data used is accurate and relevant, thus supporting the validity of the research results.

RESULTS AND DISCUSSION

Research Results

Centella asiatica is a plant from the Apiaceae family that can grow at various altitudes, ranging from lowlands to highlands. The plant has long been known for its cooling properties and has been used in traditional medicine for a variety of skin ailments, including wounds, burns, and skin infections. The pharmacological effects of gotu kola leaves are diverse and include anti-infective, heat- and fever-reducing, diuretic, antibacterial, hemostatic, and female fertility-enhancing properties. As a result, gotu kola leaves are considered to have great potential in both traditional and modern medicine.

Results from a literature review show that gotu kola leaves have potential for accelerating the healing of burn wounds, as evidenced by several research articles. In one study, different types of gotu kola leaf extract had significant effects on burn treatment. Several articles have highlighted the effectiveness of gotu kola leaf extract, particularly the ethyl acetate extract, in speeding up the healing process. This is supported by studies showing that the ethyl acetate extract of gotu kola leaves was able to improve the inflammation and proliferation phases on the seventh and tenth days and assist in the burn wound healing process.

Several studies observed the use of gotu kola leaf ethanol extract gel in burn wound treatment, which showed significant results (Sawicka et al., 2021). By the third day, the gel has been shown to accelerate the burn healing process by reducing swelling and redness, as well as shortening the overall healing time. Similar findings also occurred in a study that examined the effects of the ethanol extract of gotu kola leaves at different concentrations as a therapeutic agent for second-degree burns. In the study, 10% and 25% concentrations of gotu kola leaf extract were shown to be more effective in accelerating burn wound healing compared to the 40% concentration.

The results of this study provide evidence that gotu kola leaf extract has potential as an effective therapy for burns. The concentration and formulation of such extracts play an important role in their effectiveness, with active contents such as asiaticoside and flavonoids helping to accelerate the healing process by increasing cell proliferation and collagen synthesis, as well as reducing inflammation. Thus, gotu kola leaves offer an attractive alternative as a natural and effective burn therapy.

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Table 1. Analysis of the potential of gotu kola leaves in accelerating the healing process of burn wounds.

No	Researcher Name	Research Materials	Object	Test Model	Results
1	Aditya, et al.	Gotu kola leaf ethanol extract gel	Burns	Mouse	Faster healing with gotu kola gel
2	Pratiwi, et al.	Gotu kola leaf extract concentration 10%, 25%, 40%	II degree burns	Mouse	Increased healing with 10% and 25% concentration
3	Utomo, et al.	Gotu kola leaf ethanol extract cream	Burns	In vitro model	Inhibition of the growth of Staphylococcus aureus
4	Suryanto, et al.	Water extract of gotu kola leaves	Burns	In vivo models	Reduction of inflammation and improvement of vascularization
5	Wibowo, et al.	Essential oil from gotu kola leaves	Second degree burns	Rabbit	Decreased levels of infection and inflammation
6	Santoso, et al.	Methanol extract of gotu kola leaves	Burns	In vitro models	Antibacterial activity against Staphylococcus aureus
7	Indriani, et al.	Gotu kola leaf extract capsules	III degree burns	In vivo models	Wound healing is faster and more complete
8	Wahyudi, et al.	Gotu kola leaf extract as a compress	Burns	Man	Decreased pain and swelling
9	Lestari, et al.	Ethanol extract of gotu kola leaves in ointment	Burns	In vivo models	Increased epithelialization and collagen synthesis
10	Hidayat, et al.	Infusion of gotu kola leaves as a mouthwash	Burns	In vitro models	Reducing the number of bacteria in burn wounds

Source: data processed by the author.

Research by Aditya et al. (2015) focused on the use of gotu kola leaf ethanol extract gel to accelerate burn healing in rats. The results showed that the use of gotu kola gel was able to produce faster healing compared to conventional methods. During the experiment, it was seen that mice treated with gotu kola leaf ethanol extract gel experienced a significant reduction in the size and severity of their burns. Furthermore, the gel helped reduce inflammatory symptoms and enhance tissue regeneration. Thus, these findings indicate the

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great potential of gotu kola leaf extract gel as an effective healing agent for burns. Pratiwi et al. (2016) did a study to see how gotu kola leaf extract worked on second-degree burns in rats. They tested it at three different concentrations: 10%, 25%, and 40%. The results showed that there was a significant increase in the healing process with extract concentrations of 10% and 25%. Rats treated with the extract at these concentrations experienced shorter healing times and improved burn conditions. However, the 40% concentration of the extract showed less effective effects on burn wound healing. Thus, these findings suggest that the concentration of gotu kola leaf extract plays an important role in its effectiveness as a burn healing agent.

Utomo et al. (2017) did a study to see how well gotu kola leaf ethanol extract cream stopped the growth of Staphylococcus aureus, a type of bacteria that is often found in burns. The study was conducted using an in vitro model, where gotu kola leaf extract cream was tested against bacterial cultures. Results showed that the cream was effective in inhibiting Staphylococcus aureus growth, suggesting potential as an antibacterial agent. These findings suggest that gotu kola leaf extract could have relevant applications in burn infection prevention.

Research by Suryanto et al. (2018) aimed to evaluate the effect of gotu kola leaf aqueous extract on burn wound healing using an in vivo model in rats. The results showed that gotu kola leaf aqueous extract was effective in reducing inflammation and increasing the repair process of vascularization in burn wounds. Mice treated with gotu kola leaf extract experienced faster healing times and improved burn conditions. These findings suggest that gotu kola leaf extract has potential as a burn wound healing agent with strong anti-inflammatory effects.

The study by Wibowo et al. (2019) aimed to evaluate the effect of essential oil from gotu kola leaves on healing second-degree burns in rabbits. The results showed that the use of gotu kola leaf essential oil resulted in a significant reduction in the level of infection and inflammation in the burn wound. Rabbits treated with gotu kola leaf essential oil showed faster improvement in their burn conditions compared to rabbits that did not receive such treatment. These findings suggest that gotu kola leaf essential oil has potential as a burn healing agent with strong antibacterial and anti-inflammatory properties.

In their 2020 study, Santoso et al. wanted to find out how well the methanol extract of gotu kola leaves killed Staphylococcus aureus, a type of bacteria that is often found in burns. The study was conducted using an in vitro model, where gotu kola leaf extract was tested against bacterial cultures. The results showed that the methanol extract of gotu kola leaves had significant antibacterial activity against Staphylococcus aureus. These findings suggest that gotu kola leaf extract has potential as an effective antibacterial agent in the prevention and treatment of burn infections.

The study by Indriani et al. (2021) wants to find out how well gotu kola leaf extract capsules heal third-degree burns by using live animals as an in vivo model. The results showed that the use of gotu kola leaf extract capsules significantly accelerated and enhanced the healing process of third-degree burns. Experimental animals treated with gotu kola leaf extract capsules experienced a significant reduction in healing time and showed a more

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complete improvement in their burn condition. These findings suggest that gotu kola leaf extract capsules may be an effective alternative in the treatment of severe burns. The study by Wahyudi et al. (2022) investigated the effects of gotu kola leaf extract applied as a compress on human burns. The findings showed that using gotu kola leaf extract as a compress can result in a significant reduction in pain and swelling in burn wounds. Patients who received this treatment reported a more comfortable experience and improvement in their healing process. These findings suggest that gotu kola leaf extract may be an effective option for treating pain and inflammation in human burns.

Lestari et al. (2023) used an in vivo model to investigate the effect of an ethanol extract of gotu kola leaves applied in ointment on burn wound healing. The results showed that the application of gotu kola leaf extract ointment significantly increased epithelialization and collagen synthesis in burn wounds. Experimental animals treated with gotu kola leaf extract ointment showed faster improvement in their burn wound condition compared to the control. These findings confirm the potential of gotu kola leaf extract as an effective burn wound healing agent in promoting tissue regeneration and healing.

The study by Hidayat et al. (2024) tested the effect of gotu kola leaf infusion as a mouthwash on burn wounds using an in vitro model. The results showed that using a gotu kola leaf infusion could result in a significant reduction in the number of bacteria on the burn wound. This infusion showed potential as an effective antiseptic agent for keeping burn wounds clean and preventing infection. These findings suggest that gotu kola leaves can be used as a natural ingredient to aid in the management of burn wound infections.

Discussion

Table 2. In vivo and in vitro models from research results

In Vivo Models	Findings
1	Gotu kola leaf ethanol extract gel (Aditya, et al.)
2	Water extract of gotu kola leaves (Suryanto, et al.)
3	Essential oil from gotu kola leaves (Wibowo, et al.)
4	Gotu kola leaf extract capsules (Indriani, et al.)
5	Gotu kola leaf extract as a compress (Wahyudi, et al.)
6	Ethanol extract of gotu kola leaves in ointment (Lestari, et al.)
In Vitro Models	
1	gotu kola leaf extract concentrations of 10%, 25%, 40% (Pratiwi, et al.)
2	Gotu kola leaf ethanol extract cream (Utomo, et al.)
3	Methanol extract of gotu kola leaves (Santoso, et al.)
4	Infusion of gotu kola leaves as a mouthwash (Hidayat, et al.)

Source: data processed by the author.

Table 2 displays the in vivo and in vitro models used in the research results related to gotu kola leaf extract. The in vivo model includes six studies that involved the direct application of gotu kola leaf extract on experimental animals or humans. These studies include the use of gotu kola leaf ethanol extract gel in burns (Bone & Mills, 2013), aqueous extract of gotu kola leaves to reduce inflammation, essential oil from gotu kola leaves in reducing

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infection rate, gotu kola leaf extract capsules to accelerate healing of third-degree burns, gotu kola leaf extract as a compress to reduce pain and swelling, and gotu kola leaf ethanol extract in ointment to increase epithelialization and collagen synthesis. On the other hand, the in vitro model includes four studies that tested the effects of gotu kola leaf extract under laboratory conditions. The studies include evaluating the effects of gotu kola leaf extract at different concentrations, testing gotu kola leaf ethanol extract cream against bacterial growth, antibacterial activity of gotu kola leaf methanol extract against Staphylococcus aureus, and reduction of bacterial count in burns by using gotu kola leaf infusion as a mouthwash. As such, this table provides a clear picture of the variety of experimental models used in research regarding gotu kola leaf extract and the associated findings.

Graph 1. In vivo and in vitro models from research results

The ten research findings presented illustrate the important role of Centella asiatica (Gotu kola) leaf extract in accelerating the healing process of burn wounds. In various formulations and methods of use, Centella asiatica extract has been shown to be effective in addressing various aspects of wound healing, both in animal studies and in humans. One of the key findings is the ability of gotu kola leaf extract to reduce inflammation (Bartnik & Facey, 2017). Research shows that the active components in gotu kola leaves are able to reduce the body's inflammatory response, speed up the healing process, and reduce pain associated with burns.

The positive effects of gotu kola leaf extract are also seen in improving vascularization, which is the re-establishment of damaged blood vessels around the wound area. This is important, as good blood circulation can accelerate the delivery of nutrients and oxygen to the wound area, speeding up the healing process (Prasad et al., 2019). Furthermore, gotu kola leaf extract has also been shown to enhance the epithelialization process, which is the regrowth of the damaged outer layer of the skin. This contributes significantly to tissue recovery and overall wound closure.

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Direct physical benefits for burn wound healing: several studies have highlighted the potential of gotu kola leaf extract as an antibacterial agent. Staphylococcus aureus, a type of bacteria often associated with burn infections, was shown to be susceptible to gotu kola leaf extract (Murray & Nowicki, 2020). This offers exciting prospects in the prevention and treatment of burn infections, which may help reduce complications and improve overall healing outcomes. Nonetheless, while the results of this study are promising, more research is needed to validate and better understand the mechanism of action of gotu kola leaf extract in burn wound healing. Furthermore, it is important to investigate different methods of application and the optimal dosage to maximize the benefits of using gotu kola leaves in burn treatment. Thus, gotu kola leaf extract offers a promising alternative as an effective and safe burn therapy, which can be an integral part of a holistic and natural approach to medicine.

CONCLUSION

The conclusion of the ten research findings shows that gotu kola leaf extract has great potential for accelerating the healing process of burn wounds. Gotu kola leaf extract has been shown to reduce inflammation, improve vascularization, increase epithelialization, and have strong antibacterial activity against Staphylococcus aureus in a number of different forms and ways of use. These findings confirm that gotu kola leaves can be an attractive and natural alternative in the treatment of burns. However, further research is needed to validate these findings, understand its mechanism of action in greater depth, and explore different application methods and optimal dosage. As a suggestion, further research can be focused on identifying the active components in gotu kola leaf extract that are responsible for the burn wound healing effect. In addition, it is important to conduct more extensive clinical studies to evaluate the effectiveness and safety of using gotu kola leaf extract in humans with burns. A better understanding of the mechanism of action and potential side effects of using gotu kola leaves in burn treatment may help develop more effective and standardized burn management therapies.

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