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Plant Extracts: Potential Alternative Treatment for Bovine Mastitis Causing Pathogen *Staphylococcus aureus*

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Abstract

Bovine mastitis is a significant disease affecting dairy herds worldwide. Mastitis can be characterized by physical, chemical, and bacteriological changes in milk and various pathological changes in the glandular tissues. This disease can invariably affect the health status of cattle and eventually have a direct economic impact on the dairy industry. Mastitis can be caused by the interaction of pathogens and their environment, and one of the disease-causing pathogens, *Staphylococcus aureus*, remains the leading cause of mastitis. Treatment is directed towards the use of broad-spectrum antimicrobials. However, with the threat of antibiotic-resistant pathogens, alternative treatments are being explored. The use of plants with ethnoveterinary origins can be promising in the search for novel therapeutic regimens. This review focuses on various studies using plant extracts as a possible alternative treatment for this specific bovine-causing pathogen, *Staphylococcus aureus.* Several studies that were conducted will serve as preliminary data in the development of alternative treatments for bovine mastitis.

Keywords

Bovine mastitis; Ethnoveterinary medicine; Plant extracts; *Staphylococcus aureus*

Introduction

Mastitis is described as an inflammation of the mammary gland parenchyma. It is characterized by pathological abnormalities in the glandular tissues as well as physical, chemical, and bacterial changes in milk (1). It can account for about 38% of the total direct losses (2). The prominent bacteria responsible for causing mastitis include both gram-positive and gram-negative bacteria like *Staphylococci*, *Streptococci*, *Escherichia coli* and *Klebsiella pneumoniae* (3). The interaction between these pathogens, the host resistance, and the environment plays a major role in the occurrence of this disease (4). The treatment regimen is directed towards the use of antibiotics. However, with the occurrence of disease-resistant pathogens, it makes it harder to cure. Treatment of this disease is threatened by the development of antibiotic-resistant pathogens, and to date, no alternative treatment remedy is available (5). In addition, antibiotic residues in milk and milk products can be detrimental to public health as well. The need to find alternative solutions to mitigate these problems is vital to the welfare of dairy animals, the quality of milk and milk products, and the safety of the milk for consumers.

Staphylococcus aureus is an important mastitis-causing pathogen because of its ability to develop a persistent, infectious disease that is challenging to treat (6-8). Despite the different control strategies to reduce mastitis, *S. aureus* remains the leading cause of mastitis in dairy herds worldwide (9). This pathogen is also considered to be a primary contributor to the subclinical form of mastitis (10). The occurrence of the bacteria in mastitis and the difficulty of treatment indicate the need to find novel solutions in the treatment of this disease. The objective of this review is to present the various traditional plants that were studied for the mastitis-causing pathogen, *S. aureus*. It is, however, limited only to studies done in a laboratory setting. More research in this field is needed to determine the efficacy of these various plant extracts in different animal models and in clinical trials.

Overview of ethnoveterinary medicine

Plants are sources of a large number of biologically active molecules that can be used to treat various ailments. Ethnoveterinary medicines, the scientific term for traditional animal health care, can provide low-cost alternative treatments for various animal diseases. It is developed by farmers through experience and practice rather than by scientists in laboratories. It can be sourced locally in the community, making it more accessible (11,12). The phytochemical screening and bioactivity of different plant remedies should be further investigated to provide scientific evidence in support of ethnoveterinary practices. The discovery of various medicinal plant extracts could pave the way for novel alternative treatments for pathogens and a remedy for increasing antibiotic resistance.

Studies on plants against *Staphylococcus aureus*

Several medicinal plants have been investigated to determine their effects on *S. aureus. Malva sylvestris*, an annual plant commonly used as a medicinal plant, has been evaluated for its bioactivities (13). This plant species has been traditionally used as folk medicine in Brazil and other countries as treatment for colitis, stomatitis, and other forms of inflammation (14). The methanolic extract of the flowers of *Malva sylvestris* showed high antibacterial effects against some pathogen bacteria strains, such as *S. aureus* and *Streptococcus agalactiae*, with Minimum Inhibitory Concentration (MIC) value of 192 ug/ml and 200 ug/ml, respectively (13). The pharmacological and biological activity is due to the naphthaquinolones, anthocyanidines, flavonoids, or mucilaginous polysaccharides that have a significant concentration in plant fruits, flowers, leaves, and roots (15). A study was also conducted to determine the antibacterial activity of synthesized Fe_3O_4 nanoparticles using *Malva sylveris* and showed high antimicrobial effects against gram-positive strains, including *S. aureus* with a MIC value of 125 ug/ml (16).

Cinnamomum tamala leaf extract has antidiarrheal properties, and hypoglycaemic activity and is used for various kinds of ailments, likely for dryness of mouth, anorexia, and bladder dysfunctions (17). The antimicrobial activity of *C. tamala* against *S. aureus* (ATCC 25923) showed a 12.5 MIC value (mg/ml) (18). Researchers (19) also evaluated the potential antibacterial activity of *Cinnmomum tamala* using different crude extract preparations. They found out that ethanol, methanol, ethyl acetate, and aqueous extract showed 17.90±0.17, 20.77±0.64, 15.06±0.31 and 11.76±0.25 observed zones of inhibition (in mm diameter) against *S. aureus* (19). The presence of various secondary metabolites, including flavonoids, alkaloids, terpenoids, and tannins in *C. tamala* leaf contributed to its antibacterial activity (20, 21). These compounds are known to possess medicinal properties. Alkaloids, one of the components of the leaf extract, act on efflux inhibition, which has a putative mechanism for antimicrobial effect (22). Flavonoids, on the other hand, inhibit nucleic acid synthesis, inhibit cytoplasmic membrane function, inhibit energy metabolism, alter membrane permeability, and attenuate pathogenicity (23).

Syzygium antisepticum, a medium-sized tree native to maritime Southeast Asia, was traditionally used for postpartum recovery against puerperal fever, anaemia, blood loss, and weakness (24). The observed in vitro minimum inhibitory concentration of *S. antisepticum* extract against *S. aureus* and Methicillin-Resistant *Staphylococcus aureus* (MRSA) of 0.125 mg/ml can be attributed to its high total phenolic content (25). It was also observed that there was alteration and membrane distortion on *S. aureus* cells treated with 2mg/ml of *S. antisepticum* extract, as evidenced by TEM monographs (25).

Hypericum perforatum L., a perennial herb commonly known as St. John's Wort (Hypericaceae), has been documented for its significant biological and chemical characteristics, and ethnobotanical studies have described its use in the treatment of infectious disorders (26). Anti-MRSA activity of extracts of *H. perforatum* has been investigated in various studies with different preparations, including hydrous solution (27) and aqueous and ethanolic extracts (28). Hydrous solutions of *H. perforatum* tea inhibit gram-positive bacteria, particularly methicillin-resistant strains of *S. aureus*, with MIC values of 1.3–2.5 mg/ml (27). Similarly, the methanol extract of *H. perforatum* has an antimicrobial effect against *S. aureus* and coagulase-negative *staphylococci*-33 and 37 pathogens isolated from subclinical cow mastitis (29).

Xanthium strumarium leaf, *Combertum molle* bark, and unidentified plant (FR1) leaf were also used to inhibit the growth of *Staphylococcus aureus* and *Streptococcus agalactiae* isolated from cattle with mastitis (30). Among the three plant species, *Xanthium strumarium* leaf had the widest mean zone of inhibition (30).

In another study, the potential efficacy of *Allium sativum*, *Bunium persicum*, *Oryza sativa*, and *Triticum aestivum* in Northwest Pakistan towards pathogenic microorganisms was evaluated using the agar-well diffusion method (31). These plant species are traditionally utilized in northwest Pakistan for the treatment of mastitis (32). *S. aureus* (ATCC) and *S. aureus* (MDR) are sensitive to the alkaloids of *A. sativum* as compared to crude extract, flavonoids, and saponins. The alkaloid extract of *B.*

persicum also exhibited a zone of inhibition of 12.33 mm (31). The zones of inhibition of *A. sativum* and *B. persicum* alkaloids have no significant difference from the zones of inhibition of standard antibiotics, which suggests the efficacy of naturally occurring products (31).

Recently, methanolic extracts of the pink and white flowers of *Nerium oleander L*. were evaluated against different bacterial species, including *Staphylococcus carpae*. Both the extracts showed marked antibacterial activity against different bacterial species. However, the extract of pink flowers showed markedly higher antibacterial activity than the extract of white flowers (32,33). A recent study also showed the potential of *Anona muricata* (Linn) leaf extract as a natural source of antibacterial therapies. The findings indicate that leaf extract was most effective and has a concentration-dependent zone of inhibition against *Staphylococcus aureus* (34). Novel research was also conducted on the antibacterial activity and phytochemical components of *Calpurnia aurea* leaf extract in an effort to find a cost-effective and efficient pathogen treatment regimen. The results showed that the zone of inhibition for *C. aurea* leaf extract is larger than that of the positive control at a concentration of 75 mg/ml of petroleum extract (35).

These studies suggest the potential antimicrobial activity of these plant materials against *S. aureus*. These can serve as preliminary data in the search for novel therapeutic drugs against bovine mastitis-causing pathogens. In addition, to determine their efficacy and toxicity, these plant extracts should be tested on different animal models. Understanding the pathophysiology of bovine mastitis is also important to consider when implementing treatment to reduce its occurrence.

Conclusions

The potential antimicrobial activity of different plant extracts against *Staphyloccocus aureus*, a bovine mastitis-causing pathogen, cannot be underestimated. Several studies that were conducted will serve as preliminary data in the development of alternative treatments for bovine mastitis. In addition, this can also be promising for combating antibiotic resistance. However, further studies should be conducted to prove its efficacy.

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Authors' contributions

AA carried out the completion of the manuscript by following the PST article guidelines. The manuscript was checked and reviewed by CM. All authors read and approved the final transcript of the manuscript.

Compliance with ethical standards

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References

1. Radotis O, Gay C, Hinchkliff K. Veterinary medicine: A textbook of the diseases of cattle, sheep, pigs, goats and horses. ELBS & Baillier Tindall; 2000.
2. Albenzio M, Taibi I, Musco A, Sevi A. Prevalence and etiology of subclinical mastitis in intensively managed flocks and related changes in the yield and quality of milk. Small Ruminant Research. 2002 [cited 2022 June 1];219-26. Available from: https://doi.org/10.1016/S0921-4488(02)00022-6
3. Contreras G, Rodiguez J. Mastitis: Comparative etiology and epidemiology. Journal of Mammary Gland Biology and Neoplasia. 2011 [cited 2022 December 3];339-56. Available from: https://doi.org/10.1007/s10911-011-9234-0
4. Gera S, Guha A. Assessment of acute phase proteins and nitric oxide as indicator of subclinical mastitis in Holstein × Haryana cattle. Indian Journal of Animal Sciences. 2011 [cited 2022 December 3];1029-31. Available from: https://epubs.icar.org.in/index.php/IJAnS/article/view/11326
5. Francoz D, Wellemans V, Dupre J, Roy J, Labelle F, Lacasse P, Dufour S. Invited review: A systematic review and qualitative analysis of treatments other than conventional antimicrobials for clinical mastitis in dairy cows. Journal of Dairy Science. 2017 [cited 2023 January 5];7751-70. Available from: https://doi.org/10.3168/jds.2016-12512
6. Sender S, Pawlik A, Korwin K. Current concepts on the impact of coagulase-negative*Staphylococci* causing bovine mastitis as a threat to human and animal health – A review. Animal Science Paper and Reports. 2017 [cited 2023 January 5];123-35. Available from: https://api.semanticscholar.org/CorpusID:26552200
7. Notebaert S, Meyer R. Mouse models to study the pathogenesis and control of bovine mastitis. Veterinary Quarterly. 2006 [cited 2023 January 5];2-13. Available from: https://doi.org/10.1080/01652176.2006.9695201
8. Wall R, Powell A, Paape M, Kerr D, Bannerman D, Pursel V, Hawk H. Genetically enhanced cows resist intramammary *Staphylococcus aureus* infection. Nature Biotechnology. 2005 [cited 2023 January 5];445-51. Available from: https://doi.org/10.1038/nbt1078
9. Misra N, Wines T, Knopp C, Hernan R, Bond L, Mitchell B, JK T. Immunogenicity of a *Staphylococcus aureus*-cholera toxin A2/B vaccine for bovine mastitis. Vaccine. 2018 [cited 2023 January 6];3513-21. Available from: https://doi.org/10.1016/j.vaccine.2018.04.067
10. Saglam A, Sahin M, Celik E, Celebi O, Akca D, Otlu S. The role of *Staphylococci* in subclinical mastitis of cows and lytic phage isolation against to *Staphylococcus aureus*. Veterinary World. 2017 [cited 2023 January 6];1481-85. Available from: https://doi.org/10.14202/vetworld.2017.1481-1485
11. Khan IH, Javaid A. Identification of biologically important compounds in neem leaves through GC-MS analysis. Jordan Journal of Pharmaceutical Sciences. 2021 [cited 2023 January 3];14(3): 359-66.
12. Javaid A, Chaudhury FA, Khan IH, Ferdosi MFH. Potential health-related phytoconstituents in leaves of *Chenopodium quinoa*. Advancements in Life Sciences. 2022 [cited 2023 January 3];9 (4):574-78.

13. Zschocke S, Rabe T, Taylor J, Jager A, JV S. Plant part substitution-A way to conserve endangered medicinal plants. Journal of Ethnopharmacology. 2000 [cited 2023 January 5];281-92. Available from: https://doi.org/10.1016/S0378-8741(00)00186-0

14. Asika P, Van Averbeeke W, Sonandi A. Use of herbal remedies by small scale farmers to treat livestock diseases in central Easter Cape Province, South Africa. Journal of the South African Veterinary Association. 2000 [cited 2023 January7];87-91. https://doi.org/10.4102/jsava.v71i2.685

15. Razavi S, Zarrini G, Molavi G, Ghasemi G. Bioactivity of *Malva Sylvestri* L., a medicinal Plant from Iran. Iranian Journal of Basic Medical Sciences. 2011 [cited 2023 January 3];574-79. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3586856/

16. Esteves P, Sato A, Esquibel M, Buzzi F, Meira A, Filho V. Antinociceptive activity of *Malva sylvestris* L.. Latin American Journal of Pharmacy. 2009 [cited 2023 January 3];454-56.

17. Zohra SF, Meriem B, Samira S, Muneer A. Phytochemical screening and identification of some compounds from Mallow. Journal of Natural Products and Plant Resources. 2012 [cited 2023 January 5];512-16. Available from: https://doi.org/10.1016/j.matpr.2019.11.212

18. Mousavi SM, Hashemi SA, Zarei M, Bahrani S, Savardashtaki A, Esmaeili H, Ramavadi B. Data on cytotoxic and antibacterial activity of synthesized Fe_3O_4 nanoparticles using *Malva sylvestris*. Data in Brief. 2019 [cited 2023 Janua y 3];1-10. Available from: https://doi.org/10.1016/j.dib.2019.104929

19. Venkateshwa R. The chemical constituents and biological studies of *Chloroxylon swietenia.* Indian Drugs. 2008 [cited 2023 January 1];5-15.

20. Manandhar S, Luitel S, Dahal RK. *In vitro* antimicrobial activity of some medicinal plants against human pathogenic bacteria. Journal of Tropical Medicine. 2019 [cited 2023 January 1];1-5. Available from: https://doi.org/10.1155/2F2019/2F1895340

21. Goyal P, Chauhan A, Kaushik P. Laboratory evaluation of crude extracts of *Cinnamomum tamala* for potential antibacterial activity. Electronic Journal of Biology. 2009 [cited 2023 January 1];75-79. Available from: https://doi.org/10.12691/jfnr-7-1-1

22. Hassan W, Kazmi SN, Riaz A, Zaman B. Antimicrobial activity of *Cinnamomum tamala* leaves. Journal of Nutritional Disorders & Therapy. 2016 [cited 2023 January 1];1-5. Available from: https://doi.org/10.1007/s13562-016-0381-7

23. Mishra A, Singh B, Pandey A. *In vitro*-antibacterial activity and phytochemical profiles of *Cinnamomum tamala* (Tejpat) leaf extracts and oils. Reviews in Infection. 2010 [cited 2023 January 2];134-39.

24. Khameneh B, Iranshahy M, Soheili V, Bazzaz B. Review on plant antimicrobials: A mechanistic viewpoint. Antimicrobial Resistance and Infection Control. 2019 [cited 2023 Januar 5];1-28. Available from: https://doi.org/10.1186/s13756-019-0559-6

25. Xie Y, Yang W, Tang FC. Antibacterial activities of flavonoids: Structure-activity relationship and mechanism. Current Medicinal Chemistry. 2015 [cited 2023 January 8];132-49. Available from: https://doi.org/10.2174/0929867321666140916113443

26. Lamxay V, de Boer H, Bjork L. Traditions and plant use during pregnancy, childbirth and post partum recovery by the Kry ethnic group in Lao PDR. J Ethnobiology. 2011 [cited 2023 January 1];1. Available from: https://doi.org/10.1186/1746-4269-7-14

27. Wenqian Y, Yuk H. Antimicrobial efficacy of *Syzygium antisepticum* plant extract against *Staphylococcus aureus* and methicillin-resistant *S. aureus* and its application potential with cooked chicken. Food Microbiology. 2018 [cited 2023 January 9];176-84. Available from: https://doi.org/10.1016/j.fm.2017.12.002

28. Saddiqe Z, Naeem I, Maimoona A. A review of the antibacterial activity of *Hypericum perforatum* L. Journal of Ethnopharmacology. 2010 [cited 2022 December 30];511-21. Available from: https://doi.org/10.1016/j.jep.2010.07.034

29. Reichling J, Weseler A, Saller R. A current review of the antimicrobial activity of *Hypericum perforatum* L. Pharmacopsychiatry. 2001 [cited 2022 December 15];S116-18. Available from: https://doi.org/10.1055/s-2001-15514

30. Dadgar T, Asmar M, Saifi A, Bayat H, Ghaemi E. Antibacterial activity of certain medicinal plants against methicillin resistant and methicillin sensitive *Staphylococcus aureus*. Asian Journal of Plant Sciences. 2006 [cited 2023 January 2];861. Available from: https://doi.org/10.3923/ajps.2006.861.866

31. Okmen G, Balpinar N. Biological activities of *Hypericum perforatum* L. African Journal of Traditional, Complementary and Alternative Medicines. 2017 [cited 2023 January 1];213-18. Available from: https://doi.org/10.3923/ajps.2006.861.866

32. Saeed HM, Ferdosi MFH, Khan IH, Javaid A, Sultan MW. Antibacterial activity and GC-MS analysis of white flowers extract of *Nerium oleander* L. International Journal of Biology and Biotechnology. 2023 [cited 2023 March 3];20(1):163-68.

33. Saeed HM, Ferdosi MFH, Javaid A, Khan IH, Sattar T. Antibacterial activity and phytochemical profile of flower extract of pink oleander. International Journal of Biology and Biotechnology. 2023 [cited 2023 May 19];20(2):353-58.

34. Wilkie ED, Michael PO, Oluduro AO, Alao J. Antibacterial potential of *Annona muricata* (Linn.) leaf extract: A promising natural source for novel antibacterial therapies. South Asian Journal of Research in Microbilogy. 2023 [cited 2023 August 1];34-44. Available from https://doi.org/10.9734/sajrm/2023/v1

35. Wasihun Y, Habteweld HA, Ayenew K. Antibacterial activity and phytochemical components of leaf extract of *Calpurnia aurea*. Scientific reports. 2023 [cited 2023 July 1]. https://doi.org/10.1038/s41598-023-36837-3