Chapter 25

Therapeutic Potential of Coconut Oil and Amla Oil in Clinical and Sub Clinical Mastitis

Muhammad Rizwan[1], Tanveer Ahmed[2], Hifssa Aslam[3], Kashood Aslam[4], Sadia Sanaullah[1], Abdullah Ahmed[5], Haziq Abdullah[6], Raheel Sharif[7], Ahmed Fawad Khalil Muhammad[8], Asjad Umair Shah, Muhammad Abuzar Javaid[6] and Muhammad Anees[6]

[1]Department of Veterinary Medicine, University of Veterinary and Animal Sciences, Lahore
[2]Department of Clinical Sciences BZU Multan
3Department of Computer Science BZU Multan
[4]Center of Excellence in Molecular biology, university of Punjab, Lahore
[5]Department of Veterinary Surgery University of Veterinary and Animal Sciences, Lahore
[6]Faculty of Veterinary sciences, BZU, Multan
[7]Department of Pathology, University of Veterinary and Animal Sciences, Lahore
8Department of Meat Science and Technology University of Veterinary and Animal Sciences, Lahore
*Corresponding author: rizwanmalik4911@gmail.com

ABSTRACT

Mastitis is the Inflammation of Parenchyma of Mammary gland. There are two types of mastitis Clinical and subclinical. In clinical mastitis there are visible changes in the udder. In subclinical mastitis there is no visible change in the udder. Subclinical mastitis is one common problem in the dairy industry. It can be diagnosed by Laboratory diagnosis. In field condition mostly surf field mastitis test is used in country like Pakistan. Antibiotics are used to treat subclinical mastitis like Tylosin, Amoxicillin, Enrofloxacin, Penicillin, and Oxytetracycline. Due to emergence of antibiotics residue ethnoveterinary therapy can also be used to treat mastitis. In our study we see the effect of Coconut oil and Amal oil in treatment of mastitis. Coconut oil and Amal oil in Combination give good results. Coconut oil has better results than Amal oil in your Study.

KEYWORDS
Mastitis, Antibiotics, Ethnoveterinary therapy

Received: 28-Jun-2024
Revised: 04-Jul-2024
Accepted: 05-Aug-2024

A Publication of Unique Scientific Publishers

Cite this Article as: Rizwan M, Ahmed T, Aslam H, Aslam K, Sanaullah S, Ahmed A, Abdullah H, Sharif R, Muhammad AFK, Shah AU, Javaid MA and Anees M 2024. Therapeutic potential of coconut oil and amla oil in clinical and sub clinical mastitis. In: Zafar MA, Abbas RZ, Imran M, Tahir S and Qamar W (eds), Complementary and Alternative Medicine: Essential oils. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 220-225. https://doi.org/10.47278/book.CAM/2024.406

INTRODUCTION

Primary source of economic output for Pakistan is basically and primarily depends upon agricultural production. Socioeconomically Pakistani population is associated with agricultural industry. Pakistan ranks fifth in world milk production index. Livestock in Pakistan includes cattle, Buffalo, Sheep and Goat and their variants. The main purpose of livestock is to produce high quality meat, milk and wool (Rehman et al., 2017). Mastitis, Anthrax, Foot and mouth infection, Rabies, Lumpy skin disease Tetanus and Hemorrhagic septicemia are the major domestic animal diseases and most normal managemental sickness of animal.

Mastitis is associated with inflammation of parenchyma of mammary glands (Rizwan et al., 2022). Causes include multiple etiological agents, such as bacteria, viruses, fungi and yeast results in substantial economic losses in the dairy industry (Goulart and Mellata et al., 2022). Decreases milk production as well as causes undesirable changes in the milk composition (Grispoldi et al., 2019). Mastitis can manifest as either clinical or subclinical forms. Clinical mastitis is described by observable changes in milk, such as a change in color, consistency, or the presence of clots and flakes, with swelling and discomfort in the udder (De Vliegher et al. 2018). Subclinical mastits is the most prevalent managemental disorder of dairy industry (Viguier et al., 2009; Bobbo et al., 2017). During Sub-clinical mastitis milk production lessens by 10-26% (Dhakal et al., 2007). The mammary gland serves as the primary reservoir for these infectious agents, thereby increasing their prevalence in cases of mastitis. The incidence of contagious pathogens in mastitis cases is significantly higher compared to other causative factors. *Staphylococcus aureus, Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Escherichia Coli*, and *Corynebacterium pyogenes*, are repeatedly isolated from infected milk of sub-clinically mastitis lactating dairy animals (Rizwan et al., 2021; Qureshi et al., 2023). Subclinical mastitis is more prevalent in early-stage lactation animals than the animals that are in mid lactation stage (Abegewi et al., 2022).

The etiology of clinical mastitis is multifactorial with husbandry, management, feeding and hygiene as influencing factors (Gerjets et al. 2011). Coliform microbes cause up to 80% mastitis (Fahim et al., 2019).

The prevalence of both types of clinical and subclinical mastitis was observed to be greater in the hindquarters compared to the forequarters, and within the hindquarters, the left side exhibited a higher susceptibility compared to the right side. Laboratory tests and clinical signs can be used to detect mastitis. The clinical signs of mastitis include redness, swelling of udder and decreased milk production. Anorexia and fever may also be present in animals (Lago et al. 2011; Barlow 2011). In different countries of world like Uruguay after S. aureus, E. coli was one of leading cause of bovine subclinical mastitis. Subclinical mastitis in dairy animals is commonly detected after laboratory examination of the milk as there is no gross swelling of udder or apparent changes in the milk (Baloch et al., 2016). The incidence of clinical mastitis is 3 to 40 times lower than that of subclinical mastitis (Aqib et al., 2017).

Several diagnostic tests have been developed for early detection of mastitis, including the Surf field mastitis test, California mastitis test (CMT), and somatic cell count (SCC). However, the measurement of milk electrical conductivity for subclinical mastitis diagnosis is a novel technique that remains in frequently utilized by farmers in Pakistan (Suojala et al., 2011). Bacteriological culture is used to detect subclinical mastitis as well as by somatic cell count Mastitis which is subclinical is detected by test called California mastitis test in countries like Pakistan.

Cow factors incorporate Age, years Breed Parity, Month of calving, Milk yield, Lactation period, Calving stretch Dry period are risk factors that are related to mastitis. Herd factors incorporate Education of ranchers, Total number of animals, Lactating cows Lactating cows, No. of calves, Dung evacuations each day, Method took on for milk let down. residue milk in udder. Housing incorporates Evenness of floor, Type of sheet material, (Removal of sheet material each day, Length of cow standing region, Width of cow standing region, Distance from compost record to slow down. Climate incorporates Presence of flies (Gunawardana et al., 2014).

Subclinical mastitis can cause serious economic losses for small-scale farmers due to its significant financial impact. Additionally, the handling and consumption of unpasteurized coliform-contaminated milk and/or milk products have been associated with public health implications, including the potential transmission of pathogenic microorganisms to humans, resulting in foodborne illnesses such as diarrhea, abdominal cramps, and vomiting. Moreover, the consumption of contaminated milk and milk products has been linked to the development of antimicrobial resistance, which poses a significant threat to public health (Abegewi et al. 2022). Antibiotics residues are transferred after consumption of milk to humans (Rizwan et al. 2022).

Used in California mastitis test (sodium alkyl aryl sulfonate) is exorbitant and not applicable in our country. The test used for discovery of subclinical mastitis is the surf field mastitis test. 3% arrangement of house holding detergent is used for identification of subclinical mastitis. The Surf field mastitis test has the following properties: the development of a practical and accessible agricultural testing system, cheap, easily accessible, and user-friendly. In comparison to these properties, it is noted that Surf Excel, a product manufactured by Unilever Pakistan, falls short.

In addition to its economic impact, subclinical mastitis (SCM) also serves as a reservoir for zoonotic pathogens such as *Mycobacterium tuberculosis*, *Brucella* spp., *Leptospira* spp., and *Streptococcus* spp. These pathogens can be transmitted to humans through contact with contaminated milk or dairy products, so they are a significant risk to human health. Bacterial infections pose a significant threat to the cattle farming industry, resulting in substantial economic losses. In particular, dairy cattle are highly vulnerable to intramammary infections that occur within the three weeks preceding parturition and during early lactation. Changes in the mammary gland physiology and hormonal fluctuations, which can compromise the animal's immune system are the factors that make it susceptible to SCM. Such infections can lead to reduced milk yield and quality, increased veterinary costs, and a higher risk of culling. So, it is essential to take control and preventive measures to make the bacterial infection less effective. In subclinical mastitis a few treatments strategy is utilized in term of anti-microbial and home-grown treatments (Aqib et al., 2017). To treat subclinical mastitis anti-microbial are utilized (Doğruer et al., 2010). Tylosin, Amoxicillin, Enrofloxacin and Penicillin are antibiotics that are used to treat mastitis. Procaine penicillin is that antibiotic that is mostly used against mastitis, but advanced studies show that resistance develops by bacteria against Procaine penicillin (Rizwan et al., 2021). Antibiotic sensitivity testing indicated that Erythromycin, Enrofloxacin, and Gentamicin were the most effective antibiotics, while Streptomycin was found to be the least effective against these bacterial pathogens (Abdel-Shafy et al., 2014).

Therapeutic uses of Coconut Oil in Clinical Mastitis

Due to its detrimental effects on milk production and cow health clinical mastitis, is a significant concern in dairy farming, which is characterized by visible inflammation and abnormal milk. While antibiotics are commonly used for treatment, alternative therapies like coconut oil offer a natural and potentially effective approach to managing clinical mastitis.

Antimicrobial Properties

Coconut oil is made up of a unique composition of medium-chain fatty acids (MCFAs), most importantly Lauric acid, which show potent antimicrobial activity. Lauric acid damaged the lipid membrane of bacteria, including common mastitis-causing bacteria such as *Streptococcus agalactiae, Escherichia coli, Streptococcus aureus, Streptococcus dysgalactiae* and *Streptococcus uberis*. By focusing these bacteria, coconut oil helps to reduce the bacterial population in the mammary gland, thereby aiding in the resolution of clinical mastitis (Rizwan et al., 2021).

Anti-inflammatory Properties

Coconut oil possesses anti- inflammatory as well as antimicrobial properties, that can help cows suffering from clinical mastitis. coconut oil can reduce inflammation and associated symptoms and promote quick healing of the affected udder tissue.

Application Method

Gently massaging the oil into the affected udder quarters causes the great reveal in pain. It is important to ensure thorough coverage of the inflamed tissue with a thin layer of coconut oil. The application of coconut oil should be performed after each milking to increase absorption and efficacy of coconut oil (Rizwan et al., 2021).

Dosage and Frequency

For clinical mastitis the recommended dosage of coconut oil may vary depending on the severity of the condition of mastitis and the size of the affected udder quarters. As a general guideline, apply coconut oil in enough amount to form a thin, uniform layer over the entire surface of the inflamed udder tissue. Repeat the application of coconut oil twice daily for maximum results, ideally after each milking period. (Rizwan et al., 2021).

Therapeutic Uses of Coconut Oil for the Treatment of Subclinical Mastitis

Subclinical mastitis, a common disease among dairy cattle, poses significant economic and animal welfare concerns for dairy farmers. While conventional treatments often involve antibiotics and inflammatory treatments, the therapeutic use of coconut oil offers a natural and potentially effective alternative treatment.

Mode of Action

Coconut oil consists of a high proportion of medium-chain fatty acids (MCFAs), considerably lauric acid, which exhibits potent antimicrobial properties and anti-inflammatory properties. Lauric acid damaged the lipid membrane of bacteria, leading to their destruction. In the context of subclinical mastitis, coconut oil's antimicrobial property targets the pathogens responsible for the inflammation of the mammary gland, helping to reduce bacterial load and reduce symptoms of subclinical mastitis (DebMandal et al., 2011).

Anti-inflammatory Properties

Besides its antimicrobial effects, coconut oil also possesses anti-inflammatory action. The inflammation associated with subclinical mastitis led to tissue damage and compromised udder health. By mitigating inflammation, coconut oil aids in the healing process, helping in the restoration of normal mammary gland function.

Application Method

For subclinical mastitis treatment the application of coconut oil involves applying a thin layer of the oil directly to the affected udder quarters. It is recommended to gently massage the oil into the udder tissue, ensuring thorough coverage. The application of coconut oil should be performed immediately after milking to maximize absorption and efficacy.

Dosage and Frequency

The recommended dosage of coconut oil for subclinical mastitis treatment varies depending on the severity of the condition and the size of the affected udder quarters. A general guideline is to apply enough coconut oil to form a thin, uniform layer over the entire udder surface. Repeat the application twice daily for optimal results, ideally after each milking session.

Therapeutic Uses of Amla Oil for the Treatment of Subclinical Mastitis

Amla oil, derived from the Indian gooseberry (Emblica officinalis), is another natural product that has been used traditionally for various beauty and health purposes. While there is limited scientific data specifically on the use of amla oil for subclinical mastitis

Antimicrobial Activity

Amla oil consists of phytochemicals such as flavonoids and tannins, which have shown antimicrobial properties in some studies. These compounds may help to inhibit the growth of bacteria associated with mastitis, potentially contributing to the resolution of subclinical mastitis (Khan et al., 2018).

Anti-inflammatory Activity

Amla oil is rich in antioxidants, including flavonoids and vitamin C, which exhibit anti-inflammatory properties. By reducing inflammation, amla oil helps to reduce discomfort and swelling associated with subclinical mastitis (Akhtar et al., 2011).

Wound Healing Properties

Amla oil has been traditionally used to promote wound healing and tissue repair. In the context of mastitis, application of amla oil to cracked or damaged teats may help soothe irritation and help in the healing process (Rizwan et al., 2021).

Immunomodulatory Properties

Some scientific data suggests that amla extract may modulate immune function by promoting the activity of immune cells. This immunomodulatory effect could potentially support the body's natural defenses against bacterial infections, including those associated with mastitis (Khan et al., 2018).

Traditional Use

Amla has a long been used in Ayurvedic drug for colorful health conditions, including those affecting the guts. While anecdotal substantiation and conventional knowledge suggests its implicit efficacity for mastitis, further exploration is demanded to confirm its effectiveness and safety in this environment (Setayesh et al., 2023).

Therapeutic uses of Amla Oil for the Treatment of Clinical Mastitis

Amla oil painting, comes from the Indian gooseberry (Emblica officinalis), importantly used in Ayurvedic drug for its treatment parcels. While exploration on the specific use of amla oil painting for the treatment of clinical mastitis is limited, it emphasize advantages in easing inflammation, inducing crack mending, and antimicrobial parcels suggest that it give advantages in managing the cases.

Table 1: Comparison of Uses of Coconut and Amla Oil

Properties	Coconut Oil	Amla Oil	Reference
Antimicrobial Properties	Contains lauric acid, which show antimicrobial activity by damaging the phospholipid membranes of bacteria, fungi.and viruses.	Consist of phytochemicals such tannins and flavonoids, which possess antimicrobial properties that may help to stop bacterial growth.	(Rizwan et al., 2022)
Anti-inflammatory Effects	Show anti- inflammatory properties that may help to less inflammation associated with mastitis.	Abundant in antioxidants like vitamin C and flavonoids, which have anti-inflammatory effects, potentially reducing discomfort and swelling.	(Khan et al., 2018)
Wound Healing	Recognized for its moisturizing and nourishment properties, which help in healing cracked or damaged skin.	Traditionally used to promote wound healing and tissue repair, suggesting potential benefits for soothing and healing teat irritation.	(Rizwan et al., 2021)
Immunomodulator Effects	Some components, like capric acid, show immunomodulatory effects, helping the immune system's response to infections.	Data suggests that amla extract may enhance immune function, potentially helps the body's natural defenses against bacterial infections.	(Khan et al., 2018).
Moisturizing and Conditioning	Well-known for its moisturizing properties, helpful for keeping the skin hydrated and preventing further irritation of skin.	Used in skin care for its moisturizing and conditioning which can be advantageous for maintaining skin health in the view of mastitis.	(Setayesh et al., 2023).
Traditional Use	Utilized in traditional medicine systems for various health and beauty purposes, including skincare and haircare.	Has a long history of use in Ayurvedic medicine for a wide range of health conditions, reflecting its versatility and potential therapeutic value.	(Setayesh et al., 2023).

Anti-inflammatory Characters

Amla oil painting have bioactive composites same as flavonoids and tannins, which parade potentate-inflammatory goods. In the environment of clinical mastitis, inflammation of the mammary gland is a hallmark point. It may help to reduce inflammation, thereby easing symptoms same as bone pain and tenderheartedness along with mastitis.

Antimicrobial Properties

Bacterial infection is a common and major cause of clinical mastitis, with Staphylococcus aureus is a predominant pathogen. Amla oil painting possesses antimicrobial parcels that have been demonstrated against a wide range of bacteria, including S. aureus. By inhibiting bacterial growth and proliferation, amla oil painting may help combat the contagious element of mastitis, promoting resolution of the condition (Khan et al., 2018).

Wound Healing Effects

In addition to its anti-inflammatory and antimicrobial parcels, amla oil painting has been shown to promote crack mending. In cases of clinical mastitis where towel damage or nipple trauma may occur, the operation of amla oil painting topically to the affected area could potentially expedite the mending process, restoring the integrity of the bone towel and easing recovery.

Stress Reduction

Pain and discomfort associated with clinical mastitis can contribute to stress and anxiety in suckling matters. Amla oil painting has been traditionally used in Ayurvedic drug for its comforting and invigorating parcels. Incorporating amla oil painting into tone- care routines, similar as gentle massage ways, may help promote relaxation and emotional well- being in women managing with mastitis (Khan et al., 2018).

REFERENCES

Abdel-Shafy, H., Bortfeldt, R. H., Tetens, J., and Brockmann, G. A. (2014). Single nucleotide polymorphism and haplotype effects associated with somatic cell score in German Holstein cattle. Genetics, selection, *Evolution: Gse*, 46(1), 35-35. https://doi.org/10.1186/1297-9686-46-35

Abegewi, U. A., Esemu, S. N., Ndip, R. N., and Ndip, L. M. (2022). Prevalence and risk factors of coliform-associated mastitis and antibiotic resistance of coliforms from lactating dairy cows in North West Cameroon. *Plos One*, 17(7), e0268247-e0268247. https://doi.org/10.1371/journal.pone.0268247

Ahmad, S., Yaqoob, M., Bilal, M. Q., Muhammad, G., Yang, L.-G., Khan, M. K., and Tariq, M. (2011). Risk factors associated with prevalence and major bacterial causes of mastitis in dromedary camels (Camelus dromedarius) under different production systems. *Tropical Animal Health and Production*, 44(1), 107-112. https://doi.org/10.1007/s11250-011-9895-0

Akhtar, M. S., Ramzan, A., Ali, A., and Ahmad, M. (2011). Effect of Amla fruit (Emblica officinalisGaertn.) on blood glucose and lipid profile of normal subjects and type 2 diabetic patients. *International Journal of Food Sciences and Nutrition*, 62(6), 609-616. https://doi.org/10.3109/09637486.2011.560565

Aqib, A. I., Ijaz, M., Durrani, A. Z., Anjum, A. A., Hussain, R., Sana, S., and Ahmad, S. S. (2017). Prevalence and Antibiogram of Staphylococcus aureus, a Camel Mastitogen from Pakistan. *Pakistan Journal of Zoology*, 49, 861-867. https://doi.org/10.17582/journal.pjz/2017.49.3.861.867

Baloch, H., Rind, R., Rind, M. R., Kumar, V., Baloch, N., and Oad, R. K. (2018). Effect of Diverse Factors on the Frequency of Clinical and Subclinical Mastitis in Kundhi Buffaloes of Sindh, Pakistan. *Pakistan Journal of Zoology*, 50(5). https://doi.org/10.17582/journal.pjz/2018.50.5.1619.1628

Bobbo, T., Ruegg, P. L., Stocco, G., Fiore, E., Gianesella, M., Morgante, M., and Cecchinato, A. (2017). Associations between pathogen-specific cases of subclinical mastitis and milk yield, quality, protein composition, and cheese-making traits in dairy cows. *Journal of Dairy Science*, 100(6), 4868-4883. https://doi.org/10.3168/jds.2016-12353

DebMandal, M., and Mandal, S. (2011). Coconut (Cocos nucifera L.: Arecaceae): In health promotion and disease prevention. *Asian Pacific Journal of Tropical Medicine*, 4(3), 241-247. https://doi.org/10.1016/s1995-7645(11)60078-3

Dhakal, I. P., Dhakal, P., Koshihara, T., and Nagahata, H. (2007). Epidemiological and Bacteriological Survey of Buffalo Mastitis in Nepal. *Journal of Veterinary Medical Science*, 69(12), 1241-1245. https://doi.org/10.1292/jvms.69.1241

Doğruer, G., Saribay, M. K., Ergün, Y., Aslantaş, Ö., Demir, C., and Ateş, C. T. (2010). Treatment of subclinical mastitis in Damascus goats during lactation. *Small Ruminant Research*, 90(1-3), 153-155. https://doi.org/10.1016/j.smallrumres.2010.01.003

Fahim, K. M., Ismael, E., Khalefa, H. S., Farag, H. S., and Hamza, D. A. (2019). Isolation and characterization of E. coli strains causing intramammary infections from dairy animals and wild birds. *International Journal of Veterinary Science And Medicine*, 7(1), 61-70. https://doi.org/10.1080/23144599.2019.1691378

Goulart, D. B., and Mellata, M. (2022). Escherichia coli Mastitis in Dairy Cattle: Etiology, Diagnosis, and Treatment Challenges. *Frontiers In Microbiology*, 13, 928346-928346. https://doi.org/10.3389/fmicb.2022.928346

Grispoldi, L., Massetti, L., Sechi, P., Iulietto, M. F., Ceccarelli, M., Karama, M., and Cenci-Goga, B. T. (2019). Short communication: Characterization of enterotoxin-producing Staphylococcus aureus isolated from mastitic cows. *Journal of Dairy Science*, 102(2), 1059-1065. https://doi.org/10.3168/jds.2018-15373

Gunawardana, S., Thilakarathne, D., Abegunawardana, I. S., Abeynayake, P., Robertson, C., and Stephen, C. (2014). Risk factors for bovine mastitis in the Central Province of Sri Lanka. *Tropical Animal Health and Production*, 46(7), 1105-1112. https://doi.org/10.1007/s11250-014-0602-9

Khan, A., Ahmed, T., Rizwan, M., and Khan, N. (2018). Comparative therapeutic efficacy of Phyllanthus emblica (Amla) fruit extract and procaine penicillin in the treatment of subclinical mastitis in dairy buffaloes. *Microbial Pathogenesis*, 115, 8-11. https://doi.org/10.1016/j.micpath.2017.12.038

Qureshi, M. A., Fatima, Z., Muqadas, S. M., Najaf, D. E., Husnain, M., Moeed, H. A., and Ijaz, U. (2023). Zoonotic diseases caused by mastitic milk. *Zoonosis, Unique Scientific Publishers, Faisalabad, Pakistan*, 4, 557-572.

Rehman, A., Jingdong, L., Chandio, A. A., and Hussain, I. (2017). Livestock production and population census in Pakistan: Determining their relationship with agricultural GDP using econometric analysis. *Information Processing in Agriculture*, 4(2), 168-177. https://doi.org/10.1016/j.inpa.2017.03.002

Rizwan, M., Durrani, A. Z., Ahmad, T., Ahmad, S. S., and Chaudhry, M. (2021). Comparative therapeutic efficacy of procaine penicillin, Phyllanthus emblica fruit extract and Cocos nucifera oil against subclinical mastitis. *Livestock Science*, 251, 104655. https://doi.org/10.1016/j.livsci.2021.104655

Rizwan, M., Durrani, A. Z., Ahmad, T., Ahmad, S. S., and Chaudhry, M. (2022). Prevalence of blaZ gene and antibiotics susceptibility test profile of β-lactams resistant Staphylococcus aureus isolated from subclinical mastitis in lactating Beetal goats. *Livestock Science*, 255, 104797. https://doi.org/10.1016/j.livsci.2021.104797

Setayesh, L., Haghighat, N., Rasaei, N., Rezaei, M., Casazza, K., Nadery, M., and Asbaghi, O. (2023). The impact of Emblica Officinalis (Amla) on lipid profile, glucose, and C-reactive protein: A systematic review and meta-analysis of randomized controlled trials. Diabetes andamp; Metabolic Syndrome: *Clinical Research andamp; Reviews*, 17(3), 102729. https://doi.org/10.1016/j.dsx.2023.102729

Suojala, L., Pohjanvirta, T., Simojoki, H., Myllyniemi, A.-L., Pitkälä, A., Pelkonen, S., and Pyörälä, S. (2011). Phylogeny, virulence factors and antimicrobial susceptibility of Escherichia coli isolated in clinical bovine mastitis. *Veterinary Microbiology*, 147(3-4), 383-388. https://doi.org/10.1016/j.vetmic.2010.07.011

Viguier, C., Arora, S., Gilmartin, N., Welbeck, K., and O'Kennedy, R. (2009). Mastitis detection: current trends and future perspectives. *Trends in Biotechnology*, 27(8), 486-493. https://doi.org/10.1016/j.tibtech.2009.05.004