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Essential Oils: An Effective Antimicrobial Therapy in Bovine Mastitis

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ABSTRACT

Mastitis is termed as the inflammation of the udder and is most common in dairy animals nowadays. Many pathogens are involved in causing mastitis but *Staphylococcus aureus* is the most common pathogen which is also the main etiological agent of many respiratory and skin infections in humans. The most commonly used treatment of mastitis is the use of antimicrobials against infectious microbes which is the main reason for antimicrobial residues (AMR) because pathogens may have developed resistance against them. Depending upon the recent literature, this conclusion can be withdrawn that use of essential oils is free of public health risks and may prove good alternative to antimicrobials in the control of bovine mastitis.

Keywords: Mastitis, Essential oils, AMR, Antimicrobials, *Staphylococcus aureus*, public health

Introduction:

Bovine mastitis is the inflammatory response of udder tissues caused by various pathogens or trauma. The common etiological microorganisms include gram-negative (*Escherichia coli* and *Klebsiella spp.*), gram-positive (*Staphylococcus aureus* and *Streptococcus agalactiae*), and environmental pathogens (*Enterococcus spp.* and *Streptococcus uberis*). Recent studies showed that *S. aureus* is the most prevalent microorganism causing mastitis. Host factors like age, breeding and genetics, udder structure, host nutritional stress and immune system are also the main causes of bovine mastitis [1]. It is one of the most common diseases of dairy animals worldwide causing a huge economic loss to farmers. Moreover, it also results in low milk yield, treatment costs, medications, and culling of animals. The total failure cost due to mastitis is estimated to be about $147 per cow in a year resulting in low milk production and culling [2].

Mastitis is characterized by clinical, subclinical, and chronic cases. Clinical mastitis is very common and is easily diagnosed because the abnormalities are visible like red and swollen udder and fever [1] and severe cases of clinical mastitis result in death threat dairy animals [3]. In contrast to clinical mastitis, subclinical mastitis does not show any abnormality to the udder or milk but there is a sharp decrease in milk production with the increase in the somatic cell count (SCC) [4] and the incidence of subclinical mastitis is also very high than clinical mastitis [5]. So, the economic losses due to subclinical mastitis are more due to its prevalence and reduction in milk yield.

Diagnostic techniques in bovine mastitis:

As mastitis is causing huge losses to milk and dairy farmers, it is very necessary to diagnose the disease timely to overcome the damage. The earlier the disease is identified, the lower will be the losses. Also, mastitis-affected milk is unfit for human consumption. The easy way to diagnose the disease is a physical examination of the udder and to check for any abnormality, clinical signs, behavioral changes, or drop in milk yield. If there is any abnormality, we go for screening tests like, Somatic Cell Count, California Mastitis Test, or Surf Field Test. If any of these tests show positive results, then we can detect the pathogen through PCR-based tests, Microbial Culturing, protein-based tests, or Nano tech-based tests. After the detection of the pathogen, treatment can be initiated accordingly [6].

Treatment:

Antimicrobial therapy:

As pathogens are mainly responsible for mastitis in dairy animals, it is also necessary to treat the animals against them. However, there are several ways to control and cure mastitis like the use of antimicrobials, vaccination, bacteriophage therapy, nanoparticle-based therapy, bacteriocins, and herbal therapy [7]. Among them, antimicrobial therapy is commonly used. The antimicrobials are administered through intramuscular, intravenous, or intra-mammary route [10]. The results of the use of vaccination in mastitis are not as good. Before antimicrobial therapy, the cause of infection should be known. Also, the selection of antimicrobials for treatment should be based on history, etiology, and antimicrobial sensitivity profile against the pathogen [8]. The common effective antimicrobials used against mastitis are florfenicol, cefoperazone, cephalexin, and ceftiofur, and resistance was found against norfloxacin, tetracycline, and trimethoprim-sulfamethoxazole [9]. The main disadvantage of using antimicrobials is antimicrobial resistance (AMR) which is harmful to public health.

Recent studies showed resistance against oxytetracycline, amoxicillin, and ciprofloxacin [8]. As *S. aureus* is a common pathogen, it has developed resistance against several antimicrobials. *S. aureus* is a gram-positive bacterium and it is also associated with many infections in humans. Some common disorders caused by *S. aureus* in humans are endocarditis, urinary tract infections, sepsis, abscess of skin, food poisoning, mastitis, meningitis, and septicemia [23], [24], [25], [26].

Antimicrobials	Resistant gene(s)	Reference
Tetracycline	*tetK, tetM*	[11]
Aminoglycosides	*aacA-aphD*	[11]
Erythromycin	*ermA, ermB, ermC, ermT*	[12]
Penicillin	*blaZ, mecA*	[11]
Quinolones	*norB, norC*	[11]
Methicillin	*mecA*	[13]
Fluoroquinolone	*mepA*	[14]

Table 1: Antimicrobials resistance-related genes against *S. aureus*.

Essential oils (EOs) as an alternative therapy:

The treatment of mastitis is the use of antimicrobials through different routes but it has a risk of multidrug resistance and it is also associated with public health issues. So, there is a thriving need to use the latest treatment like products derived from natural sources [15], [16]. Milk is the most used product worldwide and for good quality milk, udder health is very important. Controlling the udder pathogens also reduces the foodborne illness. Essential oils are derived from various parts of plants containing different compounds that have therapeutic effects. EOs also have antifungal, antiviral, antimicrobial, and anti-inflammatory properties [31]. Recent studies showed the use of Essential Oils (EOs) are safe because there is no risk of residues reported yet. United States Food and Drug Authority also confirmed the use of Essential Oils as 'generally recognized as safe' (GRAS) [17]. There are many EOs used for the cure of mastitis but common are thyme (*Thymus vulgaris*) [18], lemongrass oil (*Cymbopogon flexuosus*) [19], Wild thyme *(Thymus serpyllum)* [18], mountain savory (*Satureja montana*) and oregano (*Origanum vulgare*) [20].

The use of plant-based products is also safe because they contain chemicals that are harmless to public health [21]. Silva in his study also reported that the use of lemongrass EO with MIC and MBC values ranging from 0.39 to 3.12 mg/mL and 0.39 to 6.35 mg/mL and thyme EO with MIC and MBC values ranging from 0.39 to 1.56 mg/mL and 0.39 to 3.12 mg/mL has very effective antimicrobial activity against *S. aureus* in bovine mastitis [22]. Latest data also showed that prolonged use of Essential Oils has little or no chance of AMR.

Name of EOs	Main component	MIC	MBC	Reference
Thymus vulgaris	Thymol (45.22%), p-Cymene (23.83%)	3.125 mg/mL	6.25 mg/mL	[18]
Origanum majorana	3-Cyclohexene-1-ol,4-methyl-1- (1-methylethyl)-, (R)- (44.84%), α-Terpineol (6.83%), p-Cymene (6.75%)	0.62% v/v	1.25% v/v	[27]
Cinnamomum aromaticum	e-Cinnamaldehyde (94.67%)	0.625 µL/mL	1.25–10 µL/mL	[28]

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Salvia officinalis	Carvacrol (61.01%), Thymol (20.41%), 1R-α-Pinene (7.88%)	0.625-1.25%	1.25-2.5%	[29]
Melaleuca armillaris	1,8-Cineole (72.3%), Limonene (7.8%)	6.25–25 µL/mL	12.5–50 µL/mL	[30]
Lavandula stoechas	17-Pentatriacontene (42.15%), Linalyl acetate (26.82%), Eucalyptol (18.87%)	4.37% v/v	8.75% v/v	[27]

Table 2: Main components of EOs with Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) values used against *S.aureus* in bovine mastitis

Conclusion:

The irrational use of antimicrobials in mastitis results in antimicrobial residues that are also a threat to public health i.e., persistent chronic infections due to resistant microorganisms. It can be effectively controlled by accurate diagnosis of the causative agent. The accurate diagnosis helps in reduction of antimicrobial residues. The use of EOs as an alternative therapy is effective in mastitis because they are non-toxic, harmless to living tissues, can cross skin barriers, and have antimicrobial activity against pathogens.

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