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Use of Green-synthesized Silver Nanoparticles against Mastitis

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ABSTRACT

Mastitis or udder inflammation is the arch nemesis of the dairy industry. Mastitis serves as the main profit killer for dairy farmers. In the past, this problem was dealt with antibiotics that easily treated mastitis by killing its causative pathogens. Quite recently this nuisance has become even more problematic as the bacteria began to gain antibiotic resistance against the antibiotics that were used to treat mastitis. This called for use of an immediate alternative like nanoparticles to kill the bacteria. A cheaper and better way to get these nanoparticles was found to be by extracting them from plant products.

Introduction

It is impossible that anyone who has ever worked in a dairy-related profession has not heard the word mastitis. This denotes the scale of the problem. Mastitis is a nightmare for dairy farmers and veterinarians. Every year this arch-nemesis of dairy causes losses of billions of dollars through reduced milk production and medication expenses. Along with that, the sequelae of mastitis leave the animal on a low milk production threshold for the rest of its life and the collagen fiber formation in the chronic stage is permanent damage too [7]. In the past farmers were easily able to counter this issue by using regular antibiotics like penicillin. Although all this has changed recently as the bacteria developed resistance against these antibiotics making them virtually ineffective [10]. This situation led to an increase in losses as more resources will be now needed to counter antibiotic-resistant bacteria. An immediate solution sought for such a situation was the use of nanoparticles such as silver to kill the bacteria and treat mastitis [14].

Mastitis:

Simply speaking mastitis is the inflammation of the udder or mammary glands. More specifically it can be referred to as inflammation of the udder parenchyma. Mastitis is caused by various environmental bacteria that reside and populate in the udder upon chance and to its inflammation. Mastitis is a disease with complex etiology as its pathogenesis has not been fully explained until now making it a topic of utmost importance for researchers [5]. Some of the most apparent signs of mastitis include udder inflammation, change in milk composition, change in milk quality, and sometimes even flakes in milk [3].

Mastitis appears in three forms in milk-producing animals either it can be clinical subclinical or chronic [9]. The subclinical one is the most dangerous as it can cause losses without apparent signs [8]. Mastitis can be easily diagnosed using the California mastitis test or surf field test even if it is spreading subclinically. The bacterial stains can be later identified using the Analytical Profile Index system through the biochemical profile of the bacteria [3].

Aetiology of Mastitis:

A wide range of opportunistic organisms can produce mastitis upon infection these organisms include *Staphylococcus, Streptococcus, Enterococcus, E. coli, Corynebacterium,* etc. However, in the majority of these cases, the main culprit is Staphylococcus aureus. In the past, commonly available antibiotics like penicillin were effective against this pathogen. However, quite recently it has become resistant to penicillin effectively and then rebranded by researchers as the methicillin-resistant Staphylococcus aureus or MRSA [9].

Rise of AMR in Mastitis Pathogens:

Quite recently there has been a trend of developing antimicrobial resistance against antibiotics by bacteria. This means the previously effective antibiotics are no longer usable against the same bacteria. Similarly, the pathogens of mastitis have also gained resistance to various regular antibiotics. Notably, methicillin-resistant *Staphylococcus aureus* is the most important one [2].

Mechanism of Resistance in *Staphylococcus aureus:*

Methicillin-resistant *S. aureus* gains resistance through several methods including reduction of drug efflux, changing drug target, modifying drug target, and drug inactivation (Figure 1). The most effective method adopted by S. aureus for drug resistance is by use of beta-lactamase enzyme against penicillin drugs. This type of resistance is gained through the expression of a single gene unit the Staphylococcal Cassette Chromosome mec (SCCmec) [12].

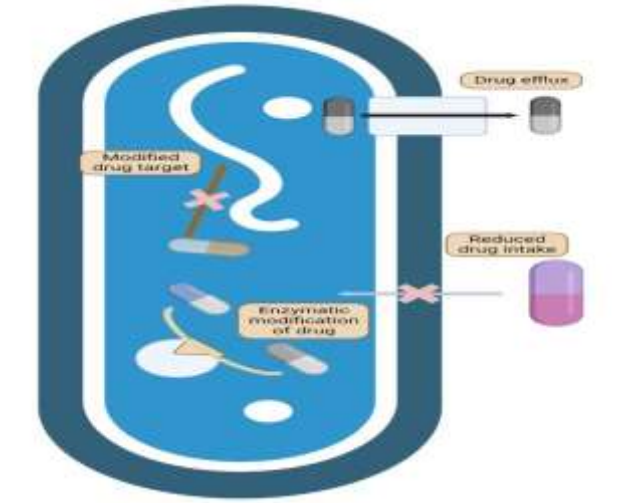

Figure 1: Mechanism of resistance adopted by *S. aureus* against antibiotics

Silver Nanoparticles:

Silver nanoparticles continue to be of utmost interest to many researchers especially the scientists working on AMR and its control. Silver nanoparticles are usually obtained as a ground form of silver particles. Recent research on silver nanoparticles has shown that these particles tend to bind with bacterial enzymes killing the bacteria [13]. Silver nanoparticles have been often integrated into fields like herbal medicine as extremely useful plant base products. Several methods can be employed to extract silver nanoparticles from plants these include boiling or crushing leaves or through the implementation of some intracellular method [4].

Plant-extracted Silver Nanoparticles:

Quite recently a trend has arisen among researchers to focus on the use of plant extracts as a cheaper and readily available alternative to the expensive traditional medicine and drugs being used commercially [1]. For several thousand years natural plants have provided us with all kinds of resources to counter diseases and nanoparticles are such an example. Besides being cheap and easily available plant-based nanoparticles also play an important role in slowing down climate change. The wondrous properties and benefits of plant-based products are so vast that they make these products seem like magic potions [4]. The biosynthesis of silver particles has gained more attention from researchers in the last decade. This trend is making more and more researchers inclined toward the development of eco-friendly procedures for manufacturing silver nanoparticles [13]. Researchers have been successful in manufacturing silver nanoparticles using *Moringa oleifera* leaves [11]. Several other

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sources of the Plantae kingdom have also been used as silver nanoparticle precursors (Table 1).

Table 1: Herbal precursors of Silver Nanoparticles.

No.	Herbs used	Other good effects	Ref.
1.	Tumeric	• Immuno booster • Detoxification • Improved digestion	[6]
2.	Peppermint		
3.	Ashwagandha		
4.	Curcuma longa		

Need for Use of Plant-based Silver Nanoparticles:

The rise of AMR has recently called for a new alternative to traditional medicine and this call was answered by nanoparticles. Although nanoparticles can be quite costly to obtain or synthesize. Another approach used to obtain nanoparticles was to get them from plant-based products. This made the availability of nanoparticles both easier and affordable [13].

Conclusion:

Mastitis is the biggest economical issue still being faced by the farmers that have shaken the very basis of the dairy industry. In the past, this issue was easily resolved by the use of antibiotics such as penicillin in the past but that too went out of option when antibiotic resistance began to rise in pathogens of mastitis. This problem was soon covered by researchers as they saw the nanoparticles. Nowadays researchers are working tirelessly to develop methods for the cheap and easy manufacture of nanoparticles from plant-based products.

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