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## THE ROLE OF ORGANISMS AS A CONTAMINANT IN MILK AND MILK PRODUCTS

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### ABSTRACT

Milk is one of the agricultural products consumed globally by millions of people. It provides essential macro and micronutrients. Although milk is a nutritionally-balanced foodstuff, it also creates an ideal environment for several microorganisms' growth. Some of the organisms that have been isolated from milk include; *Mycobacterium tuberculosis*, *Pseudomonas*, *Brucella*, *Escherichia coli*, and *Staphylococcus aureus*.

Since millions of people consume milk, its contaminations, which normally lead to an increase in microbial load, have detrimental effects among a huge population. As a result, milk has to be handled appropriately in hygienic conditions to prevent public health issues. This study aimed to evaluate the most recent literature on the antimicrobial patterns of *Escherichia coli* and *Staphylococcus aureus* isolated from milk and milk products.

*Escherichia coli* and *Staphylococcus aureus* are one of the pathogenic organisms found in milk. *E. coli* causes bacteremia, UTI, and neonatal meningitis, whereas *S. aureus* causes minor skin infections, sepsis, and toxic shock syndrome. *S. aureus* has been becoming resistant to conventional antibiotics in the recent past, and this is a threat to public health.

**Keywords:** Milk, Milk products, microorganisms, Bacterial infection, Antibiotic sensitivity

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## INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) defines milk as a whole, fresh, clean lacteal secretion usually obtained by milking animals [1]. FAO states that milk obtained within 15 days before and three days after calving is not suitable for consumption because such periods make the milk colostrum free [1]. Additionally, the milk usually contains the lowest prescribed percentage of milk fats [1]. According to [2], India is the largest milk producer globally, accounting for 18.5 percent of world production. India's milk production has been on a steady growth from 2012 to date.

### Nutritional Importance of Milk

According to [3], milk and milk products are essential for diversifying the diet. Milk had numerous nutrients that provide quality proteins and other micronutrients such as calcium and phosphorus that are easy to absorb [3, 2]. Therefore, milk can benefit both nutritionally vulnerable people and healthy people [3]. The primary source of energy and high-quality proteins with several micronutrients like phosphorus, zinc, potassium, magnesium, and calcium is milk and other products of milk [3]. The minerals found in milk are essential for industrial processes like making cheese and are also vital for human

development and health. Although milk is critical in human development, it is mainly needed during childhood [2, 3]. [4, 3] states that proteins, minerals, and lactose are the primary components in milk that support child growth and development.

According to [4], milk and milk products are suitable for the growth of strong and healthy bones as they are rich in nutrients. The intake of adequate calcium helps increase the intake of skeletal calcium retention during child growth. As a result, as the child grows, his/her peak bone mass is achieved at early adulthood than children that take less to no milk [4]. Calcium is the primary nutrient that prevents bone loss and osteoporotic fractures in older people [3]. Calcium also regulates the absorption of cholesterol, thus controls body weight and blood pressure [2].

Some recent studies have found a strong correlation between the intake of milk and periodontal diseases. The studies recommend that people consume much milk frequently to prevent periodontal diseases [5]. The other benefit of taking milk is that it reduces cholesterol absorption, which controls body weight and blood pressure [3, 4].

Unfortunately, not everybody agrees that milk only consists positive nutritional importance on human health. Currently, new controversies have emerged suggesting that milk causes various long-term effects on humans. One of the controversies indicates that the consumption of saturated fat causes a rise in cholesterol levels (low-density lipoprotein) responsible for the occurrence of heart diseases [5]. As a result, many countries used this knowledge and asked their people to consume dairy foods that have low fats.

Moreover, there are no specific significant impact of milk and milk products on increased overall cancer mortality. However, the prolonged consumption of whole milk increases prostate cancer risk [6]. Some dairy products (dietary calcium,

cheese, and whole milk) to decreased colorectal cancer [6]. This occurrence has been associated mainly with the high contents of calcium that are found in milk and products of milk. Researchers have also found that bacteria that produce lactic acid also provide protection against colorectal cancer, in addition to calcium [4].

### VARIOUS TYPES OF MILK

Milk has been used in various forms for human nutrition for a very long time. It consists of a very long and relatively rich history. There are several varieties of milk. Some varieties are very popular across India and worldwide. Some of the milk types are only found in India and no other place worldwide. Some of the different types of milk available in India are as set out in **Table 1**.

**Table 1: Definition of the most common forms of milk [3]**

Milk product	Description
Market milk	This refers to whole milk sold for individual consumption. Market milk excludes the milk used for the production of different milk products.
Pasteurized milk	This is milk that has been processed by heating either for 30 minutes at 63°C or for 15 seconds at 72°C.
Flavored milk	This is the kind of milk that flavor has been added.
Butter	This is a fat concentrate obtained by churning cream.
Cheese	Cheese is obtained from curd.
Yogurt	It is manufactured using whole milk or partially defatted milk. Yogurt has a fat content of about 0-5% and a solids content of 9-20%.
Ghee	Ghee is mostly prepared from cow or buffalo milk. It is usually obtained by clarifying butterfat. Ghee has 99-99.5% fat content.

### MILK MICROBIOLOGY

In addition to providing the human with nutrients, milk also provides an

environment favorable for microorganisms to grow. Various microorganisms such as yeasts, molds, and bacteria can grow in milk,

especially when the milk temperature is above 16°C [6]. There are multiple sources of microbial contamination in milk. Microbes have been found to enter the milk through the cow, animal feeds, unhygienic handling of milk equipment, and the person handling the milk [5]. Once the microbes gain entry into the milk, they often reproduce and increase their numbers rapidly, leading to milk spoilage which makes milk unsuitable for human consumption.

Unfortunately, if the milk with microorganisms is consumed, then a disease

outbreak or epidemic is unavoidable [6]. Therefore, contaminated milk is a threat to public health. As a result, [5, 6] state that milk hygiene is critical in producing milk and milk products. To achieve the desired milk quality, milk producers should maintain high hygienic practices throughout the milk chain to the production stage of milk products [3, 5, 6]. The milking equipment should be washed thoroughly before and after use. The sources of milk contamination are listed in **Figure 1**.

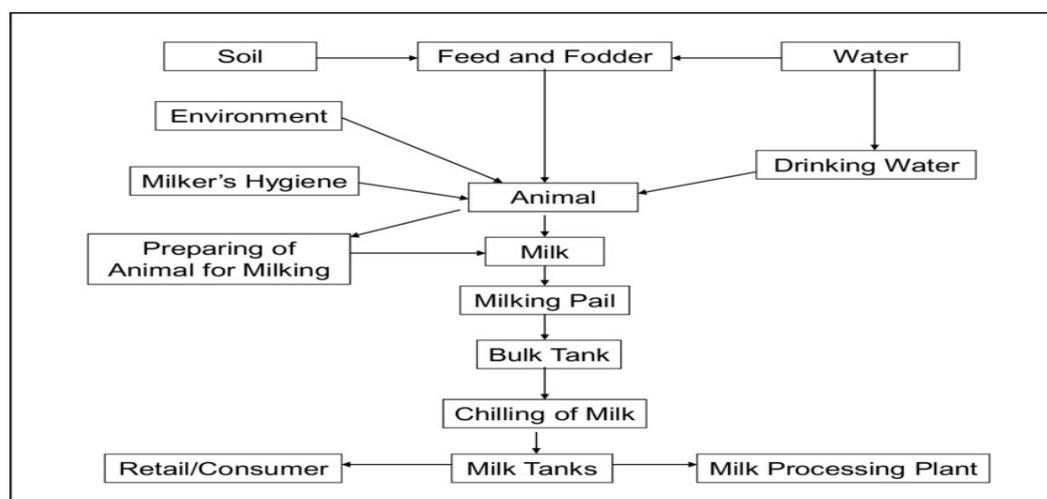


Figure 1: Sources of milk contamination [6]

### Quality Parameters of Milk

Most often, the quality of milk comes to our mind when we buy milk. For instance, we often check the milk's properties in terms of its freshness, microbial load, and composition. However, when buying milk for

home use, we do not have the ability to extensively check all the qualities. So, we just check its freshness and assume that all the other qualities are in check. Our otherwise or acceptability of the milk is affected by the quality of the milk

### Common Bacterial Contaminants in Milk

When milk is handled inappropriately, a lot of microorganisms gain entry into the milk. Some of the organisms that enter milk from any source of contamination are beneficial to the milk, whereas some are pathogenic, causing some of the most severe bacterial infections [7, 8]. Some of the beneficial contaminants in milk include lactic acid bacteria that have been applied in the manufacturing industry to

produce some of the milk products [7]. The Lactobacillus and Streptococcus have also been used in the production process. For instance, *Streptococcus thermophilus* is being used as a starter culture for yogurt production, and the lactic acid bacteria is critical in cheese making [7]. *Clostridium tyrobutyricum*, on the other hand, contributes to cheese ripening [7]. Some of the most common bacterial contaminants and their effects are as listed in **Table 2**.

Table 2: Most common bacterial contaminants in milk [6]

<i>Pseudomonas</i>	Spoilage
Brucella	Pathogenic
Enterobacteriaceae (e.g., <i>E. coli</i> , Salmonella)	Pathogenic and spoilage
<i>Staphylococcus aureus</i>	Pathogenic
<i>Mycobacterium tuberculosis</i>	Pathogenic
Streptococcus ( <i>S. thermophilus</i> , <i>S. lactis</i> , <i>S. cremoris</i> )	Pathogenic, acid fermentation and flavor production
<i>Bacillus cereus</i>	Spoilage
Lactobacillus species	Acid production

Mostly *E. coli* and *S. aureus* are frequently isolated from milk than any other bacterial species. *E. coli* and *S. aureus* are pathogenic and are the causative agents of mastitis, food poisoning, and gastroenteritis in animals and human beings [7]. Mastitis is the most common bacterial infection in dairy animals. It is often treated with bet-lactam antibiotics such as cephalosporin.

### *Escherichia coli*

*Escherichia coli* (*E. coli*) is a gram-negative bacterium commonly found in various animals that are warm-blooded and in the human gut. According to the World

Health Organization (WHO), most strains of *E. coli* do not cause life-threatening conditions/diseases [8]. However, some strains, such as the Shiga-toxin-producing *E. coli* (STEC), have been associated with severe foodborne diseases [8]. *E. coli* is often transmitted from their reservoirs to humans by consuming contaminated animal products, mainly milk and meat [7].

STEC is called so since it produces toxins called Shiga-toxins closely similar to toxins that are created by *Shigella dysenteriae* [9]. STEC can grow in temperatures between 7°C to 50°C. However,

*E. coli* grows best and rapidly at 37°C. On the other hand, STEC also grows best in acidic conditions with an optimum pH of 4.4. These *E. coli* strains are destroyed by cooking food and boiling milk to temperatures of 70°C and above.

### ***Staphylococcus aureus***

*Staphylococci* are Gram-positive bacteria characterized by individual cocci. *Staphylococci* usually have a diameter ranging from 0.5 – 1.5 µm. The staphylococci do not form spores, are non-motile, facultative anaerobes that grow by aerobic respiration or fermentation. Out of all the 32 species of staphylococci, *Staphylococcus aureus* is the most significant pathogen because of its increasing antibiotic resistance [9].

*Staphylococcus aureus* is the principal cause of a wide range of nosocomial infections. *S. aureus* has been known to be the causative agent of skin infections, bacteremia, and food poisoning [10]. World Health Organization states that *S. aureus* has evolved and is currently causing diseases in a community setting. *S. aureus* is one of the most challenging pathogens to treat because of its ability to establish infections by invading tissues and the host immune system [9].

### **ANTIBIOTIC SENSITIVITY**

The World Health Organization states that there is increased use and misuse of antibiotics in the agricultural sector. Although the use of antibiotics in the agricultural sector is beneficial and helps prevent diseases, farmers are also using antibiotics to enhance the growth of animals and increase product yield [10]. The continued use and misuse of antibiotics in the agricultural sector and humans by taking over-dose or under-dose and taking over-the-counter drugs hastened the emergence of antibiotic-resistant strains [9]. The frequent use of antibiotics, especially Beta-lactams, in the agricultural sector has led to the emergence of Beta-lactam resistant strains of both *E. coli* and *S. aureus*.

Bacteria cause most human infections. Therefore, modern medicine is underpinned by effective antibiotics. However, the emergence of resistant bacterial strains is pushing medicine to the brink of collapsing because soon, not antibiotic will be effective against any infection [10]. Drug-resistant infections are projected to kill up to 10 million people per year by 2050 if no action is taken now [10].

Drug-resistant bacteria are not only a threat to public health. They also have a negative consequence on the world's economy. The World Bank estimates that

more than 28 million people will be driven to poverty by 2050 [11]. Approximately more than 165 blood infections in the UK are known to have acquired resistance to first-line antibiotics [11]. Moreover, the emergence of drug-resistant bacterial infection doubles the recovery time, healthcare cost, and mortality [11].

## CONCLUSION

As long as the cow or buffalo is not suffering from mastitis, milk in the udder usually is sterile. However, if the animals have mastitis, the milk gets infected by many bacteria such as *Staphylococcus* species when leaving the udder. Most often, milk contamination is due to the negligence of hygienic conditions such as improper cleaning of the milking and storage equipment, dirty udder and improper milk handling techniques. Negligence of hygienic conditions when handling milk increases the population of bacteria, leading to milk spoilage or cause diseases to the consumers.

*Staphylococcus aureus* and *Escherichia coli* food poisoning is the greatest threat to public health. The high levels of contamination of milk increase the risk of food poisoning. Therefore, milk vendors need to be educated on the importance of handling milk in hygienic conditions to reduce bacterial contamination

and improve milk and milk products' wholesomeness.

Milk is a source of nutrients for human growth and development. However, it also serves as a substrate for microorganisms. When microorganisms grow on food, they lead to food spoilage and food-borne illnesses. According to the World Health Organization, milk and milk products have been associated with numerous food-borne diseases in many tropical regions. Most of the milk vendors who do not observe the proper milk handling and storage techniques. As a result, milk from vendors was found to have the highest contamination rates. Various studies have shown that processed milk and milk products contain the lowest microbial levels. This has been attributed to the hygienic conditions maintained by milk processing plants. The lower rates of contamination could also be because milk is always pasteurized before processing.

On the other hand, various studies have been conducted to test the antimicrobial susceptibility of the pathogenic organisms in milk. Some of the studies found that *E. coli* and *S. aureus* are slowly gaining resistance to most of the commonly used antibiotics such as the Beta-lactams. The resistance of pathogenic bacteria to life-saving drugs poses a significant threat to public health. The

effectiveness of the current treatment to both animals and humans may soon become hazardous and impossible if bacteria become resistant to all antibiotics.

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