The Impact of Spoiled Milk on Human Health: Causes, consequences, and Prevention Strategies

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Abstract. Milk is a widely consumed food product known for its high nutritional value, providing essential proteins, calcium, and vital vitamins necessary for human health and daily physiological functions. Despite its significant dietary benefits, milk is highly perishable, making it susceptible to spoilage, which can pose serious public health concerns. This study aims to investigate the primary factors contributing to milk spoilage, including microbial contamination, improper storage temperatures, and packaging defects. These factors can lead to the proliferation of pathogenic bacteria, compromising milk safety and increasing the risk of foodborne illnesses. The health consequences associated with milk spoilage range from acute gastrointestinal infections, such as diarrhea and vomiting, to more severe chronic conditions, including immune system dysfunction due to prolonged exposure to microbial toxins. Furthermore, a survey conducted among 50 women highlights a concerning gap in public awareness regarding the detection of spoiled milk and the potential health risks associated with its consumption. The findings underscore the urgent need for improved consumer education on proper milk handling, storage, and recognition of spoilage indicators to mitigate health risks and enhance food safety practices.

Keywords: Milk, Health, spoiled.

1. Introduction

Milk has long been considered a nutritional powerhouse, containing nutrients like calcium, vitamin D and high-quality protein supporting bone health, metabolism, and disease prevention. As the global consumption continues growing, the spoilage problem catches people's attention.

Despite the advances in pasteurization and refrigeration, milk is still susceptible to spoiled due to temperature, inadequate storage and microbial activity. Harmful bacteria like Salmonella in compromised condition will lead to rapid deterioration. Alarmingly, public awareness of these potential risk's lags behind. A survey of 50 women aged 18-25 years old reflects the ignorance of expiration dates and determines the foods' freshness relying on subjective methods like tasting and smelling a practice fraught with risk.

The consequences of consuming spoiled milk extend beyond temporary stomach upset. Acute food poisoning symptoms like vomiting and dehydration are compounded by chronic risks, including immune dysfunction and heightened susceptibility to toxins. Vulnerable groups, such as infants and the elderly, face even graver threats. Yet, solutions exist: innovations in smart packaging, stricter regulatory standards, and consumer education can curb spoilage and its fallout.

This paper examines the intersection of microbiology, public behavior, and technology, advocating for a multifaceted approach to safeguard health and reduce waste. By addressing both the science of spoilage and the human factors perpetuating it, we pave the way for a safer, more informed future in dairy consumption.

2. The importance of Milk Consumption

Milk has been known as an important nutritional resource due to its rich composition of essential nutrients including potassium, calcium, high-quality proteins, phosphorus, vitamin B2, B12, D and other essential nutrients for human's growth and other metabolic processes. Calcium, a mineral substance for building human bones before 18 years old and maintaining strong bones during adulthood. Proteins, one of the most vital nutrients for all organisms, can be provided in milk, which

is used not only for repairing and building tissues, but also muscle growth. Other essential nutrients also contribute to bodily function [1].

Drinking milk contributes to a lot of health benefits. First, Bone health. According to the previous paragraph, the abundant protein and vitamin D in milks will prevent people from osteoporosis. The recent evidence shows that milk consumption can help with weight management. The intake of milk can reduce the risk of being overweight during childhood. For adults, evidence shows that the consumption of milk helps with losing weight [2]. Moreover, the intake of milk was associated with bladder cancer, two types of diabetes, gastric cancer, and breast cancer [3].

Because of the high-quality protein that milk provides, the population growth and people's increasing awareness of nutrition, the global consumption of milk continues to rise. Looking back 10 years, in both developed and developing countries, milk is still an essential and affordable protein source. However, a vital problem caught our attention. Since the widespread reliance on milk, it also amplifies the risks of spoilage which threaten public health.

3. Milk spoilage

3.1. Milk spoilage: an issue always being ignore

Due to the high nutritional content in milk, it can support a rich amount of microbiota. It does have good bacteria that can promote our intestinal motility like lactobacilli and bifidobacteria but there is also some bacteria that will cause spoilage and disease like Pseudomonas, Clostridium, Listeria and Salmonella [4]. The pH of unspoiled milk usually is 6.7, when it falls below 5, the protein in milk will start to precipitate and congeal. One study shows that the decrease of pH is associated with the bitter and rancid taste of milk [5]. There are several factors that drive the spoilage of milk such as microbial contamination, improper storage practices and temperature fluctuations. Although a lot of factors can cause the spoilage of milk, people still ignore the problem. Some of them will leave the milk in the fridge for a couple months and consumpt it. In their opinion, as long as the dairy stays in the refrigerator, it will never go bad. This is a really risk-lacking action and it's a sign of not being responsible for your own health.

3.2. Public perspectives of milk spoilage

In order to learn deeply about the public opinions about food waste and milk spoilage, a questionnaire is assigned to 50 random women between 18-25 years old asking several questions mainly focused on spoiled food and expiration date. Since women from 18-25 years old are the group with the most purchasing power, their perspective represents the general new generation and the tendency of the following years. The questionnaire results indicate that dairy products, particularly milk, are the most frequently wasted food items, accounting for 31% of all food waste, followed by snacks, fruits, and desserts (Figure 1). This suggests that people may not pay sufficient attention to the expiration dates of dairy products, potentially leading to health risks. Additionally, while more than half of the respondents reported checking expiration dates when purchasing food, 38% do not, indicating that over one-third of the public lack's adequate awareness of food spoilage at the point of purchase. Regarding attitudes toward food expiration, nearly two-thirds of respondents stated they would consume food on its expiration date, while almost half admitted to eating food even a few days past expiration. These findings highlight a general lack of awareness regarding food spoilage and its associated health risks.

However, a more serious problem caught our attention. This question asked for the method people use to determine if the food is spoiled or not. Over 50% of the respondents determine spoiled foods by looking at their appearance (27%), tasting a little bit (8.4%) and smelling them (32.7%). All of these three ways mentioned before will directly cause different degrees of health risks or problems which reflects that people don't have proper cognition of the risks and the consequences of eating spoiled foods.

Besides our questionnaire, older respondents (low/low and medium/low) have higher risk perceptions than younger respondents (medium/high and high/high). Consumers' level of risk perception and food aversion sensitivity are actual drivers or barriers to consumers' WTB dairy products approaching their best before dates, rather than their level of knowledge.

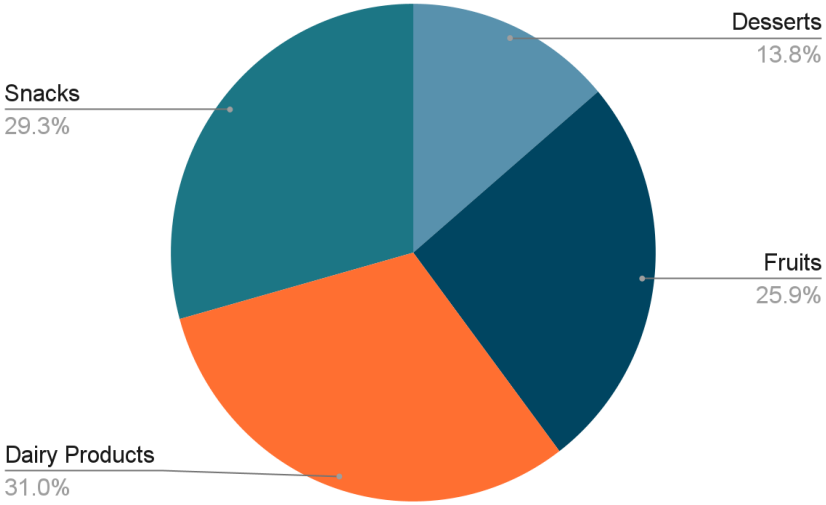

Figure 1. The most frequently wasted food in your house

4. The main reason for spoiling of milk

4.1. Bacteria

When milk, such as buffalo, sheep and goat, inside the udder are sterile. However, after milking, it is no longer sterile and can be contaminated in several ways [6]. Although pasteurization inactivates most of the bacteria but not all of the bacteria in raw milk. Pseudomonas (mainly the P. fluorescens group), Serratia, Bacillus and Hafnia have strong proteolytic potential and other kinds of Bacillus, Acinetobacter and Pseudomonas (mainly ono-fluorescent pseudomonads) have strong lipolytic ability. Studies agree that Pseudomonas is the primary species that causes the spoilage of milk [7].

4.2. Microbial contamination

When raw milks are produced, raw milks are naturally exposed to microbial contamination. A large number of microbes including bacteria, yeasts, and molds make the complicated ecosystem of milk. At the farm level, the tank milk has three mainly microbial contamination which are bacteria from mastitis organisms from within the udder, from the external surface of the udder and tests and from the surface of the milking equipment. In addition, feces, water, air, soil and feed can also be the contamination of milk [8].

4.3. Temperature and cooling rate

Raw milk’s quality is significantly influenced by the storage temperature and cooling rate during storage and transportation. The higher temperatures, the more microbial growth, which leads to a faster quality decline and spoilage. Additionally, the cooling rate also affects the quality of milk. Faster cooling will lower the microbial growth, higher pH and lower titratable acidity. Compared with milks that took 120 minutes to cool, the milk which cooled immediately had half the number of bacteria. In conclusion, both rapid and continuous cooling are necessary to ensure the quality of raw milk. Higher temperatures and slow cooling rate allow bacteria growth [9].

5. The main reason for spoiling of milk

5.1. Acute health risks

Spoiled milk can cause acute health risks due to the growth of harmful bacteria like Salmonella, E. coli. The primary symptoms of foodborne illnesses caused by spoiled milk typically include: food poisoning and gastrointestinal infections. Food poisoning is a type of foodborne illness which is a sickness people get from something they ate or drank. Food poisoning will cause nausea, vomiting, abdominal cramps, and diarrhea. Drinking spoiled milk will lead to severe stomach upset and dehydration.

5.2. Chronic health effects

Drinking spoiled milk can lead to serious problems over time. People might ingest harmful bacteria like E. Coli, or even toxins like staph. These will cause ongoing stomach issues like IBS or IBS. Over years, this could throw off your gut bacteria balance, weaken your immune system, or-in rare cases-expose to cancer-linked mold toxins. Moreover, the toxins produced by bacteria and molds can also lead to food allergies or sensitivities, potential carcinogens.

5.3. Vulnerable populations

Certain groups are more sensitive and have negative health effects of consuming spoiled milk, especially infants, elderly and the Immunocompromised populations. Infants' immune systems are still developing. If they accidentally take in spoiled milk, it may cause serious dehydration and lead to life-threatening conditions. As the immune system weakens with the growing age, older adults are at greater risk for infections. Immunocompromised populations such as the people suffering from HIV, AIDS, cancer treatment or organ transplants have weakened immune systems, which makes them highly vulnerable to bacteria which can be found in spoiled milk [10].

6. Detection and prevention of milk spoilage

The detection and prevention of milk spoilage are critical to ensuring food safety and reducing waste. Modern methods for detecting milk spoilage have advanced significantly, incorporating technologies such as hyperspectral imaging, electronic noses, and ATP bioluminescence. Best practices for milk storage and transportation emphasize maintaining the cold chain, with temperatures ideally kept below 4°C (39°F) to inhibit microbial growth. Packaging innovations, such as antimicrobial films and modified atmosphere packaging, also extend shelf life by reducing oxygen exposure and inhibiting pathogens. Furthermore, adherence to hygiene protocols during milking and processing, including equipment sterilization, is essential to minimize initial contamination. Consumer education and awareness play a pivotal role in reducing milk spoilage at the household level. Misinterpretation of expiration labels, such as "best by" versus "use by" dates, often leads to premature disposal of safe milk.

7. Conclusion

With the development of food technology, more and more innovation methods are applied to milk preservation. Advanced technologies can effectively perseverate and store nutrition in fresh milk. Smart package technologies like time-temperature indicators which allow monitoring of milk's freshness, while nanotechnology can offer antimicrobial nano-coating to avoid bacterial contamination. At policy and regulatory level, governments and food safety agents need to strengthen the measurement of milk quality. Enforcing stricter food safety standards and microbiological and chemical testing to minimize the contamination risks. Improving the label guidelines such as clarifying the definition of "Best Before" and "Use By" dates, help consumers reduce concerns about milk expiration. Raising consumer awareness is another crucial factor in preventing milk spoilage.

Through educational campaigns, consumers can gain a better understanding of food safety and learn proper milk storage practices

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