The Health Effects of Yogurt and Its Safety Hazards

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Abstract. Yogurt is fermented milk and contains various types of bacteria, including harmful and useful bacteria for human beings. Yogurt provides high levels of protein, vitamin D, and calcium that will have a beneficial effect on the bones. Also, it has shown that yogurt is able to support the digestion system by interacting with the bacteria in the gastrointestinal, and during the yogurt process, if some functional bacterium is added to ferment with yogurt, it will bring specific benefits to people. The main source of human hazards in yogurt should come from raw milk, which is the major ingredient of yogurt, and the microorganisms in raw milk are divided into three categories: lactic acid bacteria, coliform bacteria, and pathogenic microorganisms. In addition, the production environment and transportation conditions of yogurt can also have an impact on the quality of the yogurt and the microorganisms contained in it. Therefore, if people want to reduce or control the foodborne diseases caused by yogurt, people need to control the growth of harmful microorganisms in the industry and raw materials.

Keywords: Yogurt; Digestion System; Gastrointestinal; Microorganisms; Foodborne Diseases.

1. Introduction

Yogurt is a staple food in several cultures, originating from countries in Western Asia and the Middle East. Nowadays, yogurt has spread all over the world. According to figure 1, most European countries have the highest yogurt consumption compared to other regions. The country that consumes the least amount of yogurt is India, Indonesia, and South Africa.

Yogurt has become a daily necessity for many people because yogurt is a healthy food that can provide protein and calcium for people. Also, yogurt with added vitamin D or probiotics has additional benefits for people's health [2]. Every supermarket has a wide variety of flavors and types of yogurts. Yogurt has been shown to promote immunity, help maintain a healthy gut microbiota in the digestion system, and control serum cholesterol [2].

It is well known that yogurt is made by fermenting milk, from milk to yogurt, the production process is also very complicated, and there are many spoilage and pathogenic organisms in both milk and yogurt, and many potential food safety biological hazards associated with yogurt. In order to deal with those issues in yogurt, people need some controls for foodborne illnesses and outbreaks. While yogurt is able to bring some benefits to humans from the nutritional perspective, it also has some potential hazards that will be a threat to human health [1].

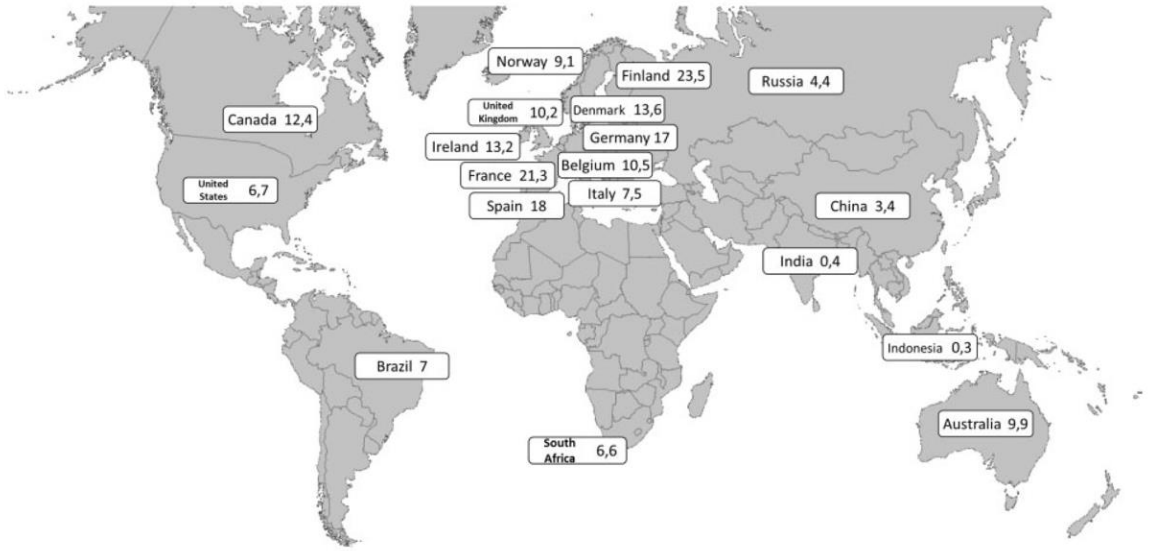

Fig. 1 Average per capita consumption of yogurt (kg) in different countries [1]

2. Ingredients of Yogurt

Milk is the main ingredient of yogurt, and different types of milk can make different types of yogurts. The types of yogurts people can buy in the market are nonfat yogurts, low-fat yogurts, and full-fat yogurts. Nonfat yogurts use skim milk, low-fat yogurts use low-fat milk, and full-fat yogurt use whole milk. People can choose different kinds of yogurts to meet their different needs. There are other dairies or non-dairy ingredients that are added to yogurt besides milk, for example, nonfat milk powder, stabilizers, sweeteners, fruit preparations, and bacterium. Yogurt needs to use skim milk powder to adjust its solid content to at least 8.25% or more, and the stabilizers in milk such as alginates and gelatins can prevent whey separation and help to make sure the fruit is evenly mixed in the yogurt by increasing firmness. Sweeteners and fruit preparations can help diversify the variety of yogurt [3]. *Lactobacillus bulgaricus* and *Streptococcus thermophilus* are the main bacterium culture in yogurt. They can produce lactic acid by fermenting the lactose in the milk, and lactic acid can lower the pH which is why yogurt is sour[3].

3. Nutritional Value of Yogurt

From the macro-nutritional aspect, yogurt has a high nutritional value, and it contains a significant number of amino acids and casein that has essential benefits for the human body. Also, because nonfat dry milk powder is applied to commercial yogurt, the protein content of commercial yogurt is higher than that of regular milk. The casein in yogurt has a beneficial effect on bones for some people, and casein and whey proteins also can control inflammation and have antioxidant and anti-tumor properties [1].

The micronutrition of yogurt also plays an important role in human health. Yogurt is a kind of dairy product that is full of vitamins including both liposoluble vitamins, for example, vitamin D, vitamin A, and vitamin E, and hydro soluble vitamins such as B2, B3, and B12. Furthermore, yogurt contains a significant amount of calcium, and because yogurt is fermented milk that is acidic, this acidic environment can enhance the biological availability of minerals. The low pH of yogurt is also able to allow calcium to be ionized for optimal intestinal absorption [1].

There are many microorganisms present in yogurt and most of them are thermophilic and bile-sensitive [1]. These microorganisms usually do not show a significant positive effect on human health. Bacteria in yogurt do not usually live in the intestine; however, bacteria migrating along the gastrointestinal tract can positively affect the digestive system by interacting with the host and resident bacteria. Not only does yogurt support the digestive system, but it also controls serum

cholesterol. Furthermore, different kinds of yogurt have various functions, for example, long-term consumption of probiotic yogurt can have a beneficial effect on females' plasma cholesterol [1, 4]. Also, different fermented bacteria in the yogurt may have a variety of functionality on human health, for example, *S. thermophilus* and *Enterococcus faecium* in fermented yogurt can help people reduce their levels of cholesterol [1].

4. Microbiota of Raw Milk

The microbiota in raw milk falls into three categories, lactic acid bacteria, coliforms, and pathogenic microorganisms. Lactic acid bacteria ferment in milk, which can convert lactose to lactic acid. According to Sullivan and Cotter, the examples of the lactic acid bacterium are "namely species of *Lactobacillus*, *Lactococcus*, *Enterococcus*, and *Streptococcus* with minor populations of *Pseudomonas*, *Hafnia*, *Clostridium*, *Leuconostoc*, *Faecalibacterium*, *Prevotella*, *Acinetobacter*, and *Aeromonas spp*".

Coliforms such as Escherichia coli are associated with pathogens, but they are not necessarily pathogenic themselves. Coliforms also can ferment lactose to produce acid and gas, which can make spoilage of the milk. People can kill them by using high-temperature short-time (HTST) pasteurization because the optimum temperature for coliforms to grow is around 37 degrees Celsius [5].

The spoilage in food is the metabolic process that causes foods to be undesirable or unacceptable for human consumption due to changes in sensory characteristics, such as texture, development of off-flavors, and off-odors. The main microorganisms that cause spoilage in milk are psychrotrophic organisms. Although pasteurization kills most psychrotrophic organisms, a few of the survival psychrotrophic organisms that can produce proteolytic and lipolytic extracellular enzymes to make themselves heat-stable can also cause the spoilage of milk, for example, Pseudomonas fluorescens and Pseudomonas fragi [5]. Besides, some of the species that are also can cause the spoilage of milk that are able to survive from pasteurization and then growth in the temperature of refrigeration, for example, "Some species and strains of *Bacillus*, *Clostridium*, *Cornebacterium*, *Arthrobacter*, *Lactobacillus*, *Microbacterium*, *Micrococcus*, and *Streptococcus*" [5].

Most foodborne illnesses are caused by raw milk that has not been pasteurized because unpasteurized milk contains a lot of pathogenic organisms, for example, *Campylobacter spp*., *Salmonella enterica* serotype *Typhimurium*, and Shiga toxin-producing *Escherichia coli* [6]. Figure2 is the data from Centers for Disease Control and Prevention (CDC), which expresses the percent of illnesses caused by outbreaks of non-pasteurized milk within different ages of people and different types of etiology. It shows that *Campylobacter spp*. cause the majority of foodborne illnesses in unpasteurized milk, and most people who get Foodborne illnesses are between the ages of one and fifty[6].

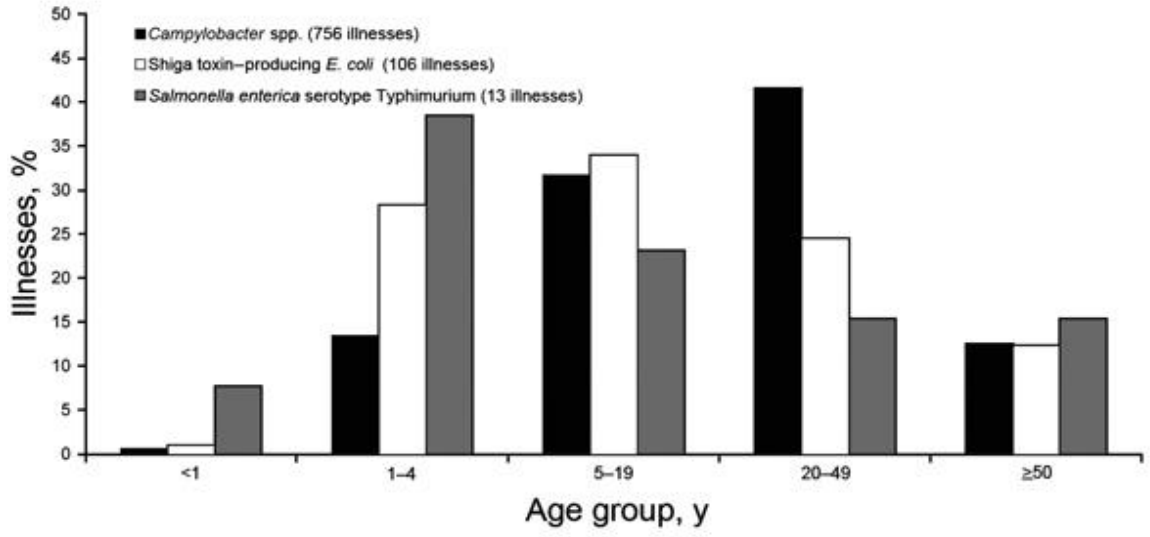

Fig. 2 Percentage of illnesses for *Campylobacter spp.*, *E. coli*, and *Salmonella* for different age groups [6]

5. Potential Spoilage of Yogurt

The potential spoilage in yogurt comes from many different areas. The spoilage microorganisms will be impacted by the manufacture or processing of the yogurts, and these spoilage microorganisms may come from the ingredients of the yogurts. The main reason that causes yogurts to spoil is yeasts and molds.

The main cause of the spoilage of yogurts is yeasts and molds that is because of the contamination in the manufacturing process. For instance, spoilage organisms can get into yogurts that have been incorrectly sealed [7]. Although the packaging material of yogurt has been decontaminated by using UVC light, infrared light, vapor, or steam sterilization, when the factory fills yogurt, the filter machine is directly exposed to the air that will not be able to prevent the contamination from the atmospheric [7]. Therefore, to reduce the spoilage organisms in yogurt, the workers at the yogurt factory should test the yeasts and molds in the factory air, and they should seal each bottle of yogurt as well as possible.

Most yogurt on the market is made with some fruit preparations to make yogurts more varied and tastier, but these fruit preparations also harbor many microorganisms that make the yogurt spoilage. As mentioned, the main cause of yogurt spoilage is yeast and mold, and the yeasts and molds could also come from these fruit preparations. When workers make the fruit preparations or add the fruit preparations into yogurts, it may allow yeasts and molds to grow, leading to the spoilage of the yogurt [7]. According to Macbean, “Contamination by yeasts and molds almost inevitably leads to growth, with the potential for spoilage of the yogurt product to which the fruit is added.”

Milk is the main ingredient of yogurt, so if factories use unpasteurized milk, the pathogenic microbes found in raw cow's milk can also be present in the yogurt. Also, if they use milk that contains spoilage microorganisms to make yogurt, the spoilage microorganism may cause the yogurt’s spoilage. Therefore, good pasteurization, rigorous and hygienic processing, and packaging will greatly reduce microbial spoilage caused by yeasts and molds [7].

6. Potential Biological Hazards of Yogurt

The potential biological hazards with yogurt may come from both intrinsic and extrinsic. The potential internal biohazard of yogurt mainly comes from the ingredients of yogurt such as milk and fruit preparations, and the external biohazard of yogurt comes from the manufacturing processing, and packaging of yogurt.

First, as the main component of yogurt, raw milk contains a lot of harmful microorganisms which come from the milking procedure, for example, the milking parlor environment and the teat surface [8]. These harmful microorganisms from the raw milk also will cause spoilage and pathogen in the yogurt, so pasteurization is the best way to deal with this issue. However, pasteurization only kills most of the microbes in the milk, such as *E. coli* 0157:H7, not all of them. As mentioned, psychrotrophic bacteria, which can grow at seven degrees Celsius, can cause the spoilage of dairy products through their extracellular enzymes that are composed of proteases and lipases [8]. The main reason that psychrotrophic bacteria are not easily pasteurized is that they have heat-resistant extracellular enzymes, which can resist both pasteurization and ultrahigh temperature processing (UHT) [8].

The common species of psychrotrophic bacteria are *Bacillus*, *Staphylococcus*, and *Pseudomonas*, and *Pseudomonas spp.* is often associated with raw milk [9]. *Pseudomonas spp.* can still survive even though pasteurization kills its bacterial cells because it has heat-stable proteases and lipase [9]. After psychrotrophic bacteria survive from pasteurization, as the yogurt in the cooling process, the temperature will decrease to seven degrees Celsius, which is the temperature that is a suitable temperature for psychrotrophic bacteria to grow. This is how psychrotrophic bacteria is the intrinsic potential biological hazard for yogurt.

Yogurt packaging materials also have potential biohazards because riboflavin is a photosensitizer, which is found naturally in yogurt, and can absorb visual light. Light can cause the oxidation of yogurt. When the riboflavin in the yogurt absorbs light and reacts with oxygen, it will degrade the lipids and proteins in the yogurt and it can lead to the yogurt off-flavors and spoilage [7].

7. Control Measures Used to Ensure Microbial Quality and Safety of Yogurt

The most important thing to ensure the quality and safety of yogurt is to reduce the spoilage and pathogen in yogurt. First of all, in order to ensure that the external factors of yogurt do not harm the quality and ensure the safety of the yogurt, workers should focus on the packaging and manufacturing processing of the yogurt. Also, to ensure the internal factors, people need to pay more attention to the growth of the harmful microorganisms in the ingredients of the yogurt.

The packaging of yogurt can lead to yogurt spoilage because riboflavin in yogurt will absorb light, causing the oxidation of yogurt. Therefore, yogurt packaging should be opaque or semi-opaque to prevent or reduce the spoilage caused by visual light [7]. During the manufacturing process of yogurt, workers need to disinfect and sterilize every device used at each step to ensure and control yeasts and molds, which are the main causes of spoilage in yogurt. Also, using ultra-clean filters to fill the yogurt can reduce the number of yeasts and molds in the manufacturing of yogurt. Also, the manufacturing processes and the types of equipment for making yogurt must be clean and disinfectant to prevent unnecessary bacteria in the yogurt [2, 7].

In addition, the temperature at which yogurt is transported and stored is also key to preventing the growth of harmful microbes. A sealed cup of yogurt should be kept at 40 degrees of Fahrenheit which can ensure the microbial quality and safety of yogurt. Also, different types of yogurts have various times of expiration and deterioration. Nonfat yogurts deteriorate faster than 4% fat yogurt [2, 7]. Therefore, people need to pay attention to the different degrees of fat in yogurt to make sure the yogurts are not metamorphic, and it safe for people to consume.

To control the microorganisms in the yogurt's ingredients, people need to use pasteurized milk to kill pathogenic microorganisms in raw milk such as E. coli 0157:H7 [2]. Pasteurization not only can destroy the pathogenic microorganisms that are present in most raw milk, but also it can destroy any microorganisms in milk that might interfere with fermentation [10]. Besides, most yogurts will add fruit preparations to make the yogurts more diversified and make the taste of yogurts become better. To ensure the quality and safety of microorganisms in yogurt, people also need to ensure the quality and safety of the fruit preparations that are added to the yogurt. The process in fruit preparations can be the source for yeasts and molds to grow that can cause the yogurt to spoil if contaminated fruit

preparations are added to yogurt [7]. To deal with this issue, it is best to ensure that the fruit preparations are made in a sterile environment, and people can monitor changes in the concentration of carbon dioxide to indicate the growth of yeasts and molds by using nitrogen as the headspace gas in the fruits preparations' containers or workers can add some legal preservatives such as sorbic in the fruits preparation [7].

8. Conclusion

Yogurt is an indispensable food for many people. Yogurt can help with digestion health and provide enough both micro- and macro-nutrients to humans. Although yogurt can bring benefits to people, it contains harmful microorganisms that will also endanger human health and food safety. Raw milk is the main ingredient for yogurt, and unpasteurized raw milk contains a lot of pathogenic microorganisms such as *Campylobacter spp.*, which will cause foodborne illness. These pathogenic microorganisms in milk will also present in the milk product (yogurt) if the milk does not pasteurize. Also, there is a lot of potential spoilage for yogurt, and the most spoilage that happened in yogurt is associated with yeasts and molds, which are everywhere in the manufacturing process and the ingredients of yogurt. To prevent these issues, making the yogurt process sterile is best.

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