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Review Article

A Mini Review on Technique of Milk Thermization

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Abstract. Thermization is a preheating procedure in which milk is heated at low temperatures for a brief time prior to further processing. It is often used in the dairy processing industry to make a variety of products, including pasteurized milk, milk powder, and cheese. Eliminating psychrophilic bacteria, avoiding milk spoiling, and halting the changes generated by lipase and protease enzymes are the objectives of this method. Despite the fact that thermization enhances the shelf life of milk, it may also result in sensory changes and the germination of *B. cereus* spores. The goal of the thermization method is to prepare milk for the upcoming processing stage, and the temperature and length of the process might vary. Thermization does not affect the flavor of milk or dairy products such as yogurt, but it may enhance the quality of cheese by decreasing the occurrence of stale and rancid flavors. The process may be carried out in a plate heat exchanger or as a pre-pasteurization treatment for raw milk to protect milk quality during lengthy storage in insulated silos.

Keywords: dairy process; protein; fat; pasteurization; heating process

1. Introduction

Pre-heat treatment is the heating of milk at the start of a sequence of milk processing operations. This technique is also often known as thermization. This approach employs relatively mild temperatures for a short period of time. The milk undergoes this heat treatment before to the subsequent processing step. After thermization, the heating temperature used to the milk processing process is typically higher. Similarly, the heating range is expanded after the thermization process. In the dairy processing industry, thermization is commonly used to create dairy products such as pasteurized milk, sterile milk, condensed milk, powdered milk, yogurt, and cheese.

According to Nefasa (2018), thermization serves the following purposes: (1) eliminating psychrophilic bacteria; (2) preventing alterations due to the enzymatic activities of lipase and protease enzymes; and (3) preventing milk spoiling. In several published works, the influence of thermization on psychoactive development that results in decomposition has been examined. Nevertheless, the research also indicates that the thermization process has a negative consequence, namely that it might result in the germination of *B. cereus* spores (Rukke et al., 2011; Rukke et al., 2016; Deeth, 2021). One of the advantages of the thermization procedure is that it extends the shelf life of milk, however milk may undergo sensory alterations (Swart et al., 1993). In this study, a more in-depth mini-review of the effects of pre-heat treatment (thermization) on the physical, chemical, and microbiological properties of cow's milk will be conducted. The writing is intended to give references for readers.

2. Procedure of Thermization

The farmers' milk will subsequently be kept in silos, which are cooling tanks. Before being processed, the milk in the tank will pass through the preheating procedure in the heating tank. The term for this first heating is thermization.

In several variants, the temperature and duration of this procedure are specified. The milk thermization procedure lasts 10 to 20 seconds at 57 to 68 °C (Nefasa, 2018). According to some sources, milk is preheated between 55 and 60 °C (Sharma et al., 2014; Abrahamsen and Narvhus, 2022). Nevertheless, raw milk is often promptly centrifuged (or prepared at a lower temperature, around 50 C) to remove fat, and then heat-treated, which prevents skim milk from acquiring a nice taste brought about by fat (Tong, et al., 2019). During 30 minutes, skim milk is heated at 500 degrees Celsius. Thermization, a less severe heating technique than pasteurization, is used to enhance the keeping quality of milk before to cheesemaking, according to Harnett et al., (2022). (2022). The temperature is 63–65 °C for 15–20 seconds. This method heats milk to a temperature near to that required for pasteurization, but in a significantly shorter amount of time. Some other research utilizes greater pre-heating temps for certain of dairy products (Tong et al., 2019).

Generally, the purpose of the thermization procedure is to prepare milk for the subsequent processing step. At the time the milk exits the silo, its temperature is still around 40 °C. The move from cold to hot temperature needs a transition. Denaturation of milk protein globules may result from uncontrolled preheating temperature fluctuations (Sharma et al., 2014). After undergoing thermization, milk is temporarily stored in a cold state, which is known as refrigeration. The treatment may be conducted simply in a plate heat exchanger intended for milk pasteurization with a typical holding period of 15 seconds (Rukke and Srhaug, 2016). It is used as a pre-pasteurization treatment for raw milk in order to preserve milk quality during extended storage in insulated silos. Moreover, the technique is utilized as a post-pasteurization treatment for dairy products (Swart et al., 1993). During thermization in several dairy processing companies, milk is often combined with a number of additional components. This is done in an effort to simplify the mixing procedure. The suitably high temperature used during the thermization process may accelerate the pace of material dissolving, allowing the material to be thoroughly mixed in less time. Figure 1 illustrates the milk thermalization procedure.

Farmers deliver fresh raw milk using tank trucks. Typically, the temperature inside the tanker truck is regulated to 5-7 °C. Prior to undergoing thermization, the milk will be held in a silo tank at 4 °C. It will be kept in the milk silo, and when required, it will flow to the PHE (Plate Heat Exchanger) to be heated. Following thermization, the milk will be chilled to 4 °C (refrigerator temperature) before to the next preprocessing step.

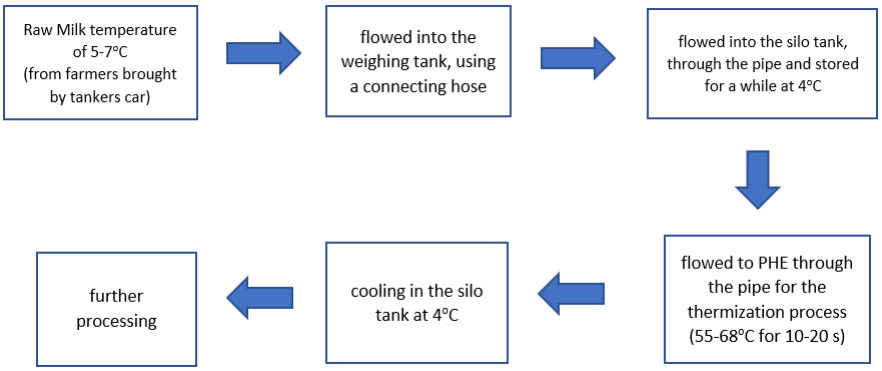

Figure 1. Procedure for Thermization Process in Cow's Milk

3. Impact of Thermization on the Sensory Quality of Milk

It has not been thoroughly examined how thermization affects the physical quality of milk. Yet, there are a number of papers that analyze the impact of thermization on the physical quality of milk and its products, particularly the sensory quality. Rukke et al. (2016) reported that the frequency of dirty and rancid taste in Norwegian (Gouda-type) or Jarlsberg cheeses generated from pasteurized, thermized, and cold-stored milk was lower than in cheeses produced from unthermized, cold-stored, and pasteurized milk. The thermization method does not alter the taste of milk or dairy products like yogurt (Routray et al., 2011; Rukke, 2016). Pre-heating at temperatures (85 °C for 15s and 137-141 °C for 4s) might impact the sensory quality of skim milk, according to the research of Tong et al. (2019). Increasing the preheating temperature improves the quality of skim milk, while the scores for fishy and salty are steadily decreased. This indicates that preheating may eliminate the unpleasant flavor of raw milk. For additional taste sensors, such as umami, sourness, and astringency, the findings were the same. In the same article, it is also said that the preheating of milk leads to the creation of volatile chemicals from milk proteins, carbohydrates, and lipids, as well as other compounds, which might change the scent of skim milk. Pre-heat effect below these temperatures (85 °C for 15 seconds and 137 to 141 °C for flavor) Due to thermization, "Canestrato Pugliese" hard cheese lost part of its sensory qualities, according to Natrella et al. (2023). A control sample of cheese with unthermized raw milk was also created. It is probable that this is

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due to a decrease in the population of indigenous bacteria. Aroma, flavor, and texture are some of the senses considered in this research. The article also argues that thermization provides cheese with a competitive edge by preserving coagulation.

4. Impact of Thermization on Milk's Chemical Quality

As a crucial step in the processing of milk, heat treatment may stimulate lipid oxidation and create flavor-related free fatty acids, methyl ketones, and oxidized fatty acids (Fenaille et al., 2006). Milk fat globule membrane (MFGM) fragments may be generated by heat treatment (at or above 60 °C) in the presence of lipids or by direct interactions with casein or serum proteins (Morin et al., 2008). The impact of thermization on the D – value (% denaturation) of whey milk protein is addressed by (Rukke et al., 2016). The D value of -Lactoglobulin is 12.0% after 15 seconds at 65 °C and 60.5% after 30 seconds at 85 ° C. In the meanwhile, the albumin concentration in bovine serum is 31% after 15 seconds at 65 °C. Moreover, thermization decreases the production of fat flocks. Tong et al. (2019) found that in the presence of fat, the preheating treatment procedure at 137–141 °C may be more susceptible to the Maillard reaction, whose product stays in the skim milk sample. In addition, the article states that the preheating of milk induces the creation of volatile chemicals from milk proteins, carbohydrates, lipids, and a few other compounds, which might change the scent of skim milk. Nevertheless, thermization at temperatures between 50 and 60 °C is unlikely to induce the Maillard reaction, lipolysis, or lipid oxidation. This is also connected to its impact on milk's flavor. Very little is known about the chemical properties of milk as a result of the thermic effect. Its effects on lactose and other substances outside whey protein have not been explored. Rukke et al. (2016) reported that using multiple analysis of variance to examine statistically significant changes in the concentrations of hydroxymethylfurfural, lactulose, and soluble whey proteins, it was not possible to discriminate between raw and pasteurized milk. Observations have shown that thermization (65 °C for 15 s) lowers the levels of individual free amino acids (FAA) during the ripening of Cheddar cheese owing to changes in the raw milk microflora that regulate the formation of FAA. According to research conducted by Natrella et al. (2023), the compositional (protein, moisture, fat) variations between raw and thermized cheeses were quite minor, and nearly nonexistent in two thermized cheeses. Nevertheless, following the ripening stage (0-300 days), cheese produced with Mild-Thermization and High-Thermization milk had less moisture, less protein, and fatter than cheese made with CR milk.

5. Impact of Thermization on Milk's Microbiological Quality and Shelf Life

Pseudomonas fluorescens is a phycotropic bacteria often found in raw milk and responsible for its deterioration. The goal of the thermization procedure is to diminish the Pseudomonas fluorescens population. This terminology may also inhibit the development of Salmonella spp and Listeria monocytogenes. Thermization at 57–68 °C for 10–20 s was intended to eliminate the unintentional bacterial flora and provide an environment conducive to the proliferation of lactic acid bacteria introduced in starting cultures (Rukke et al., 2016). The impact of thermization heating temperature and cold storage temperature on the quantity of microorganisms in raw milk is reported in Table 1. In the manufacture of CP cheese (Natrella et al., 2023) using raw sheep's milk as a source, milk that has been thermized at medium temperature, and milk that has been thermized at high temperature, it has been reported that the number of microorganisms is related (TV = total viable; TC = total coliforms; Ec = enterococci; MLb = mesophilic lactobacilli; TLb = thermophilic Thermization of milk was observed to reduce the number of microorganisms in the milk. While there was an increase when curd formation began, the microbial count recovered to normal following cheese ripening (0-300 days). Puhan reported changes in the number of microorganisms in thermally treated milk for yoghurt and cheese products (Quark) (1979). The quantity of bacteria decreased when the milk was thermalized at temperatures between 55 and 65 °C for 22 and 60 seconds, respectively. Once the pH reached 4.4 and 4.0, the number of living microorganisms was determined.

It is advised that milk be cooled after undergoing thermization to prevent contamination. Pasteurization has the ability to destroy vegetative cells that have grown from germinating spores during the cold storage interval between thermization and pasteurization, hence enhancing the quality of pasteurized milk if contamination after thermization is avoided. The precision of temperature and storage duration influences the quality of thermic milk for Cheddar cheese, as shown in Table 1. Preferred is the use of a thermic temperature of 65 °C for 15 s, followed by storage at 4-5 °C. accordance with (Swart et al., 1993). The thermization method reduces phycotropic bacteria effectively by extending the

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milk storage process at 8oC for up to three days. Alakali et al. (2008) created thermized yogurt by fermenting pasteurized milk with yogurt (a commercial yogurt culture comprising S. thermophilus and Lb. bulgaricus) and then heating it at 65 °C, 75 °C, and 85 °C for 20 minutes. The findings indicated that yogurt thermized at 85 degrees Celsius had a longer shelf life than those thermized at 75 °C (5 weeks) or 65 °C (3 weeks) when kept at an average ambient temperature of 35 °C. Three weeks of stability was observed when samples were stored at room temperature (average 35 °C). By keeping at refrigerated temperatures, the storage life may be extended. Rukkle et al. (2016) reported that thermized and rapidly cooled milk may be refrigerated for a further three days due to the fact that thermization significantly lowers the heat-labile psychotropic bacteria responsible for spoiling at low temperatures (spoilage without souring). These microbes generate heat-stable proteinases, lipases, and phospholipases at low temperatures. As an alternative to thermization, cold storage at a very low temperature (less than 2 °C) and/or purging the milk with nitrogen or carbon dioxide may be used.

Table 1, Effect of thermization temperature and quality of raw milk on microbial quality of milk after thermization and storage

Initial count (CFU/ml)	**Thermization Temperature (°C)**	**Holding time (s)**	**Count After thermization (CFU/ml)**	**After thermization and storage for 3 days _C**
				At 7°C
80 x 10^3	59.5	15	14 x 10^3	20 x 10^3
	64	15	8 x 10^3	6 x 10^3
1500 x 10^3	60	12.5	560 x 10^3	1400 x 10^3
	64	12.5	14 x 10^3	13 x 10^3
				At 4–5°C
170 x 10^3	55	60	17 x 10^3	1100 x 10^3
	65	15	1.7 x 10^3	3.4 x 10^3
				At 6 °C
199 x 10^3	65	15	No data	63 x 10^3
18 x 10^3	65	15	No data	1.6 x 10^3

(Van der Berg, 1984; Banks et al., 1986; Griffiths, 1986)

4. Conclusion

Pre-heat treatment or thermization is a process used in the dairy industry to enhance the quality of milk and dairy products during storage. This includes briefly heating the milk to relatively moderate temperatures prior to following processing stages. Thermization kills psychrophilic bacteria and inhibits changes caused by the enzymatic activity of lipase and protease enzymes, hence preventing milk from deteriorating. Moreover, it enhances the shelf life of milk, but may affect its flavor. Thermization may result in the germination of *B. cereus* spores, which is a negative outcome. Generally, thermization entails heating milk to a temperature close to that necessary for pasteurization, but in a substantially shorter period of time. The primary objective of thermization is to prepare milk for the next processing stage. Thermolysis may have an effect on the sensory qualities of milk and its products, namely flavor. Nonetheless, according to some research, cheeses made from pasteurized, thermized, and cold-stored milk are less likely to have a filthy or rotten flavor than cheeses made from unthermized, cold-stored, and pasteurized milk. In the dairy processing business, thermogenesis is used to generate dairy products such as pasteurized milk, sterile milk, condensed milk, powdered milk, yogurt, and cheese. In the dairy business, the approach is an essential way for assuring food safety and quality.

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