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Small-sized milk processing plant considerations

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SMALL-SIZED MILK PROCESSING PLANT CONSIDERATIONS

B. Macias Rosario, L. McVay, F. Aramouni, and K.A. Schmidt

Summary

Milk is widely considered one of the world's most valuable foods. As a raw material, it is available in various forms, and is found in an ever-increasing variety of nutritional products. Milk is a complex biological fluid consisting of the following components: water (87.4%), sugar or lactose (4.8%), fat (3.7%), protein (3.4%), minerals (0.7%), as well as minute amounts of vitamins. This document presents the standards, process needs, and labeling requirements of pasteurized fluid milk for the state of Kansas.

(Key Words: Raw Milk Standards, Processed Milk Standards, Processed Milk Equipment)

Raw and Pasteurized Milk Standards

The federal Food and Drug Administration (FDA) and Pasteurized Milk Ordinance (PMO) are resources for the published standards for raw and pasteurized milk that every milk producer and processor must know and follow in manufacturing fluid milk. Chemical, bacteriological, temperature, and sanitation criteria set for fluid milk are shown in Table 1. Each of the preceding attributes is described briefly below.

Antibiotics

All raw milk must be screened for presence of antibiotics before any process schedule, and all raw milk that is confirmed positive for the presence of antibiotics must be destroyed in accordance with federal guidelines. Drug-residue tests, such as those to de-

tect the presence of beta-lactam drugs, must be performed at the processing site before accepting raw milk into the premises.

Bacteria

As bacterial types and counts are indicators of animal health, sanitation practices, and previous temperature history, raw and pasteurized milk (for fluid consumption) has maximum bacteria counts established for quality assessment. For pasteurized milk, standards exist for the standard plate count (or total plate count), often abbreviated as SPC, and coliform counts. For raw milk, a standard only exists for the SPC. The SPC estimates the total number of aerobic bacteria present in the milk sample. Lower limits are mandated for pasteurized products, compared to raw milk. Milk processors may establish standards that are stricter than federal mandates. Stricter standards are especially important for milk products with extended shelf life.

Coliform counts are an index of the level of sanitation and water quality used throughout milk handling and processing. Presence of a significant number of coliform bacteria in milk indicates unsanitary conditions and practices during raw milk production or milk processing and packaging.

Composition

Pasteurized milk, according to the Code of Federal Regulations (CFR), shall contain not less than 8.25% milk-solids-not-fat and not less than 3.25% milk fat. Typically a producer may receive premiums for milk that contains

greater amounts of some components (e.g., milk fat and protein).

Somatic Cell Count

Somatic cell counts (SCC) are used as a measure of milk quality. High levels of SCC in raw milk indicate abnormal or reduced quality milk that may be caused by mastitis. Milk producers normally rely on SCC to help ensure a quality product. Thus SCC are monitored to assure compliance with federal and state milk quality standards.

Temperature

Raw milk temperature before processing should never exceed 45°F, excepting for specific conditions that are described in the PMO. Once milk is pasteurized, temperatures are not to exceed 45°F during storage and distribution. Microbial growth is directly related to temperature, as well as most enzymatic reactions. To preserve and maintain milk quality, activities of microbial growth and enzymatic reactions must be minimized.

Milk Microbiology

Raw milk is virtually sterile when it leaves the udder. Beyond this stage of milk production, microbial contamination generally occurs from two main sources: the udder and the surfaces of milk handling and storage equipment. Cow health, hygiene, and environment, as well as the cleaning and sanitizing practices, influence the number and type of microorganisms found in raw milk. Equally important are storage temperature and time that may allow microbial contaminants to multiply and increase in numbers. Typical types of microorganisms found in milk include pathogens (those that can cause disease), coliforms, lactic acid bacteria (those that efficiently use lactose as a sugar source), and psychrotrophic bacteria (those that can grow at 32 to 50°F).

The degree of cleanliness of the milking system probably influences the total bulk milk bacteria count as much, if not more, than any other factor. Cleaning is done to remove residual soil from the equipment, and a subsequent sanitizer cycle will reduce microbial loads to very low levels if done properly. However, if cleaning and sanitizing procedures are not optimized or efficient, microorganisms can grow on the residual soil on the surfaces and be available to “contaminate” other milk as it passes over these dirty or contaminated surfaces. Minimizing these microbial reservoirs prevents bacteria from growing to significant levels in the bulk tank during the storage period on the farm or the dairy plant. The longer the milk is held before processing, the greater the chance that psychrotrophs will increase in numbers. However, milk produced under ideal conditions usually has an initial psychrotroph population of less than 10% of the total bulk tank count (SPC). Under conditions of poor cooling (temperatures greater than 45°F), most bacteria are able to grow rapidly in raw milk. Depending upon the temperature, some bacteria may double in number every 30 minutes.

Milk Processing Basics

Processing of fluid milk involves the primary steps of separation, pasteurization, homogenization, packaging, and distribution. A flow diagram of fluid milk processing is shown in Figure 1. Each step will be briefly discussed.

Upon arrival at the plant, raw milk is tested to ensure that regulatory and company quality standards are met. Once the milk has been “accepted” i.e., normally free of antibiotics, contains the minimum fat and solids contents, has no off-flavors and odors, and falls within the appropriate acidity range, it is transferred into a raw milk storage tank. It must be processed within 72 hours of arrival at the plant.

The next process step is separation, where continuous flow centrifugation separates the fat phase (cream) from the nonfat phase (skim). The cream and skim fractions are recombined or the separator is adjusted to produce a “milk stream” that meets the desired milk fat content, i.e., whole, reduced/low fat and nonfat milks (Table 2).

After milk fat is adjusted to its desired fat percentage, milk is pasteurized, a process that combines heat and time to inactivate all pathogenic bacteria. Batch pasteurization is allowed if all federal and state requirements are met. Most of these requirements address equipment design and operation to ensure that heat and hold functions occur properly. A batch pasteurizer consists of a jacketed vat surrounded by either circulating water, steam, or heating coils. The milk is heated to 145°F and held at that temperature for a minimum of 30 minutes. A cutaway picture of a batch pasteurizer is depicted in Figure 2. If milk is batch pasteurized, it must be cooled quickly to maintain quality. However, the most commonly used pasteurization method in the United States is the high temperature short time (HTST) process. HTST pasteurization is a continuous, enclosed system capable of heating milk to a minimum of 161°F and holding it for a minimum of 15 seconds. Within the same system, milk is cooled relatively quickly (45 to 90 seconds) to below 40°F. The HTST is shown in Figure 3.

If milk is batch pasteurized, homogenization occurs after pasteurization. However in most HTST systems, homogenization is a component of the HTST, as raw or pasteurized milk can be pumped directly to the homogenizer and then back to the HTST without exposure to outside influences, thus reducing the risk of microbial contamination. Homogenization is a pressure treatment that reduces diameters of milk fat globules to sizes so small that fat globules no longer coalesce (i.e.,

cream) to a noticeable extent during normal refrigerated storage.

In either pasteurization process one of the last process steps is to fill containers with pasteurized milk. In most cases, milk will be pumped into a “filling machine” where cooled, pasteurized milk is packaged into cartons, sealed, and code-dated. The packaged milk should be stored at 38°F or lower until shipment to retail or wholesale stores. A wide variety of fillers and containers can be selected to package milk; however, the bottom line selection criteria should be based on safety and consumer needs. The container must protect the product from undesirable contamination and chemical reactions, and should meet consumer demands (e.g., re-closable, size, weight, etc.). Provided the appropriate package is selected, high quality milk should be acceptable for up to 14 days when maintained at cold temperatures throughout distribution and storage. This 14-day period is known as shelf life.

Shelf life is an important indicator of the quality of milk processing. Even when pasteurized milk has been heated to a minimum of 161°F for 15 seconds (or 145°F for 30 minutes for equivalent bacteria kill), and subsequently packaged under clean and sanitized conditions, some bacteria survive pasteurization. These bacteria can cause milk spoilage in about 14 days, despite refrigeration. Pasteurized milk should be stored at 34 to 38°F. Under ideal refrigeration, most containers of pasteurized milk will remain fresh 2 to 5 days after the labeled sell-by date. Once opened, milk should be consumed as soon as possible for best quality and taste.

In the United States, most pasteurized milk is fortified with vitamin D, and reduced/low-fat and nonfat milk is fortified with vitamins A and D. If vitamins are added, their quantities must meet federal guidelines for vitamin A content (not less than 2000 I.U./quart) and

Vitamin D content (not less than 400 I.U./quart). This may be considered an additional process step, depending on how and when vitamins are added.

Milk Processing Equipment

In order to process milk properly, all equipment and utensils used during processing, storing, and pumping must meet specific standards that are outlined in the PMO. For example, all multi-use containers, equipment, and utensils used in milk handling, storage, or transportation should be made of smooth, nonabsorbent, corrosion-resistant, nontoxic materials; constructed for easy cleaning; and kept in good repair at all times. Common materials that meet these requirements are stainless steel; equally corrosion-resistant, nontoxic metal; heat-resistant glass or plastic; and rubber. All of these materials are relatively inert, and resistant to scoring, chipping, and distorting under normal use.

Milk Labeling

Labeling is an important part of food production, especially for milk, because the label provides information for consumer choice. Milk labeling is regulated by the FDA, and milk and milk products must comply with labeling and nomenclature requirements set in the CFR and the Nutrition Labeling and Education Act (NLEA) of 1990. Two main issues of concern exist for the fluid milk packaging in the United States: 1) Principal Display Panel, and 2) Nutritional Facts. For further information about labeling requirements, CFR Title 21 reviews the requirements for specific food products, including fluid milk products. An example of nutritional labeling for Kansas State University's 2% reduced fat milk is shown in Figure 4. The label is intended to help consumers make choices and provide essential data concerning nutrient content.

Table 1. Chemical, Bacteriological, and Temperature Standards for Raw and Pasteurized Milk Adapted From the Pasteurized Milk Ordinance (PMO) for Grade “A” Compliance¹

Attribute	Raw Milk Standard	Pasteurized Milk Standard
Antibiotic presence	No positive results on drug residue detection methods prescribed in the PMO	No positive results on drug residue detection methods prescribed in the PMO
Bacteria Counts		
Standard Plate Count	Individual producer milk must not exceed 100,000 CFU/ml before commingling with milk. Not to exceed 300,000 CFU/ml as commingled milk prior to pasteurization	≤ 20,000 CFU/ml
Coliform	Not applicable	≤ 10 CFU/ml
Composition		
Fat		3.25 %
Solids not Fat		8.25 %
Somatic Cell Counts	Individual producer milk must not exceed 750,000 CFU/ml	
Temperature	Cooled to 45°F or less within 2 hours after milking, provided that the blend temperature after the first and subsequent milking does not exceed 50°F	Cooled and maintained to 45°F or less

¹Anon. 1999. Grade “A” Pasteurized Milk Ordinance. U.S. Public Health Service, p #19.

Table 2. Federal Standards for the Fat and Solids-Non-Fat Contents of Pasteurized Milk¹

Product	Fat content (%)	Solids-nonfat(%)
Whole milk	3.25	8.25
Reduced fat or 2% milk	2.0	8.25
Low fat or 1% milk	1.0	8.25
Fat free or Skim milk	Less than 0.5	8.25

¹U.S. Food and Drug Administration, 2003.

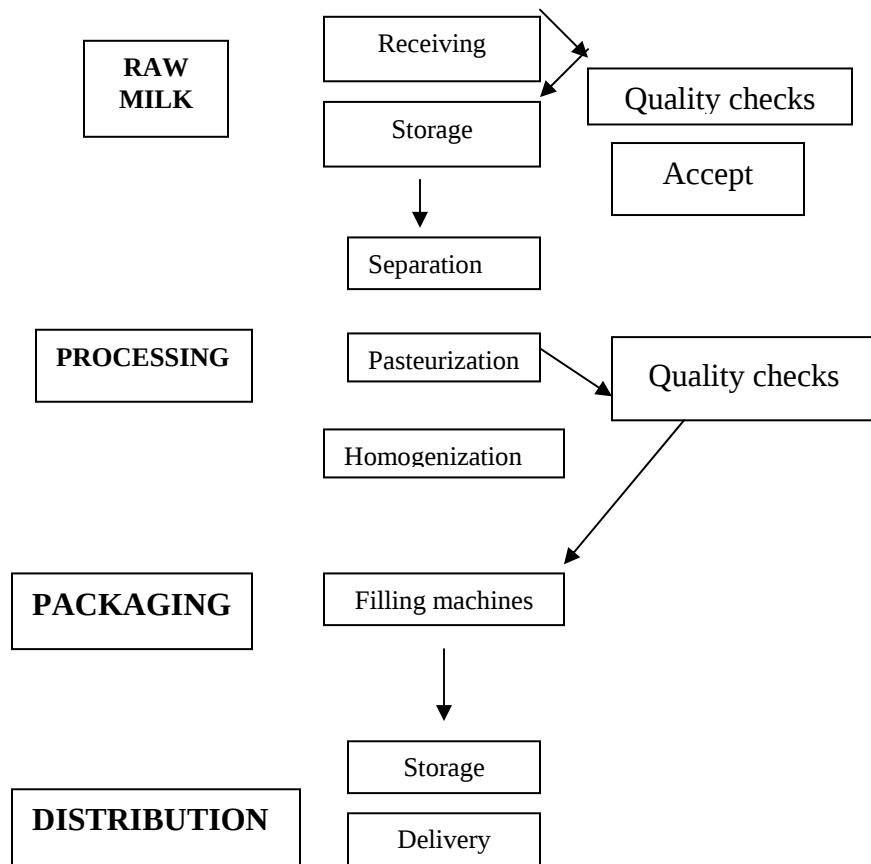


Figure 1. Milk Processing Flow Diagram.
(adapted from: <http://www.foodsci.uoguelph.ca/dairymedu/fluid.html>)

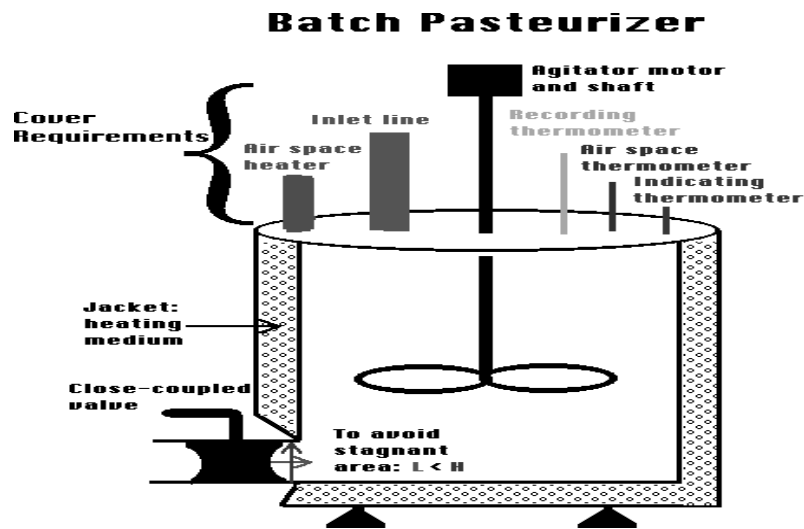


Figure 2. Batch Pasteurizer.
 (<http://www.foodsci.uoguelph.ca/dairyedu/pasteurization.html>).

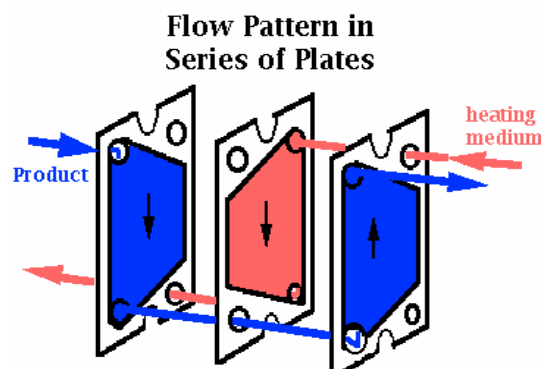


Figure 3. High Temperature Short Time Pasteurizer.
 (<http://www.state.ct.us/doag/regsinsp/dairy.htm>)



Kansas State University, Manhattan, KS

Figure 4. Nutritional Labeling of Kansas State University's 2% Reduced Fat Milk.