The Production of Quality Milk

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History records cows being milked as far back as 9000 B.C. In Florida, cows have been milked since the settlement of St. Augustine in 1565. However, it was not until colonial times in 1611 that dairy cows arrived in Jamestown. From that time until 1850, dairying changed very little. Most cattle were dual purpose (used for dairy and beef purposes) and were kept to satisfy family food needs. Milk and dairy products were in short supply and for the most part unavailable to those not living on or near the farm. Milk production was seasonal, creating periods of excess as well as deficiency in the family milk supply. Stabilization of these production fluctuations by storage and/or further processing into butter, cheese, or other milk products was precluded by the lack of refrigeration. Consequently, marketing of milk, butter, and cheese was limited to towns which could be reached by horse-drawn wagons.

Over the years modern technology has rectified these problems and today a wide array of safe, wholesome dairy products are available to people throughout the developed world.

The Production of Milk: Whose Concern Is It?

Production of quality milk is the concern of:

1. consumers of dairy products
2. retail distributors (super markets)
3. milk and milk product processors
4. dairy cooperatives
5. state regulatory departments
6. veterinarians, and
7. dairymen.

From the list it's obvious that very few of us are left out. Whether we derive a living from the dairy industry through employment or otherwise, most of us are at the very least consumers of dairy products. In the sections to follow we will examine some of these consumer interests and the efforts made in dairy product processing (from the farm to the retail shelf) to preserve the public's confidence and safety.
MILK COMPOSITION AND NUTRITIONAL VALUE

The Code of Federal Regulations, Title 21, Section 131.110 provides the following definition of milk:

"Milk is the lacteal secretion, practically free from colostrum, obtained by the complete milking of one or more healthy cows."

Nearly 12% of the American household's total food expenditure is for dairy products. Milk and milk products alone provide 10% of the total available calories in the United States food supply, and in addition, represent one of the best natural sources of essential amino acids for human nutrition. These nutritional attributes of milk have long made it a mainstay particularly in the diet of growing children. There are estimated to be some 8 to 10,000 different types of milk products available thus making it an exceptionally versatile raw product.

Milk is composed of water, fat, protein, lactose and minerals (ash). The concentration of these components will vary between cows and breeds. Normal ranges are given in Table 1.

Total milk solids refers specifically to fat, protein, lactose and minerals. This is to be differentiated from solids-not-fat milk (SNF), a frequently used term which describes the total solids content minus fat. SNF milk is known to most people as "skim milk".

The nutritional as well as economic value of milk is directly associated with its solids content. The higher the solids content the better its nutritional value and the greater the milk product yields. For example, cheese yields are directly related to milk casein content.

FLAVOR AND ODOR CHARACTERISTICS

Consumer acceptance is greatly affected by flavor. There are several factors which may produce off-flavors and/or odors in milk. Some of the more common causes of flavor and odor problems are:

- Feed and weed flavors
- wild onion or garlic
- strong flavored feedstuffs such as alfalfa silage
- Cow-barny flavors - which result when milk is obtained from unclean or poorly ventilated environments, improperly cleaned or sanitized milking equipment
- Rancid flavors - presence of free fatty acids (FFA)
- due to excessive agitation of milk during collection or transport
- breakdown of the milk fat component by proteolytic and lipolytic enzymes present in raw milk
- Malty flavors, high acid flavors
- bacterial contamination
- Oxidized flavors
- exposure of milk to sunlight
- contact of milk with oxidizing agents such as rust, copper, and chlorine
- Foreign flavors
- fly sprays, medications, etc.

MILK PROCESSING

A multitude of events take place in the process of delivering milk from the farm to the dinner table and all are designed to provide the consumer with a wholesome, nutritious and safe product. The production of quality milk and milk products begins on the farm and continues through further handling, processing and distribution.

Milk processing has three primary objectives:

- destruction of human pathogens through pasteurization
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* keeping the quality of the product without significant loss of flavor, appearance, physical and nutritive properties, and

* selective control of organisms which may produce unsatisfactory products

Milk processing plant procedures seek to:

* prevent further bacterial contamination of raw materials

* reduce bacterial numbers in milk

* protect the finished product from recontamination through careful handling, proper packaging and storage

Pasteurization is the means whereby raw milk is rendered safe for human consumption. It is the process of heating milk to a sufficient temperature for a sufficient length of time to make it free of pathogens, however, not totally free of bacteria. Table 2 shows some of these temperature/time relationships.

**BACTERIA IN MILK**

As stated earlier, certain organisms are capable of surviving pasteurization and/or refrigeration processes. These bacteria are an important concern because they reduce product shelf-life. Those of major significance are:

1. thermoduric bacteria
   * common in raw milk
   * they survive pasteurization and include
     - Enterococci
     - Microc cocci
     - Brevibacterium
     - Lactobacilli

2. psychrotrophic bacteria
   * common dairy product contaminants
   * these grow at refrigeration temperatures
   * they do not survive pasteurization
   * can produce off-flavors

3. spore-formers
   * common contaminants
   * survive pasteurization
   - Clostridial spp.
   - Bacillus spp.

The primary source of these bacteria is the environment: air, dust, dirty equipment, operators, etc. Therefore, proper cleaning and sanitizing procedures are necessary for quality control. Grade A milk quality standards allow a maximum of 100,000 bacteria/ml. in raw bulk milk. Chronic offenders of these limits risk losing their license to sell milk to the Grade A market. Most dairies are able to maintain bacteria counts between 5 to 10,000 per ml. When high counts become a problem it is generally due to one or more of the following:

* improper cleaning of milking equipment (the most common cause of high bacteria counts in milk)

* improper cooling of milk

* occasionally, a herd experiencing a high prevalence of infection due to Strep ag. or Staph sp.

**SOMATIC CELLS IN MILK**

Somatic cell counts represent another important milk quality parameter. As discussed earlier, milk with high somatic cell concentrations reduces cheese yields due to the lowered casein content (Table 3).

In addition, high cell count milk generally contains increased amounts of proteolytic and lipolytic enzymes (lipase). These presence of these enzymes in milk increases the potential for off-flavors and odors.
Somatic means body and thus a somatic cell is a body cell. There are three types of somatic cells typically found in milk: epithelial cells, macrophages, and polymorphonuclear leukocytes (PMN). Cell types found in milk obtained from non-infected glands are predominantly epithelial cells and macrophages. Milk from infected glands, however, generally contains high concentrations of PMN’s with little or no increase in other cell types. Consequently, somatic cell counts are an important indicator of udder health. Somatic cell counts are made available to dairymen from a variety of sources including milk quality laboratories operated by state and local regulatory departments, dairy cooperatives, DHIA-SCC program, and veterinary diagnostic laboratories. In general, cell counts from herd bulk milk consistently in excess of 500,000/ml are indicative of a high prevalence of mastitis in the herd.

Mastitis causes a shift in the composition of milk. In addition to lowered amounts of casein, lactose and fat levels are decreased particularly in milk with somatic cell counts in excess of 2 million.

Because the bacterial quality and somatic cell content of raw milk are important to product shelf-life, flavor and yields (particularly cheese), milk processors strive to obtain the highest quality raw product possible from their producers (Table 4).

**ANTIBIOTIC RESIDUES IN MILK**

Antibiotic residues pose a significant public health threat. Consequently, milk in Florida is routinely monitored by dairy cooperatives and the Florida Department of Agriculture and Consumer Services, Division of Dairy Industry. The official test in current use is the *Bacillus stearothermophilus* disc assay. It is particularly sensitive for penicillin but can detect other inhibitors as well. The vast majority of antibiotic residues in milk occur by accident. Dairymen can avoid residue problems by:

* properly identifying treated cows
* informing milkers of the need to withhold and the method for withholding milk
* keeping an accurate record of dates and times of treatment
* following label directions and veterinarians' advice for withholding times
* having milk tested from suspect cows if uncertain about treatment or withholding time
* having tank milk tested when it is suspected of having milk containing antibiotic residue
* isolate purchased cows and test their milk for residue prior to their entry into the milking herd.

**DAIRY COOPERATIVES**

Dairy cooperatives are organized by dairymen for the purpose of marketing milk. Thus, instead of buying milk direct from farms milk processors buy their raw product from the dairy cooperative. Dairymen are in turn paid by the cooperative for the milk they produce. Florida's dairies supply approximately 80% of the state's marketing demands. Therefore, at certain times of the year some milk must be imported to satisfy processing needs. During other times of the year, milk production is in excess of market demand and milk must be exported out-of-state. These daily marketing difficulties could be both expensive and time-consuming problems for dairymen. Consequently, the majority of producers belong to milk marketing cooperatives. Cooperatives serve the dairymen by promoting dairy products, providing an effective lobby for political concerns, and informing members on a variety of dairy industry issues such as water quality, waste management, and milk pricing.

Dairy Farmers Incorporated (DFI), represents the members of Florida's two regional cooperatives:

1. Florida Dairy Farmers Association

**REGULATORY CONTROL OF MILK AND MILK PRODUCTS**

The milk sanitation program of the United States Public Health Service evolved for three reasons:
1. the U.S. Public Health Service promotes the consumption of milk for good nutrition

2. the potential for milkborne illnesses is a significant public health threat

3. reciprocal acceptance of milk and milk products between political jurisdictions

This program has been one of the most successful in accomplishing its objectives. In 1938, milkborne disease outbreaks constituted 25% of all disease outbreaks resulting from infected foods and contaminated water supplies. Today, less than 1% of such disease outbreaks can be linked to the consumption of milk and milk products.

The United States Public Health Service/Food and Drug Administration, divisions of the Department of Health and Human Services, have developed a statement of policy and regulations with regard to milk quality. This model regulation is known as the "Pasteurized Milk Ordinance of 1978" (PMO). This document contains (among other things) the milk quality standards recommended to states, counties and municipalities. Following adoption by state legislatures, policy and standards are established for that state which may be equal to but not less lenient than those outlined in the PMO. It is here where the legal authority for milk sanitation programs originates.

In Florida, the charge for enforcement of the state-wide Milk and Milk Products Law is vested with the Florida Department of Agriculture and Consumer Services, Division of Dairy Industry. This division is composed of three functional units:

1. Office of the Director
2. Bureau of Dairy Inspection

Within this organizational framework reside the responsibilities for policy making, licensing and inspecting of dairy farms and processing plants, milk sampling and analysis, and enforcement of the Florida Grade A Milk Program. In Table 5 are the chemical, bacteriological and temperature standards as outlined in the Florida Grade A Milk Program Rules and Regulations.

THE VETERINARIAN'S ROLE

A thorough understanding of milk quality is an essential component of the knowledge base needed for a veterinarian in order to evaluate, plan, implement and monitor a mastitis control program. This is best demonstrated by considering what constitutes a "mastitis problem herd." Problem herds are herds that suffer one or more of the following:

1. a herd with bulk milk containing high somatic cell counts
2. a herd with bulk milk containing high bacteria counts
3. a herd with bulk milk containing antibiotic residues
4. a herd with an increased number of clinical mastitis cases.

Three of four listed are milk quality problems and if not corrected can result in suspension from the Grade A milk market. This has very significant economic implications to the dairymen and demands the veterinarian's immediate attention. When a dairyman is "shut-off" it means he can no longer sell his milk until the problem is resolved. This represents an emergency situation. Finding a rapid solution for such a predicament could mean the difference between losses of several thousands of dollars or minimal losses as a result of effectively managing the crisis.

This is not the case with the herd which is sporadically experiencing increased numbers of clinical mastitis cases. While this represents an important concern for the dairymen it usually does not threaten his milk market. In short, the dairyman's desire to implement a mastitis control program may more likely come as a result of a milk quality problems and not a clinical mastitis problem.

In summary, who cares about milk quality? Consumers, retail distributors, milk processors, milk cooperatives, regulatory officials, veterinarians, and dairymen all care about milk quality and with good
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reason. The future success of any business enterprise depends upon the "quality" of the product it produces. The American auto industry would certainly testify to that.
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Table 1. Normal composition of milk.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>84-90%</td>
</tr>
<tr>
<td>Fat</td>
<td>2-6%</td>
</tr>
<tr>
<td>Protein</td>
<td>3-4%</td>
</tr>
<tr>
<td>Lactose</td>
<td>4-5%</td>
</tr>
<tr>
<td>Ash</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

Table 2. Temperature and time requirements for milk pasteurization.

<table>
<thead>
<tr>
<th>Pasteurization Type</th>
<th>Temperature and Time Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch</td>
<td>Milk: 145 degrees F (63 degrees C) for 30 minutes</td>
</tr>
<tr>
<td></td>
<td>Cream: 150 degrees F (66 degrees C) for 30 minutes</td>
</tr>
<tr>
<td></td>
<td>Ice cream mx: 155 degrees F (69 degrees C) for 30 minutes</td>
</tr>
<tr>
<td></td>
<td>Eggnog: 155 degrees F (69 degrees C) for 30 minutes</td>
</tr>
<tr>
<td>HTST</td>
<td>Milk: 161 degrees F (72 degrees C) for 15 seconds</td>
</tr>
<tr>
<td></td>
<td>Cream: 166 degrees F (75 degrees C) for 15 seconds</td>
</tr>
<tr>
<td></td>
<td>Ice cream mix: 175 degrees F (80 degrees C) for 25 seconds</td>
</tr>
<tr>
<td></td>
<td>Eggnog: 175 degrees F (80 degrees C) for 25 seconds</td>
</tr>
<tr>
<td></td>
<td>Eggnog: 180 degrees F (83 degrees C) for 15 seconds</td>
</tr>
<tr>
<td>Ultra-Pasteurized</td>
<td>280 degrees F (138 degrees C) or above At least 2 seconds</td>
</tr>
</tbody>
</table>

Table 3. Effect of Somatic Cell Count on cheese yield.

<table>
<thead>
<tr>
<th>Average Somatic Cell Count cells/ml</th>
<th>Cheddar Cheese Yield lbs cheese/100 lbs milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>240,000</td>
<td>9.748</td>
</tr>
<tr>
<td>496,000</td>
<td>9.686</td>
</tr>
<tr>
<td>640,000</td>
<td>9.430</td>
</tr>
</tbody>
</table>

* J. C. Bruhn, Extension Food Technologist, U.C. Davis. 1983

Table 4. Effect of somatic cells on milk composition.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Normal</th>
<th>High cell count</th>
<th>% of normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids</td>
<td>13.1</td>
<td>12.0</td>
<td>92</td>
</tr>
<tr>
<td>Lactose</td>
<td>4.7</td>
<td>4.0</td>
<td>85</td>
</tr>
<tr>
<td>Fat</td>
<td>4.2</td>
<td>3.7</td>
<td>88</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.091</td>
<td>0.147</td>
<td>161</td>
</tr>
<tr>
<td>Total protein</td>
<td>3.6</td>
<td>3.6</td>
<td>100</td>
</tr>
<tr>
<td>Caseins</td>
<td>2.8</td>
<td>2.3</td>
<td>82</td>
</tr>
<tr>
<td>Whey proteins</td>
<td>0.8</td>
<td>1.3</td>
<td>162</td>
</tr>
</tbody>
</table>

Table 5. Requirements of Florida Milk Products Law.

<table>
<thead>
<tr>
<th></th>
<th>Grade A Raw Milk for pasteurization, ultra pasteurization or sterilization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td>Cooled to 45 degrees F (7 degrees C) or less within two hours after milking, provided that the blend temperature after the first and subsequent milkings does not exceed 50 degrees F (10 degrees C).</td>
</tr>
<tr>
<td><strong>Bacterial</strong></td>
<td>Individual producer milk not to exceed limits 100,000 per ml. prior to commingling with other producer milk. Not to exceed 300,000 per ml. as commingled milk prior to pasteurization.</td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td>Individual producer milk; no zone equal to or greater than 16mm with the <em>Bacillus tearothermophilus</em>; Commingled milk, No zone equal to or greater than 16mm with the <em>Bacillus stearothermophilus</em>.</td>
</tr>
<tr>
<td><strong>Somatic cell count</strong></td>
<td>Individual producer milk; not to exceed 1,000,000 per ml.</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>Cooled to 45 degrees F (7 degrees C) or less and maintained there at.</td>
</tr>
<tr>
<td><strong>Bacterial limits</strong></td>
<td>Grade A pasteurized or ultra pasteurized milk and milk products.</td>
</tr>
<tr>
<td>(Coliform)</td>
<td>20,000 per ml.</td>
</tr>
<tr>
<td></td>
<td>Not to exceed 10 per ml provided that, in the case of bulk milk shipments, shall not exceed 100 per ml.</td>
</tr>
<tr>
<td><strong>Phosphatase</strong></td>
<td>Less than 1 microgram per ml by the Scharer Rapid Method or equivalent.</td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td>No zone equal to or greater than 16mm with the <em>Bacillus stearothermophilus</em>.</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>None.</td>
</tr>
<tr>
<td><strong>Bacterial limits</strong></td>
<td>Less than 10 per ml of incubated products.</td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td>No zone equal to or greater than 16mm with the <em>Bacillus stearothermophilus</em>.</td>
</tr>
</tbody>
</table>

* Not applicable to cultured products.  