

MILK QUALITY AND COMPOSITION



OVERVIEW

- The quality of milk can be defined by its physical-chemical and microbiological characteristics such as flavor, nutritional value, absence of residues, toxins, and low somatic cell count (SCC).
- Physical-chemical characteristics are particularly important for manufacturing of dairy products and determinants of milk price.
- Nutritional composition of milk is affected by several factors, such as the cow's breed, genetic selection, milk yield, stage of lactation, heat stress, and feeding practices. Nutritional management can modify milk composition on a short-term basis, whereas the potential benefits from genetic selection will be shown on the long-term.

SYSTEM AFFECTED

Mammary

GENETICS

Milk composition percentages are more heritable (0.50) than actual yields (0.25) for fat, protein, and total solids.

GEOGRAPHIC DISTRIBUTION

Worldwide

SIGNALMENT

Species

All lactating ruminants

Breed Predilections

- Breed and genetic lines are important factors for determining the physiological amplitude for individual components in milk (Table 1).

Table 1 Milk composition according to cattle breed

Breed	Body wt (kg)	Milk yield (kg)	Fat (%)	True protein (%)	Lactose (%)	Ash (%)	Total solids (%)
Ayrshire	520	5760	3.95	3.29	4.60	0.72	12.77
Brown Swiss	640	6100	3.99	3.45	4.94	0.74	13.08
Guernsey	500	5270	4.72	3.56	4.71	0.76	14.04
Holstein	640	7360	3.54	3.10	4.68	0.72	12.16

Jersey	430	5060	5.13	3.79	4.83	0.77	14.42
Milking shorthorn	530	5370	4.00	3.13	4.89	0.73	12.90

- The impact of dietary changes in milk components will be restricted to the range limited by breed, genetic line, and other physiological characteristics.
- Crossbreeding is a useful tool to promote substantial increase in milk solids on a herd basis.

Mean Age and Range

N/A

Predominant Sex

Female

MILK QUALITY

- Milk fat varies widely, as much as 3 percentage units, being the component that is most responsive to diet composition. Detailed aspects of milk fatty acid synthesis are discussed elsewhere in this book (see low-fat milk syndrome).
- In the last decade, attention has been given to the fatty acid profile of feeds for human consumption and health, specifically Omega-3 fatty acids and conjugated linoleic acid (CLA). CLA (c9, t11) has been demonstrated to inhibit mammary carcinogenesis in rats. Ruminant-based fat sources (milk or meat) represent the major dietary source of CLA isomers.
- Changes in milk protein content (expressed as total nitrogen) are smaller than milk fat changes, approximately 0.6 percentage units, but still responsive to nutrition.
- Determination of true protein content in milk is a better predictor of casein content, which highly correlates to yield of dairy processing products, such as cheese.
- Feeding strategies associated to higher milk protein yield include optimizing rumen fermentation—resulting in maximal absorption of bacterial amino acids and feeding protein sources with lower ruminal degradability.
- Fat supplementation is negatively related to milk protein content (%), although milk protein yield is generally increased due to the positive effect of energy on milk yield.

BACTERIAL CONTAMINATION OF MILK

- Bacteria are the main contaminant in milk. High counts of mesophilic bacteria (better growth between 20 and 40°C) are responsible for sour milk and are common in situations of poor hygiene and refrigeration.
- Psychrotrophic bacteria are capable of growing at refrigeration temperature. They produce enzymes that break down protein and fat, which can produce off flavors. Most of these enzymes are heat resistant and can still be active after pasteurization, thus reducing the shelf life of the dairy product. The surface of the teats and milking equipment are the main sources of psychrotrophic bacteria.
- High bacteria counts are associated with poor milking hygiene, inadequate refrigeration (5 to 15°C or 41 to 59°F), long storage periods, and improper cleaning/disinfection of milking equipment and the bulk tank.
- Initial contamination and the bacteria multiplication rate will determine the bacterial load of raw milk. Initial contamination is predominantly related to 4 factors: (1) the level of mammary gland contamination due to subclinical mastitis, (2) milking hygiene and proper milking routine, (3) cleanliness of the tank(s) and equipment, and (4) the physical-chemical and microbiological

quality of the bulk milk in the system subjected to the cleaning process. Bacteria multiplication rate is inhibited or reduced by adequate refrigeration (2 to 4°C or 35.6 to 39.2°F).

- Raw milk is also a source of pathogens, and therefore it is a public health concern. Pathogens can come from the environment (e.g., *Bacillus cereus*), feeds (e.g., *Listeria monocytogenes*), or indirect contamination with feces (e.g., *Salmonella* sp.), or can be shed directly into the milk (e.g., *Brucella abortus*, *Campylobacter jejuni*, and *Mycobacterium bovis*).
- Antibiotic residues and the presence of toxins are additional threats to milk quality.

SCC AND MILK QUALITY

• Somatic cell count (SCC), which are actually leukocytes secreted into the milk, is another indicator of milk quality. In mastitic quarters, SCC is greatly increased. Milk with high SCC has lower concentration of casein, lactose, and calcium, and higher levels of whey proteins, sodium, and chloride. In addition, proteases and lipases from leukocytes are heat stable and can severely reduce the shelf life of dairy products.

- The SCC is commonly used as a measure of milk quality.
- Milk with high SCC causes a rise in whey proteins and a decrease in casein, which decrease cheese yields.
- Shorter shelf life and adverse milk flavors are the common results of an elevated SCC score.
- Somatic cell counts are based on the number of cells/mL (about 10 drops) of milk. Causes of high somatic cell counts:

1. The mammary gland is infected with mastitis-causing organisms. The contagious pathogens (e.g., *Staphylococcus aureus*, *Streptococcus agalactiae*, and others) generally cause the greatest SCC increase. An infection by an environmental pathogen (e.g., non-*Strep. agalactiae* *Streptococcus*, *Corynebacterium bovis*, and coagulase-negative *Staphylococcus*) usually causes considerably less SCC elevation.
2. Cow age and stage of lactation cycle
3. Stress and seasonality
4. Mammary injury
5. Other causes:
 - Poor milking procedures
 - Faulty milking equipment
 - Extraneous (stray) voltage, which causes cow apprehension, teat irritation, uneasiness, and poor milk-out.

NUTRITIONAL FACTORS AFFECTING MILK QUALITY

- Increasing the forage content of the diet leads to increased milk fat and depressed milk protein as well as milk yield.
- Increasing neutral detergent fiber (NDF) concentration of the diet from 25% to 37% on dry matter (DM) basis resulted in a linear decrease in milk production and milk protein and a linear increase in the fat content of milk.
- Milk protein concentration may be improved by various combinations of rumen-protected methionine and lysine if these amino acids are limiting in the diet.
- The addition of lipids in the diet generally increases the yield of milk, decreases milk protein concentration and has minor effects on milk fat content.
- The concentration of CLA and omega-3 fatty acids in milk is considerably higher from ruminants that graze on fresh pasture.

CAUSES AND RISK FACTORS

- Poor milking hygiene

- Inadequate cleaning and disinfection of equipment
- Improper refrigeration during storage and transportation
- Deficient udder and herd health
- Hard and contaminated water
- Suboptimum nutrition
- Poor quality feeds



DIAGNOSIS

Laboratory Tests

- Frequently sample and culture bulk tank milk. Before taking the sample, agitate the tank for 5 minutes and then collect the milk from the top (not from the outlet). Label the sample with the date and tank number if applicable, and refrigerate it immediately.
- Tests to request include SCC, standard plate count (SPC), coliform count, preliminary incubation (PI), bulk tank culture for mastitis pathogens, and laboratory pasteurization count (LPC). Those results indicate the health status of the herd, the hygiene practices, and whether refrigeration and cleaning are adequate.
- For high milk quality, target:
 - SCC under 200,000 cells/mL
 - SPC under 20,000 cfu/mL
 - PI under 20,000 cfu/mL
 - LPC under 100 cfu/mL

ASSOCIATED CONDITIONS

The concentration of milk fat is intimately associated with rumen health. Abnormally low milk fat content can be indicative of ruminal acidosis or grain overload.

AGE-RELATED FACTORS

Lactating animals are the only ones affected, but non-lactating animals can be affected by mastitis.



MISCELLANEOUS

ZOONOTIC POTENTIAL

Should a mammary gland become infected with a zoonotic agent, drinking raw milk could result in human infections.

SEE ALSO

Body condition scoring: dairy cattle (www.fiveminutevet.com/ruminant)

Low-Fat Milk Syndrome

Mastitis: Bulk Tank Monitoring and Somatic Cell Counts

(www.fiveminutevet.com/ruminant)

Mastitis: Camelids
Mastitis: Coliform
Mastitis: Fungal
Mastitis: Involvement of Milking Equipment and Stray Voltage
(www.fiveminutevet.com/ruminant)
Mastitis: Milking Procedures and Teat Disinfection (www.fiveminutevet.com/ruminant)
Mastitis: Minor Bacteria
Mastitis: Monitoring (www.fiveminutevet.com/ruminant)
Mastitis: Mycoplasmal
Mastitis: No Growth
Mastitis: Pharmacology (www.fiveminutevet.com/ruminant)
Mastitis: Small Ruminant
Mastitis: Staphylococcal
Mastitis Streptococcal
Goat Milk Quality
Feeding for Milk Components (www.fiveminutevet.com/ruminant)

ABBREVIATIONS

- CLA = conjugated linoleic acid
- DM = dry matter
- LPC = laboratory pasteurization count
- NDF = neutral detergent fiber
- PI = preliminary incubation
- SCC = somatic cell count
- SPC = standard plate count

Suggested Reading

- Berry, D.P., Buckley, F., Dillon, P., Evans, R.D., Rath, M., Veerkamp, R.F. 2003. Genetic relationships among body condition score, body weight, milk yield, and fertility in dairy cows. *J Dairy Sci.* Jun; 86(6):2193–204.
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