Please do not write on these & Return Them in good condition. Write your answers on a separate piece of paper.

12

Lactation

Learning Objectives

After you have studied this chapter, you should be able to:

- Describe the process of lactation.
- List the components of milk.
- Identify the major components of the mammary gland.
- Identify and describe a typical lactation curve.
- Explain the problem of lactose intolerance.
- Describe the process by which various components are added to milk.
- Compare and contrast the effect that species has on milk composition.
- Explain the process by which BST increases milk production.

Key Terms

Alveoli
Bovine somatotropin (BST)
Calcium
Casein
Colostrum
Involution
Lactation
Lactation curve
Lactogenesis
Lactose
Lactose intolerance
Lipoproteins
Mastitis
Milk
Myoepithelial cells
Oxytocin
Parturient paresis
Parturition
Pituitary gland
Saturated fats
Secretory cells
Unsaturated fats

INTRODUCTION

Lactation The process of producing milk.

Parturition The process of giving birth.

Milk The normal secretion of the mammary glands of female mammals.

Lactation, the process of producing milk, occurs in all mammalian species. In fact, the production of milk following **parturition**, the process of giving birth, is a major, if not sole, factor that defines the difference between mammals and other classes of animals. All mammalian species rely on milk for the nourishment of young. In addition, humans rely on milk throughout life as a readily available source of many nutrients including calcium, protein, fat, carbohydrates, and many trace minerals and vitamins. Thus the role of lactation in animal production is extremely important, not only for nourishment of young animals, but as a primary product marketed for human consumption. However, the production of milk is an extremely complicated process, and optimum production requires knowledge in all disciplines associated with animal production.

Milk is defined as the liquid—comprised of water, triglycerides, lactose, protein, minerals, and vitamins—that is produced and secreted by the mammary glands of the females in mammalian species. Milk varies in composition and consistency both among species and within species. The primary sources for milk consumed by humans include goats, sheep, water buffalos, and, of course, cows. However, around the world, many other species, including camels, llamas, and yaks, are used to produce milk for dairy products. The basic structures of the mammary gland in all species, both on a cellular and anatomical level, are remarkably similar.

MAMMARY GLAND DEVELOPMENT, ANATOMY, AND FUNCTION

Development of the mammary gland, irrespective of the species, requires a coordinated effort of the endocrine, anatomical, and physiological systems of the female. In the prenatal period, the basic structures of the mammary gland develop. From birth to puberty, the mammary gland develops at about the same rate as the rest of the body, primarily under the influence of growth hormone. At puberty and with each subsequent estrous cycle, the female sex hormones progesterone and estradiol stimulate growth in the mammary gland at a rate more rapid than the rest of the body. In the pregnant female, progesterone stimulates the lobule-alveolar development, which is required to prepare the gland for milk synthesis. Close to parturition the hormone prolactin, necessary for initiation and maintaining lactation, is secreted. At parturition, the blood levels of progesterone and estrogen decrease abruptly and **lactogenesis** occurs. There are two stages of lactogenesis. In *stage I lactogenesis*, immunoglobulin uptake occurs and **colostrum** is formed, much of this prior to parturition. In *stage II lactogenesis*, copious milk secretion begins, and during the next few days colostrum production is shut down and milk of normal composition is produced.

The primary structures of the mammary gland responsible for producing milk are the **alveoli**. The alveoli are spherical (Figure 12–1) and capable of storing the

Lactogenesis The series of cellular changes during which mammary epithelial cells convert from the non-secretory state to the secretory state.

Colostrum Specialized milk produced in the early days following parturition to provide extra nutrients and immune function to the young.

Alveoli Spherical-shaped structures making up the primary component of the mammary gland. Consist of a lumen, which is surrounded by secretory cells that produce the milk, and myoepithelial cells, which contract to squeeze the milk out of the lumen into the mammary gland ducts.

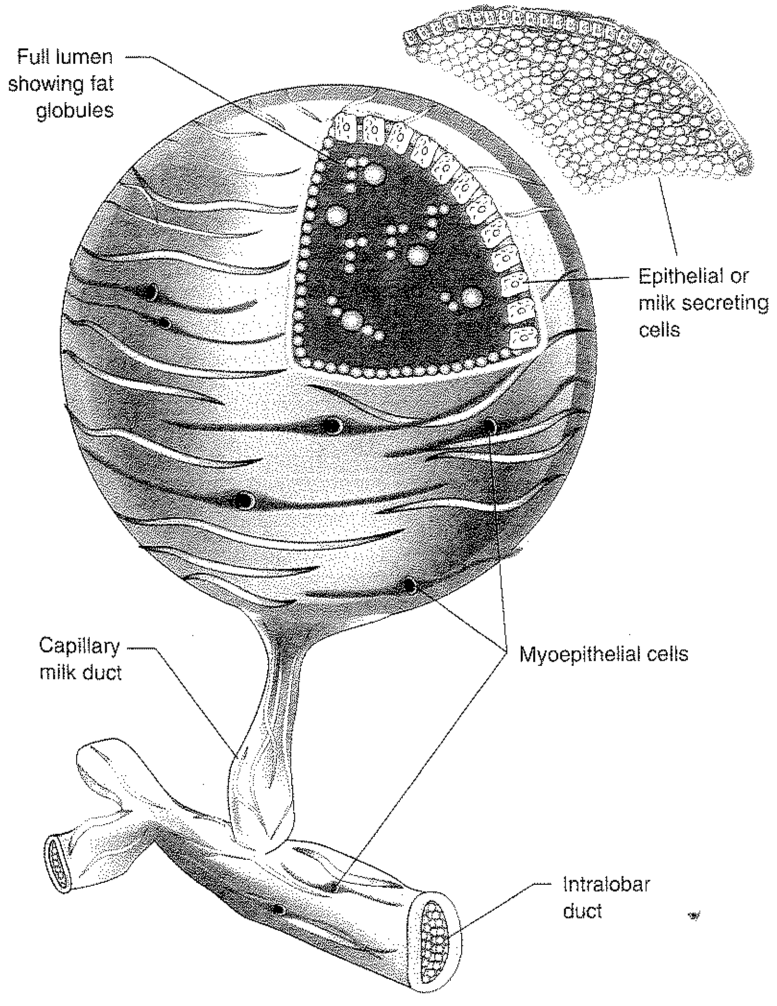

Figure 12–1
Alveoli—the primary mammary structure responsible for producing milk.
Source: Turner, 1969. Used with permission.

Secretory cells The functional units of the alveoli that absorb nutrients, make the milk components, and transport the milk into the lumen of the alveoli.

Oxytocin A hormone produced in the hypothalamus and secreted by the posterior pituitary gland that stimulates contraction of muscle cells in the uterus to aid in parturition and the myoepithelial cells surrounding the alveoli to force milk out of the lumen into the mammary gland ducts.

Pituitary gland A small gland hanging just below the brain. Made up of the posterior pituitary gland and anterior pituitary gland.

Myoepithelial cells Specialized muscle cells that surround the secretory cells of the alveoli and cause them to contract when stimulated by oxytocin.

Mastitis Inflammation of the mammary gland, most often caused by bacterial infection.

milk produced by the **secretory cells** that surround the outside of the lumen, not unlike a water-filled balloon in which the water can be pushed out the opening. Milk is produced by these specialized secretory cells, which are housed in the alveoli and contain the necessary enzymes to produce the components unique to milk. These secretory cells have three primary functions: (1) to absorb the necessary precursors (nutrients) from the bloodstream; (2) to transform these nutrients into the lactate, fat, and protein in milk; and (3) to transfer the newly synthesized milk into the lumen of the alveolus. In addition, many minerals and vitamins are absorbed from the bloodstream and are combined with the synthesized components prior to discharge into the alveolus. Fat, carbohydrate, protein, minerals, and vitamins are secreted in a liquid form. Therefore, the components are diluted in water and the milk remains in the alveolus until the milk is released.

Milk release, or letdown, is facilitated by the action of a hormone, **oxytocin**, released from the **pituitary gland**, which sits at the base of the brain. The oxytocin acts on specialized muscle cells called **myoepithelial cells**, which surround the secretory cells, causing them to contract. As the muscles contract, milk is squeezed from the lumen of the alveolus. Upon discharge of milk, the alveolus deflates, making room for more milk to be produced. The release of oxytocin depends on the female recognizing a stimulus, most often stimulation of the teats, such as the young beginning to nurse or the udder being washed. However, the female may be conditioned to respond to other factors associated with milk removal, such as the visual appearance of its offspring, or even the sound of a vacuum pump used to draw the milk from mammary glands at milking time.

The milk produced in the secretory cells is transferred directly into the lumen of the alveoli. The alveoli are arranged in lobules, and the contents are drained by a complex ductwork system that carries the milk to the skin surface. The ducts terminate at the skin surface in structures referred to as *nipples* or *teats,* depending on the species. In cows and goats, the ducts terminate into a *gland cistern,* which is connected to a teat cistern and finally to a streak canal. It is the streak canal through which the milk ultimately leaves the female in these species. Surrounding the streak canal is a muscular ring, or teat sphincter, that is responsible for closing the streak canal after milk is released. In addition to holding the milk in the teat canal, this muscular ring, which is normally in a constricted configuration, prevents foreign materials from entering the mammary gland. This includes preventing the entrance of microbes, thereby providing the first line of defense in protecting the integrity of the mammary gland from infection. During milk release, the teat sphincter relaxes, allowing milk to pass through the canal. However, once the teat sphincter releases, it remains that way for 15 to 60 minutes. Therefore, the teat canal is susceptible to entry by microorganisms for an hour after each milking. For this reason, cows must be kept standing immediately after milking to keep bacteria from entering the mammary gland. Most dairy producers accomplish this by providing feed after milking.

The prevention of bacterial entry is essential due to the susceptibility to **mastitis**, an inflammation of the mammary gland most often attributed to bacterial infection. Mastitis is one of the leading causes of illness in dairy cattle and leads to the use of antibiotics that gain entrance to the milk. Because the law requires that antibiotics cannot be present in milk consumed by humans (referred to as *zero tolerance*), the use of antibiotics severely limits profitability by requiring milk from treated cows to be wasted and also increases the liability of the producer. Further, if not treated appropriately, mastitis can result in cellular damage to the mammary gland, reducing the animal's ability to produce milk. Severe cases can be fatal (Figure 12–2).

Although cows begin producing milk immediately after calving, milk production does not peak until several weeks after parturition. The reason for this is not known,

Figure 12–2
The cut surface of an udder affected by mastitis. The glandular tissue is severely inflamed due to a bacterial infection. Notice the tan, cloudy fluid (pus) filling the gland sinus. (Photo by Dr. Rodger Panciera. Courtesy Oklahoma Center for Veterinary Health Services.)

but it is likely owing to a physiological and biochemical adjustment period required by the animal for peak production. Generally, cows reach their peak production at 50 to 70 days postcalving. After that point, the secretory cells become less functional and a progressive decline in milk production is observed. The mammary gland undergoes a gradual **involution**, decreasing in weight, volume, and productivity. However, this involution is reversed with the next pregnancy, and successive lactations often are progressive in production. This increase and decline of production during lactation is referred to as the **lactation curve** (Figure 12–3). The curves for different species have their own characteristic shapes. The rate at which a female's milk production declines after reaching its peak is referred to as *persistency*. A slower rate of decline, which produces more milk for longer periods, is referred to as *more persistent*.

Involution An organ's return to its normal state or normal size.

Lactation curve A plot of milk production over the life of the lactation period.

COMPONENTS OF MILK

Carbohydrates

Lactose, the primary carbohydrate found in the milk of virtually all species, is only produced by secretory cells in the mammary gland. Lactose is synthesized in the secretory cell by combining glucose with another 6-carbon carbohydrate—galactose.

Lactose Disaccharide comprised of one glucose unit attached to a galactose sugar.

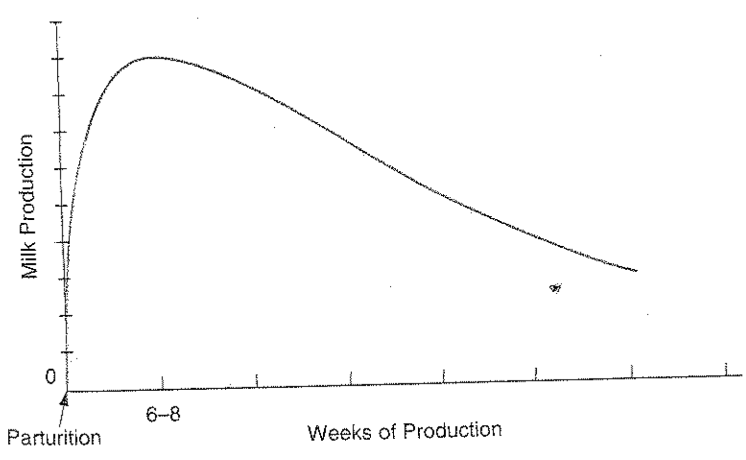

Figure 12–3
Lactation curve of a dairy cow. Volume of milk production generally increases for 6 to 8 weeks. After the peak, production declines until the end of the lactation.

Because the mammary gland is incapable of synthesizing glucose, all of the glucose used to produce lactose must be provided by the circulating blood. Therefore, one of the primary limiting factors in milk component synthesis is the availability of glucose. This requirement puts a tremendous metabolic demand on the cow, rendering her susceptible to several metabolic conditions during times that milk production is high.

As discussed in the chapter on nutrition, ruminant animals do not absorb much glucose. Instead, the microorganisms in the rumen break down most of the soluble carbohydrates into volatile fatty acids (VFAs). These VFAs (acetate, propionate, and butyrate) are absorbed through the rumen wall and travel through the bloodstream to the liver. The liver is able to make glucose out of propionate but is not able to make glucose out of acetate. Acetate and butyrate can be used to make milk fat or can be oxidized for energy to run milk synthesis. Therefore, the glucose that becomes available for the mammary gland depends greatly on what is supplied to the liver. Feeds (e.g., corn and other grains) broken down into propionate increase the production of glucose in the liver, thereby providing more glucose to the mammary gland to meet its potential to make lactose.

Because lactose is a disaccharide, it must be degraded in the small intestine after consumption. An enzyme, lactase, is present in the small intestine of most species to degrade the lactose into glucose and galactose, which are finally available for absorption. However, in individuals with less lactase, the lactose is not degraded, resulting in gastrointestinal distress known as **lactose intolerance.** Individuals who suffer from lactose intolerance generally experience cramps and diarrhea following milk consumption. Lactose intolerance is a genetic condition. Its incidence is lowest in people of Scandinavian and western European descent, in which only 2–8% of the population suffers from the condition. However, about 90% of Japanese, Thais, and Filipinos are afflicted to some extent. Estimates in the United States suggest that approximately 70% of the African American population is also affected. Fortunately, the condition can be alleviated through the consumption of cultured dairy products, such as yogurt. In addition, lactase pills can be taken as milk is consumed and most of the lactose is degraded in the small intestine before any deleterious effects are felt. Recent studies suggest that even individuals with severe lactose intolerance are able to consume small amounts of milk without symptoms.

Lactose intolerance Condition in humans where the lack of the enzyme lactase leads to stomach distress following milk consumption.

Protein

The protein in milk exists in many different forms. The primary protein in milk is **casein**, which comprises more than 80% of the total protein in milk. As with lactose, the mammary gland is the only tissue capable of making casein. Casein exists in many different forms that can be further subdivided by biochemical characteristics. The casein proteins carry negative charges, owing to the phosphate groups held in association with the proteins. To secrete these negatively charged proteins, the secretory cells draw calcium out of the bloodstream. Therefore, the negatively charged proteins are largely responsible for the high concentrations of calcium found in milk. Caseins are essential to the cheese-making process, and efforts are currently under way to select animals with casein fractions in their milk that will make better cheese.

Casein The major protein of milk.

In addition to casein are the milk serum proteins (lactoglobulin, lactalbumin, and immunoglobulins). The concentration of these proteins is much lower in milk compared with casein, but still comprises approximately 18% of the protein in milk from cows. When digested, milk serum proteins provide high concentrations of amino acids that are available for the consumer of the milk to use in synthesis of other proteins. As a critical component in the synthesis of casein, lactalbumin is frequently secreted into milk. Beta-lactoglobulin likely plays a role in the binding of proteins.

The concentration of immunoglobulins varies greatly immediately after parturition. The first milk produced by mammals is referred to as colostrum. This milk is extremely high in protein concentration because of the large proportion of immunoglobulins (antibodies) secreted into the milk. These immunoglobulins increase the ability of the offspring to resist pathogens in the environment. However, the functionality of the immunoglobulins depends on the absorption of the antibodies from the small intestine. The young of species depending on this *passive* form of immunity have a short period of time immediately after birth during which the immunoglobulins are absorbed directly from the small intestine. However, gut closure occurs rapidly, most often within the first 24 hours. Therefore, the offspring must be provided this colostrum milk as soon after birth as possible. In addition, some species also confer immunity to their offspring through the production of specific antibodies in the mammary gland against antigens introduced by the young during nursing. The nursing young not only benefits from a generalized immunity, but also from a specific immunity for the particular pathogens present in the environment. Because these immunoglobulins are proteins, the protein concentration in colostrum milk is extremely high. However, by 3 to 4 days postparturition, the milk has returned to normal composition. This timing corresponds to the gut closure in the offspring.

Lipids

The percentage and chemical makeup of fats in milk varies greatly by species. For example, milk may contain virtually no fat (in black rhinoceros) or up to 50% fat by weight (in seals). In addition, the amount of fat in milk is influenced by feed type and stage of lactation, among other factors. Of the primary lipids—triglycerides, cholesterol, and phospholipids—the vast majority of lipid in milk is made up of triglycerides (>90%). The fatty acids that make up triglycerides vary in length and degree of saturation. Fatty acids in milk derive from two sources: (1) fatty acids extracted from blood-borne **lipoproteins**, whose composition varies with diet, and (2) production in the mammary gland. Thus the source of the fatty acids in milk affects the characteristics of milk fat.

In ruminant species, the vast majority of **unsaturated fats** are saturated by the microorganisms in the rumen. Therefore, when the fats are absorbed in the small intestine, most are saturated. These fats are then packaged into lipoproteins and travel throughout the body. The mammary gland is then offered predominantly **saturated fats** to incorporate into milk. Because humans have a dietary essential requirement for at least one unsaturated fat—linoleic acid—some vegetable oil is traditionally added to human infant milk formulas based on cow's milk. By adding the vegetable oil, sufficient linoleic acid is incorporated into the formula to satisfy the needs of human babies.

Of the fats made in the mammary gland, the primary precursor for fatty acid synthesis in nonruminants is glucose. However, because ruminant species have very limited supplies of glucose, the primary precursor for fatty acid synthesis is one of the volatile fatty acids—acetate. Acetate is produced in the rumen when ruminants consume a high-fiber diet, so the amount of fat showing up in milk can be changed by manipulating the amount of fiber in the diet. Historically, we have selected feed to promote high milk-fat production in the dairy cow. The amount of milk fat is less

Lipoproteins Compounds in the bloodstream that carry the lipids (fats) in the blood.

Unsaturated fats Fatty acids that are not saturated with hydrogens, but instead have double bonds. The number of double bonds changes the physical, biochemical, and metabolic characteristics of the fats compared with saturated fats.

Saturated fats Fatty acids that are completely saturated with hydrogens, and thus do not contain any hydrogen bonds.

emphasized today, due to consumers' preference for lower-fat dairy products. More emphasis today is placed on the other components, like protein content. Dairy cows tend to be fed to produce as much as their genetics and environment will allow while maintaining an adequate milk-fat test.

Calcium

Milk serves as a very good source of minerals, particularly calcium. Human requirements for calcium are highest in the young because calcium and phosphate are used to build the matrix of bone. In our adult years, our bones remodel. This process continues to require calcium, although at lower levels. However, as we age, bone breakdown often exceeds the replacement of the matrix, resulting in conditions such as osteomalacia and osteoporosis. Women are particularly susceptible to osteoporosis because the protective actions of estrogen are lost at menopause. Calcium consumption can be critical in preventing, or at least lessening, the devastating effects of these diseases. This is why the medical and nutritional communities so strongly encourage milk consumption (Figure 12–4).

As mentioned earlier, the reason that milk is high in calcium is the presence of strongly negative-charged proteins in milk. The secretory cells offset the negative charge by combining the protein with calcium that has been removed from the bloodstream. However, this process puts a stress on the cow. It is not uncommon for calcium levels in the blood of high-producing dairy cows to fall precipitously low when extraordinarily high levels of protein are produced. This condition, **parturient paresis** (otherwise known as milk fever), generally occurs near calving time, when the production of colostrum milk requires calcium to be put into the milk faster than the cow is able to replace it from the diet. The cows exhibit paralytic symptoms, and the condition, if not treated quickly, can be fatal (Box 12–1).

Parturient paresis Metabolic disorder generally occurring within 72 hours of calving. Caused by low blood serum calcium level.

As indicated in Table 12–1, tremendous variation is seen in the composition of milks among species. In dry-matter percentage alone, milk ranges from 12% to

Figure 12–4
Dowager's hump in elderly women is linked to poor bone mineralization, especially calcium. Milk is an excellent dietary source of calcium. Source: Nordicphotos/Alamy

BOX 12–1

BOVINE PARTURIENT PARESIS

Parturient paresis, also known as milk fever, is a disease of mature dairy cattle that typically occurs in the 72-hour period following calving or parturition. Affected cows may initially be excitable and restless and are unstable on their feet. If the disease is not treated, cows become unable to stand and often lie with the head tucked into the flank. At this stage of the disease, cows show signs of inappetence, depression, and may have cold extremities. As the disease worsens, cows may bloat, and untreated animals gradually lose consciousness and die. Parturient paresis is caused by a sudden calcium loss associated with the onset of milk production, which leads to low blood serum levels of ionized calcium. Muscle contraction depends on adequate calcium levels, so when serum calcium falls below normal, muscle weakness occurs. The disease is most common in older, high-producing dairy cows; Jerseys may be affected more commonly than other breeds of dairy cows. Quick recognition of disease symptoms and rapid treatment with intravenous calcium gluconate solution are critical for saving the life of an affected cow. Nutritional modification leading up to the time of calving is often helpful in preventing the disease. One method involves feeding a low calcium diet prior to calving so that cows begin to mobilize their own body stores of calcium and are therefore better able to respond to the sudden calcium loss associated with lactation. The addition of anionic salts to the diet, which enhances calcium absorption through the digestive tract as well as **resorption** of calcium from bone, is another nutritional modification that may be used to prevent milk fever.

Table 12–1
Average Concentrations of Some Constituents in the Milk of Selected Species

Species	Fat (%)	Protein (%)	Lactose (%)	Dry Matter (%)
Camel	4.9	3.7	5.1	14.4
Cat	10.9	11.1	5.9	15.6
Cow	3.4	3.2	4.6	11.8
Dog	8.3	9.5	3.7	20.7
Goat	3.5	3.1	4.6	11.7
Guinea pig	3.9	8.1	3.0	15.8
Llama	4.7	4.2	5.9	15.6
Pig	9.6	6.1	4.6	21.2
Human	3.5	1.3	7.5	12.0
Rabbit	12.2	10.4	1.8	26.4
Rat	15.0	12.0	2.8	31.0
Reindeer	22.5	10.3	2.5	36.7
Water buffalo	10.4	5.9	4.3	21.5
Whale	36.6	10.6	2.1	50.0

Sources: Davies et al., 1983; Riek and Gerken, 2006; and Hurley, 2007.

approximately 50% in whales. This increase in dry-matter percentage is related to a combination of necessity for delivery to young (whales nurse in an aquatic environment) and to a demand for a high proportion of protein and fat for fast-growing young.

Resorption The loss of tissue through normal physiological means or through a pathological process.

OTHER FACTORS IN MILK PRODUCTION

One of the hormones critically involved in the production of milk is growth hormone, otherwise known as *somatotropin*. This hormone is released from the pituitary gland and increases the production of milk by the secretory cells, either through increased activity of the enzymes involved in the production of milk components, through increased availability of the precursors to the secretory cells, or through a combination of the two effects. In fact, it is likely that one of the primary mechanisms by which genetic improvement in milk production has been so rapid in the dairy cattle industry is selection of those lines of cattle that are more responsive to the positive effects of somatotropin. In the 1930s, researchers at Cornell University observed increased milk production from cows injected with ground-up pituitary extracts. Years later, with the isolation of the somatotropin protein, this response was again observed, although to a much larger extent. In the 1980s, methods in biotechnology had advanced sufficiently that recombinant DNA methods could be employed to produce sufficient amounts of the bovine somatotropin such that it would be possible to explore its use to improve the production of milk from dairy cattle. In the early 1980s, drug companies became interested in the production and sale of a **bovine somatotropin (BST)** product that could be injected into cows to supplement their natural levels of somatotropin.

Bovine somatotropin (BST) Hormone that acts on various target tissues in the body. Injections of BST increase milk production.

Of course, years of testing for drug effectiveness and safety for human consumption ensued. In 1985, the Food and Drug Administration (FDA) reported to the U.S. Congress that dairy products produced from milk from BST-treated cows were safe for human consumption. In addition, the National Institutes of Health concluded that milk and meat from BST-treated cows were just as safe for human consumption as were milk and meat from nontreated cows. These results have been supported by numerous studies, and no studies have indicated that the human consumption of milk produced from BST-treated cows is in any way harmful. Based on the results of numerous studies, the FDA approved the use of BST on November 5, 1993. Congress mandated a required 90-day moratorium on the sale of BST, and the commercially available product from Monsanto became available to dairy producers on February 3, 1994.

Bovine somatotropin has dramatic effects on the production of milk from dairy cows. An immediate increase of 10–20% in milk production is commonly observed, and the lactation persistency is improved. With increased milk produced per animal, the efficiency of milk production improves because the cost of maintaining the cow is less as a percentage of total requirements. However, the increase in milk requires increase in feed intake and appropriate nutritional management to support the increased production. There is also a cost for the BST.

It is important to note that BST is a naturally occurring hormone in cattle. Therefore, the addition of exogenous BST only supplements the hormone that is already present in the cow. Second, because BST is a protein, even if it did cross through the secretory cells and become discharged into the milk, it would be broken down in the stomach of the consumer, thereby rendering it inactive. Finally, the somatotropins are species specific. That is, the growth hormone in humans is different from the growth hormone in cows, which is different from the growth hormone in horses. Therefore, even if a person was injected with BST, the response would not be observable, because of the body's inability to recognize the foreign protein.

SUMMARY AND CONCLUSION

Milk production requires tremendous coordination among the endocrine, physiological, biochemical, and anatomical functions in the female body. The nutritional requirement of the lactating animal is dramatically increased, not only because of the components transferred into the milk, but also owing to the increase in body functions required to produce the milk. Although levels of production and composition of milk vary greatly by species, the biosynthesis of the milk components is very similar among species. Levels of production have increased in those species primarily used for milk production. This increase in milk production can be attributed to several factors, including increased productive capacity of the mammary gland, increased knowledge of nutritional requirements of the female, better control of environmental conditions, and implementation of new technologies such as BST to improve milk synthesis capacity. Is there a physiological limit to the amount of milk that a cow or goat can produce? The answer to that question may never be determined. What is known, however, is that tremendous potential continues to be realized in the production and efficiency of milk production in the United States and around the world.

STUDY QUESTIONS

1. What is lactation?
2. What is milk? What are the constituents of milk?
3. What are the alveoli? What do they do? What are the functions of the secretory glands in the alveoli?
4. What hormone facilitates milk letdown? What kinds of things can cause milk letdown?
5. What are the purposes of the teat sphincter? Does it provide protection from infection at all times? How can this problem be managed?
6. What is mastitis? Why is it such a physiological problem? Why is it such an economic problem?
7. What is the lactation curve? Describe what it illustrates.
8. What is milk sugar? Where is it manufactured? Where do the components come from?
9. What is lactose intolerance? Is there a cure for it?
10. What is casein? Where is it made? What is the link between casein and calcium in the mammary gland? How might biotechnology be used to determine the best bulls to produce superior cheese-making daughters?
11. In addition to casein, what are the other proteins found in milk? What does each do?
12. What is colostrum? What does it do? What is the difference between active and passive immunity?
13. Is there a difference from species to species in the fat content of milk? What is unique about the fat of a ruminant milk?
14. How does dietary fiber affect milk-fat production in the ruminant? How would the fat in milk be decreased by changing the ration? Increased?
15. What are osteoporosis and osteomalacia? How is calcium linked to these diseases? How is milk drinking a part of the solution?
16. What is milk fever? What mineral is it linked to?
17. What is somatotropin? BST? How do each of these work? What is the source of each?
18. Is BST safe? What are the negatives associated with its use?

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