CHAPTER 2

LITERATURE REVIEW

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2.1. Friesian Holstein Dairy Cow Description

According to Blakely and Bade (1991), cow race have taxonomy classification as follows:

Phylum	: Chordate
Subphylum	: Vertebrata
Class	: Mammalian
Sub class	: Theria
Infra class	: Eutheria
Order	: Artiodactyls
Sub order	: Ruminant
Infra order	: Pechora
Family	: Bovidae
Genus	: Bos
Group	: Taurinae
Species	: *Bos taurus* (European Cattle)
	Bos indicus (Indian Cattle/ Zebu Cattle)
	Bos sondaicus (Wild Ox/ Balinese Cattle)

For many years, Holsteins were bred and strictly culled to obtain animals which would make best use of grass, the area's most abundant resource. The intermingling of these animals evolved into an efficient, high-producing black-and-white dairy cow.

Friesian Holstein's halfblooded dairy cattle constitutes to usufruct cross among FH's dairy cattle with local cow with marking that similarly with FH but relatively inferior milk production than FH and also smaller body measure (Siregar, 1996). Result of that cross have character between parent second it, where is wight increase warms up high enough and can adapt by environmentally tropical one good manners (Syarief dkk., 1998).

In Indonesia, the nation's dairy cow population PFH is also the largest among the nations of the other dairy cows. Cow milk production in Indonesia an average of 10 liters / cow per day (Asfar, 2011).

2.2. Ruminant Digestive System

Based on its digestive system, livestock can be grouped into ruminant's livestock and non ruminant livestock. Ruminant livestock has 4 abdominal components. Since that is digestive system on breeding ruminant more perfect than breeding non ruminant (Siregar, 1994). Dairy cattle includes in ruminant's breed faction. Breeding bellying component ruminant is rumen, reticulum, omasum, and abomasum (Siregar, 1994).

Ruminants have four stomachs (gastric compound) which is the rumen, reticulum, omasum and abomasum. In ruminant digestion will occur: a) mechanical namely through the mouth, b) Fermentative occurs in reticulo-rumen by rumen microbes and c) hydrolytes by digestive enzymes produced by the landlord (animal itself) occur in the abomasum. In contrast to other livestock, whereas in ruminants occurs before the fermentation process and its capacity is very large intestine (Siregar, 1994).

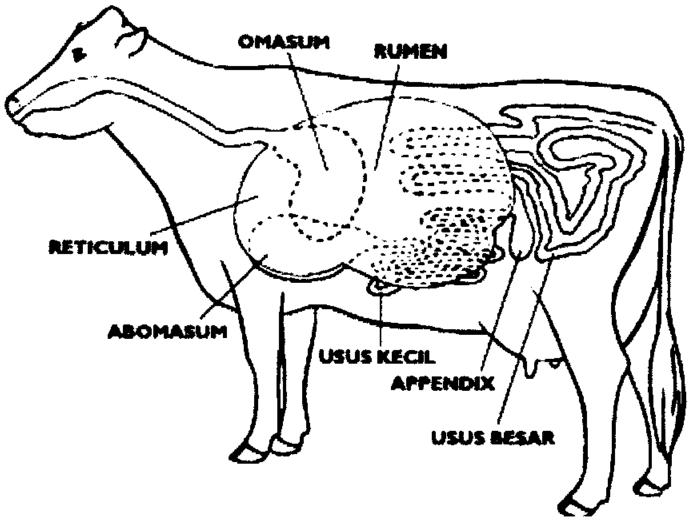

Figure 2.1. Ruminant Digestive System (source: GKSI, 1995)

Leek (2004) said that ruminant, so named because they ruminate (chew the cud), posses a stomach consisting of a nonsecretory forestomach and a secretory stomach compartment (the abomasum). The forestomach acts as a microbial fermentation vat, whereas abomasums, like the stomach of non ruminant animals, is largely concerned with the hydrolysis of protein by pepsin in an acid medium, plus the breakage of bacteria by the action of lysozyme.

The forestomach consist of three compartments (the reticulum, the rumen, and the omasum) and is where microbial fermentation of the ingesta occurs. It is their fermentation end products (volatile fatty acids, etc.) that the ruminant absorbs and uses as its prime metabolic substrates (Leek, 2004).

Reticulum is approximately spherical and the esophagus enters dorsomedially at the cardia. The reticular groove runs ventrally from the cardia to the reticulo-omasal orifice. The reticulum is partially separated from the cranial sac of rumen by the ruminoreticular fold, which even when contracted leaves a large orifice between the reticulum and the rumen. For this and other reasons the ruminoreticulum operates as a combined functional unit despite the clear anatomical differences between these two compartments (Leek, 2004).

The rumen is divided into dorsal and ventral sacs by an incomplete partition formed by the cranial and caudal pillars and the right and left longitudinal pillars. The dorsal parts in divided into (1) the cranial sac lying between the ruminoreticular fold and the cranial pillar, (2) the dorsal sac, and (3) the caudodorsal blind sac. The ruminoreticulum occupies the entire left side of the abdomen and, depending on the degree of stomach filling, also extends ventrally on the right side (Leek, 2004).

Omasum is a kidney-shaped structure and is relatively larger in cattle than in sheep and goats. On the luminal side of its lesser curvature is the short omasal canal connecting the reticulo omasal orifice with the omaso-abomasal orifice. The body of the omasum consist of many parallel leaves (lamellae) attached at the greater curvature, with their free edges parallel to and in contact with the omasal canal. The leaves bear small papillae that further enhance the internal surface area volume ratio of omasum (Leek, 2004).

The abomasum consists of fundic, body, and pyloric regions. The mucosa is thrown up in about 12 high folds (rugae) that run spirally over the fundic and body parts and are absent from the pyloric region. A constriction (the pylorus) separates the pyloric region from the duodenum (Leek, 2004).

The small intestine is the location where a further breakdown of the food material occurs. Secretion of enzymes, pancreatic juice and bile, aid in further digestion of the ingesta. This generally occurs in the upper portions of the intestine. The end products of the digestion process are absorbed in the lower section of the small intestine. When we refer to by-pass protein and fats, it is here that these proteins and fats have their positive nutritional effects.

The large intestine is where residues of the ingested feed are deposited. Feed residues do undergo some fermentation. There are absorption sites for water, minerals and nitrogen (Leek, 2004).

2.3. The Nutrients of Milk

Milk is an unavoidable part of human consumption. The different types of milk also affect the difference in nutritional content. Milk contains minerals, proteins, fats, carbohydrates and vitamins which are beneficial to human health. Therefore, milk is also called a perfect food. The nutrients in milk include sources of energy (lipids and carbohydrates), proteins to provide amino acids, vitamins, minerals (ash) for electrolytes, and water. The relative amounts of these nutrients in milk vary among species (Table 2.1) (Cunningham *et al.*, 2007).

Table 2.1. Typical values for constituents of milk in grams per liter.

Species	Lipids	Lactose	Protein	Total Mineral	Calcium
Cow	38	48	37	7.0	1.3
Mare	16	50	24	4.5	1.0
Ewe	70	40	60	8.0	1.9
Sow	80	46	58	8.5	2.0
Doe	40	45	35	7.8	1.2

Source : (Cunningham *et al.*, 2007).

Milk is an unavoidable part of human diet. Different types of milk that we consume include different kinds of nutrients. Milk provides us with minerals, protein, fat, carbohydrate, and vitamins. So it is also called as a complete diet.

It is recommended that every human being should consume a certain amount of milk for fulfilling their nutritional deficits. Milk can be consumed either as a drink or in the form of milk-derivates like dairy products.

Milk is a colloidal suspension of solids in liquid. Fluid whole milk is approximately 88% water, 8,6% SNF (solids-non-fat), and 3%-4% milk fat. The SNF is the total solids minus the milk fat. It contains protein, lactose, and minerals. Even though milk is a liquid, their 12% total solid is similar to the solids content of many solid foods (Taylor *et al.*, 2001).

Fresh milk has amphoteric properties, meaning that it can be in the nature of acid and alkaline properties. Naturally fresh milk ranged from 6.5 to 6.7 pH. When the pH of milk is lower than 6.5, meaning there is colostrum or bacterial activity (Saleh, 2004).

The nutrients in milk of most importance to humans are protein, calcium, potassium, phosphorus, other trace elements, vitamin A, riboflavin and thiamine.

Milk is a complex mixture of water, fats, proteins, lactose, minerals, vitamins and enzymes, together with some cells. The milk fat containing around sixty-six different fatty acids is emulsified and dispersed in the water in small globules (Chamberlain *et al.*, 1990).

According to Director General of Animal Husbandry Decree No. 17 in 1983, cow's milk is milk that includes fresh milk, whole milk, pasteurized milk, and milk sterilization. Fresh milk is pure milk that does not have the heating process. Pure milk is the liquid that comes from the udder of healthy cows. Whole milk obtained by milking the right, without reducing or adding any other components or materials. While according to ISO 01-3141 1998 which meant fresh milk is a liquid that comes from healthy cows and clean udder obtained by milking the content of their natural right is not reduced or added anything whatsoever and has not received any treatment.

Factors which affect composition are age of cow, stage of lactation, calving interval, seasonality, feeding, milking technique, health (Thomas, 1983), environmental, characteristics and breed (Sasimowski, 1987).

Dairy cattle have values that range from 3,5% to 5,5%. In the past, milk was sold on a fat basis and breeds that had a relatively fat content of milk (e.g., the Jersey with 5% fat) found more acceptance in dairy operations than is currently in case. Small farms produced mainly cream (for butter manufacture); the fat-concentrated portion of milk was produced by use separator that separated cream on the basis of specific gravity and centrifugal force, Because milk is now sold on a solids, not fat, basis, breeds that produce more milk (and protein) are produce milk with a high fat level. On the other hand, cows which suffer from tuberculosis or inflammation of the udder produce less fat, while those which have had foot-and-mouth disease tend to produce more of it (Sasimowski, 1987).

According to American's regulation, qualified milk good should contain minimum 3,25% fat (USDA A-A-20338) but at Indonesia, fat that regulate at SNI'S standard minimum just 3% fat (SNI 01 3141 1998).

In whole milk, the approximate 3%-4% milk fat is a mixture of lipids existing as microscopic globules suspended in the milk. The fat contributes about 48% of the total calories in whole milk. Fat-soluble vitamins (A, D, E, and K) are normal components in milk fat. Milk fat contains most of the flavor components of milk, so when milk fat is decreased, there may be a concurrent reduction in flavor (Taylor *et al.*, 2001).

The synthesis and release of milk by alveolar epithelial cells is a remarkable physiological process. Alveolar cells synthesized fats, proteins, and carbohydrates and extrude the products into the lumen of the alveolus. Fat droplets first accumulate in the basal cytoplasm of the cell and then move to the apex, where the droplet protrudes into the alveolar lumen. The cell membrane constricts about the base of the fat droplet, so fat is dispersed in milk in small droplets, surrounded by cell membranes; the droplet often contains portions of cell cytoplasm (Cunningham *et al.*, 2007).

According to Taylor *et al.*, 2001, approximately 500 different fatty acids and derivates from 2-26 carbon atoms in length have been identified in milk. Milk fat from ruminant animals contains both short-chain and long chain fatty acids.

According to bulletin of National Research Council, 1976 the fatty acids of fat are typically composed as follows (by mass fraction).

Table 2.2. Fatty Acids Composition of Fat

Saturated Fatty Acids	Percentages	Unsaturated Fatty Acids	Percentages
Palmitic acid	31%	Oleic acid	24%
Myristic acid	12%	Palmitoleic acid	4%
Stearic acid	11%	Linoleic acid	3%
Lower (at most 12 carbon atoms) saturated fatty acids	11%	Linolenic acid	1%
Pentadecanoic acid and heptadeca-noic acid	traces		

Source : National Research Council, 1976.

Most of the lipids in milk are in the form of triglycerides, and these are the primary source of dietary energy in milk. Triglycerides are composed of fatty acids and glycerol. The fatty acids for the synthesis of milk triglycerides may be derived from the blood or synthesized within the mammary gland. The mammary glands of ruminants depend on blood acetate and β-hydroxybutyrate to provide carbon for fatty acid synthesis, with acetate being the primary source. Most milk triglycerides have fatty acids with chains 4 to 14 carbon atoms in length – short-chain fatty acids.

2.5. The Importance of Fat

Fat refers to a large group of natural molecules consisting of the elements carbon, hydrogen, and oxygen include fatty acids, evening, sterols, vitamins are soluble in fat (eg A, D, E , and K), monoglycerides, diglycerides, phospholipids, glycolipids, terpenoids (including sap and steroids) and others (Ophartd, 2010).

Fat is an organic material which is insoluble in water but soluble in organic solvents and was instrumental in biochemistry and physiology of the body tissues of animals. Fats are organic substances that contain carbon, hydrogen, and oxygen. Fat contains more carbon-hydrogen in comparison with oxygen.

Commonly it can be said that fat accomplishes basic function for human, which is: (1) As energy reserve in shaped fat cells. 1 gram of fat result 39.06 kjoule or 9,3 kcal; (2) Fat has cellular function and structural component on cell membrane that bearing with carbohydrate and protein to pass the water current, ion and other molecules, sticking out and turns in at cells; (3) Underpinning organic compound function as signal conductor, as in prostaglandin and steroid hormone and bile gland; (4) As suspense divide vitamin A, D, E and K that beneficiating to biological process; (5) Function as detention of shock after protect vital organs and protects body from external temperature that insufficiently amicable; (6) Fat also constitute circulation's medium energy in body and main component that form membrane of all cell types (Ophartd, 2010).

Fat provides dietary energy; serve as a source of heat, insulation, and protection for the animal body; and provide essential fatty acids. Fats has 2.25 times morre energy per gram than protein ŏr carbohydrates. Fats also aid the absorbtion of fat-soluble vitamins (Schoenherr, 2002).

According to Aminuddin, 1980, there are several factors that affect the digestibility / absorption of fat, which is a long chain of fatty acids, fatty molecular weight, degree of saturation of fats, monoglycerides are more easily absorbed compared with free fatty acids, age, pH of the intestinal microflora, and existing sources of protein.

Lipids are digested and absorbed primarily in the upper part of the small intestine, but considerable absorption can take place as far down as the ileum (Ensminger *et al.,* 1990).

Fat serves the following function when added to dairy rations : it (1) increases the caloric density of the ration without lowering the forage (fiber) content, (2) controls dust, (3) lessens the wear and tear on feed mixing equipment, (4) facilitates pelleting of feeds, (5) increase palatability, (6) helps to homogenize and stabilize certain feed additives, especially those of a very fine particle size, and (7) increase the total amount of milk, fat, and SNF (solids-non-fat), but results in a slight decrease in the percentage of both fat and SNF (Ensminger *et al.*, 1990).

Like the carbohydrates, the fats contain carbon, hydrogen, and oxygen with percentages are 77% carbon, 12% hydrogen, 11% oxygen. And the character of the food fat has the same influence on the nature on the milk fat as it does on the depot fat. Later studies have specifically shown that the essential fatty acids in milk fat can be increased by dietary fats rich in them (Maynard *et al.*, 1973).

Of the components of milk, fat is the most important energy source. Milk fat is composed of a number of lipids, including monoglycerides, diglycerides, triglycerides, free fatty acids, phospholipids, and steroids; triglycerides are the main component of a milk fat. The types of lipid synthesized are complex, with great variations in both chain length and saturation of fatty acids observed on the basis of species. The amount of fat produces varies greatly both within and among species (Cunningham *et al.*, 2007).

2.6. Metabolism of Fat in Dairy Cow

Lipids assimilation can be divided into four phases: (1) emulsification, (2) hydrolysis, (3) micelle formation, and (4) absorption. Emulsification is the process of reducing lipid droplets to a size that forms stable suspensions in water or water based solutions. In the gut the emulsification phase begins in the stomach as the lipids are warmed to body temperature and subjected to the intense mixing, agitating, and sieving actions of the distal stomach. This distal-stomach activity tends to break lipid globules up into droplets that pass into the small intestine. In the small intestine, emulsification is completed by the detergent action of bile acids and phospholipids. These bile products reduce the surface tension of the lipids and allow the droplets to become even further divided and reduced in sized (Figure 2.2) (Cunningham *et al.*, 2007).

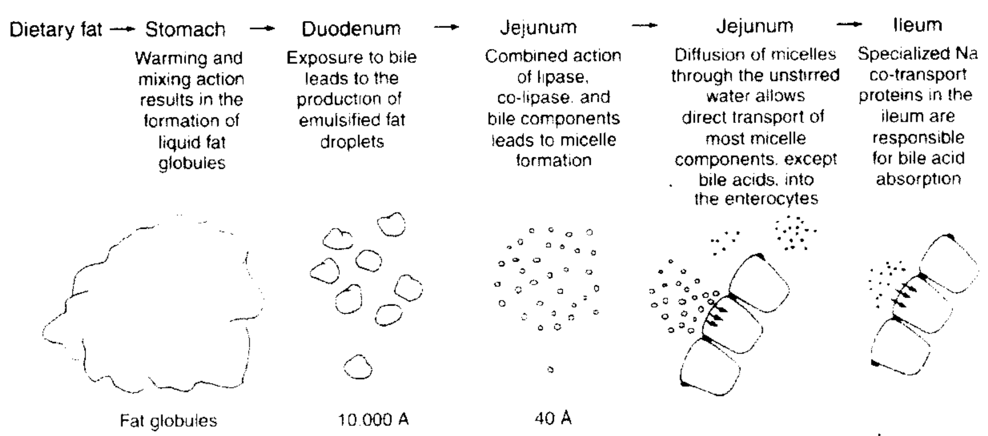

Figure 2.2. Sites and reactions involved in fat digestion and absorption (Å, angstoms) (Cunningham *et al.*, 2007).

While in the bile-coated, or emulsified-droplet, stage, the lipids are subject to the actions of hydrolytic enzymes. Lipase cleaves the fatty acids off each end of the triglyceride molecule but does not attack the central fatty acid, resulting in the formation of two free or nonesterified, fatty acids and a monoglyceride from each molecule of triglyceride hydrolyzed (Figure 2.2).

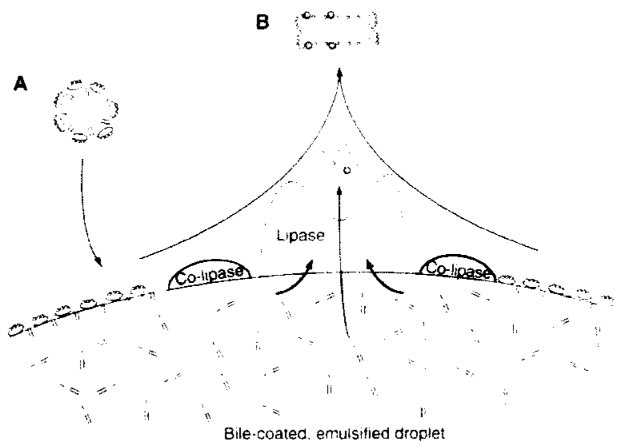

Figure 2.3. Portion of the surface of a bile-coated, emulsified fat droplet (Cunningham *et al.*, 2007).

Bile components reach the surface of the droplet through micelles (A) coming from the gallbladder. Co-lipase clears bile constituents from an area of the surface of the droplet, allowing the attachment of lipase. Lipase catalyzes the formation of fatty acids and monoglycerides from triglycerides. The surface components and products of lipase action combine to form micelles (B) containing fatty acids and monoglycerides as well as bile constituents (Figure 2.3).

The products of hydrolytic lipid digestion (fatty acids, monoglycerides, etc.) combine with bile acids and phospholipids to form micelles, small water-soluble aggregations of bile acids and lipids. The soluble micelles allow the lipids to diffuse through gut lumen into the unstirred water layer and into close contact with the absorptive surface of the apical membrane (Figure 2.3) (Cunningham *et al.*, 2007).

2.7. Lactogenesis Process

Lactogenesis is the establishment of milk secretion, and galactopoiesis is the continued production of milk by the mammary glands (Frandson *et al.*, 2003). In dairy cows, the amount or the percentage of fat is easily changed through changing the diet fed. Lactation, the production of milk by the mammary gland, is a distinguishing characteristic of mammals, whose young at first feed solely on milk from their mothers. Even after they start to eat other feeds, the young continue to nurse until they are weaned (separated from their mothers so they cannot nurse). The mammary Gland serves two functions: (1) it provides nutrition to animal offspring, and (2) it is a surce of passive immunity to the offspring. The importance of milk as a nutritional source to perpetuate each mammalian species has been known since the beginning of history. Only during the past few decades have basics mechanism of immunity through milk been determined (Taylor *et al.*, 2001).

2.8. Complete Feed for Dairy Cow

Complete feed is forage feed ingredients, concentrates, minerals, vitamins and amino acids mixed one, formulated specifically to the needs of each nutrient that needed by cattle (Linn *et al.*, 1996). Form of complete feed adjustments considered effective and more efficient because it is generally feeding on livestock forage and concentrate separately performed that requires much effort and time (Romziah dkk., 2003).

The advantage is the complete feed there is a balance between the consumption of forage, concentrate and feed additive (Linn *et al.*, 1996). Complete feed can meet the needs of livestock throughout the season according to the tropical climate found in Indonesia. Complete feed helps meet the nutritional needs of farmers in dairy cows, especially in the dry season.

Ruminant rations generally consist of forage and concentrates. Of rationing in the form of a combination of both materials would be the fulfillment of member opportunities nutrients and relatively low cost (Siregar, 1994)

The quality of quantity of food eaten by the cow not only affects yield but quality as well for milk (Thomas *et al.*, 1983). Complete feeds are prepared products that provide all the nutrients, along with roughage, required to support the form of animal production for which they were designed (Ensminger *et al.*, 1990).