CHAPTER II

BACKGROUND INFORMATION

Heat stress has significant impact on dairy production. Heat stress occurs when the sum of the cow's physical heat production increase and the environmental heat become greater than it ability to dissipate heat. The principal climatic factors causing heat stress are temperature, humidity, solar radiation and wind speed (Armstrong, 1994). An understanding of the control of body temperature in dairy cow under heat stress and the relationship of this to productivity must come from approach in which the animal is viewed in relation to both its thermal and nutritive environments. This is because the effect of heat on body temperature is determined not only by the climate (i.e., high temperature, radiant and high humidity) but also the available food and water. The cow's physical heat production is a combination of internal factors as well as external factors. Internal heat load comes from basic body functions such as respiration, digestion, production, as well as other daily maintenance requirements. The amount of energy required to maintain a constant core body temperature at any time during the day is least within a range of ambient temperatures. In this region, the animal relies primarily on adjustments in behavior and thermal insulation to minimize change in internal body temperature. This factor will be influenced by stage of lactation, production, as well as quantity, quality and type of feed consumed. External physical heat loads are management factors that effect physical activity and performance. Cow comfort, layout of facilities, stocking densities and fly control can all impact the cow's external physical heat load. Environmental heat is a combination of the direct effects of temperature and solar radiation increasing the heat load, and the indirect effects of humidity and air movement reducing the cow's ability to dissipate its heat load. Heat load will increase as temperature, humidity and solar radiation increase and air movement decreases. When the cattle cannot dissipate sufficient heat to maintain thermal balance, body temperature rises and heat stress occurs. The most noticeable responses to heat stress are reduced milk yield, feed intake, impaired reproductive performance and often body weight loss. Animals try to attain a constant body temperature independent of the temperature of the surrounding (Monteith and Mount, 1973). Dairy cow has several mechanisms to help dissipate body heat and maintain body temperature which include:

1. Conduction

Conductive heat exchange occurs between stationary objects, such as to still air or water in the environment. The amount of heat loss by this route is dependent on the thermal gradient, thermal conductivity of the contact material and amount of surface contact with the conducting material. Conductive heat exchange usually accounts for only a small portion of heat exchange in hot environment.

2. Convection

Convective heat exchange represents an over greater potential for heat loss. It includes the heat loss between moving objects, as during exposure to wind or currents of water. The factors that determine the effectiveness of this exchange route are the same as for conduction. There are both natural and forced forms of convection. The natural convection occurs when air is warm near the body surface and the rises with a decrease in the density. It is increased with disruption of the hair, together with an increase in airflow over an animal. A more important avenue for heat loss from an animal is the forced convection. This type is used to move the exchange medium. Inside the body, it occurs with the movement of blood through the circulatory system. The primary objective is to bring more heat to the skin surface for dissipation. This is accomplished with cutaneous vasodilation and a redirection of blood flow to the skin.

3. Radiation

This process results in significant heat exchange between most objects. It differs from the other avenues of exchange in that it can take place in a complete vacuum condition. Exposure to sunlight can result in the large flow of energy into the animal and produce heat stress. In contrast, animal can loss energy by infrared radiative exchange during exposure to the clear night sky, to result in effective animal cooling.

4. Evaporation

Heat loss by evaporative of water is an effective and efficient means of heat transfer to the environment. The two areas for evaporation from the body include respiratory (panting) and skin (sweating) sites.

If the environmental temperature is lower than the body temperature, heat will dissipate from the animal by radiation, convection and conduction, so called sensible heat. Radiation occurred when heat is transported via thermal radiation from the animal to the surroundings. Cooling by convection occurs when the layer of air next to the skin is replaced with cooler air and depends on air speed and temperature difference. Conduction appears when the animal has contact with surrounding object surfaces and heat flows from warm to cold. Evaporative occurs when sweat or moisture is evaporated from the skin or respiratory tract. These kinds of heat loss are called latent heat.

Every interaction which an animal has with its thermal environment involves heat exchange. The rate of exchange determining the degree to which cattle remain in the thermal equilibrium with their environment. During the day, heat-gain from solar radiation and metabolism usually exceed heat –loss from radiation, convection and evaporative so that some heat is stored and body temperature rises. At the night, the heat-flow reverses and stored heat dissipated back to the environment and body temperature falls.

Effect of temperature humidity index on lactating cow

Climate is of great importance to animal production, especially in tropical regions, where there are high ambient temperatures throughout the year. Chronic heat stress can substantially affect dairy cattle productivity (Hahn, 1999). The temperature humidity index (THI) is commonly used for measurement of environmental heat load in dairy cattle. THI was developed by the US Weather Bureau as a warm-weather discomfort index for evaluating conditions likely to result in livestock stress and is derived from measurements of air temperature and humidity. THI is commonly used to indicate the degree of heat stress on dairy cattle. Hahn and Mader, (1997) categorized the severity level of livestock welfare by using THI to four levels. THI $\leq$ 74 generally does not cause significant problems for healthy animals. Under alert conditions (THI = 75 – 78), producers can expect some decrease in the rate of weight gain. Under danger conditions (THI = 79 – 83), animals show noticeable decreases in weight gain and, when handled, transported or overcrowded, may be severely affected. Under emergency conditions (THI $\geq$ 84) without management intervention, animal mortality can occur, especially when such conditions are prolonged.

DMI starts to decline and maintenance expenditures increase when environmental temperatures exceed 25 °C (NRC, 1981). However, THI may describe more precisely the effects of the environment upon the cow's ability to dissipate heat. Milk yield and TDN intake decline slightly when the THI exceeded 72 and decline sharply when an index of 76 was exceeded (Johnson et al., 1963). Igono et al. (1992) proposed that the THI could be used to evaluate the thermal stress of the environment. This index combines relative humidity and temperature into a single value to estimate the potential environmental heat load.

During hot periods, dairy cow show signs of disrupted behavior, impaired physiological functions, and an increased incidence of morbidity (Hahn and Mader, 1997). A coping strategy of cattle during heat stress is to decrease metabolic heat production by lowering feed intake, which adversely affects productivity. The major changes involved in this acclimation and acclimatization are shown below

1. Physiological change

1.1 Rectal temperature (RT)

The most obvious index of thermal strain is the response in body temperature (Brody, 1948). The temperature of a homeothermic animal's body relatively uniform and constant, but various parts of the body do have different temperature. Variations of temperature from site to site in the body are caused by a disparity in the insulation of each part (Curtis, 1981). Core body temperature may be measured at several locations. The most frequently used site is the rectum which is perfectly adequate for steady state conditions and rectal temperature is a very useful index of heat tolerance under field conditions (Robertshaw, 1985). The RT have a significant increase ($P<0.05$) from 37.3 to 39.3 $^{\circ}$C, respiration from 28 to 81 breath/min and pulse rate from 64 to 81 pulse/min during ambient temperatures of 32 $^{\circ}$C in hot period (Itoh et al., 1998). It is known that the heat stress increases rectal temperature, as well as respiratory and pulse rate in cattle (Marai et al., 1997 and Bernabucci et al., 1999).

Lough et al. (1990) found that rectal temperature of the six mid-lactation Holstein cows increased $P < 0.01$ with thermal stress compared with those of cows on thermal comfort sequence with *ad libitum* intake and intake restricted. Elvinger et al. (1992) reported an increases in the rectal temperature of lactating cows ($P<0.01$) compare with cattle that become heat stress form the environmental temperature. RT is sensitive indicator of thermal balance and may be used to asses the negative effects of hot environments on growth, lactation and reproduction of dairy cows (Johnson, 1980 and West, 1999). It has been shown that a rise of 1 $^{\circ}$C or less in rectal temperature is enough to reduce intake and production in dairy cows (Johnson et al., 1963).

1.2 Respiratory rate (RR)

Respiration is a form of convective heat transfer. The inhaled air closely corresponds to the body temperature by the time it reaches the trachea due to the heat and moisture exchange (Yousef, 1985). Respiration rate is useful indicator of an animals thermal load. Moreover, in panting animals which include cattle, it is an excellent index and the first visible sign of thermal stress (Brody, 1948). The transference of heat through respiration is an important pathway of heat transfer for most mammals over a wide range of environmental conditions (Eigenberg et al., 1999). Measuring respiration rate appears to be the most accessible and easiest approach for evaluating the degree of heat stress in farm animals (low: 40 – 60 breaths per minute, medium high: 60 – 80, high: 80-120 and severe stress: above 150 breaths per minute in cattle) (Silanikove, 2000).

The normal respiration rate was proximately 10 – 30 breaths/min (Hafez, 1968) and the respiration rate would be increased when environmental temperature increased. When the ambient temperature was higher and cows could not dissipate heat effectively, heat stress would occur and resulted in higher rectal temperature (Johnson et al., 1960). The ability of an animal to withstand the of climatic stress under warm conditions has been assessed physiologically by changes in rectal temperature and respiratory rate. Rectal temperature and respiratory rate are suggested as a useful indication of heat tolerance (Lemerle and Goddard, 1986).

Legates et al. (1991) studied the effect of climatic chamber condition found at 40 °C compared temperature with a field conditions at 29 °C in 4 breeds of cattle (Jersey, Guernsy, Airshire and Holstein). They found that respiration rates of all of the 4 breeds of cattle under climatic chamber conditions were higher ($P<0.05$) than the field condition. Ominski et al. (2001) studied the physiological response of lactating dairy cows during thermoneutral phase, heat stress phase and thermoneutral recovery phase. Rectal temperature and respiration rate were difference during experimental phase (P<0.001). Exposure to heat stress conditions resulted in a 0.6 °C rise in mean daily rectal temperature. Respiration rate increased from 60 breaths per minute during thermoneutral phase to 87 breaths per minute as a result of exposure to heat stress phase.

1.3 Animal behavior

Livestock are subjected to a wide variety of stressors (e.g. thermal, nutrition and production. The behavioral responses and ability of animals to cope with acute and chronic stress is also attracting new interest. In hot climates, high ambient temperature, high direct and indirect solar radiation, lack of air movement and humidity are the main sources of environmental factors that impose strains on animals. Temperature is one of the most important environmental factors affecting the behavior of grazing animals. Strain in animal production most commonly refers to adverse physiological effects that eventually result in a decline in production, such as weight loss or infertility (Finch, 1984).

The most immediate reaction of cattle to heat stress is to limit their food intake. Cows often modify their behaviors in an attempt to maintain intake while avoiding stressful conditions. Changes in eating patterns from day to night feeding occur with hot days and cooler nights. Cows modify their feeding behavior during hot weather. Seath and Miller (1948) showed that Jersey and Holstein cows spent only 11% of their time grazing on hot sunny days when the shade temperature was 30°C, whereas at night when the shade temperatures was 27 °C they spent 37% of their time grazing. Intake of concentrate and hay declined by 5% and 22% for Holstein cows as the environmental temperature increased from 64 to 85° F (McDowell, 1969).

2. Feed intake

The high ambient temperature has a considerable influence on farm animals, causing them to compensate, within limits, by altering voluntary feed intake, metabolism and heat dissipation. A common practice in the dairy industry is to reduce forage in the diet during hot weather to increase nutrient density while reducing fiber content. Consumption of forage declined sharply relative to concentrates as environmental temperature increased from 17.8 to 30 °C, suggesting that cows preferentially reduce fiber intake during hot weather. These results suggested an antagonistic relationship between dietary fiber content and hot environment (McDowell, 1972). High environmental temperatures also increased respiration rate and water intake, which consequently reduced DMI due to gut fill (Mallonee et al., 1985).

Holter et al. (1996) reported that the minimum daily THI was more closely correlated with DMI than maximum THI in Jersey cows. Reductions in DMI commenced when minimum THI exceeded 56 to 57 and continued until THI reached 72. West (1994) studied cows offered diets containing control, low, medium and high NDF (30.2, 33.8, 33.7 and 42%, respectively) fed during cool and hot weather. Dry matter intake (kg/d) and DMI/BW (kg/100kg of BW) declined linearly with increasing dietary NDF during the cool and hot temperature. Smith and Matthewman (1986) pointed out that feed reduction in dairy cow was a response to high environmental temperature to reduce heat production from metabolic processes.

Bernabucci et al. (1999) studied influence of short and long term to a hot environment of four 10 mo-old, half-sibling Friesian heifers. Exposure to the elevated temperature-humidity index was responsible in reduced DMI and increase water intake ($P<0.01$). The heat stressed heifers had higher water consumption per kilogram of DM ingested ($P<0.05$) than did non-stressed heifers. Ominski et al. (2001) found difference in DMI ($P<0.001$) and water intake ($P<0.05$) during thermoneutral phase, heat stress phase and thermoneutral recovery phase. Heat exposure resulted in a 6.5% decrease in DMI.

3. Water intake

Livestock water consumption depends on a number of physiological and environmental conditions such as (i) type and size of animals, (ii) physiological state (growing, pregnant or lactating), (iii) level of activity, (iv) level of dry matter intake and (V) air temperature. Water is the most critical nutrient for cattle and the need is intensified for those subjected to hot climatic conditions. Cows need to increase water intake during times of heat stress to dissipate heat through the lungs (respiration) and by sweating. Water consumption will increase by as much as 50%. If water supplies are not adequate or heat stress becomes severe, cows invert water normally used in milk synthesis to the metabolic processes of heat dissipation. Classical work demonstrated that water losses through the lungs increased gradually and losses from the skin increased sharply as ambient temperature increased from about 16°C to 35°C (Kibler and Brody, 1950). Cows acclimated to 21.1 °C and then exposed to 32.2 °C for 2 week increased water consumption 110% and water losses from the respiratory tract and from skin surface increased by 55% and 177% at the high temperature (McDowell and Weldy, 1967).

As the food consumption decreases with increasing temperature the water consumption increases, with large individual variations in the quantity drunk and in the frequency of drinking. Water consumption is closely tied to feed DMI; Murphy and Morgan. (1983) reported a highly significant ($P<0.0001$) correlation of 0.626 between DMI and water intake. Water consumption increased from 35.6 L/d at 24 d prepartum to 65.2 L/d at 42 d postpartum as DMI increased from 9.6 to 16.2 kg/d and milk production increased to 25.7 kg/d (Wordford et al., 1984). Water is critical for dissipation of excess body heat. Water intake is highly correlated with milk yield and DMI (correlation coefficients of 0.94 and 0.96, respectively) (Dado and Allen, 1994). Collier et al. (1981) found that the cows under 30 °C drank more water up to 29% than those raise under the temperature of 18 °C. Bernabucci et al. (1999) reported the effect of exposure to high temperature was responsible for increased water intake (P<0.01) from 27.55 L/d to 42.61 L/d and reduced DMI (P<0.01) from 8.01 to 7.48 kg/d.

Greater water content in the rumen tended to accelerate ruminal turnover (Silanikove, 1992), which may be beneficial to cows during hot weather because the rate of passage of digesta is slower and may contribute to gut fill. Consumed water may have a direct cooling effect via the recticulorumen, in addition to the cooling effects of panting and sweating.

4. Milk production

Lactating dairy cows exposed to high ambient temperature, often coupled with high relative humidity (RH) or radiant energy (direct sunlight) usually respond with reduced milk yield. As a result, the cow develops numerous physiological mechanisms for coping with this stress. Unfortunately, these responses have negative effects on the physiology of the cow and milk yield. The reductions in voluntary intake and the subsequent declines in milk production are consistent response to heat stress in lactating dairy cows (Mohamed and Johnson, 1985). Smith (1984) mentioned relationship between heat stress and milk production of dairy cattle by separating the heat resources from direct and indirect results. The direct results are ambient temperatures, radiation, humidity and wind velocity. The indirect results are feed intake and metabolic rate. All mentioned factors would affect milk production performance.

Metabolic heat production increases as the productive capacity of dairy cows improves. Cows yielding 18.5 and 31.6 kg/d of milk produced 27.3 and 48.5% more heat respectively, than dry cows (Purwanto et al., 1990). The amount of milk produced depended on the amount of feed ingested and hormonal system involving in milk production. In addition to the responses observed above, several production responses to heat stress were found. Heat stress reduced daily milk yield by 21% as the THI values went from 68 in the spring period to 78 in the summer period (Bouraoui et al., 2002). Milk production decreased by 4.8% when animals were exposed to heat stress compared with that produced during the thermoneutral phase (Ominski et al., 2001).

THI is widely used in hot areas all over the world to assess the impact of heat stress on dairy cows. Milk production is another trait that is negatively influenced by higher ambient temperatures, humidity and/or THI (Brody, 1948: Ravagnolo et al., 2000). According to Johnson (1985), milk production is not affected by heat stress when mean THI values are between 35 and 72. Milk yield decreases of 10 to 40% have been reported for Holstein cows during the summer as compared to the winter (Du Prez et al., 1990). THI values above 72 seem to be the threshold where the effects of heat stress begin to be evident in reduced milk production (Lemerle and Goddard, 1986). Milk yield declined by 0.2 kg per unit increase in THI when THI exceeded 72. (Ravagnolo et al., 2000). Heat stress environments have been associated with depression in milk fat percentages (Rodriguez et al., 1985). Heat stress significantly reduced milk fat content from 3.58% during the spring to 3.24% during the summer (Bouraoui et al., 2002).

5. Digestibility

The disappearance of the nutrient passing through the tract in absorption is called digestibility. A digestion trial involves a record of the nutrients consumed and of the amounts of them voided in the feces. It is essential that the collected feces represent quantitatively the undigested residue of the measured amount of consumed feed. As a general measure of the nutritive value of a feed, digestibility coefficients are used to compute its content of total digestible nutrients. For many years investigators have sought an indirect method of assessing digestibility.

Marker indicator

Marker indicator is an indirect method of recent development. The accuracy and usefulness of which have become definitely established. It involves the use of an inert reference substance as an indicator. A number of markers are presently used in nutritional studies. These can be divided into internal and external markers. Markers provide a method for indirect quantitation of digestive parameters. Therefore, markers used in nutritional research must be appropriately selected for each species. The requirements for an ideal marker have been listed by Faichney (1975) and can be briefly stated as follows:

1. Should be inert, with no toxic physiological effects on the animal microflora.
2. Should not be absorbed or metabolized within the gastrointestinal tract.
3. Should be physically similar to or intimately associated with the material it is to mark.
4. Should not influence gastrointestinal secretion, digestion, absorption, or motility.
5. Should have physiochemical properties that allow for precise, quantitative analysis and must not interfere with other analyses.

In general, digesta may be divided into two fractions, a liquid phase and a particulate phase. It is assumed that an appropriate marker is in equilibrium with the pool of the fraction that it is intended to label and that it is recoverable.

Internal markers are integral components of the feedstuff. Several internal markers have been used in animal digestion studies including lignin, silica, acid insoluble ash (AIA), rare earths and plant fibers such as indigestible acid detergent (ADF) and neutral detergent fiber (NDF). Lignin was one of the first plant components used as an internal marker. Each of these feed fractions does have limitations in usefulness. Lignin is a theoretically indigestible fraction of the plant cell wall. There are, however, reports of lignin disappearance during digestion which are discussed by Merchen (1998).

External markers are indigestible substances added to a feedstuff. Chromium sequioxide (Cr_2O_3) is used most frequently as an external marker in nutrient digestion studies because it is relatively easy to analyze, inexpensive, and can be readily incorporated into the animal feed (Titgemeyer, 1997). Once fecal concentrations of Cr_2O_3 reach equilibrium, after 5 to 6 d, fecal samples can be collected off the ground or form rectal grab sample.

High ambient air temperatures and high levels of direct and indirect solar radiation are major factors influencing the productivity of ruminants in desert and tropical regions (Robertshaw, 1985). Increasing digestibility in dairy that exposure to heat is due to depressed feed intake, reduced passage rate and increased rumen retention time. Bernabucci (1999) reported effects of exposure to a hot environment on diet digestibility in four, 10 mo-old Friesian heifers. Digestibility coefficients for dry matter (DM), organic matter (OM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were significant difference ($P<0.05$) between thermal comfort and elevated temperature humidity index (57.3 vs 68.4, 59.3 vs 70.2, 51.4 vs 66.6 and 44.2 vs 60.9, respectively). West et al. (1999) studied the effects of diets with increasing NDF concentrations in thirty-two dairy cows on nutrient digestion during cool and hot weather conditions. In hot environmental period, apparent digestibility of NDF increased linearly as NDF content.

Allantoin

Rumen microbes are rich in nucleic acid; around 18% of the total nitrogen (N) is presented in form of nucleic acids or 11% in purines (Perez et al., 1997). Rumen microbes contribute the major source of protein supply to the ruminants. The purines from the rumen microbes are metabolized and excreted in the urine as their end products; hypoxanthine, xanthine, uric acid and allantoin. The ability to accurately measure microbial protein supply is of prime in dairy nutrition. Previous work characterizing protein synthesis by the rumen microbial population has required surgical cannulation of the rumen and duodenum. However, cannulation is costly, increases animal care concerns, and DMI and milk production (Wenham, 1979). This has led to the development of noninvasive techniques to measure microbial protein synthesis.

Topps and Elliott (1965) first proposed the use of urinary purine derivatives as a metabolic marker of microbial synthesis in ruminants, whereas more recent studies have worked towards establishing methods relating purine derivative excretion to microbial yield. This method assumes that nucleic acids entering the duodenum are all of microbial origin. Purine nucleotides are degraded in the intestine and absorbed. Adenine and guanine are catabolized and excreted via four possible routes: renal, mammary gland, recycling via saliva (Chen et al., 1990; Sibanda et al., 1882) and secretion into the intestines (Chen, 1989). The purine derivatives are excreted primarily as allantoin but also as hyproxanthine, xanthine and uric acid (Chen, 1989). Allantoin and uric acid are the only purine derivatives excreted by cattle due to high xanthine oxidase activity in the blood and tissues, which converts xanthine and hypoxanthine into uric acid prior to excretion (Chen and Gomes, 1992). Allantoin is the end product of purine metabolism in ruminants and in most other mammalian species.

The urinary excretion of purine derivatives (allantoin, uric acid, xanthine and hypoxanthine) appears to be a reliable noninvasive method to estimate microbial protein flow to the duodenum in ruminants (Chen, 1989). The use of urinary purine derivatives requires a total collection of urine for several days. Milk is considered to be the ideal for allantoin analysis because it is collected quantitatively and is easily sampled (Gonda and Lindberg, 1997). Recently, promising results on the possible use of milk allantoin excretion to estimate protein flow to the duodenum has been evaluated in several studies (Chaiyabutr et al., 1999; Shingfled and Offer, 1998; Timmermans et al., 2000 and Valadares et al., 1999). There is a positive relationship between milk allantoin excretion and microbial nitrogen flow in dairy cattle fed a wide range of diets and with different physiological states (Timmermans et al., 2000). The excretion of allantoin in milk was reported to be positively correlated with DMI and energy. Giesecke et al. (1994) reported excretion of allantoin in milk was correlated to concentration in plasma (r = 0.84). As milk yield increased, percentage of milk allantoin increased from 0.6 to 2.4% of total excretion (r = 0.85). Daily milk yield was correlated with plasma allantoin (r = 0.78) and milk allantoin excretion (r = 0.95). The Generation of allantoin from purine nucleosides was showed in Figure 1.

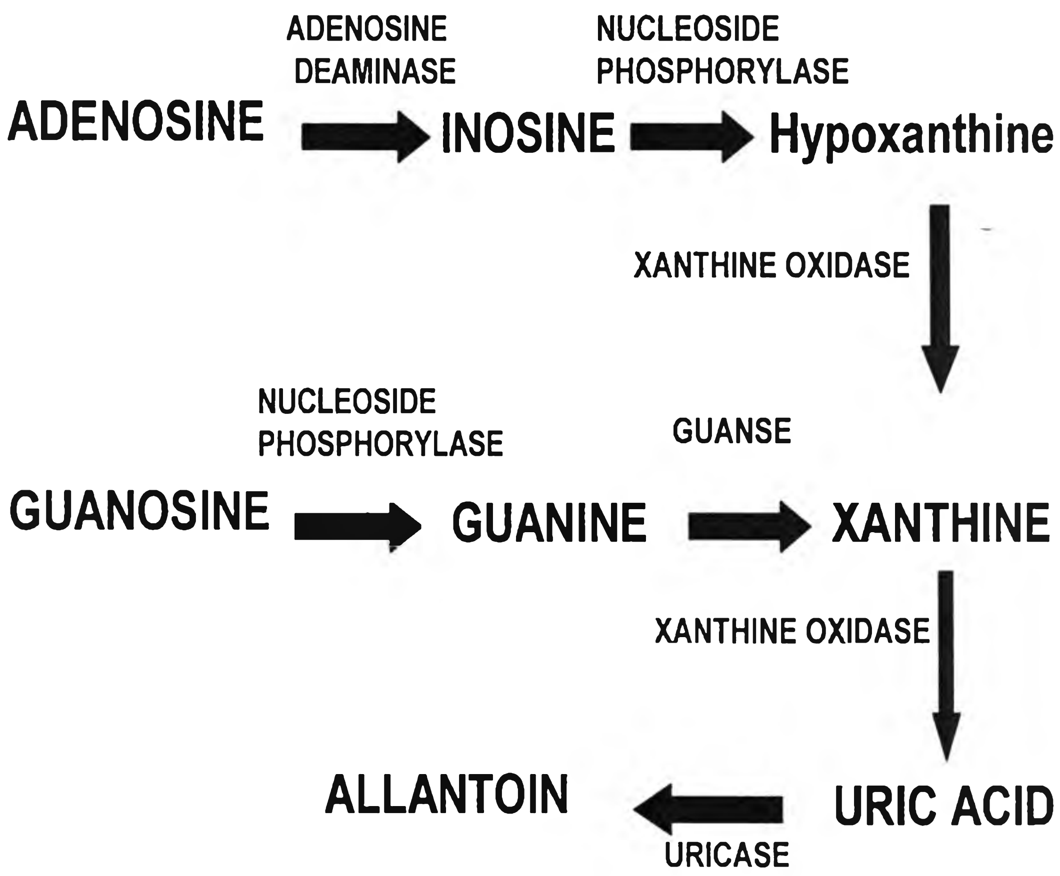

Figure 1. Generation of allantoin from purine nucleosides by way of the purine bases hypoxanthine, xanthine and guanine.

6. Rate of passage

Knowing the passage rates of feeds from the rumen is important for understanding different aspects of digestion, for example a correct estimation of protein utilization and of digesta flow. Passage rates through the gastro-intestinal tract depend on a lot of factors. The ruminal content is divided into two phases, liquid and solid phase. The liquid phase is known to have faster passage rate than the solid phase. For the solid phase, the larger a particle is the longer it takes to pass through the rumen. When the level of dietary protein increases all the passage rates tend to increase. The disappearance of nutrients from the digestive tract occurs because of digestion and outflow. The differences of the particle's disappearance depend on rate of passage and rate of digestion (Owens and Hanson, 1992).

Passage rate is one of the most important parameters influencing disappearance of digesta from the rumen and intake. Various methods have been developed for its estimation, some based on the plant and some within the animal. If, however, the physical model is rejected as having any influence and intake is controlled only by a metabolic mechanism. Measuring the rate of passage has depended on the kinetics of marker disappearance from the rumen or whole tract, where the markers are either internal, e.g. lignin, or externally applied particles, e.g. rare earth markers.

The environment temperature has a significant influence on the animals causing them to compensate by voluntary feed intake, metabolism and heat dissipation to keep the body temperature constant (Miaron and Christropherson, 1992). Heifers exposed to hot environment reduced their DMI and increased the water intake compared to the period under thermal comfort. Rumen passage rate was faster during the period in thermal comfort but the digestibility of DM, OM, NDF and ADF was lower (Bernabucci et al., 1999). Reducing forage consumption of heat stressed cows is an adaptive response to balance heat production from rumen fermentation.

Environmental modification

Summer condition in Thailand may require cooling below ambient temperature for optimum production. High ambient temperature, relative humidity, and radiant energy compromise the ability of the lactating dairy cow to dissipate heat coupling with metabolic heat makes it difficult to maintain thermal balance. Elevated body temperatures initiate compensatory and adaptive mechanisms to reestablish homeothermy and homeostasis. A cow loses heat through its skin surface and respiratory tract. It does not have a large number of sweat glands. Without application of cooling methods, the animal will loose a large amount of heat through its respiratory tract.

Beede and Collier (1986) identified three management strategies to minimize the effects of heat stress: physical modification of the environment, genetic development of heat tolerant breeds, and improved nutritional management practices. There are several available methods that can reduce the house temperatures to below the outside ambient temperatures. Environmental modification is necessary to maintain productivity of the lactating dairy cow. Shade for dairy cattle is considered essential to minimize loss in milk production and reproduction efficiency. Shade was the simplest method to reduce the impact of high solar radiation. Shades can be either natural or artificial. Shading in a hot climate reduced rectal temperature by 2 to 4.1%, respiratory rate by 29 to 60%, improved DMI by 6.8 to 23.2%, and improved milk yield by 9.4 to 22.7% compared with unshaded cows (Mallonee et al., 1985; Schneider et al., 1986). Armstrong, (1994) reported a difference of 26 breaths/min in a group of Holstein cows cooled with a system based on sprays and fans using three different flow water according environment temperatures, compared with the use of just shades.

Abelardo et al. (2002) determined the effect of a cooling system based on sprinklers and fans, on productive of Holstein cows during summer. Milk production during the study was higher ($p<0.01$) in cows of cooling system installed under the shades group (E) compared with those in shades at the middle of the pen (S) (30.5 ± 0.94 vs 26.6 ± 0.98 kg). These results agree with those obtained in Armstrong et al. (1993), which cooling systems based on spay and fans were compared with shades under hot environment temperature in lactating cows.

The combination of tunnel ventilation with evaporative cooling systems has been used in swine and poultry operations for many years to cool the environment. It has been reported (Huhnke et al., 2001) that evaporative cooling could reduce the number of hours at higher level of temperature-humidity index (THI) in some environments. Evaporative cooling has been used very successfully to cool dairy cattle in hot air climates. Evaporative cooling can be accomplished by passing air over a water surface, passing air through a wetted pad.