MANAGEMENT PROTOCOL FOR AVERTING DROP OF MILK PRODUCTION IN DAIRY CATTLE DURING SUMMER

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MANNUTHY, THRISSUR - 680 651

KERALA, INDIA

2009

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Thesis submitted in partial fulfillment of the

requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University, Thrissur

2007

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DECLARATION

I hereby declare that the thesis entitled **“MANAGEMENT PROTOCOL FOR AVERTING DROP OF MILK PRODUCTION IN DAIRY CATTLE DURING SUMMER”** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy NISANTH.P

CERTIFICATE

Certified that this thesis entitled " **MANAGEMENT PROTOCOL FOR AVERTING DROP OF MILK PRODUCTION IN DAIRY CATTLE DURING SUMMER"** is a record of research work done independently by **Dr. Nisanth.P** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Nisanth.P,** a candidate for the degree of Master of Veterinary Science in Livestock Production Management, agree that the thesis entitled "**MANAGEMENT PROTOCOL FOR AVERTING DROP OF MILK PRODUCTION IN DAIRY CATTLE DURING SUMMER"** may be submitted by Nisanth.P, in partial fulfilment of the requirement for the degree.

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ACKNOWLEDGEMENTS

I express my deep sense of gratitude to ***Dr. A. Kannan****, Associate Professor, AICRP on Pigs, Centre for Pig Production and Research, and Chairman of the Advisory Committee for the valuable guidance, scholarly advice and constant encouragement that helped me to do this work. I can never forget the wholehearted support rendered to me throughout the period of study.*

Dr. P.C. Saseendran*, Professor and Head, Department of Livestock Production Management, and member of the advisory committee, with his gentle aura and fatherly affection inarguably influenced my strategy of work. I recollect with immense gratitude the interest he bestowed upon my project, timely advice, enthusiasm and constructive review of my manuscript.*

I owe my gratitude to ***Dr. Joseph Mathew****, Professor, Department of Livestock Production Management, and member of the advisory committee, for the affectionate support and advice he has provided me throughout the course of the study.*

It is my privilege to get the effective supervision and trustworthy guidance of ***Dr. V. Prasad****, Professor and Head, University Livestock Farm, Mannuthy and Member of the Advisory Committee. I hereby express my sincere gratitude to him.*

Dr. Anil K.S*, Associate Professor, Department of Livestock Production Management, has always been a source of great help and encouragement. I am thankful to him for his keen interest in my work.*

I also acknowledge the help given to me by ***Dr.Sujatha****, Associate Professor, Department of Statistics in carrying out the statistical studies associated with the research work.*

I am grateful to ***Dr. E. Nanu****, Dean i/c, College of Veterinary and Animal Sciences, Mannuthy in providing the facilities to conduct the research.*

The assistance and support provided by ***Drs. Jyothish sankar and Jinesh kumar****, Teaching Assistants, University Livestock Farm, Mannuthy for conduct of the research work is acknowledged to its real worth. I am also thankful to farm supervisors* ***Kuttettan, Thulasi , Pushpan*** *and all the* ***staff & labourers*** *of the farm for their wholehearted help in conducting the feeding trial.*

I am extremely thankful for the lively association and brotherly affection showered by my seniors ***Hareesh Mash****,* ***Acty Sir and Sunilgi,*** *during the entire period of study.*

I am tempted to individually thank all of my friends ***Anto, Vikku****,* ***Jyothi****, ,* ***Pachi, Chettan, Thankachan, Suryan, Kallu, Thoma ,Pramod, Jesto , Arun and Mantaan*** *who have joined me in the discovery of what is life about and how to make the best of it.*

I owe a special word of thanks to my friends ***Drs. Roymon and Sandeep Jose Joseph*** *for their invaluable help and support for collecting research articles.*

Words fall short as I try to put forth the feeling of gratitude to my juniors ***Saifu , Anij ,Nanappan, Thattu, Dayamon ,Aravind, Aji,*** *with their constant support and help. I will always remember the comfort and warmth of their company.*

The men behind the curtains deserve special mention. I mean the help and co-operation extended by ***Mohanettan, Reghu, Mathai chettan*** *of Livestock production Department is gratefully acknowledged.*

I treasure the wholehearted support and encouragement provided by my colleague ***Dr. Muhammad Aslam*** *during the entire period of my study and research.*

I am extremely thankful to ***Dr. Jesto George and Dr. Pramod*** *they helped me much for preparing this thesis. It was a pleasure to work with them and the dedication shown by them really impressed me.*

I warmly remember and acknowledge ***Dr Sabin George, Famey mathew*** *and* ***Allen mon*** *for their company and love.*

The help rendered by my colleagues ***Dr. Sany Thomas*** *and* ***Dr. Ayub*** *need special mention here.*

I cannot forget the timely help, moral support, love and motherly affection shown by ***Saradhechi*** *of Livestock production Department.*

My deepest gratitude goes to my family for their unflagging love and support throughout my life. I am indebted to my ***father*** *for his care and love. He is* s*imply perfect. He provided the best possible environment for me to undergo higher studies and had never complained in spite of all the hardships in his life. I feel a deep sense of gratitude for my* ***mother*** *who formed part of my vision and taught me the good things that really matter in life*. *I have no suitable word that can fully describe her everlasting love to me.*

I remember the love and affection showered on me by my ***brother , Neha ,Sandhyechi, Makku, Santhoshettan, Mercy aunty, Kennedy uncle, Swapna and Nandu .*** *I am at loss for words to thank them for their prayers and support.*

Finally, I would like to thank my best friend ***Smitha*** *whom I have known for more than eight years for helping me get through the difficult times, and for all the emotional support, her endless love and encouragement throughout this entire journey. Her principle, to see the good in everything made me feel responsible to life. Without whom I would have struggled to find the inspiration and motivation needed to complete this thesis.*

I wish to thank everybody with whom I have shared experiences in life. Specially those who also played a significant role in my life , to those which with the gift of their company made my days more enjoyable and worth living.

Last but not least, thanks to God for my life through all tests in the past few years. You have made my life more bountiful. May your name be exalted, honored, and glorified.

Dedicated to My Family, Friends & Vava

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Introduction

INTRODUCTION

India has acquired the distinction of being the largest milk producer in the world with a total production of 101 million tons (Economic survey, 2007).The bovine population of our country comes to 233.1million; out of which 185.2 million are cattle and 97.9 million are buffaloes (17th Livestock census, 2003). The livestock sector contributes over 4 per cent to the total GDP and about a quarter of the GDP from agriculture and allied activities. The national commission on agriculture observed that next to agriculture, dairying is the most important subsidiary occupation.

Climate is one of the limiting factors in dairy production which causes reduction in performance and productivity of animal. The Climate in India comprises of a wide range of weather conditions across a vast geographic scale and varied topography. Most parts of India are subjected to a humid subtropical climate. There is a range of temperature that is conducive to health and performance of dairy cattle termed as thermo neutral zone. The zone of comfort for Indian cattle is 20^{o}C to 35^{o}C whereas exotic cattle perform best in a temperature zone of 13^{o}C to 18^{o}C. The maintenance of nearly constant body temperature in this range depends upon balancing heat production and heat loss.

The homeotherms can adjust body temperature by regulating metabolic heat production, over a range of thermoneutral temperature. However, if the effective temperature falls or rises beyond this zone, metabolic heat production cannot increase or decrease sufficiently to maintain homeothermy. This results in hyperthermia during summer. As the milk production increases, heat production rises with the metabolism of large amount of nutrients, which makes high producing cows more vulnerable to hyperthermia in a high ambient temperature and humidity than low producers.

Milk production of dairy animals is greatly influenced by ambient temperature above or below which the critical levels has a direct adverse effect on physiological processes and as a result milk production may decrease from 3 to 10 per cent in lactating animals (Collier *et al.,* 1982). During hot-dry and hot-humid seasons, high ambient temperature in conjunction with high humidity adversely affects the animal productivity (McDowell, 1972). During this period, high temperature restricts feed intake and the availability of inadequate nutrients for milk synthesis which causes a rapid mobilization of body reserves and high losses in body weight (Armstrong, 1994).

Physiological responses like rectal temperature, respiration rate and heart rate are markedly changed during heat stress (Flamenbaum *et al.,* 1986; Omar *et al.,* 1996; Prasanpanich *et al.,* 2002). These responses have been used as a measure of dairy cow comfort and adaptability to an adverse environment (Roman- Ponce *et al.,* 1977). In addition, the hormone profile of lactating animals also changes (Johnson, 1974). Plasma cortisol concentrations have been used as physiological marker of stress. During heat acclimatization, there is reduction of plasma cortisol that helps the animal in reducing the heat production (Yousef and Johnson, 1967).

In Kerala introduction of exotic germplasm was done with the implementation of cross breeding programme transforming more than 81.76 per cent of the cattle population into medium to high producing cross breds in a comparatively short span of 40 years. As a result the average yield per cow per day increased from less than a litre to 7.2 litres and milk production in the state climbed to 20.63 lakh tons in 2005-2006 (Economic survey, 2007). Continuous genetic progress for increasing milk production will cause greater effect of heat stress in crossbreds than indigenous cattle owing to their exotic inheritance.

The climatic condition in kerala is unique and distinct from the other region of India. The mean annual air temperature is uniform and records around 27^{o} C. During summer the temperature varies between 29^{o}C to 36^{o}C and daily maximum temperature may even shoot up to 40^{o}C.The mean relative humidity varies between 85 and 95 per cent and the lowest humidity is around 65 per cent. The average wind velocity is around 5-10 m/sec and thus the state of Kerala falls under per humid and humid climatic type.

It has been seen that an improvement in genetic make up can contribute to a limited extent in increasing milk production and the remaining is dependent on proper managemental practices. Several management practices have been suggested by researchers through out the world to alleviate the challenges associated with heat stress .Modifications in housing, management and nutrition invariably invite additional expenditure without eliminating the adverse effects of heat stress completely. An understanding of heat stress is necessary to develop an effective and economically viable system to manage cows during hot weather.

Feeding during the cooler hours of the day or at night is one of the practices that has been recommended by several researchers and nutritionists (Beede and Shearer, 1991, 1996; Dildey, 1996; Hutjens, 1998) and has been utilized by dairy producers (Beede and Shearer, 1996) to alleviate the detrimental effects of heat stress.

Hence the present study is undertaken to assess the effect of feeding during cooler hours over the conventional feeding management and to suggest a management protocol for summer stress alleviation.

Review of Literature

2. REVIEW OF LITERATURE

Dairy animals are homeotherms and therefore, when the environmental temperature rises or falls abnormally, the animals are subjected to stress. The optimum productivity of cattle and buffaloes were recorded at an air temperature of 13- 18^{o}C, relative humidity of 60 to 70 per cent, wind velocity of 5-8 kmph and a medium level of solar radiation (McDowell, 1972).Environmental heat stress factors resulted in sizeable economic loss to the producers of intensively managed livestock through the reduction of growth, production and reproduction.

The climatic variables such as temperature, humidity, air velocity and thermal reaction are involved in the heat balance, the production performance and health of animals. Under such conditions, by understanding the principles of the physiological and other reactions of domestic animals, the managemental practices can be altered in order to maintain economic feasibility.

Feeding during the cooler hours of the day or at night is one technique that has been recommended by several researchers and nutritionists (Beede and Shearer, 1991; Dildey, 1996; Hutjens, 1998) and has been utilized by dairy producers (Beede and Shearer, 1996) to alleviate the detrimental effects of heat stress. Hence dietary management is necessary to reduce the lowered feed intake and to maintain physiologic homeostasis. Shifting greater proportion of feed intake to night time would reduce the energy expenditure of cows during daytime, possibly their lower heat dissipitation and reduced heat load upon them. A review based on the available literature is presented below.

2.1 ENVIRONMENTAL VARIABLES

Thermal environment exert a profound influence on various physiological responses and ultimately on the productivity of animals. The principal climatic factors which resulted stress were air temperature, humidity and solar radiation. Wind was found to be a partial heat stress factor when environmental temperature exceeded body temperature.

2.1.1 Atmospheric Temperature

Shrode *et al*. (1960) studied the effect of air temperature, wind velocity, solar radiation and vapour pressure on physiological parameters in cattle and concluded that air temperature is the most important environmental variable with respect to variation in physiological responses.

Harris *et al.* (1960) reported that solar radiation was of considerable importance as a direct cause of increased body temperature and respiration rate of animal exposed to sun.

The ambient temperature of the air surrounding an animal's body was found to be extremely important for its comfort and normal physiological process. Normally, heat is released from warm skin of livestock to the cooler air around it by conduction, when the temperature rose above the comfort range (13-18°C), and heat loss diminished when the air temperature exceeded skin temperature, heat flowed in a reverse direction and the animals were subjected to heat stress (McDowell, 1972).

Chikamune *et al.* (1983) compared the physiological responses of swamp buffaloes and cattle to different climatic conditions. In both species there were positive and highly significant correlation between seasonal temperature and respiration rate, where as a negative correlation was reported between air temperature and pulse rate. They also showed that upon exposure to direct sunlight, buffaloes become more hyperthermic than cattle but recovered rapidly by shading, showering and wallowing.

The cows when exposed to temperatures of 20, 32 and 20°C for successive 7 days periods, the respiration rate were 46, 106 and 53 per min and rectal temperature were 38.7, 39 7 and 38.3°C respectively (Mohamed, 1984).

Dolejs *et al*. (2000) stated that at high ambient temperature the heat load in cattle will be greater than their ability to lose heat and the animals were subjected to heat stress.

West *et al.* (2003) found that changes in cow body temperature (measured as milk temperature) were most sensitive to same day climatic factors. The variable having the greatest influence on cow a.m. milk temperature was the current day minimum air temperature, while cow p.m. milk temperature was most influenced by the current day mean air temperature.

2.1.2 Relative Humidity

Bianca (1965) reported that when air temperature was below 24°C, humidity had no effect on heat stress as the direct heat output mechanisms were adequate at these temperatures and evaporation played only an insignificant part.

Above 24°C, the body functions of various cattle breeds were significantly affected by air humidity because evaporation is inhibited by the reduction in water vapour pressure gradients between skin, lungs and the air. This effect is purely a physical one. The relationship established for the rate of heat loss from the bovine respiratory tract indicated that at 29°C and 60 per cent relative humidity, a cow was able to loose 3.4 Wm2 of heat while at 90 per cent relative humidity, this was reduced by 25 per cent (Mc Dowell, 1972) .

Ghosal and Guha, (1974) stated that under hot humid conditions, the respiratory volume was more than double that of a hot dry environment and the evaporative heat loss was lower under hot humid conditions.

Starr (1981) had stated that heat balance could become a problem at 20°C and above when relative humidity exceeds 60 per cent.

Thiagarajan (1989) reported a mean relative humidity of 75.75 per cent in unshaded location of University Livestock Farm, Mannuthy, Kerala.

Ravagnolo et al. (2000) reported that maximum temperature and minimum relative humidity were the most critical variables to quantify heat stress, and both variables are easily combined into a temperature humidity index which can be can be used to estimate the effect of heat stress on production .

Kurihara and Shiova (2003) observed no significant differences in live-weight, body temperature and respiration rate between 28ºC-40 per cent and 28ºC-80 per cent relative humidity. However, the effect of 28ºC had more effect on the cows feed intake (on a dry matter basis), milk yield and milk composition, at a high humidity (80 per cent) than when humidity was low (40 per cent).

Beatty *et al.* (2006) conducted experiments on *Bos taurus* and *Bos indicus* cattle in climatic controlled rooms, for assessing physiological responses to prolonged, continuous heat and humidity and it was found that *Bos taurus* cattle experience significant physiological changes during exposure to prolonged and continuous high heat and humidity.

2.1.3 Air Movement

In assessing the suitability of an animal house, the effect of air flow on the animal's comfort found to be as important as temperature and humidity. The rate at which air moves over the skin of an animal affected the rate of heat loss from the body surface. In hot, humid environment, air movement was low (below 5 kmph) and evaporation is reduced (Mc Dowell, 1972).

A wind speed of 2.25 m per sec was quoted by Mc Dowell (1972) as ideal in hot dry day time environment and the restoration of heat balance is encouraged by wind speeds of the order 2.25 to 4.50 m per sec after sunset. In the real humid regions the congregation of animals reduced air circulation and restricted heat loss so that net effect of shade was minimum.

Ludri and Singh (1979) found that increased air movement by fans in a hot and humid climate, decreased the rectal temperature, respiration and pulse rates and increased the milk yield by 1.22 kg per cow per day.

An increase in air velocity increased heat loss when the body temperature was higher than the ambient temperature. In tropical zones, the advection of hot air over the animal has increased heat stress and in cold locations, air motion enhanced cold stress. In climatic zones between these two extremes air movement generally mitigated climatic stress (Starr, 1981).

Thiagarajan (1989) reported that under the hot, humid conditions the higher wind velocity in the open paddock favoured the cows considerably than the cows in the shelter. He also opined that under hot, humid conditions ventilation is most important and animals do not need much elaborate housing in order to utilise beneficial effects of free ventilation.

Kurihara and Shiova (2003) reported that at 10ºC, the effect of wind on the milk production of Holstein cows was not significant. However, at 27ºC the wind velocity of 2 m/s is found to be beneficial.

2.2 PHYSIOLOGICAL RESPONSES TO HEAT STRESS

Physiological parameters like respiration rate, heart rate, body temperature and skin temperature gives an immediate response to the climatic stress and consequently the level of comfort to the animal (Bianca, 1965). These responses have been used as a measure of dairy cow comfort and adaptability to an adverse environment or as sensitive physiological measure of environmental modification (Roman-Ponce *et al.,* 1977).

2.2.1 Rectal Temperature

Razdan *et al.* (1968) studied the effect of environmental variables on physiological responses of Tharparker cattle. Rectal temperature and respiration rate and were found to posses a high positive correlation with ambient temperature and the zone of thermoneutrality was found to be between 15^{o}C and 38 ^{o} C.

Panday and Roy (1969) reported significant correlation between rectal temperature and ambient temperature.

Oldrich *et al.* (1973) reported that rectal temperature for both Scottish Highlands and Zebu increased with an increase in ambient temperature. The Zebu however had the highest mean rectal temperature at lowest ambient temperature.

Amakiri and Funsho (1979) showed that domestic animals exhibit a diurnal rhythm of body temperature, which depends mainly on the climatic conditions. Mean morning (38.62^{o}C) and late afternoon (39.19^{o}C) rectal temperature for various cattle breeds differed significantly ($P< 0.01$).

Patel and Dave (1988) reported that rectal temperature and respiration rate during hot-humid season had significant positive correlations with maximum ambient temperature and temperature humidity index (THI).

In buffaloes, skin temperature increased as the intensity of solar radiation increased and skin temperature was found to be positively correlated ($P< 0.01$) with rectal temperature (Das *et al.,* 1997).

Brosh *et al.* (1998) stated that changing the time of feeding to late afternoon could be beneficial to the animals in reducing their heat loads as the increase in respiration and rectal temperature from morning to afternoon was greater when the feed was given in the morning rather than in the late afternoon.

Koubkova *et al.* (2002) reported a significant ($P< 0.05$) increase in rectal temperature (37.3 to 39.3°C), respiration rate (28 to 81 breath/min) and pulse rate (64 to 81 pulse/min) of high yielding dairy cows during exposure to high ambient temperature.

Srikandakumar and Johnson (2004) studied the effect of heat stress rectal temperature and respiratory rate in Holstein, Jersey and Australian Milking Zebu cows and found that heat stress increased ($P<0.01$) rectal temperature and respiratory rate in all three breeds.

Aharoni *et al.* (2005) studied the efficacy of feeding such cows at night, to reduce the heat load upon them in a hot climate. The rectal temperature and respiration rate were smaller for night time fed animals they did not differ significantly from day time fed cows.

2.2.2 Respiration Rate

Seath and Miller (1946) reported that increased respiratory frequency is the first reaction when animals are exposed to environmental temperature above thermoneutral zone.

Mullick and Kehar (1952) reported higher values of respiration rate, pulse rate and rectal temperature with rise in ambient temperature.

Respiration rate continues to rise linearly with increased environmental temperature until it reaches a certain temperature where the rate of increase in respiration rate slows down (Bianca, 1961).

Rao and Mullick (1965) studied that respiration rate, pulse rate and rectal temperature varied greatly with slightest variation in air temperature.

Sharma *and* Saikia (1974) showed a positive correlation of air temperature, rain fall and humidity with that of pulse rate, respiration rate and body temperature in crossbred cattle.

A significant increase in respiration rate, pulse rate and rectal temperature was observed in Haryana cattle with increase in ambient temperature and relative humidity. The morning values of physiological reactions were lower than the evening values during different seasons (Lal *et al.,* 1987).

Nauheimer-Thoneick *et al.* (1988) reported that when lactating cows were subjected to an ambient air temperature of 30°C, the respiratory rate increased by 130 per cent of the normal.

In addition to the ambient temperature, wind velocity also affects respiration rate, heart rate and rectal temperature negatively and significantly whereas black globe thermometer readings have significant influence on the respiration rate (Thiagarajan and Thomas, 1991).

Hagiwara *et al.* (2002) reported that the effective temperature at which respiration rate started to increase was lower (17°C) for high-producing cows (>35 kg milk/day) than that (22°C) of low producing cows.

Ominski *et al.* (2002), reported that time of feeding had no effect in vaginal temperature and respiration rate during heat exposure or during the recovery period.

Kurihara and Shiova (2003) stated that when the cattle were allowed out into a pasture at night, physiological parameters such as respiration rate and rectal temperature decreased immediately.

2.3 BODY WEIGHT

Tripathi *et al.* (1972) found that sprinkling of water and provision of shed during summer resulted in faster body weight gain in Murrah heifers as compared to control ones.

Morrison *et al.* (1973) reported that sprinkling of water over cattle kept under shades during summer in the Imperial Valley of California for 1 min. after every 30 min., when the temperature was above 27°C resulted in higher rate of body weight gain (2.40 lb vs. 3.06 lb) compared with cattle under shade and not sprinkled.

Mortinez *et al.* (1980) observed the first 10 months of lactation of Holstein Friesian cows as 17.45, 17.85, 16.80, 15.47, 14.30, 13.40, 12.32, 17.35, 10.25 and 8.47 kg, respectively and the body weight as 544.6, 488.4, 477.7, 487.1, 493.3, 506.2, 517.4, 525.9, 534.2 and 545.4 kg respectively.

Bhaskaran *et al.* (1981) observed a body weight gain from 294.83 + 11.19 at parturition to 307.42 ± 11.01 kg at 6th fortnight in one group of crossbred cows. In another group body weight loss from 317.92 ± 14.96 kg at parturition to 209.75 ± 12.73 kg at 6th fortnight was also observed. Patil and Deshpande (1981) also observed gaining in body weight in seven cows at the rate of 2.375 kg per week and loosing body weight in nine cows at the rate of 1.546 kg per week.

At Mannuthy, Alexander (1983) reported the post partum body weight of crossbred cows at 15,30, 45,60 and 75 days as 317.30 ± 15.16, 314.50± 15.55, 315.70 ± 15.42, 317.20 ± 15.50 and 322.75 + 38.02 kg respectively.

Thiagarajan (1989) observed a uniform body weight change in crossbred cows, during the course of lactation period at shaded and unshaded locations .

Body weight of cows kept in spray and fans (SF) was higher than the cows cooled evaporatively (EC), suggesting that feed intake for the SF cows may have been directed more towards weight gain than toward milk production (Ryan *et al.,* 1992).

Body weight at different ages and feed conversion efficiency had overall positive correlation with microclimate variables except THI whereas weight gain had overall negative correlation with microclimate variables except THI (Patel *et al.,* 1995).

2.4 HAEMATOLOGICAL PARAMETERS

2.4.1 Haemoglobin

The average normal value of haemoglobin was found to be 11 g per cent (range 8-15 g per cent) in cattle (Schalm *et al.,* 1975).

Talvelkar *et al.* (1980) found that haemoglobin value (10.79 ± 0.24 g per cent) was slightly higher in crossbred cows than those in Gir cows (10.58 ± 0.33 g per cent).

Bahga *et al.* (1980) reported that haemoglobin value was higher in lactating buffaloes which were not cooled by showers or wallowing and exposed to normal environment. Radadia *et al.* (1980) reported that mean haemoglobin value of lactating murrah buffaloes under shower, cooled drinking water, cooled drinking water + shower and no treatment, were 10.25, 12.28, 12.58 and 10.48 g per cent, respectively.

According to Bioucek *et al.* (1990) exposing dairy cows to high temperature during day time had no effect in haemoglobin per cent.

Gupta *et al.* (1996) reported that haemoglobin concentration of cows in mid-pregnancy, late-pregnancy, after parturition and milking were 12.46 + 0.45, 10.31 ± 0.40, 10.34 ± 0.58 and 9.97 ± 0.53 g per cent, respectively.

Das *et al.* (1997) reported that mean haemoglobin value of crossbred cattle in the New Alluvial and Red Laterite zones of west Bengal were 10.790 ± 0.246 and 12.406 ± 0.291 g per cent.

Srikandakumar and Johnson (2004) examined the effect of heat stress on milk production, rectal temperature, respiratory rate and blood chemistry in Holstein, Jersey and Australian Milking Zebu cows and found that the total haemoglobin was elevated ($P < 0.01$) in all three breeds when they were subjected to heat stress.

2.4.2 Packed Cell Volume (PCV)

The average normal haematocrit percentage for cattle was reported to be 35 (range 24 to 48per cent) (Schalm *et al.,* 1975).

Most investigators reported that haematocrit percentage decreased in the heat stressed animals (Bond *et al.,* 1991) due to red cell destruction and/or to haemodilution and to reduction in cellular oxygen requirements to minimize the metabolic heat load (Lee, 1965) .

Talvelkar *et al.* (1980) reported that haematocrit percentage (37.61 ± 1) was non significantly higher in crossbred cows than those in Gir cows (36.59 ± 1.66).

Haematocrit value was higher in buffaloes which were not cooled by showers or wallowing and exposed to normal environment (Bahga *et al.,* 1980).

Radadia *et al.* (1980) reported that haematocrit per cent of lactating murrah buffaloes under shower, cooled drinking water, cooled drinking water + shower and no treatment, were 34.6, 33.05, 35.55 and 33.8, respectively.

Mohamed (1984) stated that haematocrit value did not differ, when pregnant cows were exposed to successive 7 day periods at 20, 32 and 20°C.

Bioucek *et al.* (1990) reported that exposing dairy cows to high temperature during day time had no effect in haematocrit per cent.

Gupta et *al.* (1996) reported that haematocrit percentage of cows in mid-pregnancy, late pregnancy, after parturition and lactation were 31.7 ± 0.60, 29.8 + 0.59, 32.1 ± 0.98 and 30.7 ± 0.71, respectively.

2.4.3 Erythrocyte Sedimentation Rate (ESR)

Normal erythrocyte sedimentation rate in cattle was reported to be zero mm per hr (Sharma and Jhanwar, 1973; Schalm *et al.,* 1975; Talvelkar *et al.,* 1980; Benjamin, 1985). It was 1-8 mm per 24 hr (Ferguson, 1970) , 3 mm per 24 hr (Bunce, 1974).

Benjamin (1985) reported that the suitable time interval to read erythrocyte sedimentation rate (ESR) value in cattle was 8 or 24 hr.

Xavier (1981) observed that the climatic variable showed a non significant influence on ESR in buffaloes. Ambient temperature showed a non significant influence on ESR of both sheep and goats in Mannuthy (Gowri, 1998).

Sreekumar (1988) reported that exercise and environmental stress increased the erythrocyte sedimentation rate in cattle. The speed of setting is inversely related to the number of red cells (Schalm *et al.,* 1975).

2.5 CORTISOL LEVELS DURING HEAT STRESS

Plasma cortisol concentrations have been used as a physiological marker of stress. During heat acclimation there is reduction of plasma cortisol that help in reducing the heat production of animals (Yousef and Johnson, 1967). An initial increase in cortisol occurs due to acute heat stress followed by a decline after prolonged exposure in cows (Alvarez and Johnson, 1973). Therefore, the animals adjust physiologically to elevated heat loads by decreasing adrenal corticoid output.

Christison and Johnson (1972) observed that moderate heat stress (35°C) increased plasma cortisol levels from 30 to 37 µg/litre, the levels continued to rise for 2 hours after onset of heat: exposure and plateaued around 43 µg/litre 2-4 hour after exposure. After 7-10 weeks of mild heat stress, plasma cortisol levels decreased to 25 µg/litre. Abilay *et al.* (1975) reported that in Guernsey heifers cortisol increased significantly to 9.1 ng/ml at 37.5°C from 5.5 ng/ml at 18.2°C (55per cent RH).

Lee *et al.* (1976) studied the effect of temperature-season on cortical function in bovines and it was reported that under cool, intermediate and hot conditions the corticoid levels were 42.3, 36.3 and 22,8 ng/ml respectively. Reported that the lower levels of plasma corticoids in the hot temperate season suggests that animals were able to adjust physiologically to elevated heat loads by decreasing adrenal corticoid output.

. Wise *et al.* (1988) found that cortisol decreased to 3.0 ng/ml from 6.2 ng/ml in heat stressed Holstein cows (control, 41.7°C, protected, 26.0°C). According to them higher concentration's of this catabolic hormone may have been produced by heat stressed cows to maintain milk production. Glucocorticoids affect protein and lipid metabolism. In liver they have got anabolic action but in skeleton muscles and adipose tissue they have got catabolic activity. Further, they organize the function of the sympathoadrenal system, which helps in managing stress conditions (Hadley, 1988).

Kumar *et al.* (1993) found low plasma cortisol levels during early lactation phase, 0.98 ± 0.15 ng/ml as compared to mid and late lactation values of 1.16 ± 0.13 and 1.56 ± 0.19 ng/ml, respectively.

Cortisol secretion is regulated by hormonal interactions among the hypothalamus, the pituitary and the adrenal gland. Neural stimuli originate from brain in response to stress. Physical stress can include exercise, cold exposure, burns etc. (Orth *et al.,* 1992).

2.6 PLASMA GLUCOSE LEVELS DURING SUMMER SEASON

Blood glucose as the precursor of lactose, is the most important substrate required to maintain milk production since ruminants depend on gluconeogenesis for their glucose requirements. Moreover, energy balance of the animal is also responsible for the changes in the levels (Blum *et al.,* 1973).

Vasilatos and Wangsness (1981) reported higher plasma glucose levels at 90 days postpartum than at 30 days postpartum. In view of this, plasma concentration of glucose may not reflect actual utilization or availability and these measurements alone do not preclude changes in glucose metabolism. Jindal (1988) reported overall average concentration of blood glucose in cows as 49.83 mg/100ml respectively.

Flamenbaum *et al.* (1995) studied in Holstein cows the effect of cooling by sprinklers and ventilators during summer (June to Oct.) and reported that glucose levels in cooled and uncooled cows were 3.17 and 3.29 mmol/L.

Jindal (1988) reported overall average concentration of blood glucose in buffaloes as 47.47 mg/100ml respectively. Yash Pal (1996) reported that glucose levels were more in buffaloes than in cows during early lactation due to differences in milk production. The glucose levels in cows and buffaloes ranged between 37.40 to 42.20 mg/100ml and between 39.88 to 44.30 mg/100ml, respectively.

Srikandakumar and Johnson (2004) studied the effect of heat stress on changes in milk production, rectal temperature, respiratory rate and blood chemistry in three groups of six mature Holstein, Jersey and Australian Milking Zebu (AMZ) dairy cows and reported that the plasma glucose increased ($P< 0.01$) with heat stress in Holstein and AMZ cows but decreased ($P < 0.01$) in Jersey cows.

Abenil *et al.* (2007) studied the metabolic conditions of lactating Friesian cows during the hot season and reported that the decrease in plasma glucose during the hotter period was evident.

2.7 MILK PRODUCTION

Optimum milk production usually is obtained within the comfort zone. Even moderate increases in temperature above comfort zone result in measurable decline in milk production. Temperature below comfort zone also has adverse effects on milk production. Reduction in feed intake is largely responsible for the decreased milk production in heat exposed lactating animals.

Christensen *et al.* (1975) found that milk yield of Friesian cows started falling when ambient temperature and relative humidity exceeded to 21°C and 60 per cent respectively.

Zook *et al.* (1975) reported no effect of summer modification in a free stall shelter in dairy cattle on milk yield, fat and protein content.

Hassan *et al.* (1979) reported that average daily milk yield of crossbred cows were 7.8, 7.6, 5.6 and 5.1 kg during winter, spring, summer and autumn, respectively.

Rodriguez *et al.* (1985) reported that relative humidity and air temperature were associated with 1.6 to 5.6 per cent of variability in milk production. Nauheimer-Thoneick *et al.* (1988) found that switching over of lactating cows from an environment of 15°C and 70 per cent RH to 30°C and 50 per cent RH conditions reduced milk yield by 30.6 per cent in early lactation and 25.9 per cent in late lactation.

Ludri and Singh (1987) reported that milk production of Karan Fries cows can be sustained by providing ad libitum green fodder and water during extreme summer and the composition of milk also remained unaffected.

High yielding cows are more vulnerable to heat stress (Silanikove *et al.,* 1997) and the effect of heat stress is more during early lactation (McDowell *et al.,* 1975; Sharma *et al.,* 1988; Barash *et al.,* 2001). This would be expected because cows during the first trimester of lactation fie either in a negative or near negative energy balance, and decreases in energy intake due to low feed intake would reduce milk production. Cooling can alleviate heat stress and can improve thermal balance and productive performance in dairy cows.

Ravagnolo *et al.* (2000) reported that the average test-day yield for milk was about 26.3 kg for a temperature-humidity index <72 and decreased at about 0.2 kg per unit increase in the temperature-humidity index ≥72. The authors concluded that THI can be used to estimate the effect of heat stress on production.

Umphrey *et al.* (2001) studied the interrelationships between rectal temperature and milk yield during summer in lactating Holsteins of Alabama and reported that the partial negative correlation between milk yield and rectal temperature for cows.

Ominski *et al.* (2002) observed decrease in milk yield (not significant) for evening-fed cows than for morning-fed cows, which were transferred from thermoneutral to heat-stress conditions. However, the decline in milk yield with time was lower for the night time fed cows, and after several months in the trial, they produced more milk than the day time fed cows and concluded that there was some long-term effect on performance of evening fed cows.

Kurihara and Shiova (2003) reported that the milk production of cows which consumed more than 20 kg of feed per day (dry matter basis) decreased with a rise in effective temperature and no significant differences with a higher effective temperature in the milk production of cows which consumed less than 20 kg of feed (dry matter) per day.

West (2003) observed that when lactating cows were exposed to moderate and hot humid weather, milk yield declined linearly with respective increases in air temperature or THI during the hot period and milk temperature increased linearly with increasing air temperature.

Aharoni *et al.* (2005) examined the efficacy of feeding cows at night, by avoiding their access to feed for 5 1/2 h during the hot hours of the day, so as to reduce the heat load upon them in a hot climate. Cows on night time feeding had similar milk yield to that of day time fed cows as their efficiency of energy utilization for milk production was higher. The decline of milk yield with time was greater in the day time fed than other and concluded that night time fed cows had better milk yield persistence over time.

Abenil *et al.* (2007) studied the production performance in lactating Friesian cows and found that milk yield declined during the hotter period with a higher reduction in milk yield for cows in the mid-stage of lactation.

2.8 MILK COMPOSITION

Sud and Singh (1974) reported that values of fat, protein and lactose varied from 6.5 to 10.5, 3.3 to 4.24 and 4.6 to 5.6 percent.

Eley *et al.* (1978) did not find any difference in milk fat content between cows kept at 38.78 or 30.05°C ambient temperature. Similarly, Nauheimer-Thoneick *et al.* (1988) also did not observe any statistically significant difference in fat percentage of German Holstein Friesian cows subjected to 30°C constant temperature in the climatic chamber even though their milk yield declined by 26 to 30 per cent.

On the other hand Fuquay *et al.* (1980) found that milk fat percentage of cows subjected to 22 to 31°C air temperature was significantly lower than the cows subjected to 17 to 20°C.

Radadia *et al.* (1980) found that during summer, solids not fat (SNF) yield of buffaloes when cooled by showering, providing cooled drinking water and showering with cooled drinking water was 9.61, 9.57 and 9.81 per cent respectively whereas it was only 9.40 per cent in control. The difference was statistically significant.

Average milk fat percentage of Brown Swiss x Ongole, HF x Ongole were 4.19 and 3.66 (Babu Rao and Jayaramakrishna, 1983). Naikare *et al.* (1992) reported that milk fat percentage of Friesian x Gir, Jersey x Gir, Friesian x JG, Jersey x FG and Brown Swiss x FG cows were 3.93, 4.36, 3.94, 5.99 and 3.94, respectively. The milk fat per percentages in the fortnights of 3, 6, 9, 12 and 15 were 3.28, 3.73, 3.99, 4.35 and 4.60 in morning samples, and 3.81, 4.30, 4.64, 4.93 and 5.23 in evening samples for crossbred cows of Kerala (Iype *et al.*,1994) .

Ravagnolo *et al.* (2000) observed that for milk fat and protein, the test yield was 0.92 and 0.85 kg at a temperature-humidity index <72, respectively, and declined at a rate of 0.012 and 0.009 kg per unit increase in the temperature-humidity index ≥72.

Aharoni *et al.* (1999, 2002) and Barash *et al.* (2001) were able to detect heat-load depression effects on milk fat and protein concentrations by analyzing large-scale databases obtained from test days of many cows in many herds over a period of several years. Such effects are expected to be much more obvious when comparing from summer and winter conditions than when comparing feeding schedules under the same environmental conditions.

Ominski *et al.* (2002) observed milk composition for evening-fed cows than for morning-fed cows that were transferred from thermoneutral to heat-stress conditions. No significant differences in milk fat and protein concentrations were observed from morning fed and evening fed cows.

Aharoni *et al.* (2005) examined the efficacy of feeding cows at night, to reduce the heat load upon them in a hot climate. No significant differences in milk composition were observed between night and day times fed animals. Higher numerical fat and protein concentrations were observed in the milk of the night time cows than in that of the day time fed.

2.9 FEED INTAKE CHANGES DURING SUMMER

Environmental temperature has direct effect on animal energy expenditure and voluntary feed intake. Animals maintain body warmth by regular feed intake, but under thermal stress reduces feed intake to prevent hyperthermia. Heat stress is well known to depress feed intake in dairy cows. High temperature restricts feed intake causing a rapid utilization of body reserves and high losses in body weight. During heat stress reduced feed intake is related to the heat increment associated with feed intake. There is direct effect of heat stress on hypothalamic feed intake centers, increased gut fill due to reduced rate of passage and increased water intake, and the increase in respiration rate (McDowell *et al.,* 1976).

Thomas *et al.* (1969) in crossbred cattle found that dry matter intake was significantly less in summer by 0.59 kg DM per day per 100 kg body weight compared to winter.

Mohamad, (1984) reported the daily dry matter intake of cows as 10.5, 6.6 and 9.8 kg, when they were exposed to successive 7 days periods at 20, 32 and 20°C ambient temperature. Nauheimer-Thoneick *et al.* (1988) reported that in lactating cows, at 30°C ambient temperature, the DM intake was reduced by 30.7 per cent in early lactation and 24.6 per cent in late lactation compared to 15°C.

At high ambient temperature (40°C) the feed intake is reduced by 20-40 per cent compared to cows kept in thermoneutral environment (Armstrong ,1994).

Sharma and Singh (2001) found that feed intake was significantly higher in cows managed in loose housing system than closed housing or loose housing with shed.

Ominski *et al.* (2002) tested the response of morning- and evening-fed cows to short-term heat stress and found significant decrease in dry matter intake for evening-fed cows than for morning-fed cows.

Dry matter intake declined linearly with respective increases in air temperature or THI during the hot period when lactating cows were exposed to moderate and hot, humid weather (West *et al.,* 2003).

Aharoni *et al.* (2005) examined the efficacy of feeding such cows at night, which avoiding their access to feed for 5 1/2 h during the hot hours of the day, to reduce the heat load upon them in a hot climate found that cows on night time feeding had significantly lower feed intake when compared to that of day time fed cows.

Materials and Methods

3. MATERIALS AND METHODS

3.1 LOCATION AND CLIMATIC CONDITIONS

The study was conducted at the University Livestock farm and fodder research and Development scheme (ULF and FRDS), Kerala Agricultural University, Mannuthy, Thrissur which is situated 22.25m above the mean sea level, at 10'32" North latitude at 76'16" East longitude.

The experiment was conducted from February to May 2008, covering the hottest part of the summer. During the period of experimentation the average daily temperature varied between a minimum of 24^{o}C to a maximum of 33^{o}C. The relative humidity varied between 52 to 83 per cent.

3.2 EXPERIMENTAL ANIMALS

The experiment was carried out on twelve crossbred cows on mid lactation selected from the herd maintained at ULF and FRDS, Mannuthy. The animals were divided into two groups of six each, uniformly with regard to age, milk yield and parity and were randomly allotted to two treatments T1 and T2.

3.3 TREATMENTS

All the animals were tied–up in the shed for the entire experimental period, where individual feeding, watering and care were taken. The treatment period was four months from February to May. During this period all the management practices were kept similar in both the treatment groups, except the watering and feeding management.

3.3.1 Treatment-1 (T1)

The T1 animals were maintained on routine management protocol followed in the ULF and FRDS based on the recommendations of package of practices (Anon., 2001)

3.3.2 Treatment-2 (T2)

The T2 animals were maintained on concentrate mixture, green grass as roughage and water availability at all times. The 1/3rd of the concentrate and roughage was fed during the day time and rest in evening and early morning.

3.4 MANAGEMENT OF EXPERIMENTAL ANIMALS

3.4.1 Housing

All the experimental cows were housed with facilities for individual feeding and watering. Stall feeding was practiced throughout the experimental period. The animals were washed daily in the morning before 9 A.M. Stall was cleaned twice daily before morning and afternoon milking with frequent removal of dung.

3.4.2 Feeding

The experimental animals of the two treatments T1 and T2 were maintained on their respective feeding regime. ICAR (1985) and revised fortnightly based on the individual body weight and milk yield. The remaining concentrate and roughage left behind by each animal was collected and weighed separately every day to calculate the actual dry matter intake.

3.5 PARAMETERS OBSERVED

3.5.1 Environmental Variables

The macroclimatic data for maximum, minimum, dry and wet bulb temperature, relative humidity and wind speed were obtained from the observatory unit of Department of meteorology, College of Horticulture, Kerala Agricultural University located at about 3 km from ULF and FRDS. In addition microclimatic data of the experimental shed was recorded daily, throughout the experimental period.

3.5.1.1. Maximum and Minimum Temperature

Daily maximum and minimum temperature were recorded inside the shed using maximum and minimum thermometer to quantify the microenvironment prevalent around the animals in both the treatment groups.

3.5.1.2 Dry and Wet Bulb Temperature

Dry bulb temperature was recorded using dry bulb thermometer and wet bulb temperature using a wet bulb thermometer, with its bulb covered with a clean absorbent muslin wick. The wick was thoroughly wetted with clean distilled water. Dry bulb and wet bulb temperatures were recorded at 7.30 am and 2.00 pm daily.

3.5.1.3 Relative Humidity

Relative humidity was evaluated from dry bulb and wet bulb temperatures by using hygrometric table.

3.5.2 Physiological Parameters

Physiological parameters like respiration rate and rectal temperature were measured and recorded twice daily, at 7.30 A.M and at 2.30 P.M on two consecutive days in a week.

3.5.2.1 Rectal Temperature

The physiological parameter, rectal temperature (Radostits *et al.,* 2000) was taken at last of to avoid possible changes in the RR due to disturbance to animal. It was recorded by inserting digital clinical thermometer in rectum till a beeping sound indicating constant value was reached.

3.5.2.2 Respiration Rate

Respiration rate (Radostits *et al.,* 2000) was recorded first among physiological parameters. Reading was made from sufficient distance without disturbing animal by counting flank movements for two consecutive minutes and then averaged (breaths/minute). Stop watch was used for the measurement of time.

3.5.3 Milk Yield

The milk yield of animals was recorded individually at the morning and afternoon and total yield was calculated by weighing the quantity in kg at each milking.

3.5.4 Milk Composition

Milk samples were collected at fortnight intervals for quality analysis, from each animal at milking. The individual samples were analysed for total solids, solids not fat and fat as per standard procedures (Davis, 1999).

3.5.5 Body Weight

Body weight was recorded on a weigh bridge balance (Sastry and Thomas, 2005) having last count of 5kg and of 1000kg. The body weight of the animal was recorded on the basis of two consecutive observations to avoid variations. Body weight was recorded at the start of the experiment and at regular fortnight intervals till the end of the experiment. Animals were weighed on the morning after milking.

3.5.6 Daily Feed Intake

The intake of roughages was assessed by providing weighed quantities of grass to individual cows and weighing the leftovers. The dry matter percent of the roughages was calculated. The concentrate feed consumption was calculated by individual weighing the feed given daily. The dry matter percent of concentrate was estimated fortnightly. (AOAC, 1990).

3.5.7 Hematological Parameters

Blood samples from the experimental animals were collected individually in the morning before feeding from the jugular vein at fortnight intervals. Haemoglobin erythrocyte sedimentation rate and packed cell volume (Reece, 2005) blood glucose (Kaneko and Harvey, 1997) were estimated as per standard procedures. The serum samples obtained from individual cows were stored in deep freezer (-18^{o}C) for hormonal assay.

3.5.8 Estimation of Cortisol

3.5.8.1 The Ubi Magiwel Cortisol Quantitative Sh-101 Kit

The Ubi Magiwel Cortisol Quantitative Sh-101 was used to measure the serum cortisol levels of the animals. It is a solid phase enzyme linked immunosorbent assay (ELISA) which provides quantitative measurement of Cortisol in the serum.

3.6 STATISTICAL ANALYSIS

The data collected on various parameters during the course of the experiment were analysed statistically as per Snedecor and Cochran (1994).

Results

4. RESULTS

The results obtained from the present study are given under the following headings.

4.1 ENVIRONMENTAL VARIABLES

4.1.1 Macroclimatic Changes

Mean of the macroclimatic variables such as maximum and minimum temperatures, mean temperature, relative humidity at morning, relative humidity at afternoon, mean relative humidity, wind speed, rainfall, rainy days and sunshine hours during the experimental period have been presented in Table 1.

During the experimental period, the mean maximum temperature ranged from 33.0 to 33.6°C and the minimum temperature from 22.9 to 24.9°C. The per cent relative humidity in the morning varied from 78.4 to 89.1, while in the afternoon it ranged from 40.9 to 59.8. In general, the variation in the climatic profile was small during the experimental period.

4.1.2 Microclimatic changes

Mean of the microclimatic variables such as maximum and minimum temperatures, mean temperature, relative humidity at morning, relative humidity at afternoon and mean relative humidity during the experimental period have been presented in Table 2.

Table 1. Mean environmental variables during the period of experiment

Sl. No.	Environmental variables	February	March	April	May	Mean
1	Maximum temperature (ºC)	33.63	33.19	33.20	33.00	33.26
2	Minimum temperature (ºC)	22.92	23.41	24.95	24.69	23.99
3	Mean temperature (ºC)	28.27	28.30	29.08	28.85	28.63
4	Relative humidity morning (%)	80.36	78.42	89.10	87.35	83.81
5	Relative humidity afternoon (%)	40.90	49.00	59.87	58.16	51.98
6	Mean relative humidity (%)	60.60	63.70	74.48	72.76	67.89
7	Wind speed (Kmph)	4.45	4.89	3.19	3.55	4.02
8	Rainfall (mm)	29.7	205.3	11.5	65.6	78.03
9	Rainy days	3	7	8	8	6.5
10	Sunshine hours per day	7.1	6.9	6.3	6.5	6.7

Table 2. Mean microclimatic variables during the period of experiment

Sl. No.	Environmental variables	February	March	April	May	Mean
1	Maximum temperature (ºC)	33.13	32.89	32.60	32.00	32.65
2	Minimum temperature (ºC)	22.21	23.41	25.16	25.31	24.02
3	Mean temperature (ºC)	27.67	28.15	28.88	28.65	28.33
4	Relative humidity morning (%)	83.64	82.09	88.15	86.78	85.16
5	Relative humidity afternoon (%)	52.63	53.12	58.94	57.61	55.57
6	Mean relative humidity (%)	68.13	67.60	73.54	72.19	70.36

During the experimental period, the mean maximum temperature ranged from 32.0 to 33.1°C and the minimum temperature from 22.2 to 25.3°C. The-per cent relative humidity in the morning varied from 82.09 to 88.1, while in the afternoon it ranged from 52.63 to 58.9.

4.2 PHYSIOLOGICAL RESPONSES

4.2.1 Rectal Temperature

The mean value of rectal temperature of the experimental animals in the two treatment groups recorded during the experimental period are listed in Table 3 and graphically represented in Fig.1. The average rectal temperature during morning was 101.40 ± 0.02 and 101.45 ± 0.02°F respectively for the two treatments groups T1 and T2 which increased to 102.07 ± 0.03 and 102.09 ±.0.04°F respectively in the afternoon.

4.2.2 Respiration rate

The mean respiration rates of the cows recorded at the mornings were 28.92 and 29.22 per min respectively for the cows in T1 and T2. The corresponding values at the afternoon were 49.23 ± 0.31 and 47.13 ± 0.44 per min.The data on the mean respiration rate are summarized in Table 4 and depicted graphically in Fig. 2.

4.3 BODY WEIGHT

The mean value of fortnightly recorded body weight of the experimental animals in the two treatment groups recorded during the experimental period are

Table 3. Fortnightly mean rectal temperatures recorded during the period of experiment

Fortnight	T1		T2	
	Morning	Evening	Morning	Evening
1	101.18	102.47	101.33	102.31
2	101.27	102.12	101.34	102.29
3	101.23	102.25	101.58	102.22
4	101.40	101.99	101.51	102.67
5	101.33	102.05	101.45	102.68
6	101.38	102.46	101.46	101.99
7	101.46	101.99	101.46	102.48
8	101.46	102.13	101.54	102.06
Mean	101.34	102.18	101.46	102.34

Table 4. Fortnightly mean respiratory rates recorded during the period of experiment

Fortnight	T1		T2	
	Morning	Afternoon	Morning	Afternoon
1	27.92	56.38	29.48	58.48
2	28.43	60.38	29.85	58.15
3	29.43	60.58	29.20	58.10
4	29.37	57.97	28.77	55.87
5	29.48	57.35	28.37	56.60
6	28.52	54.20	28.85	56.35
7	28.87	58.23	29.68	56.98
8	29.42	57.85	29.62	55.22
Mean	28.93	57.87	29.23	56.97

Table 5. Fortnightly average body weight of experimental animals (Kg)

Fortnight	Body weight (Kg)	
	T1	T2
0	348.83 ± 17.11	353.66±12.20
1	354.00 ± 16.74	355.33 ± 10.30
2	357.16 ± 13.91	359.33 ± 11.35
3	356.00 ± 15.18	361.50 ± 10.84
4	361.16 ± 14.67	359.50 ± 11.25
5	360.16 ± 14.39	367.33 ± 13.18
6	363.66 ± 13.81	365.33 ± 12.89
7	362.33 ± 15.98	367.33 ± 11.91
Average±SE	357.91 ± 14.21	361.16 ± 11.05

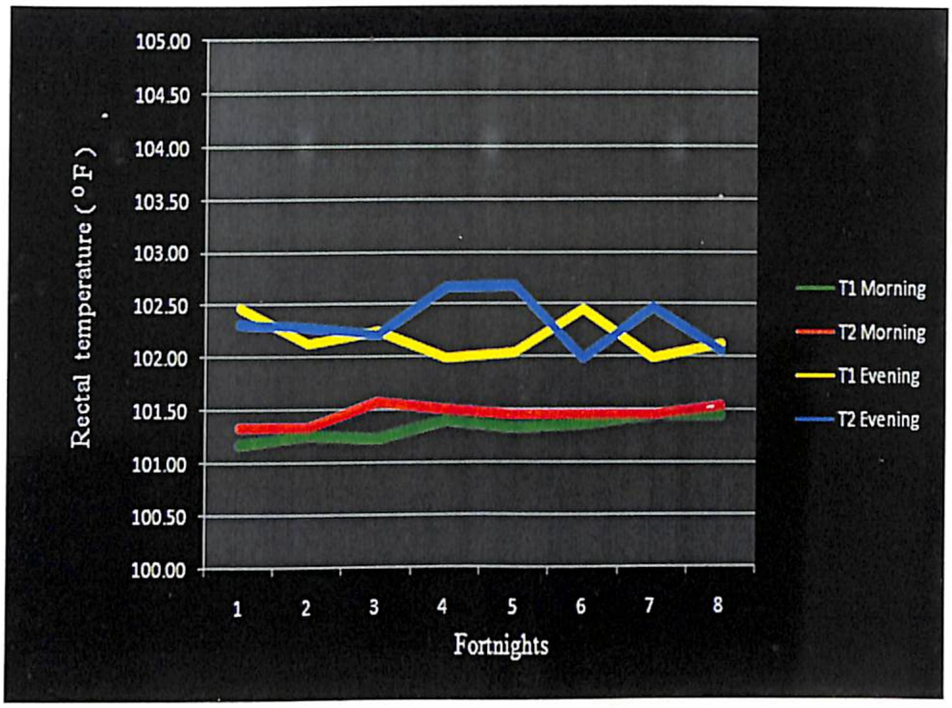

Fig.1. Average fortnightly rectal temperature of cows maintained on two dietary treatments

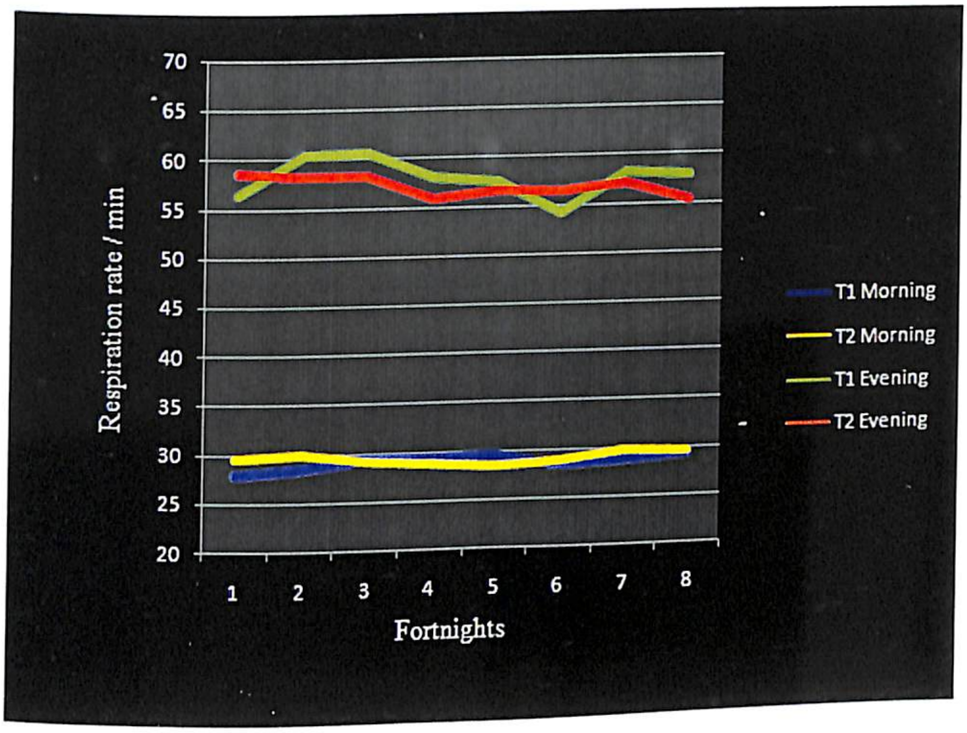

Fig.2. Average fortnightly respiration rate of cows maintained on two dietary treatments

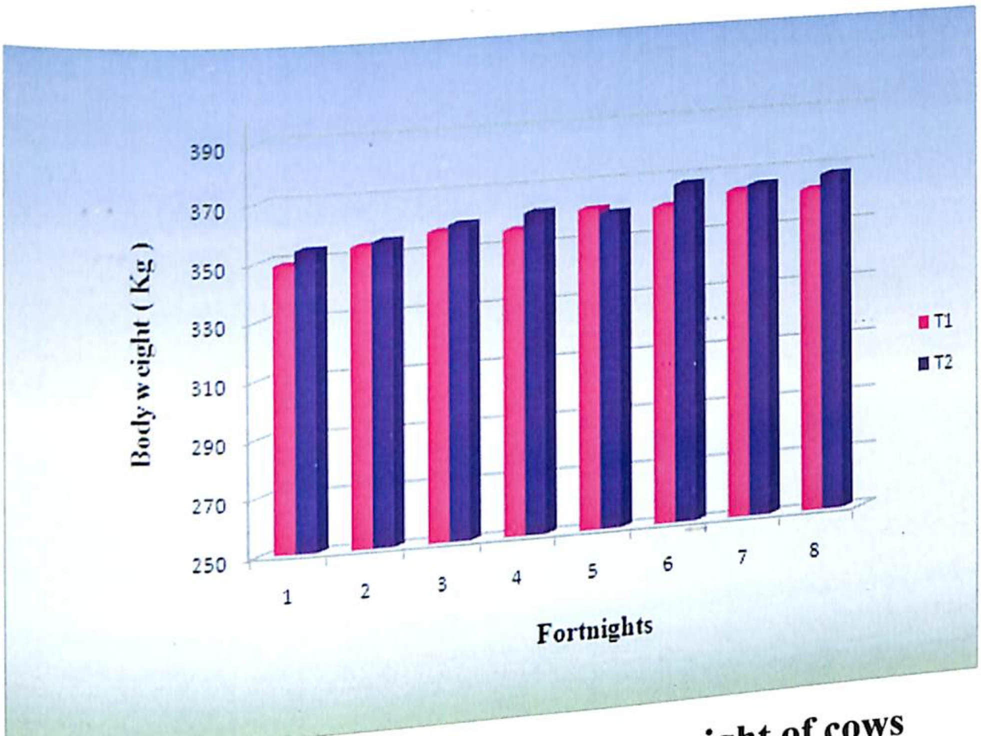

Fig.3. Average fortnightly body weight of cows maintained on two dietary treatments

listed in Table 5 and graphically represented in Fig. 3. The initial body weight of the animals in the two groups was 348.83 ± 17.11 and 353.66 ± 12.20 kg while the final weight was 362.33 ± 15.98 and 367.33 ± 11.91 kg respectively for T1 and T2.

4.4 HAEMATOLOGICAL PARAMETERS

4.4.1 Haemoglobin

The mean haemoglobin values of the cows in the T1 and T2 were 11.76 and 12.18 g per cent respectively .The initial haemoglobin content of the animals in the two groups were 11.14 ± 0.65 and 11.62 ± 0.39 g per cent while the final values were 11.99 ± 0.43 and 12.39 ± 0.41 g per cent respectively for T1 and T2. The mean value of the haemoglobin content of experimental animals in the two treatment groups are summarized in Table 6 and graphically represented in Fig.4.

4.4.2 Packed cell volume (PCV)

The fortnightly average of PCV of the experimental animals are given in Table 7 and represented in Fig.5. The mean PCV values of the cows in the T1 and T2 were 30.29 ± 0.42 and 29.86 ± 0.33 per cent respectively. The initial PCV values were 29.11 ± 0.88 and 29.62 ± 0.94 per cent while the final values were 3.43 ± 1.63 and 29.55 ± 0.73 per cent respectively for T1 and T2.

4.4.3 Erythrocyte Sedimentation Rate (ESR)

The overall average erythrocyte sedimentation rate of the cows in T1 and T2 were 3.12 ± 0.08 and 2.90 ± 0.06 mm per 24 hours respectively. The initial erythrocyte sedimentation rate of the animals in the two groups were 3.19 ± 0.27 and

Table 6. Fortnightly average of Haemoglobin (Hb) of experimental animals

Fortnight	Hb (%)	
	T1	T2
1	11.14 ± 0.65	11.62 ± 0.39
2	11.16± 0.46	12.83± 0.45
3	12.07 ± 0.50	12.54 ± 0.29
4	12.15 ± 0.51	11.76 ± 0.45
5	11.58 ± 0.60	12.57 ± 0.39
6	11.83 ± 0..39	12.56 ± 0.22
7	12.20 ± 0.45	11.63 ± 0.42
8	11.99 ± 0.43	12.39 ± 0.41
Average±SE	11.76 ± 0.17	12.18 ± 0.14

Table 7. Fortnightly average of Packed cell volume (PCV) of experimental animals

Fortnight	PCV (%)	
	T1	**T2**
1	29.11 ± 0.88	29.62 ± 0.94
2	30.25± 1.14	28.80 ± 0.84
3	31.71± 0.72	29.97 ± 0.77
4	29.81 ± 0.95	30.22 ± 1.53
5	30.53 ± 1.11	29.32 ± 1.07
6	30.76± 1.98	30.99 ± .49
7	29.76 ± 1.20	30.38 ± 1.15
8	30.43 ± 1.63	29.55 ± 0.73
Average±SE	30.29 ± 0.42	29.86 ± 0.33

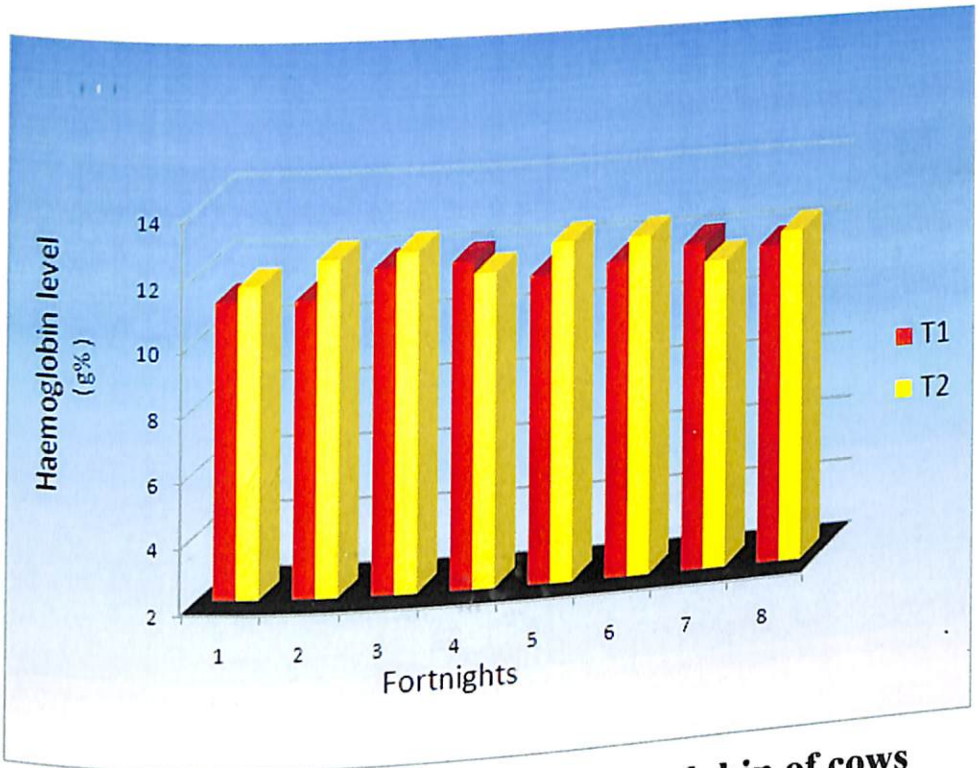

Fig.4. Average fortnightly haemoglobin of cows maintained on two dietary treatments

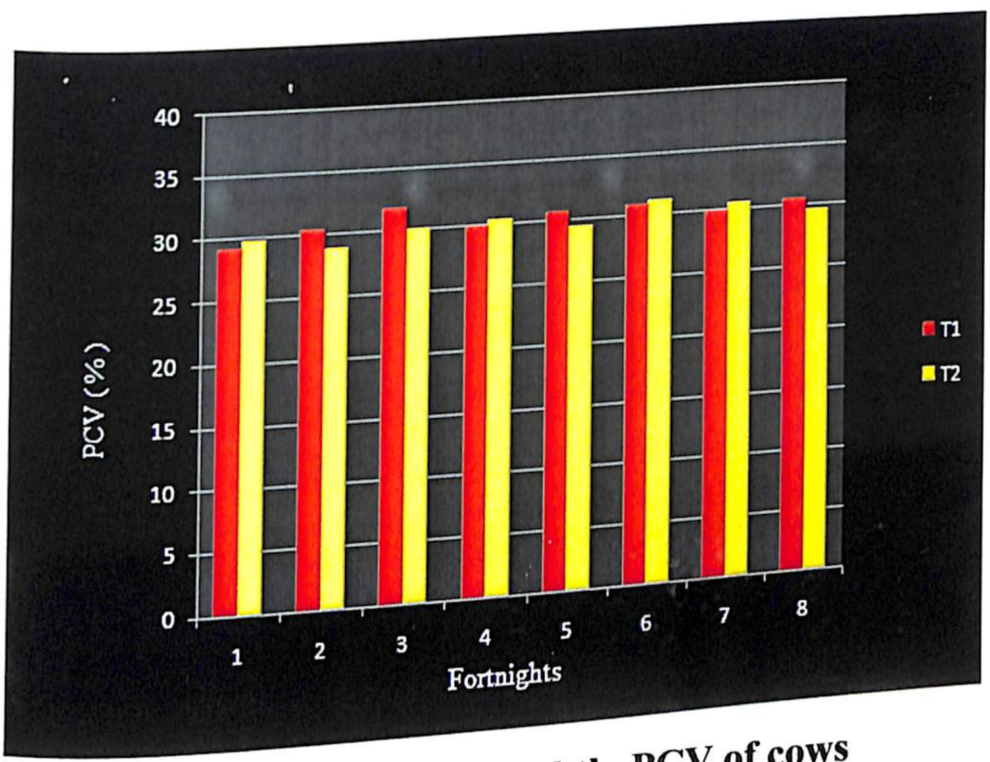

Fig.5. Average fortnightly PCV of cows maintained on two dietary treatments

2.76 ± 0.13 mm per 24 hours while the final values were 3.14 ± 0.22 and 2.97 ± 0.20 mm per 24 hours respectively for T1 and T2. The mean value of the haemoglobin content of experimental animals in the two treatment groups are summarized in Table 8 and graphically represented in Fig.6.

4.5 PLASMA CORTISOL LEVEL

The mean plasma cortisol level was between 8.61 to 13.3 ng/ml in experimental group, in comparison to 9.55 to 18.96 ng/ml in control group. The overall average plasma cortisol level in the control and experimental animals were 12.27 ± 0.58 and 10.84 ± 0.34 ng/ml respectively. The data on the mean plasma cortisol concentration are summarized in Table 9 and depicted graphically in Fig. 7.

4.6 PLASMA GLUCOSE LEVEL

The mean plasma glucose level of the cows in the T1 and T2 were 42.6 and 42.82 mg per cent respectively .The initial plasma glucose level of the animals in the two groups were 44.46 ± 2.48 and 46.96 ± 3.12 mg per cent while the final values were 44.15 ± 1.40 and 41.94 ± 1.21 mg per cent respectively for T1 and T2. The mean value of the haemoglobin content of experimental animals in the two treatment groups are summarized in Table 10 and graphically represented in Fig.8.

4.7 MILK PRODUCTION

The fortnightly average of daily milk production of the experimental animals is given in Table11 and represented in Fig. 9. The average daily milk yields at the beginning of the experiment were 9.60 ± 0.31 and 10.22 ± 0.83 kg and declined to 6.12 ± 0.70 and 8.00 ± 1.41 kg respectively for T1 and T2 towards the end of the experiment. The cows in the T2 showed a greater persistency in milk production.

Table 8. Fortnightly average Erythrocyte Sedimentation Rate (ESR) of experimental animals

Fortnight	ESR (mm/24 hr)	
	T1	**T2**
1	3.19± 0.27	2.76 ± 0.13
2	3.15± 0.27	2.92± 0.17
3	2.86 ± 0.24	2.87 ± 0.26
4	2.96± 0.27	2.78 ± 0.22
5	3.05± 0.19	2.9 ± 0.16
6	3.51 ± 0.15	3.17 ± 0.08
7	3.12 ± 0.29	2.88 ± 0.17
8	3.14± 0.22	2.97± 0..20
Average±SE	3.12 ± 0.08	2.90 ± 0.06

Table 9. Fortnightly average Plasma Cortisol of experimental animals (ng/ml)

Fortnight	Plasma Cortisol (ng/ml)	
	T1	**T2**
1	18.97 ± 2.38	13.30 ± 0.84
2	15.52 ± 1.21	11.92 ± 1.75
3	11.23 ± 0.55	11.08 ± 0.70
4	11.03 ± 1.58	10.97 ± 0.68
5	10.90 ± 0.59	10.78 ± 0.27
6	10.70 ± 0.65	10.38 ± 0.82
7	10.33 ± 0.90	9.68 ± 0.82
8	9.55 ± 0.56	8.62 ± 0.28
Average±SE	12.28 ± 0.58	10.84167 ± 0.34

Table 10. Fortnightly Blood glucose of experimental animals

Fortnight	Blood glucose (mg %)	
	T1	T2
1	44.46 ± 2.48	46.96 ±3.12
2	41.54± 1.30	41.01± 1.52
3	40.17± 2.15	43.08 ± 1.93
4	45.82 ± 2.20	43.87± 2.50
5	40.24 ± 2.13	40.67 ± 2.08
6	40.57± 1.57	44.46 ± 2.48
7	43.87 ± 2.50	40.56 ± 2.00
8	44.15 ± 1.40	41.94 ±1.21
Average±SE	42.60 ± 0.72	42.82 ± 0.77

Table 11. Fortnightly average milk yield of experimental animals (Kg)

Fortnight	Milk yield (Kg)	
	T1	T2
1	9.60 ± 0.33	10.22 ± 0.83
2	8.70 ± 0.26	9.97 ± 1.08
3	8.29 ± 0.22	9.41 ± 1.09
4	7.98 ± 0.22	9.14 ± 1.19
5	7.44 ± 0.14	8.60 ± 1.32
6	7.29 ± 0.36	8.14 ± 1.28
7	7.21 ± 0.36	8.10 ± 1.16
8	6.12 ± 0.70	8.00 ± 1.41
Average±SE	7.83 ± 0.18	8.95 ± 0.40

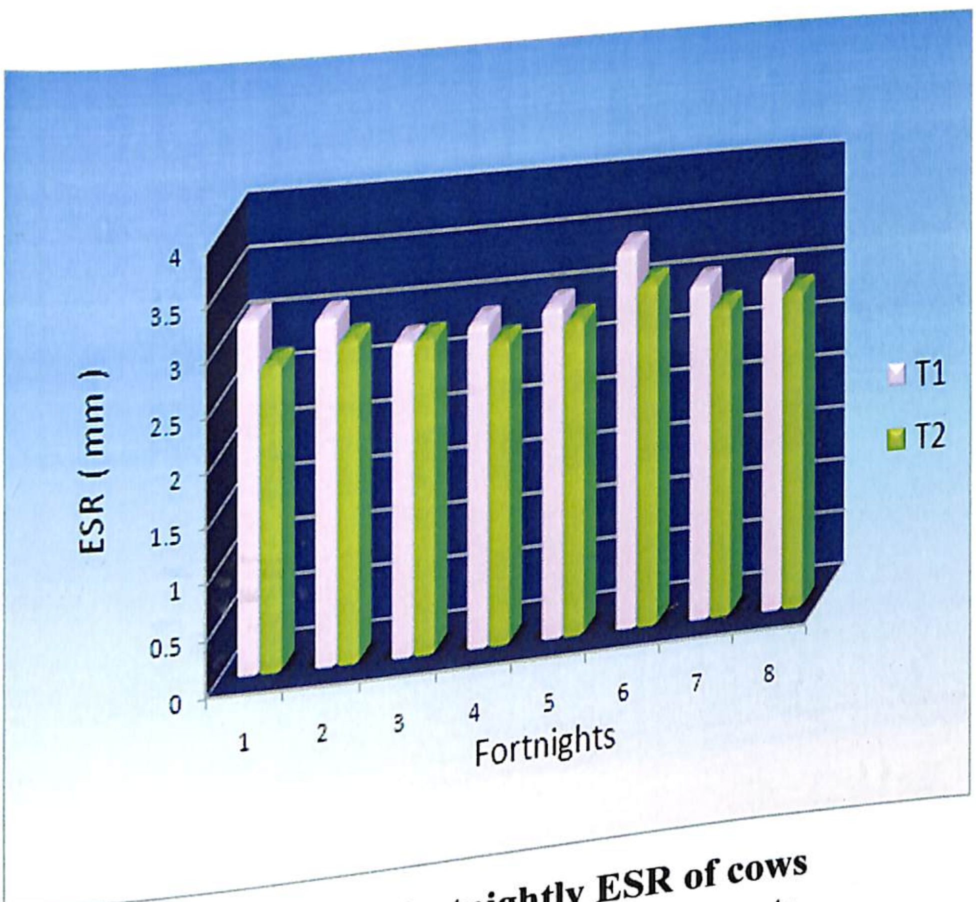

Fig.6. Average fortnightly ESR of cows maintained on two dietary treatments

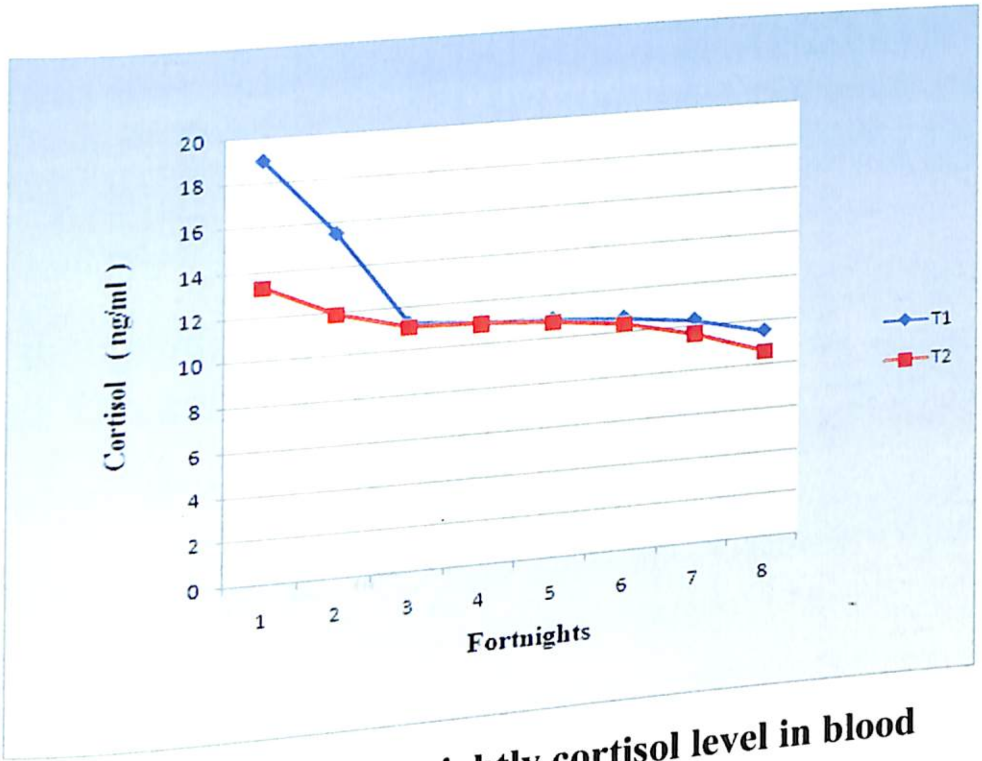

Fig.7. Average fortnightly cortisol level in blood of cows fed on two dietary treatments

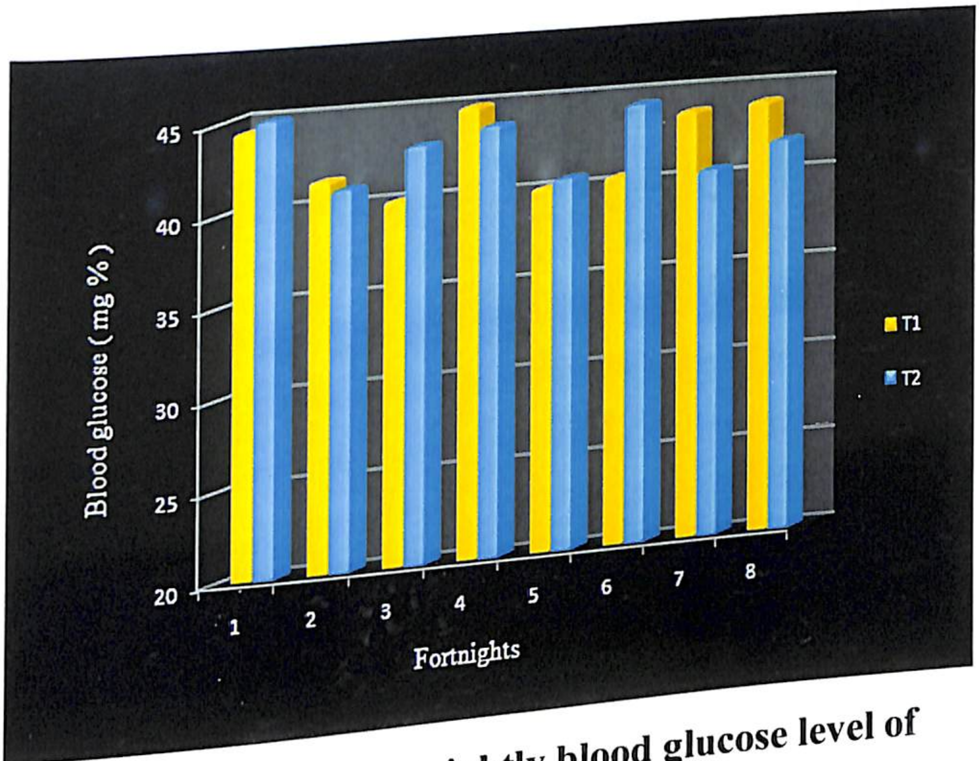

Fig.8. Average fortnightly blood glucose level of cows fed on two dietary treatments

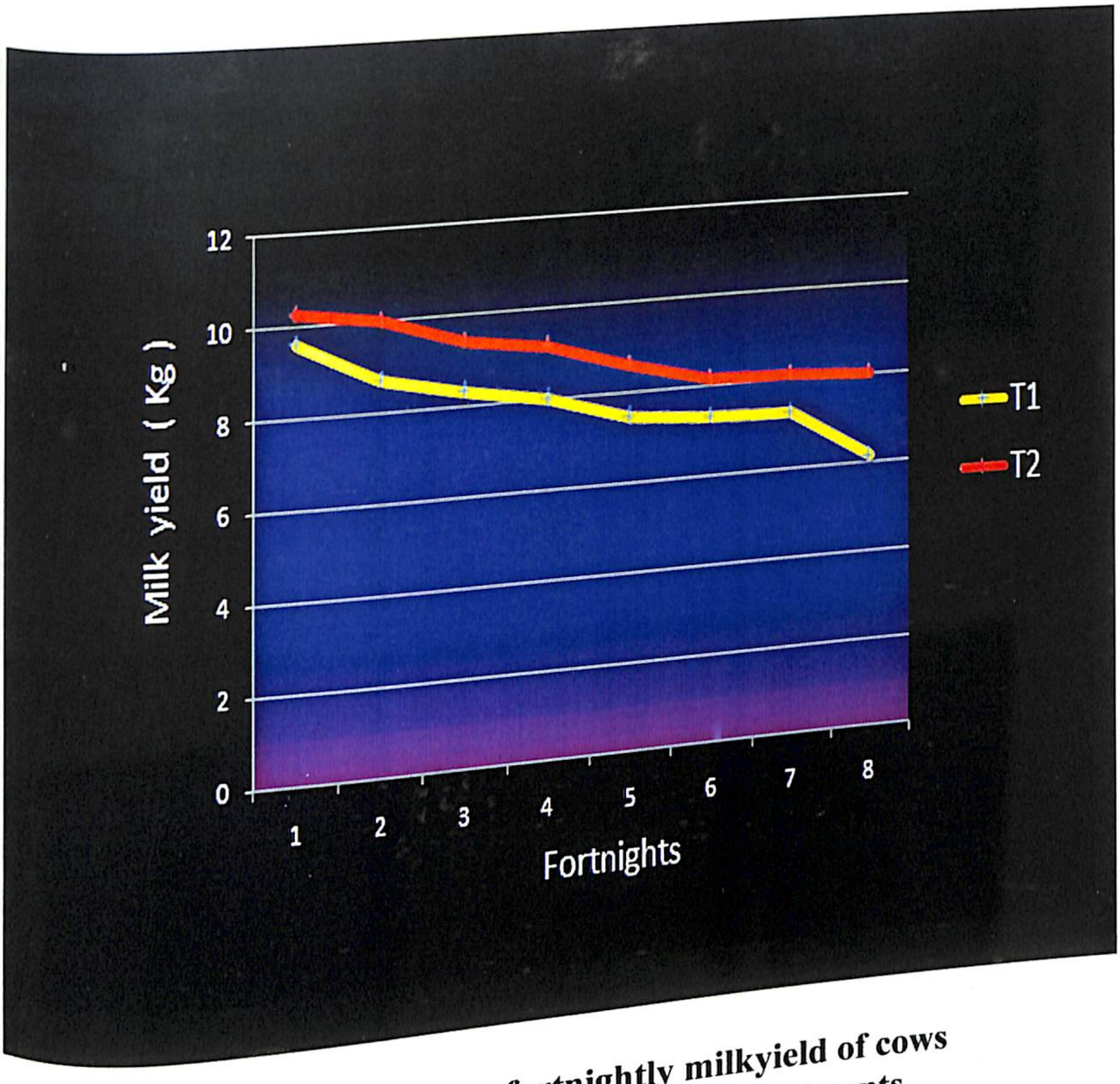

Fig.9. Average fortnightly milkyield of cows maintained on two dietary treatments

4.8 MILK COMPOSITION

The data regarding the composition of milk viz. milk fat, total solids and solids not fat (SNF) collected from the cows of both the treatments at fortnightly intervals are given in Tables 12,13 and 14 respectively and depicted graphically in Fig.10,11 and 12. The average milk fat per cent of the samples collected at the beginning and end of the experiment were 4.25 ± 0.21 and 4.7 ± 0.27 for T1 and 4.35 ± 0.34 and 4.5 ± 0.31 for T2 respectively. The initial total solids and SNF per cent for T1 and T2 were 12.75 ± 0.24 and 12.48 ± 0.28 and 8.50 ± 0.32 and 8.13 ± 0.33 while the final values were 12.98 ± 0.20 and 12.80 ± 0.22 and 8.28 ± 0.35 and 8.30 ± 0.30 respectively.

4.9 DRY MATTER INTAKE

The average dry matter intake at the beginning of the feeding period was 10.76 ± 0.33 and 11.88 ± 0.44 kg respectively for the two treatment groups T1 and T2 which increased to 11.23 ± 0.24 and 12.03 ± 0.46 kg respectively towards the end of the feeding period. Significant difference ($P < 0.05$) was obtained during the second fortnight between the two groups. The data on the fortnightly average daily dry matter intake are summarized in Table15 and depicted graphically in Fig. 13.

Table 12. Fortnightly average milk fat of experimental animals

Fortnight	Milk fat (%)	
	T1	T2
1	4.25 ± 0.21	4.35 ± 0.34
2	4.15 ± 0.23	4.20 ± 0.32
3	4.25 ± 0.22	4.16 ± 0.29
4	4.40 ± 0.18	4.15 ± 0.33
5	4.53 ± 0.22	4.41 ± 0.29
6	4.55 ± 0.29	4.40 ± 0.28
7	4.60 ± 0.31	4.50 ± 0.34
8	4.70 ± 0.27	4.50 ± 0.31
Average±SE	4.42 ± 0.08	4.33± 0.10

Table 13. Fortnightly average of total solids in milk of experimental animals

Fortnight	Total solids (%)	
	T1	**T2**
1	12.75 ± 0.24	12.48 ± 0.28
2	12.69 ± 0.20	12.52 ± 0.32
3	12.86 ± 0.21	12.67 ± 0.21
4	12.78 ± 0.24	12.68 ± 0.25
5	12.54 ± 0.19	12.46 ± 0.30
6	12.47 ± 0.20	12.55 ± 0.28
7	12.76 ± 0.17	12.53 ± 0.31
8	12.98 ±0.20	12.80±0.22
Average±SE	12.73 ± 0.07	12.40 ± 0.15

Table 14. Fortnightly average of SNF in milk of experimental animals

Fortnight	SNF (%)	
	T1	T2
1	8.50 ± 0.32	8.13 ± 0.33
2	8.54 ± 0.28	8.32 ± 0.26
3	8.61 ± 0.32	8.51 ± 0.24
4	8.38 ± 0.34	8.53 ± 0.42
5	8.00 ± 0.28	8.04 ± 0.26
6	7.92 ± 0.39	8.15 ± 0.31
7	8.16 ± 0.43	8.03 ± 0.36
8	8.28 ± 0.35	8.30 ± 0.30
Average±SE	8.30 ± 0.11	8.25 ± 0.10

Table 15. Fortnightly average of daily dry matter intake of experimental animals (Kg)

Fortnight	Dry matter intake (Kg)	
	T1	**T2**
1	10.76 ± 0.33	11.88± 0.44
2	10.85 ± 0.52	11.98 ± 0.64
3	11.01 ± 0.43	11.98 ± 0.60
4	10.88 ± 0.21	12.25 ± 0.39
5	11.62 ± 0.19	11.92 ± 0.53
6	11.18 ± 0.44	11.89 ± 0.34
7	10.91 ± 0.23	12.23 ± 0.51
8	11.23 ± 0.24	12.03 ± 0.46
Average±SE	11.05 ± 0.33	12.02 ± 0.46

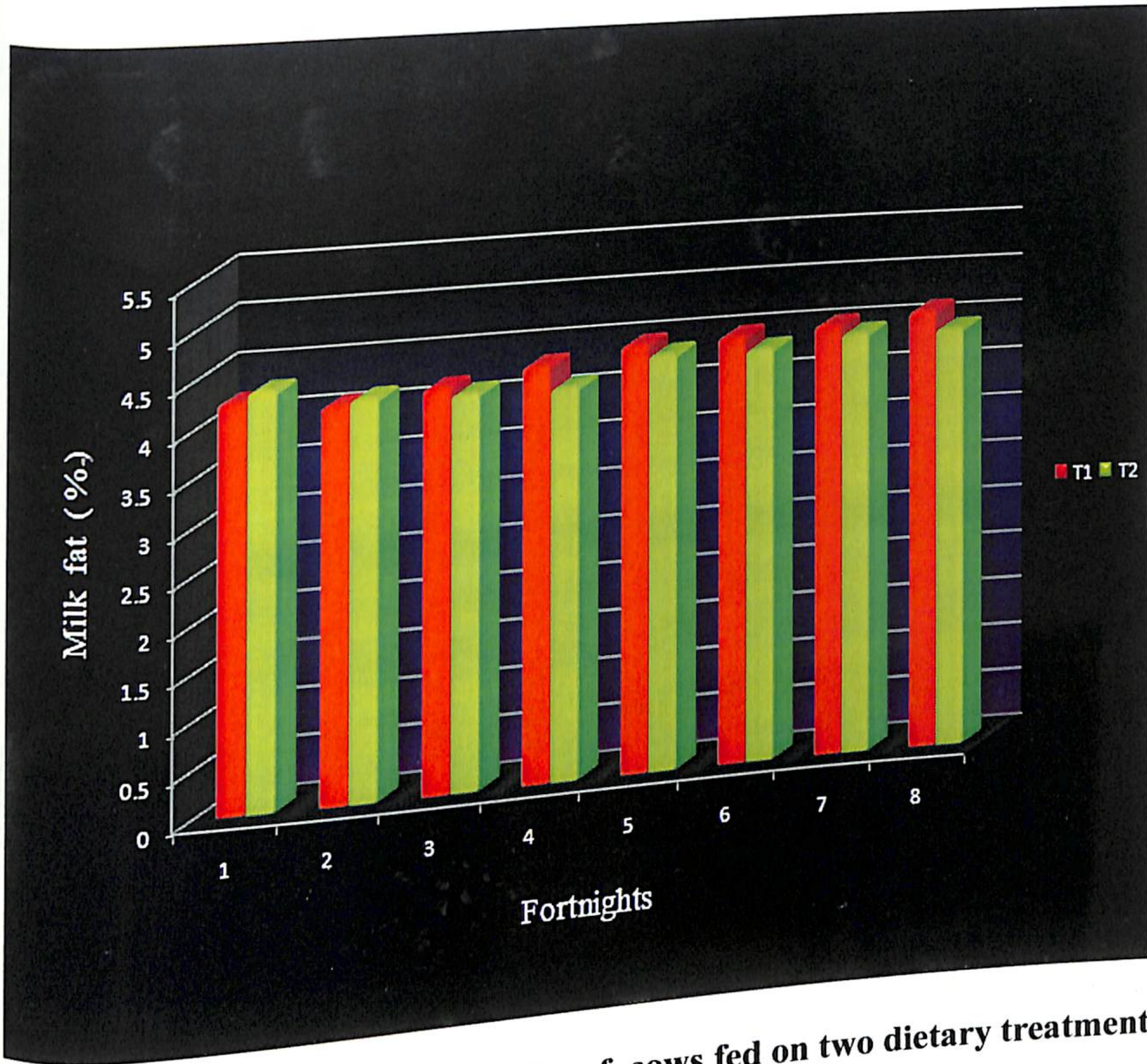

Fig.10. Average fortnightly milkfat of cows fed on two dietary treatments

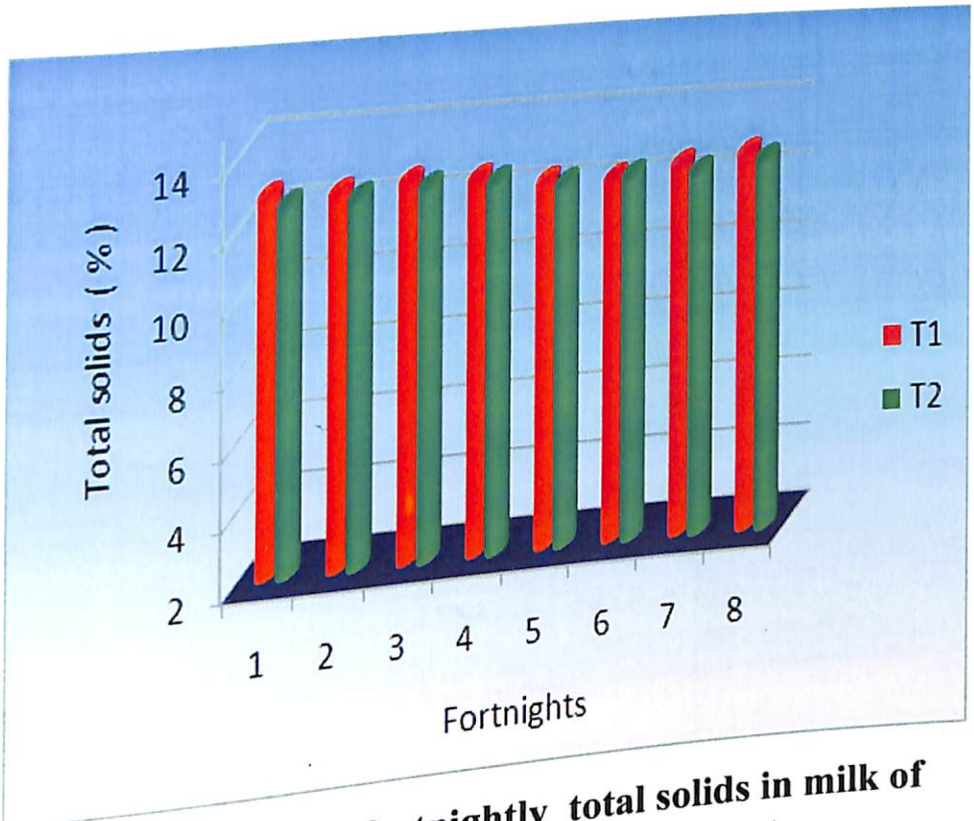

Fig.11. Average fortnightly total solids in milk of cows fed on two dietary treatments

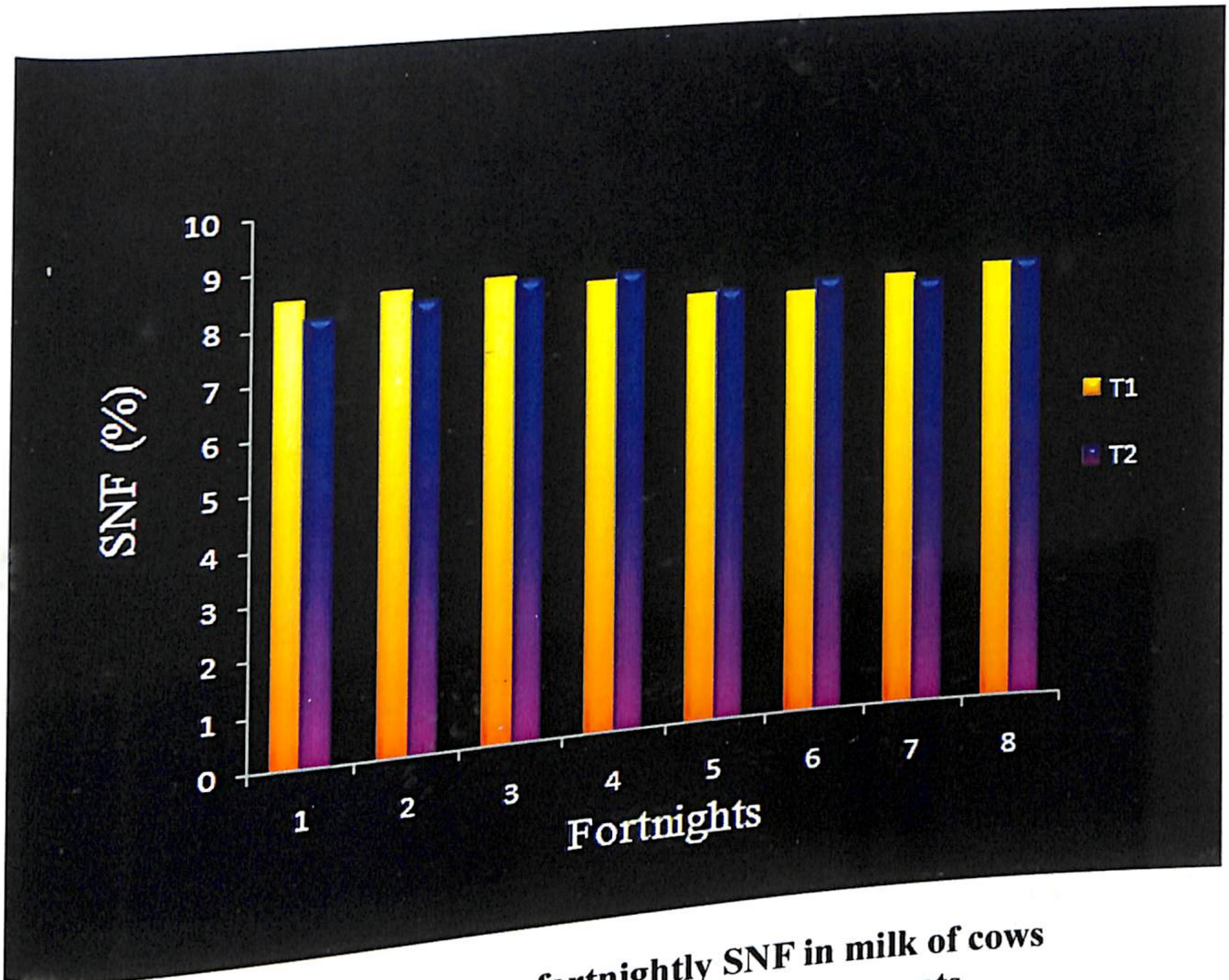

Fig.12. Average fortnightly SNF in milk of cows maintained on two dietary treatments

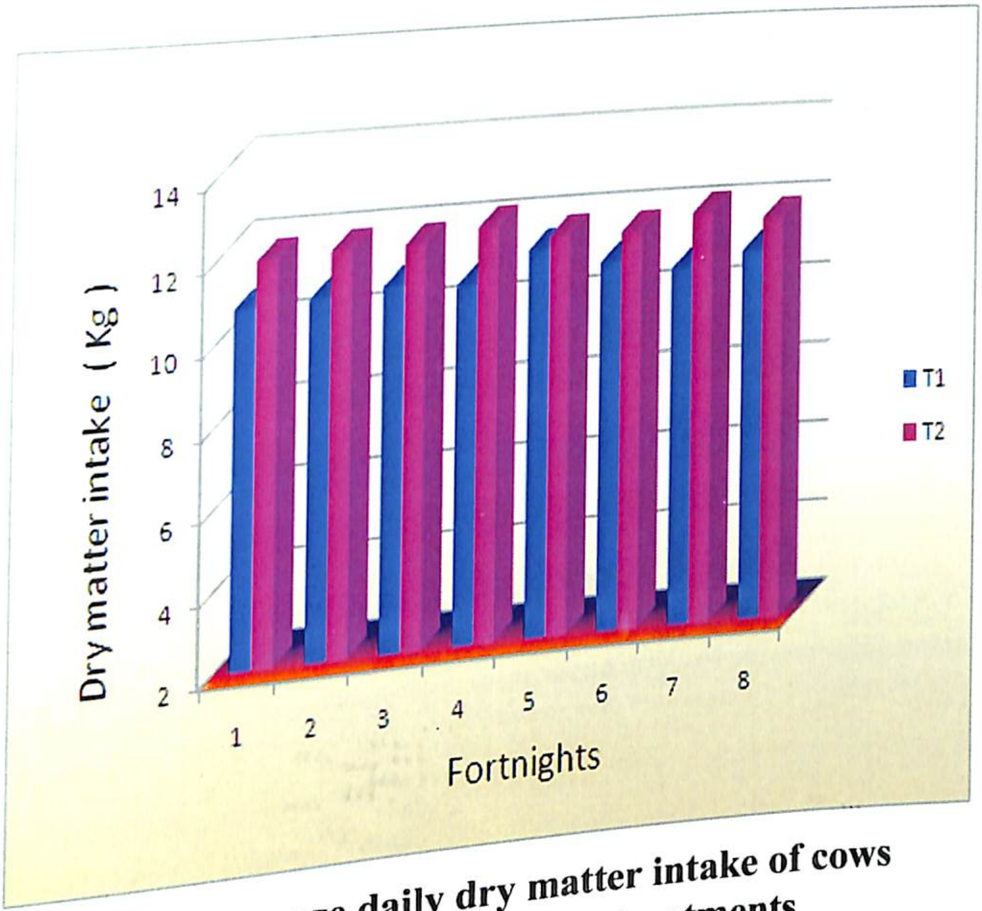

Fig.13. Average daily dry matter intake of cows maintained in two dietary treatments

Discussion

5. DISCUSSION

5.1 CLIMATIC VARIABLES

5.1.1 Ambient Temperature and Relative Humidity.

During the experimental period, the mean maximum temperature ranged from 32.0 to 33.1°C and the minimum temperature from 22.2 to 25.3°C. The per cent relative humidity in the morning varied from 82.09 to 88.1 while in the afternoon it ranged from 52.63 to 58.9. Mean of the microclimatic variables such as maximum and minimum temperatures, mean temperature, relative humidity at morning, relative humidity at afternoon and mean relative humidity during the experimental period have been presented in Table 2. The maximum temperature recorded inside the shed was slightly lower than the outside temperature. The minimum temperature was slightly higher to that of the air temperature prevailed at the atmosphere during cooler hours of the day.

In general, the ambient temperature prevailed during the study period was higher than what was reported as comfortable or ideal temperature for better livestock production (McDowell, 1972). The relative humidity recorded was higher than 50 per cent and some times even crossing 90.0 per cent. Starr (1981) suggested that heat balance could become a problem at 20°C and above, when relative humidity is in excess of 60.0 per cent. The excess humidity levels recorded in the present study at Mannuthy could be classified as hot and humid nature of the study place.

5.2 PHYSIOLOGICAL RESPONSES

5.2.1Rectal Temperature

The mean value of the rectal temperature of experimental animals in the two treatment groups recorded during the period of experiment are listed in Table 3 and graphically represented in Fig. 1. The average rectal temperature during morning was 101.40 ± 0.02°F and 101.45 ± 0.02°F respectively for the two treatments groups T1 and T2 which increased to 102.07 ± 0.03°F and 102.09 ±.0.04°F respectively in the afternoon. This observations were in accordance with Amakiri and Funsho (1979) that the maximum diurnal rise in rectal temperatures were observed in the early afternoon and minimum rectal temperatures were observed in early hours of the morning and the difference was highly significant. Panday and Roy (1969) also reported that there is significant correlation between rectal temperature and ambient temperature.

In the present study the average rectal temperature during morning and afternoon between T1 and T2 did not differ significantly. This was in agreement with that of Aharoni *et al.* (2005) regarding the efficacy of feeding cows at night, to reduce the heat load upon them in a hot climate found that the rectal temperature and respiration rate were smaller for night time fed animals but they did not differ significantly from day time fed cows.

5.2.2 Respiration Rate

The mean respiration rates of the cows recorded at the mornings were 28.92 and 29.22 per min respectively for the cows in T1 and T2 . The corresponding values for afternoon were 49.23 ± 0.31 and 47.13 ± 0.44 per min.

The data on the mean respiration rate are summarized in Table 4 and depicted graphically in Fig. 2. Mean values clearly indicated that the high ambient temperature increased respiratory rate in the afternoon. The increase was about double of the morning value. This was in agreement with Nauheimer-Thoneick *et al.* (1988) who reported that when lactating cows were subjected to an ambient air temperature of 30^{o}C, the respiratory rate increased by 130 per cent of the normal.

In the present experiment, the respiration rates for morning and afternoon did not differ significantly between T1 and T2 . This indicated that night time feeding alone had no effect in reducing respiration rate during high ambient temperature when compared to day time fed. Similarly Ominski *et al.* (2002), reported that time of feeding had no effect in vaginal temperature and respiration rate during heat exposure or during the recovery period.

5.3 BODY WEIGHT

The mean fortnightly body weight of the experimental cows maintained on routine management protocol (T1) and the cows maintained on concentrate mixture, green grass as roughage with 2/3rd fed during night time (T2) are set out in Table 5 and depicted graphically in Fig. 3. The average initial body weights of cows were 348.83 ± 17.11 and 353.66 ± 12.20 kg. The average body weight on completion of the feeding trial was 362.33 ± 15.98 and 367.33 ± 11.91 kg respectively for T1 and T2. On scrutiny of the data on body weight recorded at fortnightly intervals, it was evident that all the animals recorded a gain in body weight during the experimental period of 120 days of lactation with a total gain of 23 and 14 kg for T1 and T2 respectively. The animals in both the groups were in good nutritional status as indicated by physical condition and body weight gain. The increase in body weight could be correlated with the increased dry mater intake during each fortnight. The overall average body weight was 357.91 ± 14.21 and 361.16 ± 11.05 kg respectively for T1 and T2.

Fortnightly body weight of the animals in the two groups showed no significant difference ($P > 0.05$). Similarly, Mortinez *et al.* (1980) found that there was a uniform reduction in body weights of Holstein Friesian cows up to the peak yield period and thereafter the cows had shown a tendency to regain body weights in the later lactation period. Bhaskaran *et al.* (1981) and Patil and Deshpande (1981) observed positive as well as negative body weight changes in crossbred cows during early lactation period.

5.4 HAEMATOLOGICAL PARAMETERS

The data on haematological parameters like haemoglobin, packed cell volume and erythrocyte sedimentation rate estimated during the experimental period are given in the Table 6, 7 and 8 illustrated in Fig.4, 5 and 6. None of the parameters studied were significantly affected ($P > 0.05$) by night time feeding. It was noted that all the values obtained were within the normal levels specified for cows.

5.4.1 Haemoglobin

The average haemoglobin values were 11.76 ± 0.17 and 12.18 ± 0.14 g per cent for T_1 and T_2 respectively during the 120days of lactation. Statistical analysis of the data revealed no significant difference between the two treatments. This is in accordance with the finding of Bioucek *et al.* (1990) who reported that exposing dairy cows to high temperature during day time had no effect in haemoglobin per cent, which is in contrast to the observations by Srikandakumar and Jhonson (2004).

5.4.2 Packed cell volume

The overall mean packed cell volume for the animals in T1 group during the first fortnight was 29.11 ± 0.88 and 30.43 ± 1.63 per cent during the eighth fortnight, while the values for the cows in T2 group were 29.62 ± 0.94 and 29.86 ± 0.33 per cent respectively for first and eighth fortnight. Results revealed that the difference in PCV per cent between treatments were non significant. The present observation in PCV per cent remained to be in accordance with the observations by Talvelkar *et al*. (1980) in crossbred cows and Mohamed (1984) who reported that PCV value did not differ when the cows were exposed to successive seven day periods at 20, 32 and 20°C. Similarly Bioucek *et al.* (1996) reported that exposing dairy cows to high temperature during day time had no effect in haematocrit per cent.

5.4.3 Erythrocyte Sedimentation Rate

The mean erythrocyte sedimentation rate for the two groups T1 and T2 were 3.12 ± 0.08 and 2.90 ± 0.06mm per 24 hours respectively with a range of 3.14 to 3.19 for T_1 and 2.76 to 2.97 for T2. Statistical analysis of the data revealed no significant difference between the two treatments. The values obtained were in accordance with previous studies in cattle by Sharma and Jhanwar (1973) and Schlam *et al*. (1975). Sreekumar (1988) reported that exercise and environmental heat stress increased ESR in cattle. But, Xavier (1981) reported that climatic variables had no effect on ESR in buffaloes. Gowri (1998) reported that ambient temperature had no effect on ESR of both sheep and goats.

5.5. PLASMA CORTISOL LEVEL

The mean plasma cortisol level was between 9.55 to 18.96 ng/ml in T_1 and that for T2 ranged from 8.61 to 13.3 ng/ml. The overall average plasma cortisol level in T1 and T2 were 12.27 ± 0.58 and 10.84 ± 0.34 ng/ml respectively. The data for mean plasma cortisol concentration are summarized in Table 9 and depicted graphically in Fig. 7. The average plasma cortisol level for the animals in the T1 group during the first fortnight was 18.96 ± 2.38 and 9.55 ± 0.56 during the eighth fortnight while the values for the cows in T2 group were 13.3 ± 0.84 kg and 8.61 ± 0.282 respectively for first and eighth fortnight. The mean cortisol level was higher at the beginning of the experiment both in T1 and T2 and gradually declined to lower levels towards the end. Statistically significant difference ($P < 0.05$) in plasma cortisol was obtained between two groups during the first and second fortnights, the values being 18.69 ± 2.38 , 15.51 ± 1.21 kg and 13.3 ± 0.84,11.91 ± 1.75 for T1 and T2 respectively. The overall average plasma cortisol level was significantly higher in the T1 in comparison to T2.

Similarly Alvarez and Johnson (1973) reported that an initial increase in cortisol occurs due to acute heat stress followed by a decline after prolonged exposure in cows. Therefore, the animals adjust physiologically to elevated heat loads by decreasing adrenal corticoid output. Yousef and Johnson(1967) also stated that during heat acclimation there was reduction of plasma cortisol that help in reducing the heat production of animals and it is concluded that night time feeding of lactating cows during summer season considerably reduced the plasma cortisol level compared to the day time fed.

5.6 PLASMA GLUCOSE LEVEL

The average serum glucose level for the animals in the T1 group during the first fortnight was 44.46 ± 2.48 and 44.15 ± 1.40 mg per cent during the eighth fortnight while the values for the cows in T2 group were 46.96 ± 3.12 and 41.94 ± 1.21 mg per cent respectively for first and eighth fortnight. No significant difference observed between the two groups ($P > 0.05$) following night time feeding. Jindal (1988) reported the overall average concentration of blood glucose in cows as 49.83 mg/100ml. Abenil *et al.* (2007) reported that there is decrease in plasma glucose in Friesian cows during hotter periods.

5.7 MILK PRODUCTION

The fortnightly average of daily milk yield from the experimental cows belonging to T1 and T2 are presented in Table 6 and illustrated graphically in Fig. 3. The cows in T2 maintained the peak yield up to third fortnight whereas the animals in T1 showed a decline in peak yield from the second fortnight itself. Average milk yield for the animals in the T1 group during first fortnight was 9.60 ± 0.33 and 6.12 ± 0.70 kg during eighth fortnight, while the values for the cows in T2 group were 10.22 ± 0.83 kg and 8.00 ± 1.41 kg respectively for first and eighth fortnight.

The cumulative average milk yield for the T1 and T2 were 7.83± 0.18 kg and 8.95 ± 0.40 kg during the experimental period of 120 days of lactation. On statistical analysis of data by independent T test no significant difference could be observed at each fortnight between treatments. Milk yield is observed over fortnights after a steady state of yield has reached. It is most appropriate that the decreasing phase of yield is measured as a repeated measures ANOVA since the rate of decrease of any order is measured. From the ANOVA for both T1 and T2, the cubic order contrast was found to be significant for T1 where as the only linear contrast was significant for T2. This means the rate of decrease is uniform for T2 where as the rate of decrease for T1 is itself at a higher order.

The increase in milk yield may be attributed to the increased dry matter intake which showed a linear increase during the course of the experiment. Scrutiny of the data on milk production during first 120 days of lactation further revealed the T2 cows maintained the peak yield as well as persistency of milk production better than the cows in the control group (T1). This finding is in accordance with Aharoni *et al.* (2005) who examined the efficacy of feeding cows at night and found that cows on night time feeding had similar milk yield to that of day time fed cows but the decline of milk yield with time was greater in the day time fed than other .They concluded that night time fed cows had better milk yield persistence over time.

Similarly Ominski *et al.* (2002) observed decrease in milk yield for evening fed cows than for morning-fed cows that were transferred from thermoneutral to heat-stress conditions. The decline in milk yield with time was lower for the night time fed cows, and after several months in the trial, they produced more milk than the day time fed cows and found that there was some long-term effect on performance of evening fed cows. Hence it is concluded that the comparatively higher milk yield and better persistency observed in T2 maybe due to effect of night time feeding.

5.8 MILK COMPOSITION

The values for the milk components viz. milk fat, total solids and solids not fat are given in Tables 12, 13, 14 respectively and are illustrated graphically in Fig 10, 11 and 12. Average milk fat per cent during the eight fortnights ranged from 4.25 to 4.70 for T1 and 4.35 to 4.5 for T2 with a total average of 4.42 ± 0.08 and 4.33 ± 0.10 respectively. Statistical analysis revealed no significant difference (P> 0.05) between the two groups regarding the average fat per cent in the present study.

Similarly Nauheimer-Thoneick *et al.* (1988) did not find any statistically significant difference in fat per cent of German Holstein Friesian cows subjected to

30ºC constant temperature in the climatic chamber even though their milk yield declined by 26 to 30 per cent. Ominski *et al.* (2002) observed milk composition for evening-fed cows than for morning-fed cows that were transferred from thermoneutral to heat-stress conditions. No significant differences in milk fat and protein concentrations were observed from morning fed and evening fed cows.

The average total solids per cent of milk for the two groups T1 and T2were 12.73 ± 0.07 and 12.40 ± 0.15 respectively with a range of 12.75 to 12.98 for T1 and 12.48 to 12.80 for T2. The statistical analysis revealed no significant difference ($P > 0.05$) between the two groups.

The average solids not fat (SNF) values for T1 and T2 were 8.30 ± 0.11 and 8.25 ± 0.10 respectively and there were no significant difference between the two groups ($P > 0.05$). Babu Rao and Jayaramakrisha (1983) reported that the average milk solids not fat per cent of Ongole x Brown Swiss and Ongole x Holstein Friesian cows were 9.09 and 8.68 respectively.

The present study is comparable with Aharoni *et al.* (2005) who examined the efficacy of feeding cows at night, to reduce the heat load upon them in a hot climate found that no significant differences in milk composition were observed between night and day time fed animals. Higher numerical fat content were observed in the milk of the night time cows than in that of the day time fed.

5.9 DRY MATTER INTAKE

The average daily dry matter intake (DMI) of the animals in the two groups at fortnightly intervals are presented in Table 15 and graphically represented in Fig. 13. The average daily dry matter consumption of the cows in the first fortnight for groups T1 and T2 were 10.76 ± 0.33 and 11.88 ± 0.44 kg and the dry matter intake in the eighth fortnight were 11.23 ± 0.24 and 12.03 ± 0.46 kg respectively. The overall average daily dry matter intake by the animals of T1 and T2 during the experimental period of 120 days of lactation was 11.05 ± 0.33 kg and 12.02 ± 0.46 kg, the corresponding average dry matter intake when expressed as per cent body weight were 3.11 ± 0.04 and 3.35 ± 0.06 for the two groups respectively.

A linear increase in dry matter consumption could be observed for the two groups from the first fortnight to the eighth fortnight with the dry matter intake by the animals of T2 being comparatively better than the animals of T1. On statistical analysis a significant difference ($P< 0.05$) in dry matter intake was obtained between the two groups during the fourth and seventh fortnights, the values being 12.25 ± 0.39 , 10.88 ± 0.21 kg and 12.23 ± 0.51,10.91 ± 0.23 for T2 and T1 respectively. The higher dry matter intake recorded in the T2 animals could be attributed to increased frequency of feeding in the night time.

It is concluded that heat stress reduced the feed consumption as reported by Thomas *et al.,* (1969) and McDowell (1976). In contrary to the present findings, Aharoni *et al.* (2005) reported the efficacy of feeding such cows at night, which avoiding their access to feed for 5 1/2 hour during the hot hours of the day, to reduce the heat load upon them in a hot climate found that cows on night time feeding had significantly lower feed intake when compared to that of day time fed cows.

From the overall results obtained in the present study it could be concluded that the night time feeding of the animals during summer season has improved the dry matter intake with comparatively higher milk yield and better persistency and found that there was some long-term effect on performance of evening fed cows.

Summary

6. SUMMARY

A study was conducted to assess the effect of feeding management on milk production and metabolic profile of crossbred cows in mid lactation. Twelve healthy crossbred cows having a peak yield of minimum eight litres in the previous lactation, were selected as the experimental animals. The animals were divided into two groups of six each as uniformly as possible with regard to age, milk yield and parity and were randomly allotted to two dietary treatments, T1 consisting of basal concentrate mixture and green grass as roughages and T2 consisting basal concentrate mixture, green grass as roughage of which $1/3^{rd}$ of the concentrate and roughage is fed during the day time and rest in the evening and early morning with water availability at all times.

Daily maximum temperature, minimum temperature and relative humidity were recorded inside the shed using maximum and minimum thermometer to quantify the microenvironment prevalent around the animals in both the treatment groups. Physiological parameters like respiration rate and rectal temperature were measured to give an immediate response to the climatic stress and consequently the level of comfort to the animal. Individual records of daily intakes of concentrate and roughage, daily milk production and fortnightly body weight were maintained through out the experiment. Milk samples were collected at fortnightly intervals and were analysed for milk fat, total solids and solids not fat. Blood was collected at fortnight intervals for estimating haemoglobin, erythrocyte sedimentation rate, packed cell volume, plasma glucose and cortisol.

During the experimental period, the mean maximum temperature ranged from 32.0 to 33.1°C and the minimum temperature from 22.2 to 25.3°C. The percent relative humidity in the morning varied from 82.09 to 88.1 while in the afternoon it ranged from 52.63 to 58.9. The maximum temperature recorded inside the shed was slightly lower than the outside temperature. The excess humidity and temperature levels recorded in the present study at Mannuthy could be classified as humid and hot.

The average rectal temperature during morning was 101.40 ± 0.02°F and 101.45 ± 0.02°F respectively for the two treatments groups T1 and T2 which increased to 102.07 ± 0.03°F and 102.09 ±.0.04°F respectively in the afternoon. The average rectal temperature during morning and afternoon between T1 and T2 did not differ significantly. The mean respiration rates of the cows recorded at the mornings were 28.92 and 29.22 per min respectively for the cows in T1 and T2. The mean values clearly indicated that high ambient temperature increased the respiratory rate in the afternoon. The respiration rate for morning and afternoon recording was not found to be differed between T1 and T2. This indicated that night time feeding alone had no effect in reducing the physiological parameter such as respiration rate during high ambient temperature when compared to day time fed.

The average initial bodyweight of cows of T1 and T2 at the beginning of experiment was 348.83 and 353.66 kg. Thereafter there was an increase in body weight for animals in both the groups and there was a total gain of 23 kg for T1 and 14 kg for T2 towards the end of the experiment. The increase in body weight could be correlated with the increased dry mater intake during each fortnight. Average body weight of animals revealed no significant difference for the both groups during all the fortnight studied.

The overall average dry matter intake for the animals of T1 and T2 were 11.05 and 12.02 kg respectively and the values differed significantly ($P < 0.05$) during the fourth and seventh fortnight. There was a linear increase in dry matter consumption by the animals of the two groups from the first fortnight to seventh fortnight with the dry matter intake by the animals of T2 were comparatively better than that of the animals of T1. The higher dry matter intake recorded in the T2 animals could be attributed to increased frequency of feeding in the night time.

The cows in T2 maintained the peak yield up to third fortnight whereas the animals in T1 showed a decline in peak yield from the second fortnight itself. The average milk yield for the animals in the T1 group during the first fortnight was 9.60 ± 0.33 and 6.12 ± 0.70 kg during the eighth fortnight while the values for the cows in T2 group were 10.22 ± 0.83 kg and 8.00 ± 1.41 kg respectively for first and eighth fortnight. The increase in milk yield may be attributed to the increased dry matter intake which showed a linear increase during the course of the experiment. Scrutiny of the data on milk production during first 120 days of lactation further revealed that comparatively higher milk yield and better persistency was observed in T2 and concluded that there was some long-term effect on performance due to night time feeding.

The average milk fat percentage of T1 and T2 showed no significant difference in all the eight fortnights with the overall average values being 4.42 and 4.33 respectively for the two groups. The total solids and solid not fat percentages for the experimental cows in T1 and T2 were 12.73 and 8.30 per cent and 12.40 and 8.25 respectively. It is revealed that no significant difference ($P>0.05$) between the two groups regarding the total solids and solid not fat percentages.

The average haemoglobin values were 11.76 ± 0.17 and 12.18 ± 0.14 g per cent for T1 and T2 respectively during the 120days of lactation. Statistical analysis of the data revealed no significant difference between the two treatments. The overall mean packed cell volume for the animals in the T1 group during the first fortnight was 29.11 ± 0.88 and 30.43 ± 1.63 percent during the eighth fortnight while the values for the cows in T2 group were 29.62 ± 0.94 and 29.86 ± 0.33 percent respectively for first and eighth fortnight which did not differ significantly. The mean erythrocyte sedimentation rate for the two groups T1 and T2 were 3.12 ± 0.08 and 2.90 ± 0.06mm per 24 hours respectively with a range of 3.14 to 3.19 for T1 and 2.76 to 2.97 for T2. Statistical analysis of any of the haematological parameters studied did not seem to be influenced by the feeding management.

The average plasma cortisol level for the animals in the T1 group during the first fortnight was 18.96 ± 2.38 and 9.55 ± 0.56 during the eighth fortnight while the values for the cows in T2 group were 13.3 ± 0.84 kg and 8.61 ± 0.282 respectively for first and eighth fortnight. The mean cortisol level was higher at the beginning of the experiment both in T1 and T2 and gradually declined to lower levels towards the end. On statistical analysis a significant difference ($P < 0.05$) in plasma cortisol was obtained between the two groups during the first and second fortnights. The overall average plasma cortisol level was significantly higher in the T1 in comparison to T2. and concluded that night time feeding of lactating cows during summer season considerably reduced the plasma cortisol level compared to the day time fed.

The average serum glucose level for the animals in the T1 group during the first fortnight was 44.46 ± 2.48 and 44.15 ± 1.40 during the eighth fortnight while the values for the cows in T2 group were 46.96 ± 3.12 kg and 41.94 ± 1.21 respectively for first and eighth fortnight. There was no significant difference observed between the two groups ($P > 0.05$) following night time feeding.

From the overall results obtained in the present study it could be concluded that the night time feeding of the animals during summer season has improved total milk production and helped to maintain the higher milk yield as well as persistency of milk production in lactating crossbred cows and found that there was some long-term effect on performance of evening fed cows.

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MANAGEMENT PROTOCOL FOR AVERTING DROP OF MILK PRODUCTION IN DAIRY CATTLE DURING SUMMER

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Abstract ot the thesis submitted in partial fulfillment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University, Thrissur

2007

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ABSTRACT

A study was conducted to assess the effect of feeding management on milk production and metabolic profile of crossbred cows in mid lactation. Twelve healthy crossbred cows having a peak yield of minimum eight litres in the previous lactation, were selected as the experimental animals. The animals were divided into two groups of six each as uniformly as possible with regard to age, milk yield and parity and were randomly allotted to two dietary treatments, T1 consisting of basal concentrate mixture and green grass as roughages and T2 consisting basal concentrate mixture, green grass as roughage of which 1/3rd of the concentrate and roughage is fed during the day time and rest in the evening and early morning with water availability at all times.

Daily maximum temperature, minimum temperature and relative humidity were recorded inside the shed using maximum and minimum thermometer to quantify the microenvironment prevalent around the animals in both the treatment groups. Physiological parameters like respiration rate and rectal temperature were measured to give an immediate response to the climatic stress and consequently the level of comfort to the animal. Individual records of daily intakes of concentrate and roughage, daily milk production and fortnightly body weight were maintained through out the experiment. Milk samples were collected at fortnightly intervals and were analysed for milk fat, total solids and solids not fat. Blood was collected at fortnight intervals for estimating haemoglobin, erythrocyte sedimentation rate, packed cell volume, plasma glucose and cortisol.

The ambient temperature prevailed during the study period was higher than what was reported as comfortable or ideal temperature for better livestock production and the excess humidity and temperature levels recorded in the present study at Mannuthy could be classified as humid and hot.

The average rectal temperature during morning and afternoon between T1 and T2 did not differ significantly. The mean values clearly indicated that high ambient temperature increased the respiratory rate in the afternoon. The respiration rate for morning and afternoon recording was not found to be differed between T1 and T2.

Average body weight of animals revealed no significant difference for the both groups during all the fortnight studied. The average daily dry matter intake linearly increased as the lactation progressed in both the groups. Dry matter intake by the animals of T2 was comparatively better than the animals of T1 with a significant increase ($P<0.05$) during the fourth and seventh fortnight. Scrutiny of the data on milk production during first 120 days of lactation further revealed that comparatively higher milk yield and better persistency was observed in T2. There was no significant difference in any of the milk composition parameters between the treatments.

The haematological parameters such as haemoglobin, packed cell volume, erythrocyte sedimentation rate and plasma glucose estimated at the fortnight intervals were not significantly affected by the two dietary treatments. On statistical analysis a significant difference ($P< 0.05$) in plasma cortisol was obtained between the two groups during the first and second fortnights. The overall average plasma cortisol level was significantly higher in the T1 in comparison to T2.

From the overall results obtained in the present study it could be concluded that the night time feeding of the animals during summer season has improved total milk production and helped to maintain the higher milk yield as well as persistency of milk production in lactating crossbred cows and found that there was some long-term effect on performance of evening fed cows.