METABOLIC PROFILE AND CLINICAL MANAGEMENT OF POST-PARTUM UDDER OEDEMA IN DAIRY CATTLE

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"METABOLIC PROFILE AND CLINICAL MANAGEMENT OF POST-PARTUM UDDER OEDEMA IN DAIRY CATTLE"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Mannuthy,
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CERTIFICATE I

Certified that the thesis entitled **"METABOLIC PROFILE AND CLINICAL MANAGEMENT OF POST-PARTUM UDDER OEDEMA IN DAIRY CATTLE"** is a record of research work done independently by **Shri.Venkatesa Kumar, E.,** 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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VENKATESA KUMAR.E

To

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LIST OF ABBREVIATIONS

A:G ratio	- Albumin:Globulin ratio
AST	- Aspartate aminotransferase
BUN	- Blood urea nitrogen
Ca:P ratio	- Calcium:Phosphorus ratio
CBC	- Complete blood count
CMT	- California Mastitis test
DLC	- Differential leucocyte count
Hb	- Haemoglobin
MCV	- Mean corpuscular volume
MCH	- Mean corpuscular haemoglobin
MCHC	- Mean corpuscular haemoglobin concentration
PCV	- Packed cell volume

INTRODUCTION

INTRODUCTION

India is the largest milk producer (74 million tonnes) in the world (FAO, 1998). This has been achieved by genetic upgradation and cross breeding programmes in our indigenous cattle by using exotic germplasm. As the production increases, the dairy cattle tend to loose their disease resistance and are prone for production diseases.

One of the most important problem, occurring in dairy cattle is udder oedema. It is a commonly occurring condition usually associated with parturition in dairy cattle. Though, it is associated with parturition, it has not been categorized either as production disease or metabolic disease by earlier workers. Moreover, scientists do have difference of opinion about the etio-pathogenesis of udder oedema viz., managemental defects at pre-partum, hormonal factors, heriditary factors, etc. To assess the possibility and to determine the origin of udder oedema the metabolic profiles should be carried out (Rebhun, 1995).

The metabolic profile test is based on the concept that laboratory measurements of certain components of the blood will reflect the nutritional status of animal, with or without the presence of clinical abnormalities. Several modifications were made by different workers by including many investigations other than blood parameters like analysis of rumen fluid, urine, water, soil, etc.

Eventhough, udder oedema is considered as physiological by most of the scientists, the dairymen used to complain that it is persisting for a long period even after calving and not responding to local treatments like cold water application, astringent application, etc. Severe and persistent udder oedema is of considerable importance to the dairymen and warrants veterinary intervention (Vigue, 1961a). Extensive udder oedema further leads to complications like trauma of udder and teats, mastitis, rupture of suspensary ligaments, ketosis, etc. So, the

dairymen face an economic loss due to reduced milk production by udder oedema itself and due to the concurrent diseases as well as their treatments.

Though udder oedema is an important problem in Kerala, no systematic study has so far been conducted in this aspect. Certain indigenous plants such as *Tribulus terrestris* Linn. (Neringil - Malayalam) are reported to be successfully used by Ayurveda physicians for the treatment of oedema in human beings. The cost of this line of treatment is cheap when compared to the therapy using modern diuretic drugs. The efficacy of this drug in cows with udder oedema has not yet been scientifically studied.

Under these circumstances, a study was proposed on "Udder oedema in cattle" with the following objectives.

1) To findout the etio-pathogenesis of udder oedema in Kerala.
2) To study the metabolic profile of cattle suffering from post-partum udder oedema.
3) To compare the efficacy of indigenous plant '*Tribulus terrestris* Linn' with 'Frusemide' in the treatment of udder oedema.

2. REVIEW OF LITERATURE

Udder oedema is mostly a disease of dairy cattle and is characterized by an excessive accumulation of fluid in the interstitial tissue spaces. It has been described as one of the most serious conditions affecting the world's dairy cattle industry at the present time (Hays and Albright, 1966; Rebesko *et al.*, 1974; Hicks and Pauli, 1976; Hutjens, 1980; Dentine, 1982; Al-Ani, 1984 and Prabhakar *et al.*, 1991).

2.1 Occurrence

Udder oedema occurred mostly in first-calf heifers as well as in older cows.Cows with higher production potential especially cows with pendulous udder were more susceptible to this condition (Greenhalgh and Gardner, 1958; Schmidt and Schultz, 1959; McCuistion, 1960; Hays and Albright, 1966; Mitchell *et al.*, 1976 and Conway *et al.*, 1977).

Vigue (1963) stated that incidence of udder oedema and ketosis were more in obese dairy cows.

Emery *et al.* (1969) reported that first-calf heifers had the highest incidence of udder oedema and usually took longer time to clear-up. They also suggested the reason for this as, the better vascular circulation in adult cows when compared to heifers.

According to Coppock *et al.* (1974) the incidence of udder oedema in cows at parturition was not associated with the length of dry period. They also recorded 96.4 per cent of udder oedema cases at first calving and 81.5 per cent at later calvings.

Conway *et al.* (1977) reported that udder oedema occurred more commonly at calving than at 20 days pre-partum and 10 days post-partum in cows.

Dentine and McDaniel (1983) observed that the severity of udder oedema increased linearly with age at first calving. Malvern *et al.* (1983) reported that the prepartum mammary oedema increased with age of heifer and gestation length and decreased as calf birth weight increased; however, it was unrelated to seasonal fluctuations in temperature and photoperiod.

Vestweber and Al-Ani (1985) recorded that most of the Holstein cows with udder oedema were in their third and fourth lactation.

Kellerman and Wendt (1988) stated that the cows with female calves had more incidence of udder oedema.

Nestor *et al.* (1988) opined that udder oedema was not related to age of animal.

Thakur *et al.* (1989) stated that the occurrence of udder oedema among the cows was just one to two days before parturition. They also recorded incidence of 73.9 per cent in Holstein-Friesian crossbred cows and 26.8 per cent in Jersey crossbred cows.

Dorp *et al.* (1999) reported that the occurrence of udder oedema was mainly during the first two lactations.

2.1.1 Breed

Occurrence of udder oedema was more severe in Holstein-Friesian and Guernseys than Jerseys, Ayrshires or Brownswiss (Hays and Albright, 1966).

Coppock *et al.* (1974) and Thakur *et al.* (1989) recorded higher incidence in Holstein-Friesian cows than in other breeds.

2.1.2 Season

Severity of udder oedema was more in cows calving at autumn and winter than at spring and summer (Hays and Albright, 1966).

2.3 Etiology

The exact etiology of udder oedema was unknown (Vestweber and Al-Ani,1985 and Rebhun, 1995).

2.3.1 Inheritance

A genetic study suggested that there was a significant positive correlation between udder oedema and milk yield in cows (Norman and Van Vleck, 1972).

Hungerford (1990) and Rebhun (1995) referred that the genetic predisposition might be one of the factor for occurrence of udder oedema in cows.

2.3.2 Mammary blood and lymph flow

Heidrich and Renk (1967) reported that circulatory disturbance might be the cause for udder oedema in cows.

Cows with udder oedema had a 17.1 per cent lower mammary blood flow than cows without udder oedema at parturition. The changes in mammary blood flow might be a factor in the development of udder oedema at calving (Al-Ani and Vestweber, 1984).

Prasad *et al.* (1999) reported that the incompletely developed mammary vein, inadequate venous return and inability of the lymphatics to remove large amount of fluid in the interstitial tissue following first kidding might be responsible for the congestion of udder in goats.

2.3.3 Venous blood pressure

Udder oedema was said to be the result of hyperaemia, which might be active (congestive oedema) or passive owing to venous stasis caused by foetal pressure on the large veins in the pelvic cavity and on milk veins where they enter

the abdominal cavity (Meites *et al.*, 1950 and Joshi *et al.*, 1978). However, Jones *et al.* (1984) contradicted the above and commented that the occlusion of milk vein would cause asymmetrical udder oedema and would get relieved immediately after parturition. Al-Ani and Vestweber (1986) pointed out that the gravid uterus usually situated more posteriorly in the abdominal cavity and was not in the pathway of the venous drainage through the milk veins.

Vestweber and Al-Ani (1985) noted that there was significant elevation of blood pressure in the cranial superficial epigastric veins of the Jersey cows with udder oedema when compared to the control Jersey cows at parturition.

2.3.4 Feeding

The effect of increased grain feeding upon the development of udder oedema was still a matter of controversy (Al-Ani and Vestweber, 1986).

Fountaine *et al.* (1949); Greenhalgh and Gardner (1958) and Schmidt and Schultz (1959) reported that the amount of grain feeding during pre-partum period or dry period had no influence on udder oedema in cows.

Hemken *et al.* (1960) and Johnson and Otterby (1981) found significant increase in the severity of udder oedema in cows fed varying amounts of concentrate before parturition.

Emery *et al.* (1969) recorded that the heifers fed more grains before parturition had both higher body condition scores and severe udder oedema than heifers fed roughage alone.

Sandstedt (1980) noted that the oedema of udder was related to the amount of protein fed during final week of gestation.

2.3.5 Salt intake

Hemken *et al.* (1969) found that heifers with restricted water and sodium chloride intake before parturition had less udder oedema than controls.

Randall *et al.* (1974) reported that udder oedema was increased by addition of either sodium chloride or potassium chloride.

Hicks and Pauli (1976) correlated serious udder oedema problems with anaemia in spring season (spring anaemia) and with hypomagnesaemia in summer due to application of excess potassium fertilizer to the crop.

Conway *et al.* (1977) found that more severe udder oedema occurred in heifers than in cows when supplemented with sodium chloride. However, Jones *et al.* (1984) recorded that both heifers and cows were equally affected with udder oedema on sodium chloride supplementation.

Sanders and Sanders (1981 and 1982) suggested that excess dietary potassium was one of the cause for the udder oedema in cows. They also opined that the potassium to calcium and magnesium ratio (cationic ratio) should not be more than 2.2.

Nestor *et al.* (1988) reported that the addition of sodium chloride or potassium bicarbonate to the diet increased the severity of udder oedema.

Vestweber *et al.* (1989) reported that the long held theory of excessive dietary sodium chloride was not the major cause for udder oedema.

2.3.6 Plasma proteins

Larson and Kendall (1957) observed that there was a parallelism between udder oedema and drop in serum protein level at parturition.

Larson and Hays (1958) also stated that the drop in serum protein at parturition resulted in lowered osmotic pressure of blood and subsequent oedema in the udder. They suggested that the drop in serum protein level was due to the passage of globulin from the blood to the mammary gland in the process of transferring passive immunity to newborn calf by way of colostrum. The high

producing cows had more transfer of these immunoglobulins when compared to heifers.

Vestweber and Al-Ani (1984) found that the total protein and globulin in cows with udder oedema and control cows were at their lowest values during parturition; however, the two groups were not significantly different.

Nestor *et al.* (1988) also found that there was drop in the serum protein at parturition. There was a significant correlation between udder oedema score and serum protein values which indicated that the serum protein might be a factor related to the severity of udder oedema.

Rebhun (1995) reported that hypoproteinaemia, especially low albumin fractions in affected cows, might be a factor for the development of udder oedema.

2.3.7 Hormones

Loppnow (1959) and Mittelholzer (1959) reported that over-production of aldosterone, oestrogen and antidiuretic factor were related to oedema of the udder in cows.

Mittelholzer (1959) suggested that the complete change in the hormone dominance of the cows at parturition influenced the ion exchange of connective tissue and favoured retention of sodium which might be a cause for udder oedema.

Malvern *et al.* (1983) found that plasma oestrogens and progesterone had a significant association with mammary oedema during the pre-partum period. They hypothesised that oestrone and oestradiol-17 alpha might promote, whereas progesterone and oestradiol-17 beta might antagonize the development of pre-partum oedema of udder. In addition, oestradiol-17 beta might also antagonize post-partum oedema.

Kellerman and Wendt (1988) found that there were no clear relationship between udder oedema and 17-beta-oestradiol and also recorded lower cortisol level in cows with udder oedema than in normal cows.

Kolk *et al.* (1991) observed that adrenal responsiveness of two heifers with severe udder oedema was impaired after one month of parturition. So they attributed adrenal insufficiency as a cause for udder oedema in heifers.

2.3.8 Miscellaneous factors

Gouge *et al.* (1959) reported that the untrained use of the milking machine elicited the oedema and hyperaemia of udder. They also reported that the failure of "letdown" of milk which was observed in heifers after parturition could cause udder oedema and congestion.

Lamb *et al.* (1979) stated that in unexercised cows, udder oedema occurred earlier when compared to exercised animals during the prepartum period. Exercise did not affect the duration of oedema after calving.

According to Thomas *et al.* (1990) the increased membrane permeability might be the primary cause for udder oedema in cows.

2.4 Type of udder oedema in cows

Oedema of udder occurred normally to a greater or lesser extent in all mammals when parturition approached and during puerperium. At times, the oedematous swelling might be associated with functional disturbances and pathological changes. Differentiation between pathological and physiological oedema of the udder was based upon the fact that the former occurred in association with or without parturition and had an inflammatory or non-inflammatory character (Heidrich and Renk, 1967).

Al-Ani and Vestweber (1986) reported that there were two forms of udder oedema in cattle.

1) Acute or physiological form

2) Chronic or pathological form

The occurrence of oedema was near parturition in the former and during lactation in the latter.

Radostits *et al.* (1994) reported that the congestion of udder at parturition was physiological but it might be significantly severe to cause oedema of the belly, udder and teats in cows. In most cases the oedema disappeared within a day or two of calving, but if it was extensive and persistent, it might interfere with sucking and milking and should be treated.

Rebhun (1995) reported that physiological oedema increased up to calving and then began to reduce gradually over two to four weeks. Pathological oedema persisted longer than physiological oedema. Pathological oedema of udder might also persist for months following parturition and even for the entire lactation.

2.5 Clinical signs

Vigue (1961a), Belloff and Diener (1963) and Al-Ani and Vestweber (1984) observed that the oedematous swelling extended down to the base of the teat. The teats themselves appeared shortened and drawn into the surrounding oedematous udder.

All the four quarters of udder did not show the same amount of oedema. Asymmetrical enlargement of one half or quarter was known as "Skew udder". Oedematous swelling of the udder forced the animal to stand with her hind legs wide apart, with the teats almost reaching the ground, the gait was impeded, difficulty in lying down and getting up and milk usually unchanged. Occasionally the milk might be somewhat reddened, owing to the admixture of some erythrocytes but such discolouration was not unusual for animals fresh in milk without udder oedema. The udder skin was taut, shining, slightly reddened and

somewhat sensitive to pain. The swollen part of udder was cold to feel and known as "Cold oedema" (Heidrich and Renk, 1967).

Clinically, udder oedema had two distinct stages. During the first stage there was a gradual congestion of the skin of the udder. During second stage, digital pressure produced pitting of the oedematous areas, which lasted for several minutes. The udder skin was thick and hard on digital palpation and all four quarters of udder were involved. The base of the teats were also oedematous especially the rear teats. In this condition milking was difficult. Subcutaneous oedema extended from rear udder up to the vulva and from the fore udder to the umbilicus and in extreme cases up to the brisket. (Al-Ani *et al.*, 1985 and Thakur *et al.*, 1989).

Hungerford (1990) described udder oedema as 'rubber bag' or 'leather bag' or 'caked udder' characterised by hardening limited to the floor of all the four quarters of udder, normal milk and sometimes painful udder.

Grant (1996) observed that pathological udder oedema in ewes was characterised by pale, cold to touch, firm with pitting on pressure and with normal teats.

Cook (1998) reported that the extensive oedema of udder occurred in first-calf heifers two days post-partum and all the four teats were cold to touch.

Prasad *et al.* (1999) reported that the udder oedema in a Himalayan goat was bilateral, extending almost the entire teats except the tips. The swollen areas were bulbous in shape at the ventral udder, pinkish in colour and warm but painless.

2.6 Complications of udder oedema

Simpson (1932) reported the subsequent attacks of udder oedema resulted in udder skin necrosis.

Vigue (1961a) observed that udder oedema resulted in shortening of the teats and rigid swelling at their base and caused difficulty in milking. There was poor milk letdown. Frequently, the milk had to be discarded for the presence of blood from ruptured capillaries. The pendulous udder caused the teats to be frequently injured. The weakened oedematous udder was much more susceptible to infections. Most common consequence of severe oedema of mammary gland was complete breakdown of the suspensory ligaments resulting in sagging of the udder.

Cadwallader and McEntee (1966) stated that repeated attacks of udder oedema in cows resulted in scleroderma of udder.

According to Heidrich and Renk (1967) the recrudescent oedema led to permanent enlargement of mammary gland and by stretching and partial tearing of the suspensory apparatus, the udder gradually became a "step or pendulous" resulting in tear on the skin of udder at base of the teats. Occasionally oedematous swelling at the base of the teats extended to entire teats. The swelling and the proximity of the teats to the ground rendered milking most difficult. Pendulous udder and teats were easily prone to injuries. They also observed that the severe thickening of the subcutaneous connective tissue and development of a "Keel" or "Comb" along the median line of the udder skin. Sometimes fibrous thickening extended to the teats led to narrowing of the lumen and teats became shorter and thicker. Thus many good milking cows with normal milk had to be culled simply because of milking difficulties.

Amstutz (1982) reported that in conjunction with the udder oedema, milk production of the herd declined about 50 per cent from its former level. The oedematous udder was warm to touch but the milk was normal initially. When untreated, the affected cows eventually developed mastitis.

Teat injury and occurrence of mastitis were also reported in cows with udder oedema (Vestweber and Al-Ani, 1985;Nestor *et al.*, 1988 and Prabhakar *et al.*, 1991)

Al-Ani *et al.* (1985) and Thakur *et al.* (1989) found several areas of separation in the skin of the oedematous udder which allowed exudation of clear straw coloured fluid in severely affected cases.

Rebhun (1995) reported that the interstitial oedema in mammary gland caused pressure differentials that interfered with normal production and letdown of milk. Chronic or pathological oedema had a negative effect on the lactational potential, as these cattle never reached their projected production.

Cook (1998) reported that severe udder oedema of dairy heifers caused large areas of darkening, necrosis and sloughing of the skin of the udder.

2.7 Udder measurements and oedema scoring system

Greenhalgh and Gardner (1958) reported that the judgement by visual inspection appeared to be a more satisfactory method of assessing the severity of the udder oedema than measuring of length and width of the udder.

Mitchell *et al.* (1976), Dentine and McDaniel (1983 and 1984), Al-Ani *et al.*, (1985) and Nestor *et al.* (1988) reported that the score from one to five could be applied for udder oedema, in which, one - no oedema; two - slight oedema (oedema at the base of the udder and around the teats); three - moderate oedema (swelling covering the lower half of the udder); four - severe oedema (almost the entire udder oedematous); five - very severe oedema (the entire udder oedematous and some oedema on the brisket, thighs, or both).

Sigmund (1981) reported that the cows with udder oedema had large basal circumference of the udder.

Nestor *et al.* (1988) found that the oedema score was higher in Jersey than Holstein cows and their mean values were 3.70±0.10 and 3.30±0.08, respectively.

2.8 Complete blood count (CBC) in early post-partum period and in cows with udder oedema

Agarwal *et al.* (1965) reported neutrophilia in freshly calved Haryana cows.

Larson *et al.* (1980) reported that the mean PCV and Hb values in dairy cattle during 14 to 21 days post-partum were 31.1±0.34 per cent and 12.1±0.18g/100 ml, respectively.

Rao *et al.* (1981) observed that there was non-significant decrease in mean PCV level in recently calved Ongole cows when compared to normal cycling cows. The mean PCV levels in recently calved and normal cycling Ongole cows were 26.83±0.95 and 28.94±0.93 per cent, respectively.

Sanders and Sanders (1981) reported that the haemogram was found to be normal in dairy cows with udder oedema when compared to control cows.

According to Jones *et al.* (1984) there was mild anaemia (approximately 8.0 g/dl haemoglobin) in two out of six Friesian cows with udder oedema.

Prasad *et al.* (1987) recorded that the total leucocyte count (TLC), mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH) values were high in recently calved dairy cows. They also recorded eosinophilia in recently calved dairy cows. The mean values of Hb, PCV, total erythrocyte count, MCV, MCH and MCHC were 9.23±0.31 g/dl, 30.71±0.81 per cent, 4.18±0.42 x 10^6/µl, 77.72±7.06 fl, 23.24±1.96 pg and 30.02±0.45 per cent, respectively. They also stated that the mean total leucocyte count, neutrophils, lymphocytes, eosinophils, monocytes and basophils were 12.34±1.34 x 10^3/µl, 23.71±3.58 per cent, 62.71±3.98 per cent, 11.14±1.24 per cent, 2.43±0.61 per cent and 0.28±0.18 per cent, respectively.

The mean haematocrit values of Holstein and Jersey cows with udder oedema were 35.40±0.40 and 34.30±0.40 per cent, respectively. The mean haematocrit values of both the breeds combined together on the first day, third day and tenth day post-partum were 36.80±0.45, 35.00±0.44 and 33.50±0.44 per cent, respectively (Nestor *et al.*, 1988).

Vestweber *et al.* (1989) reported that the PCV in Holstein cows with udder oedema at parturition and 210 minutes after intravenous treatment with 500 mg of Frusemide were 31.08±2.66 and 34.00 per cent, respectively.

Rajora and Pachauri(1994) reported that the mean PCV level in healthy dairy cows during first week of post-partum was 0.267±0.011/l.

Grant (1996) noted no abnormalities in haemogram of ewes with udder oedema.

2.9 Serum biochemical changes in early post-partum and in cows with udder oedema

Randall *et al.* (1974) reported that correlation co-efficient of blood serum protein, potassium, sodium and osmolarity with udder oedema were small.

2.9.1 Total serum protein

Vestweber and Al-Ani (1984) reported that the mean concentration of total serum protein in cows with and without udder oedema at prepartum, partum and post-partum periods did not differ significantly.

Prasad *et al.* (1987) noted that the mean total serum protein level in crossbred cows during early post-partum was 6.28±0.08 g/dl.

Nestor *et al.* (1988) reported that the mean total serum protein level in Holstein and Jersey cows affected with udder oedema were 7.31±0.9 and

6.91±0.8 g/dl, respectively. They also reported that the mean total serum protein value of both breeds combined together at first day, third day and tenth day post-partum were 6.84±0.9, 7.03±0.9 and 7.65±0.9 g/dl, respectively.

Pandey and Parai (1989) reported that the total serum protein value remained unaffected by calving.

Kolk *et al.* (1991) observed that the plasma total protein values in Holstein-Friesian cows with udder oedema were within the normal range.

Rajora and Pachauri(1994) stated that the mean total serum protein value of healthy cows during first week after parturition was 70.714±2.485 g/l.

Haloi *et al.* (1997) reported that the mean total serum protein value in healthy cows during post-partum period was 7.98±0.05 g/dl.

2.9.2 Serum albumin

Vestweber and Al-Ani (1984) reported that the mean serum albumin levels in cows with udder oedema and without udder oedema at prepartum, partum and two weeks post-partum periods did not differ significantly.

Rajora and Pachauri(1994) reported that the mean serum albumin level in healthy cows one week post-partum was 29.286±0.680 g/l.

Sivaraman and Thiagarajan (1994) stated that the mean serum albumin value in early lactating Jersey crossbred cows was 2.58±0.04 g/dl.

Haloi *et al.* (1997) recorded mean serum albumin level of 4.09±0.05 g/dl in healthy cows during post-partum period.

Cook (1998) reported that the first-calf heifers with udder oedema had normal serum albumin levels.

2.9.3 Serum globulin

Vestweber and Al-Ani (1984) reported that the mean serum globulin levels in cows with and without udder oedema at prepartum, partum and two weeks post-partum periods did not differ significantly.

Rajora and Pachauri(1994) observed that mean serum globulin level was 41.429±1.962 g/l in dairy cows during the first post-partum week.

2.9.4 Albumin:Globulin ratio (A:G ratio)

The mean A:G ratio in healthy cows during first post-partum week was 0.713±0.026 (Rajora and Pachauri1994).

Haloi *et al.* (1997) noted the mean A:G ratio of 1.09±0.03 in healthy cows during post-partum period.

2.9.5 Serum glucose

According to Rao *et al.* (1981) the normal mean serum glucose level in recently calved Ongole cows was 37.11±1.27 mg/dl.

Gupta and Rai (1987) reported that the mean serum glucose values recently calved cattle within 34 to 36 h and five to seven days post-partum were 49.16±12.63 and 48.74±10.68 mg/dl, respectively.

Prasad *et al.* (1987) reported that the mean serum glucose level in cows at early post-partum period was 57.06±4.15 mg/dl.

Pandey and Parai (1989) reported that the mean serum glucose value in healthy cows at calving was 41.73±0.71 mg/dl. They also found that there was a decreasing trend for mean serum glucose level after calving and it got reduced from 41.73±0.71 to 36.76±0.41 mg/dl. The decline continued for almost one month after calving.

Vestweber *et al.* (1989) observed no significant change in the mean serum glucose levels in the Holstein cows with and without udder oedema at parturition and the mean values were 60.85±14.90 and 57.58±13.92 mg/dl, respectively.

Rajora and Pachauri(1994) reported a decreased mean serum glucose value (2.950±0.412 mmol/l) in apparently healthy cows during first post-partum week.

Sivaraman and Thiagarajan (1994) reported that the mean serum glucose level in early lactating Jersey crossbred cows was 35.46±2.04 mg/dl.

According to Gupta *et al.* (1995) the mean serum glucose level in healthy cows one month after calving was 53.88±11.59 mg/dl.

Haloi *et al.* (1997) recorded that the mean serum glucose value in healthy cows during post-partum period was 56.82±0.89 mg/dl.

2.9.6 Serum sodium

Murtuza *et al.* (1979) reported that the mean serum sodium value in Haryana cattle at late pregnancy and early lactation were 139.87±1.18 and 133.87±3.31 mEq/l, respectively.

Sanders and Sanders (1981) recorded 140 to 142 mEq/l of serum sodium level in dairy cows affected with udder oedema.

The serum sodium level in Holstein cows with udder oedema was found to be normal (Jones *et al.*, 1984).

Vestweber and Al-Ani (1984) reported that the mean serum sodium levels in cows with and without udder oedema before parturition, at parturition and two weeks following parturition did not differ significantly.

Prasad *et al.* (1987) reported that the mean serum sodium level in recently calved crossbred cows was 137.43±2.57 mEq/l.

According to Vestweber *et al.* (1989) the mean value of serum sodium in Holstein cows with and without udder oedema at parturition were 145.08±4.57 and 144.33±2.71 mEq/l, respectively.

Kolk *et al.* (1991) reported that plasma sodium level was found to be normal in Holstein-Friesian cows affected with udder oedema.

Cook (1998) reported that the serum sodium level was found to be normal in first-calf dairy heifers with udder oedema.

2.9.7 Serum potassium

Murtuza *et al.* (1979) recorded that the mean serum potassium values in Haryana cattle at late pregnancy and early lactation were 4.27±0.15 mEq/l and 4.89±0.09 mEq/l, respectively.

Sanders and Sanders (1981) noted that the mean serum potassium value in dairy cows affected with udder oedema varied between 5.5 to 6.5 mEq/l.

Jones *et al.* (1984) observed that the serum potassium level in Holstein cows affected with udder oedema were found to be normal.

Vestweber and Al-Ani (1984) reported that the mean serum potassium levels in cows with and without udder oedema before parturition, at parturition and two weeks following parturition did not differ significantly.

Prasad *et al.* (1987) recorded that the mean serum potassium value in recently calved crossbred cows was 4.76±0.21 mEq/l.

According to Vestweber *et al.* (1989) the mean serum potassium values in Holstein cows with and without udder oedema at parturition were 4.27±0.31 and 4.14±0.17 mEq/l, respectively.

Kolk *et al.* (1991) noted that the serum potassium levels in Holstein-Friesian cows with udder oedema were found to be normal.

Cook (1998) recorded the range of serum potassium level as normal in first-calf heifers with udder oedema.

Tripathi (1999) stated that the serum potassium levels were only a rough guide to note potassium depletion because potassium was primarily an intracellular ion.

2.9.9 Serum calcium

According to Murtuza *et al.* (1979) the mean serum calcium levels in Haryana cattle during late pregnancy and early lactation were 11.22±0.40 and 9.85±0.10 mg/dl, respectively.

Larson *et al.* (1980) found that the mean serum calcium level in dairy cattle 14 to 21 days post-partum was 8.24±0.26 mg/dl.

The normal mean serum calcium level of recently calved Ongole cows was 10.42±0.35 mg/dl (Rao *et al.*, 1981).

Jones *et al.* (1984) recorded the serum calcium level as normal in Holstein cows affected with udder oedema.

Vestweber and Al-Ani (1984) reported that the mean serum calcium levels in cows with and without udder oedema before parturition, at parturition and two weeks following parturition did not differ significantly.

Gupta and Rai (1987) reported that the mean serum calcium levels in recently calved healthy cows within 34 to 36 h and five to seven days post-partum were 10.08±1.24 and 11.00±0.96 mg/dl, respectively.

The mean serum calcium level in crossbred cows during early post-partum was 8.79±0.43mg/dl (Prasad *et al.*, 1987).

The mean serum calcium levels in Holstein and Jersey cows with udder oedema were 9.99±0.28 and 9.21±0.30 mg/dl, respectively. The mean serum calcium level in both the breeds combined together were 9.10±0.37, 9.43±0.36 and 10.58±0.37 mg/dl during first, third and tenth days of post-partum period, respectively (Nestor *et al.*, 1988).

Pandey and Parai (1989) reported that the mean serum calcium level in healthy cows at calving was 8.92±0.18 mg/dl.

Vestweber *et al.* (1989) observed that the mean serum calcium levels in Holstein cows with and without udder oedema at parturition were 8.48±0.73 and 8.39±1.02 mg/dl, respectively.

Rajora and Pachauri(1994) reported that the mean serum calcium level in healthy cows during first post-partum week was more than that of pre-partum period. The values in pre-partum and first post-partum week were 1.846±0.057 and 2.10±0.125 mmol/l, respectively.

2.9.10 Serum inorganic phosphorus

According to Murtuza *et al.* (1979) the normal mean serum phosphorus levels in Haryana cattle during late pregnancy and early lactation were 5.24±0.43 and 3.44±0.13 mg/dl, respectively.

Rao *et al.* (1981) reported that the mean serum phosphorus level in recently calved Ongole cows was 5.16±0.29 mg/dl.

Vestweber and Al-Ani (1984) reported that the mean serum phosphorus levels in cows with and without udder oedema before parturition, at parturition and two weeks following parturition did not differ significantly.

Gupta and Rai (1987) recorded decreased serum phosphorus values in healthy cows within 34 to 36 h and five to seven days post-partum period and the values were 4.48±0.39 and 4.86±0.47 mg/dl, respectively. They also suggested that the change in dietary calcium:phosphorus ratio (Ca:P ratio) during early part of lactation and decreased level of parathormone after three to four days post-partum might be responsible for hypophosphataemia.

Prasad *et al.* (1987) reported that the mean serum phosphorus level in crossbred cows during early post-partum period was 5.47±0.27 mg/dl.

Pandey and Parai (1989) recorded that the mean serum phosphorus value of healthy cows at calving was 4.08±0.42 mg/dl.

Vestweber *et al.* (1989) observed that the mean serum phosphorus values in Holstein cows with and without udder oedema were 5.25±0.93 and 4.89±0.94 mg/dl, respectively.

Rajora and Pachauri(1994) reported that there was a non-significant increase in mean serum phosphorus level after parturition when compared to pre-partum period. The values were 1.522±0.039 and 1.771±0.092 mmol/l during pre-partum and first post-partum week, respectively.

According to Gupta *et al.* (1995) the mean serum phosphorus level in healthy cows one month post-partum was 5.69±0.38 mg/dl.

2.9.11 Serum magnesium

Murtuza *et al.* (1979) reported that the normal mean serum magnesium levels in Haryana cattle during late gestation and early lactation were 2.17±0.09 and 2.28±0.12 mg/dl, respectively.

Larson *et al.* (1980) observed that the mean serum magnesium level in dairy cattle during 14 to 21 days post-partum period was 2.24±0.08 mg/dl.

Rao *et al.* (1981) reported the normal serum magnesium level (3.47±0.23 mg/dl) in recently calved Ongole cows.

Jones *et al.* (1984) reported that the serum magnesium levels in Friesian cows affected with udder oedema after parturition were found to be normal.

Gupta and Rai (1987) reported that the mean serum magnesium values of cows during 34 to 36 h and five to seven days post-partum period were 2.10±0.26 and 2.21±0.24 mg/dl, respectively.

Prasad *et al.* (1987) observed that the mean serum magnesium level of healthy cows at calving was 3.024±0.136 mg/dl.

Rajora and Pachauri(1994) reported that there was increased serum magnesium level in first post-partum week when compared to pre-partum period. The mean serum magnesium levels were 1.040±0.51 and 1.189±0.77 mmol/l during prepartum and first post-partum week, respectively.

2.9.12 Serum aspartate aminotransferase (AST)

According to Prasad *et al.* (1987) the normal mean serum AST value of crossbred cows during early post-partum period was 30.63±2.27 units/ml.

Sivaraman and Thiagarajan (1994) reported that the mean serum AST value of early lactating Jersey crossbred cows was 28.34±2.24 units/ml.

Haloi *et al.* (1997) reported that the mean AST value of healthy cows during post-partum period was 41.92±0.79 units/ml.

2.9.13 Serum creatinine

Vestweber *et al.* (1989) observed that the mean serum creatinine value in Holstein cows with and without udder oedema at parturition were 1.27±0.37 and 1.34±0.22 mg/dl, respectively.

2.9.14 Blood urea nitrogen (BUN)

Rao *et al.* (1981) stated that the mean BUN level in recently calved Ongole cows was 19.57±0.75 mg/dl.

Jones *et al.* (1984) reported that the BUN levels in Friesian cows affected with udder oedema were normal.

Vestweber *et al.* (1989) observed that the mean values in Holstein cows with and without udder oedema at parturition were 16.77±2.89 and 16.50±4.42 mg/dl, respectively.

2.10 Normal haematological and biochemical values in cattle

Aleyas and Alikutty (1973) reported the following haematological values in healthy Jersey and crossbred (Jersey x Sindhi) cows.

Parameters	Mean values	
	Jersey	Crossbred
1. PCV (%)	36.00	28.58
2. Hb (g/dl)	10.28	9.10
3. TEC ($x10^6$/cmm)	5.33	5.19
4. TLC (/cmm)	7479	7963
5. Differential leucocyte count		
i) Lymphocytes (%)	66.91	59.66
ii) Neutrophils (%)	17.25	28.91
iii) Monocytes (%)	13.58	9.00
iv) Eosinophils (%)	2.08	2.25
v) Basophils (%)	0.17	0.16

Jain (1986) reported the following haematological values in healthy cattle.

Parameters	Range	Average
1. Erythrocytes ($x10^6/\mu l$)	5.0-10.0	7.0
2. Haemoglobin (g/dl)	8.0-15.0	11.0
3. PCV (%)	24.0-46.0	35.0
4. MCV (fl)	40.0-60.0	52.0
5. MCH (pg)	11.0-17.0	14.0
6. MCHC (%)	30.0-36.0	32.7
7. Leucocytes (/µl)	4000-12000	8000
8. Differential leucocyte counts (Absolute)		
i) Neutrophils	600-4000	2000
ii) Lymphocytes	2500-7500	4500
iii) Eosinophils	0-2400	700
iv) Monocytes	25-840	400
v) Basophils	0-200	50

Khatsu (1994) reported the following haematobiochemical values of healthy cows.

Parameters	Mean ± SE values
1. PCV (%)	29.86 ± 0.62
2. Hb (g %)	11.17 ± 0.23
3. TEC (millions/cmm)	6.21 ± 0.31
4. TLC (thousands/cmm)	4.83 ± 0.29
5. Differential leucocyte count	
i) Lymphocytes	62.57 ± 2.43
ii) Neutrophils	30.00 ± 2.16
iii) Eosinophils	6.71 ± 0.85
iv) Basophils	0.21 ± 0.11
v) Monocytes	0.5 ± 0.17
6. Serum glucose (mg/dl)	49.94 ± 1.34
7. BUN (mg/dl)	21.91 ± 2.24
8. Serum calcium (mg/dl)	9.7 ± 0.21
9. Serum phosphorus (mg/dl)	5.29 ± 0.22
10. Serum magnesium (mg/dl)	2.28 ± 0.12
11. Total serum protein (g/dl)	7.89 ± 0.32
12. Serum albumin (g/dl)	3.38 ± 0.13
13. A:G ratio	0.80 ± 0.07
14. Serum sodium (mEq/l)	134.81 ± 1.26
15. Serum potassium (mEq/l)	4.72 ± 0.20

2.11 Examination of milk

Sanders and Sanders (1981) reported that the results of California mastitis test (CMT) and milk culture were negative in dairy cows with chronic udder oedema.

Jones *et al.* (1984) reported that there was normal milk cell counts in Friesian and Shorthorn cows with chronic udder oedema.

The cultural examination of milk samples did not reveal any bacterial or fungal infection in cows with udder oedema (Thakur *et al.*, 1989 and Prabhakar *et al.*, 1991).

Grant (1996) reported no organisms in the milk of ewes affected with udder oedema.

2.12 Urinalysis

2.12.1 Specific gravity

Benjamin (1985) reported that the specific gravity of urine in cattle ranged between 1.025 to 1.045 and its mean value was 1.035.

Vestweber *et al.* (1989) reported that the specific gravity of urine in cows with and without udder oedema at parturition were 1.02±0.01 and 1.03±0.01, respectively.

2.12.2 pH

Benjamin (1985) reported that the normal healthy cattle had alkaline urine and pH ranged between 7.4 to 8.4.

Vestweber *et al.* (1989) reported that the pH of urine in cows with and without udder oedema at parturition were 8.23±0.33 and 8.10±0.49, respectively.

2.13 Treatment

Gouge *et al.* (1959) reported that treatment with acetazolamide was successful in pre-parturient and post-parturient udder oedema in cows.

Mittelholzer (1959) reported that diuretic drugs were extensively used for the treatment of udder oedema in cattle, but unlike human oedema, the effect of diuretics on bovine udder oedema was slower to appear under field conditions.

Cowie (1960) stated that the intravenous dose of 100 to 150 mg of Hydrochlorothiazide in addition to the intramuscular dose might be required to treat chronic udder oedema in cattle.

Vigue (1961a) reported that the cows with udder oedema recovered within four to seven days following administration of 250 mg of hydrochlorothiazide intramuscularly every 48 h.

Vigue (1961b) reported that the average duration of udder oedema in the cows treated with two grams of sodium acetazolamide twice daily orally per cow was 10.0 days, while the control cows with udder oedema receiving a placebo had an average recovery time of 19.2 days. The difference between the two mean recovery times was highly significant.

Ansari and Prasad (1970) stated that the fruits of *Tribulus terrestris* Linn. could be used as diuretic, tonic, promote strength and digestive power.

The roots, leaves and fruits of *Tribulus terrestris* Linn. (Neringil) were having diuretic properties. In south India, there was a method of administration, in which the fruits and roots were boiled with rice to form a medicated water, which was taken in large quantities. The decoction prepared from fruits could also be used. The drug undoubtedly had diuretic properties, but showed no advantage over many of the diuretics in the British pharmacopoeia. The diuretic properties were

due to the large quantities of the nitrates as well as the essential oils which were present in the seeds (Dried fruits) (Kirtikar and Basu, 1975 and Nadkarni, 1982).

Ahlers (1977) and Vestweber *et al.* (1989) found that among the diuretics, frusemide was the most potent diuretic with rapid onset of action (two to five minutes) and short duration of action. An intramuscular or intravenous dose of 500 mg once a day or 250 mg twice daily was effective in treating udder oedema in cows.

Amstutz (1982) and Vestweber *et al.* (1989) reported that the most common treatment for udder oedema in cows was administration of diuretics and corticosteroids, singly or in combination. Other treatments included application of hot and cold compresses, use of udder supports, milking prior to parturition, frequent milking (three to four times daily), reduced salt intake, forced exercise and induction of parturition.

Thakur *et al.* (1989) reported that udder oedema in cows was treated successfully by massaging the udder together with application of hot and cold water, application of thrombophob ointment twice daily on the oedematous part, potassium nitrate 6 gm daily orally and frusemide 300 mg intramuscularly once a day for three days followed by 200 mg daily, till recovery. Corticosteroid like dexamethasone at the dose rate of 8 mg per animal by intramuscular route was also given.

Hungerford (1990) reported that udder oedema could be managed by bathing and massage of the udder together with frusemide at the dose of 500 mg per 450 kg body weight by slow intravenous or intramuscular injections

Jackson (1996) stated that the overzealous use of loop diuretics could cause serious depletion of total body sodium. The increased delivery of sodium ion to the distal tubule, particularly when combined with activation of the renin-angiotension system, lead to increased urinary excretion of potassium ion and

hydrogen ion causing a systemic alkalosis. He also stated if the dietary potassium intake was not sufficient during the diuretic treatment period, hypokalaemia might develop. Increased magnesium ion and calcium ion excretion through urine might lead to hypomagnesaemia and hypocalcaemia, respectively.

Whitaker (1998) reported that pre-partum milking was practised by many with apparent success in preventing the occurrence of udder oedema.

2.14 Prevention and control

Sanders and Sanders (1981) stated that udder oedema in cows could be prevented by feeding reduced potassium in the ration.

Thomas *et al.* (1990) opined that pre-partum supplementation of vitamin E might prevent udder oedema in cows.

Lema *et al.* (1992) reported that the pre-partum feeding of calcium chloride reduced the severity of udder oedema in Holstein heifers.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study was conducted in the Department of Clinical Medicine, College of Veterinary and Animal Sciences, Mannuthy for a period of three semesters, during the year 1999 and 2000.

Twenty crossbred cows affected with post-partum udder oedema, persisting even after four days of calving, in and around Thrissur were used for the study. They were subjected to metabolic profile test and were randomly divided into two experimental groups for treatment trials. During the course of treatment three animals from group I and one animal from group II developed mastitis and they were excluded from the study. However, their pre-treatment values were used to compare with healthy control cows.

Six apparently healthy cows maintained under similar field conditions during first post-partum week were selected as control and were subjected to metabolic profile test.

3.1 Experimental design

Group	Animals	Procedure adapted	Therapy	Remarks
I	Ten cows with post-Partum udder oedema	Clinical materials collected and analysed before and after treatment	Frusemide @ 1 mg/kg body weight intramuscularly twice daily	Three animals developed mastitis
II	Ten cows with post-partum udder oedema	-do-	Drenched with 250 ml of freshly prepared decoction obtained from the fruits of indigenous plant *Tribulus terrestris* Linn (Neringil - Malayalam) twice daily	One animal developed mastitis
III	Six healthy control cows	Clinical materials collected once and analysed	No treatment	

3.2 Parameters studied

3.2.1 History

3.2.2 Clinical signs

3.2.3 Complete blood count (CBC)

a) Packed cell volume (PCV) (per cent)

b) Haemoglobin (Hb) (g/dl)

c) Total Erythrocyte count (TEC) ($x10^6$/cmm)

d) Erythrocytic indices

i) Mean corpuscular volume (MCV) (fl)

ii) Mean corpuscular haemoglobin (MCH) (pg)

iii) Mean corpuscular haemoglobin concentration (MCHC) (per cent)

e) Total Leucocyte count (TLC) (/cmm)

f) Differential Leucocyte count (DLC) - Absolute and Relative Counts

3.2.4 Metabolic profile test (Serum biochemistry)

a) Total serum protein (g/dl)

b) Serum albumin (g/dl)

c) Serum globulin (g/dl)

d) Albumin:Globulin ratio (A:G ratio)

e) Serum aspartate aminotransferase (AST) (IU/l)

f) Serum sodium and potassium (mEq/l)

g) Serum calcium (mg/dl)

h) Serum inorganic phosphorus (mg/dl)

i) Serum magnesium (mg/dl)

j) Serum glucose (mg/dl)

k) Blood urea nitrogen (BUN) (mg/dl)

l) Serum creatinine (mg/dl)

3.2.5 Urinalysis (Qualitative)

a) Physical characters

i) Colour

ii) Specific gravity

iii) Transparency

b) Chemical characters

i) pH

ii) Protein

iii) Ketone bodies

iv) Glucose

v) Blood

vi) Bile salts

vii) Bile pigments

3.2.6 Special examination of udder

Detailed history and results of clinical examination of udder were recorded before and after treatment in the proforma (Annexure-I).

Special examination of udder was conducted before and after treatment as per the following modified protocol suggested by Rosenberger (1979).

a) Circumference of the udder (cm)

b) Circumference and length of teats (cm)

c) Distance between teat tip and the ground (cm)

The measurement was taken from the ground to the teat tip of the udder with severe oedema.

d) Palpation of udder and teats

e) Extent of oedema

f) Clinical examination of milk which included the following

i) Visual examination

ii) Cultural examination of milk

g) Subjective udder oedema score was recorded before treatment as per Mitchell *et al.* (1976) and Al-Ani and Vestweber (1984).

3.3 Procedures adapted

3.3.1 Complete blood count (CBC)

Blood sample (approximately 2.5 ml) was collected from jugular vein of each animal before and after treatment in a sterile vial with EDTA (1 mg per ml of blood) for the haemogram. Complete blood count was done as per Schalm *et al.* (1975).

3.3.2 Serum biochemistry

Blood sample (approximately 10 ml) was collected from jugular vein of each animal before and after treatment in a sterile screw capped test tube without anticoagulant for serum separation.

All the biochemical analyses were carried out by using photometer 5010 (Boehringer Mannheim) under standard conditions of operation.

a) Total serum protein: Biuret method (Weichselbaum, 1946).
b) Serum albumin: Bromocresol-green method (Doumas, 1971).
c) Serum globulin and A:G ratio: Calculated from values of total protein and albumin (Benjamin, 1985).
d) Serum aspartate aminotransferase (AST): Modified International Federation of clinical chemistry (IFCC) method (Anonymous, 1986).
e) Serum sodium and potassium: Flame photometer (Oser, 1971).
f) Serum calcium: O-cresolphthalein complexone, without deproteinization (Raysarkar and Chauhan, 1967).
g) Serum inorganic phosphorus: Modified metol method (Morin and Prox, 1973).

h) Serum magnesium: Modified Orange and Rhein method (Orange and Rhein, 1951).

i) Serum glucose: Enzymatic colorimetric method (Trinder, 1969).

j) Blood urea nitrogen (BUN): Blood urea was estimated by Diacetyl monoxime (DAM) method (Marsh *et al.*, 1965). Blood urea nitrogen was calculated by multiplying blood urea value with the factor 0.467.

k) Serum creatinine: Jaffe method, without deproteinization (Bartels, 1971).

3.3.3 Urinalysis

Physical and chemical characters of urine were assessed as per Benjamin (1985).

3.4 Treatment

Group I: Animals were treated with Frusemide* at the dose rate of 1 mg per kg body weight intramuscularly twice daily till recovery.

Group II: Animals were drenched with 250 ml of freshly prepared decoction obtained from the dried fruits of indigenous plant *Tribulus terrestris* Linn (Neringil - Malayalam) twice daily till recovery.

3.4.1 Preparation of decoction

Hundred grams of dried fruits of *Tribulus terrestris* Linn was soaked in one litre of water over night. Then it was boiled and concentrated to become 500 ml. The decoction was obtained by decantation.

3.5 Statistical analysis

The data collected were analysed with student's 't' test and paired 't' test as per Snedecor and Cochran (1980).

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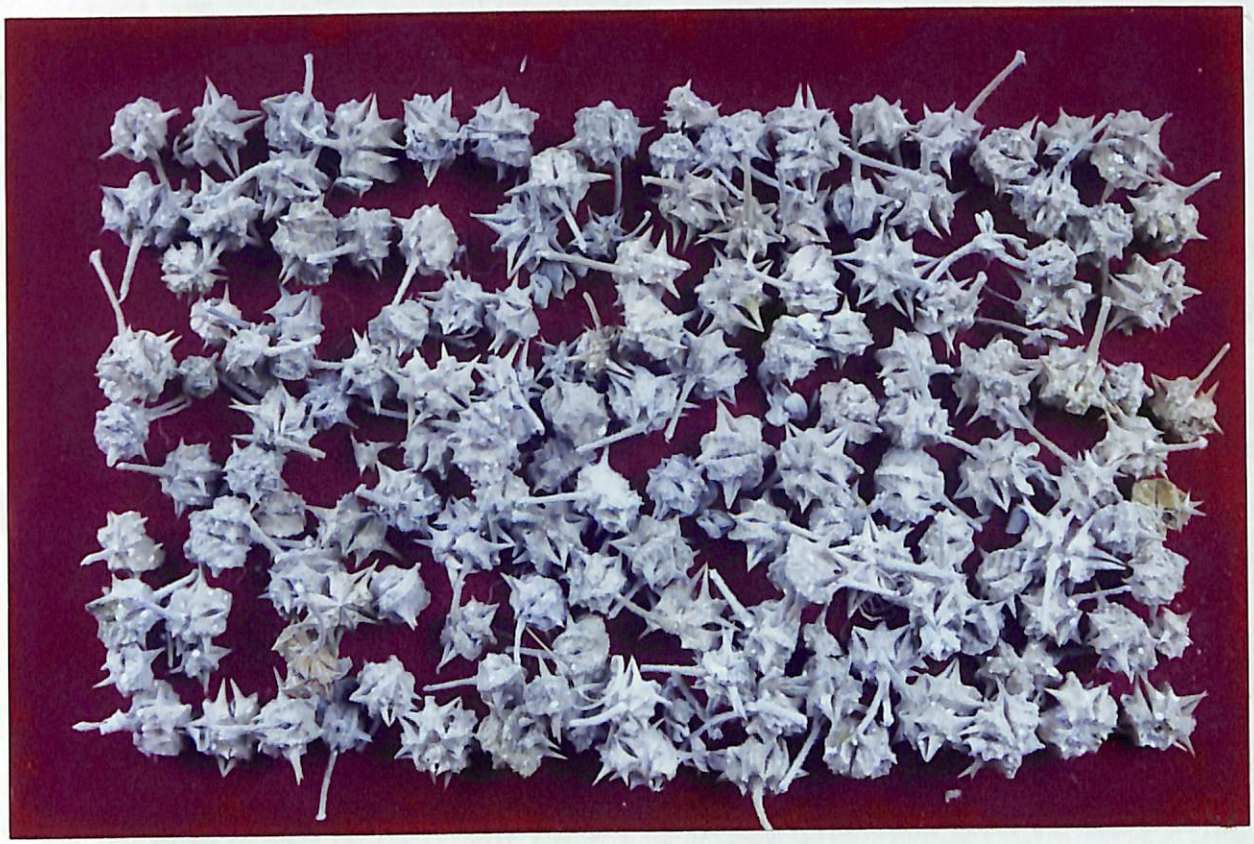
* LASIX - Frusemide, 20 mg/2ml, Hoechst, Mumbai, India.

Plate 1. Dried fruits (seeds) of *Tribulus terrestris* Linn (Neringil - Malayalam)



RESULTS

4. RESULTS

Results of the parameters studied viz., haemogram, metabolic profile test (serum biochemistry), udder measurements and urinalysis were statistically analysed and presented.

4.1 History and Epidemiology

Out of twenty cows studied, fourteen cows (70 per cent) developed udder oedema two to three days prior to parturition, two animals (10 per cent) eight to ten days prior to parturition and four animals (20 per cent) on the day of parturition. Oedema persisted in all the cows even after three to four days post-partum.

Eleven animals were primiparous (55 per cent), seven in second calving (35 per cent) and two in the third calving (10 per cent).

Average age at first calving was higher in first-calf heifers with udder oedema (43.18 months) than control heifers without udder oedema (40 months).

Cows with female calves had more incidence of udder oedema (60 per cent) than cows with male calves (40 per cent).

The owners were feeding these cows with more of concentrates (approximately three to five kilograms) per animal per day and were reducing the fodder feeding during the last trimester of gestation. Apart from the salt content of concentrates (5 per cent salt), these cows which developed udder oedema were fed with an additional amount of 75 to 150 g salt per day during the last trimester of gestation and early post-partum period. These animals were not let out for grazing during the last trimester of gestation. Most of the animals were kept indoor without much exercise throughout the gestation period.

4.2 Clinical signs

Results of clinical observations were recorded as per the proforma (Annexure I). Two cows (10 per cent) had very severe udder oedema (oedema extended up to the brisket in front and up to the escutcheon region towards the back of the udder) (Plate 8 and 10), twelve cows (60 per cent) had severe udder oedema (oedema up to umbilicus) (Plate 2) and six cows (30 per cent) had moderate udder oedema (oedema mostly confined to the udder and rarely extended around the udder) (Plate 3). Twelve cows showed severe udder oedema in the fore quarters when compared to hind quarters. Four cows showed severe oedema in the hind quarters (Plate 4) and remaining four cows showed equally severe oedema in hind and fore quarters.

The oedematous udder was pale to pinkish in colour, cold to slightly warm, pitting on pressure and painful. Udder oedema extended up to the base of teats in eleven animals (Plate 2 and 5). Other animals did not show any oedema of the teats on visual inspection. However, in these animals the teats were drawn little bit into the oedematous udder (Plate 6) and led to difficulty in milking. Complete milking was impossible in all the cases.

The milk samples were apparently normal in fourteen cows and six animals showed mild haemagalactia. Milk samples from all the animals with udder oedema showed absence of growth in bacteriological media. Apart from the udder involvement the animals were apparently normal clinically. Feeding habit, rumination, defecation and micturition were normal. The body temperature, pulse and respiratory rates were within the normal range and their mean values were 101.14 ± 0.12°F, 60.60 ± 0.81 / min and 30.20 ± 0.67 / min, respectively.

The mean body temperature, pulse and respiratory rates of healthy control cows were 101.03 ± 0.50°F, 59.67 ± 1.61 / min and 29.67 ± 1.84 / min, respectively.

Plate 2. **Cow with severe udder oedema extended upto umbilicus and base of teats**

Plate 3. **Cow with moderate udder oedema with shortened teats**

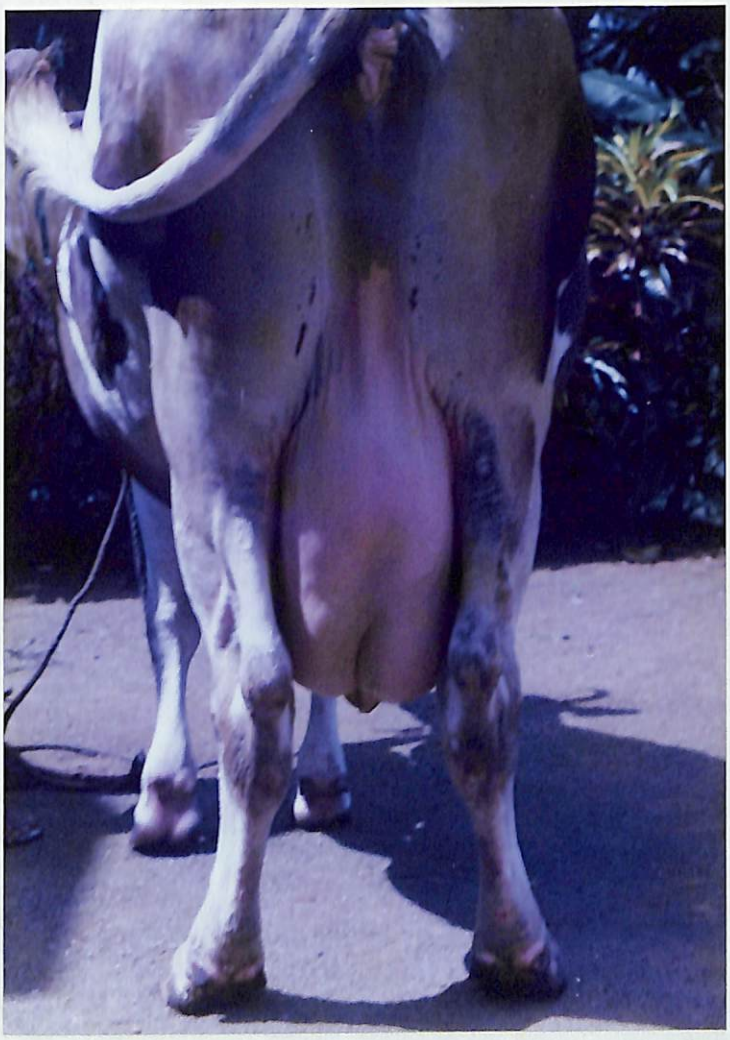
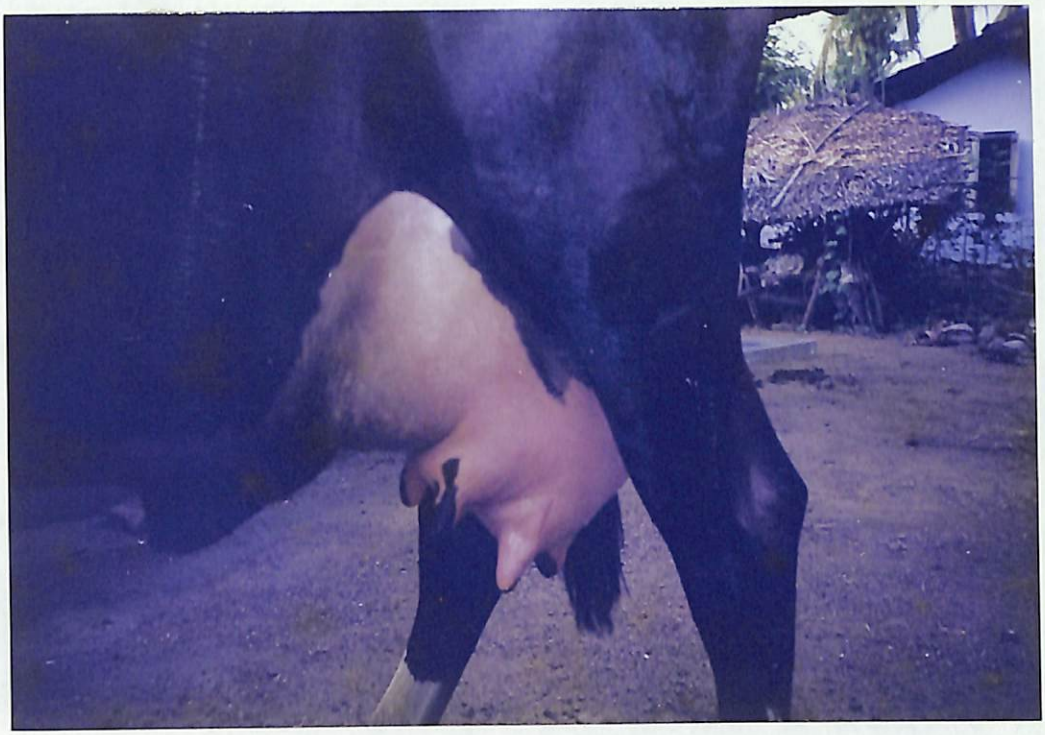


Plate 4. **Cow with moderate udder oedema with more involvement of hind quarters**

Plate 5. **Cow with udder oedema extended upto escutcheon with oedematous teats**



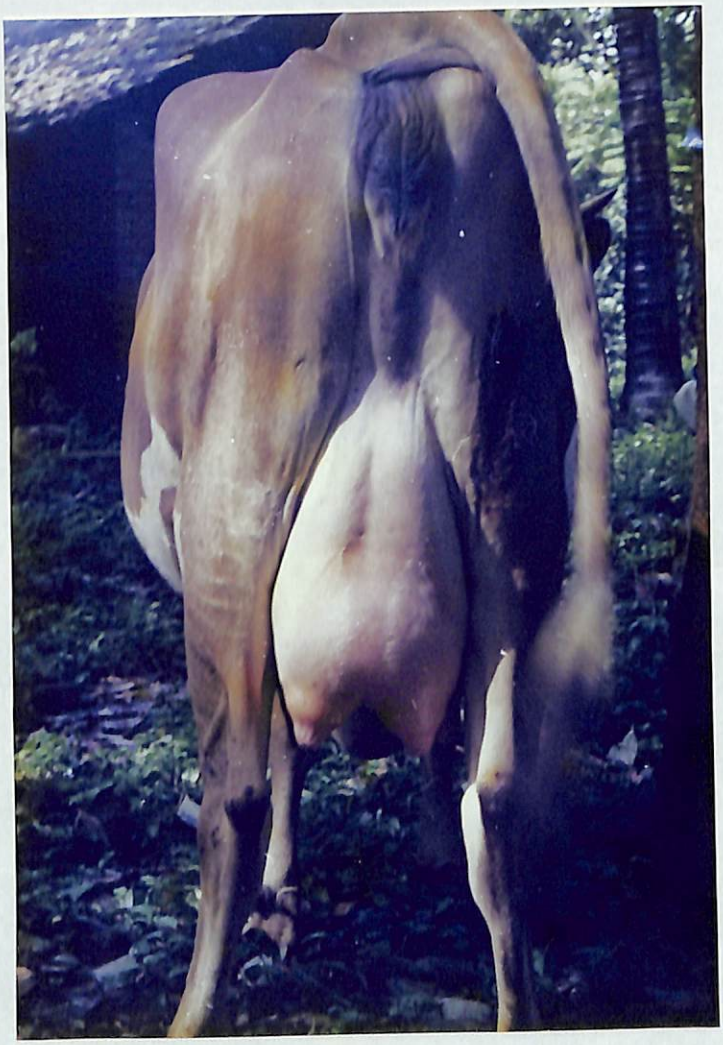


Plate 6. **Cow with udder oedema - Hind teats drawn little bit into the odematous udder and base of fore teats oedematous (Before treatment with *Tribulus terrestris* Linn)**

Plate 7. **After treatment with *Tribulus terrestris* Linn (3 days) udder showed the normal architecture**

Plate 8. **Cow with very severe udder oedema - oedema extended from the escutcheon to the brisket region (Before treatment with *Tribulus terrestris* Linn)**

Plate 9. **After treatment with *Tribulus terrestris* Linn (6 days) udder oedema completely relieved**

Plate 10. Cow with very severe udder oedema extended forward beyond the umbilicus (Before treatment with Frusemide)

Plate 11. Same animal after treatment with Frusemide (6 days)

4.3 Complications of udder oedema

Out of six cows with haemagalactia, mastitis developed in four animals two to three days after starting the therapy. Three animals that developed mastitis belonged to Group I (treated with frusemide) and one animal belonged to Group II (treated with *Tribulus terrestris* Linn). Those animals affected with mastitis were excluded from the study for comparing the efficacy of two lines of treatment.

One animal with extensive udder oedema developed a tear of about three to four centimeters on the udder skin between the fore quarters and straw coloured fluid oozed out of this wound. After the course of treatment, this wound developed into a maggot wound.

4.4 Haematology

4.4.1 Haematological values of healthy control and cows with udder oedema (pre-treatment)

Haematological parameters other than mean corpuscular volume (MCV) did not differ significantly between healthy control and cows with udder oedema (Table 1).

The pre-treatment mean corpuscular volume (MCV) of cows with udder oedema showed significant increase ($P<0.01$) when compared to healthy control cows and their mean values were 56.43 ± 0.85 fl (51.69 to 60.76 fl) and 52.35 ± 0.56 fl (50.00 to 53.57 fl), respectively (Table 1).

4.4.2 Haematological values of Group I cows (Frusemide treatment)

The pre and post-treatment haematological parameters did not differ significantly (Table 2).

Table 1

Haematological values in healthy control and cows with udder oedema (Before treatment)

Sl. No.	Parameters	Mean ± SE in healthy control cows (n=6)	Mean ± SE in cows with udder oedema (n =20)
1	Packed cell volume (%)	30.83±1.17 (27.00-35.00)	30.75±0.72^{NS} 23.00-36.00)
2	Haemoglobin (g/dl)	10.27±0.56 (8.80-12.40)	10.01±0.32^{NS} (7.40-13.00)
3	Total erythrocyte count (x10^6/cmm)	5.90±0.26 (5.05-6.75)	5.45±0.12^{NS} (4.50-6.75)
4	Mean corpuscular volume (fl)	52.35±0.56 (50.00-53.57)	56.43±0.85** (51.69-60.76)
5	Mean corpuscular haemoglobin (pg)	17.37±0.27 (16.51-18.37)	18.29±0.44^{NS} (15.30-22.57)
6	Mean corpuscular haemoglobin concentration (%)	33.20±0.61 (31.03-35.43)	32.68±0.63^{NS} (27.06-36.97)
7	Total leucocyte count (/cmm)	8350.00±497.22 (7150-10050)	9727.50±507.16^{NS} (6950-13500)
8	Differential leucocyte count (Relative)		
	i) Neutrophil (%)	30.00±1.80 (26.35)	32.05±0.68^{NS} (26-37)
	ii) Lymphocyte (%)	62.17±2.07 (56-68)	63.60±0.62^{NS} (58-67)
	iii) Monocyte (%)	4.00±0.53 (2-6)	3.00±0.34^{NS} (1-7)
	iv) Eosinophil (%)	3.67±1.14 (1-7)	1.25±0.24^{NS} (0-4)
	v) Basophil (%)	0.17±0.16 (0-1)	0.10±0.07^{NS} (0-1)
9	Differential leucocyte count (Absolute)		
	i) Neutrophil (/cmm)	2521.67±255.96 (1859-3618)	3112.35±174.01^{NS} (1846-4860)
	ii) Lymphocyte (/cmm)	5082.83±328.51 (4284-6358)	5930.08±334.90^{NS} (4504.0-8877.5)
	iii) Monocyte (/cmm)	332.00±47.63 (187-525)	298.55±39.74^{NS} (71.5-808.5)
	iv) Eosinophil (/cmm)	309.67±97.01 (71.5-612.5)	121.68±22.91^{NS} (0-324)
	v) Basophil (/cmm)	14.58±14.58 (0-87.5)	13.13±9.26^{NS} (0-132.5)

** Significant (P <0.01) Ranges are given in brackets

NS - Non significant

Table 2

Haematological values of cows with udder oedema before and after treatment with Frusemide (Group I) (n=7)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Packed cell volume (%)	30.43 ± 1.52	31.14 ± 0.55^{NS}
2	Haemoglobin (g/dl)	10.23 ± 0.70	10.86 ± 0.28^{NS}
3	Total erythrocyte count (x10^6/cmm)	5.53 ± 0.27	5.63 ± 0.12^{NS}
4	Mean corpuscular volume (fl)	55.04 ± 0.81	55.44 ± 1.20^{NS}
5	Mean corpuscular haemoglobin (pg)	18.51 ± 0.62	19.88 ± 0.77^{NS}
6	Mean corpuscular haemoglobin concentration (%)	33.93 ± 1.06	34.90 ± 0.98^{NS}
7	Total leucocyte count (/cmm)	9685.71± 790.93	9771.43±469.03^{NS}
8	Differential leucocyte count (Relative)		
	i) Neutrophil (%)	34.10 ± 1.12	32.71 ± 1.63^{NS}
	ii) Lymphocyte (%)	61.14 ± 1.03	62.30 ± 1.58^{NS}
	iii) Monocyte (%)	3.30 ± 0.86	3.29 ± 0.97^{NS}
	iv) Eosinophil (%)	1.43 ± 0.53	1.60 ± 0.95^{NS}
	v) Basophil (%)	-	0.14 ± 0.09
9	Differential leucocyte count (Absolute)		
	i) Neutrophil (/cmm)	3327.00±324.03	3204.64±238.90^{NS}
	ii) Lymphocyte (/cmm)	5905.57±457.13	6088.71±374.36^{NS}
	iii) Monocyte (/cmm)	319.93 ± 93.67	303.86 ± 86.62^{NS}
	iv) Eosinophil (/cmm)	133.21 ± 44.66	136.92 ± 86.90^{NS}
	v) Basophil (/cmm)	-	13.57 ± 9.02

NS - Non significant

4.4.3 Haematological values of Group II cows (*Tribulus terrestris* Linn treatment)

The pre and post-treatment haematological parameters did not differ significantly (Table 3).

4.4.4 Pre-treatment haematological values in both the treatment groups (I & II)

The pre-treatment haematological values between two treatment groups did not differ significantly (Table 4).

4.4.5 Post-treatment haematological values in both the treatment groups (I & II)

The post-treatment haematological values between two treatment groups did not differ significantly (Table 5).

4.5 Metabolic profile test (Serum biochemistry)

4.5.1 Serum biochemistry of healthy control and cows with udder oedema (pre-treatment)

Serum biochemical parameters other than serum inorganic phosphorus did not show significant difference between control group and cows with udder oedema (Table 6).

The serum inorganic phosphorus values of cows with udder oedema showed significant decrease ($P<0.05$) when compared to control cows and their mean values were 4.59 ± 0.19 mg/dl (3.57 to 7.14 mg/dl) and 5.52 ± 0.36 mg/dl (3.93 to 6.63 mg/dl), respectively (Table 6).

4.5.2 Serum biochemistry of Group I cows (Frusemide treatment)

The post-treatment serum potassium values in cows with udder oedema (Group I) were significantly lower ($P<0.05$) when compared to pre-treatment

Table 3

Haematological values of cows with udder oedema before and after treatment with *Tribulus terrestris* Linn (Group II) (n=9)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Packed cell volume (%)	31.44 ± 0.58	32.67 ± 0.53 NS
2	Haemoglobin (g/dl)	9.91 ± 0.35	10.38 ± 0.36 NS
3	Total erythrocyte count (x10^6/cmm)	5.53 ± 0.11	5.83 ± 0.14 NS
4	Mean corpuscular volume (fl)	56.95 ± 1.35	56.23 ± 1.02 NS
5	Mean corpuscular haemoglobin (pg)	17.95 ± 0.69	17.89 ± 0.70 NS
6	Mean corpuscular haemoglobin concentration (%)	31.60 ± 1.06	31.80 ± 1.03 NS
7	Total leucocyte count (/cmm)	9766.67±799.78	9377.78±482.10 NS
8	Differential leucocyte count (Relative)		
	i) Neutrophil (%)	32.00 ± 0.65	33.70 ± 0.83 NS
	ii) Lymphocyte (%)	64.22 ± 0.61	62.20 ± 0.98 NS
	iii) Monocyte (%)	2.70 ± 0.37	2.00 ± 0.39 NS
	iv) Eosinophil (%)	1.00 ± 0.29	1.40 ± 0.21 NS
	v) Basophil (%)	0.11 ± 0.12	0.20 ± 0.13 NS
9	Differential leucocyte count (Absolute)		
	i) Neutrophil (/cmm)	3104.90± 235.22	3197.83±160.49 NS
	ii) Lymphocyte (/cmm)	6272.44±517.06	6197.83±160.49 NS
	iii) Monocyte (/cmm)	272.11 ± 46.86	194.39 ± 48.26 NS
	iv) Eosinophil (/cmm)	102.70 ± 28.71	127.11 ± 22.28 NS
	v) Basophil (/cmm)	14.14 ± 16.61	18.35 ± 11.71 NS

NS - Non significant

Table 4

Comparative haematological values before Frusemide and *Tribulus terrestris* Linn treatments in cows with udder oedema

Sl. No.	Parameters	Before treatment values (Mean ± SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Packed cell volume (%)	30.43±1.52	31.44±0.35 ^{NS}
2	Haemoglobin (g/dl)	10.23±0.70	9.91±0.35 ^{NS}
3	Total erythrocyte count (x10^6/cmm)	5.53±0.27	5.53±0.11 ^{NS}
4	Mean corpuscular volume (fl)	55.04±0.81	56.94±1.35 ^{NS}
5	Mean corpuscular haemoglobin (pg)	18.51±0.62	17.95±0.69 ^{NS}
6	Mean corpuscular haemoglobin concentration (%)	33.93±1.06	31.60±1.06 ^{NS}
7	Total Leucocyte count (/cmm)	9685.71±790.93	9766.67±799.78 ^{NS}
8	Differential leucocyte count (Relative)		
	i) Neutrophil (%)	34.10±1.12	32.00±0.65 ^{NS}
	ii) Lymphocyte (%)	61.14±1.03	64.22±0.61 ^{NS}
	iii) Monocyte (%)	3.30±0.86	2.70±0.37 ^{NS}
	iv) Eosinophil (%)	1.43±0.53	1.00±0.29 ^{NS}
	v) Basophil (%)	-	0.11±0.12
9	Differential leucocyte count (Absolute)		
	i) Neutrophil (/cmm)	3327.00±324.03	3104.90±235.22 ^{NS}
	ii) Lymphocyte (/cmm)	5906.57±457.13	6272.44±517.06 ^{NS}
	iii) Monocyte (/cmm)	319.93±93.67	272.11±46.86 ^{NS}
	iv) Eosinophil (/cmm)	133.21±44.66	102.70±28.71 ^{NS}
	v) Basophil (/cmm)	-	14.14±16.61

NS - Non significant

Table 5

Comparative haematological values after Frusemide and *Tribulus terrestris* Linn treatments in cows with udder oedema

Sl. No.	Parameters	After treatment values (Mean ± SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Packed cell volume (%)	31.4±0.55	32.67±0.53 ^{NS}
2	Haemoglobin (g/dl)	10.86±0.28	10.38±0.36 ^{NS}
3	Total erythrocyte count (x10^6/cmm)	5.63±0.12	5.83±0.14 ^{NS}
4	Mean corpuscular volume (fl)	55.44±1.20	56.23±1.02 ^{NS}
5	Mean corpuscular haemoglobin (pg)	19.88 ±0.77	17.89±0.70 ^{NS}
6	Mean corpuscular haemoglobin concentration (%)	34.90±0.98	31.80±1.03 ^{NS}
7	Total Leucocyte count (/cmm)	9771.43±493.03	9377.78±482.10 ^{NS}
8	Differential leucocyte count (Relative)		
	i) Neutrophil (%)	32.71±1.63	33.70±0.83 ^{NS}
	ii) Lymphocyte (%)	62.30±1.58	62.20±0.98 ^{NS}
	iii) Monocyte (%)	3.29±0.97	2.00±0.39 ^{NS}
	iv) Eosinophil (%)	1.60±0.95	1.40±0.21 ^{NS}
	v) Basophil (%)	0.14±0.09	0.20±0.13 ^{NS}
9	Differential leucocyte count (Absolute)		
	i) Neutrophil (/cmm)	3204.64±238.90	3197.83±160.49 ^{NS}
	ii) Lymphocyte (/cmm)	6088.71±374.36	6197.83±160.49 ^{NS}
	iii) Monocyte (/cmm)	303.86±86.62	194.39±48.26 ^{NS}
	iv) Eosinophil (/cmm)	136.92±86.90	127.11±22.28 ^{NS}
	v) Basophil (/cmm)	13.57±9.02	18.35±11.71 ^{NS}

NS - Non significant

Table 6

Serum biochemical values in healthy control and cows with udder oedema (Before treatment)

Sl. No.	Parameters	Mean ± SE in healthy control cows (n=6)	Mean ± SE in cows with udder oedema (n=20)
1	Total serum protein (g/dl)	8.24±0.42 (6.83-9.78)	8.06±0.22^{NS} (6.76-9.80)
2	Serum albumin (g/dl)	3.40±0.21 (2.60-3.98)	3.64±0.15^{NS} (2.60-5.50)
3	Serum globulin (g/dl)	4.83 ±0.31 (4.23-6.29)	4.42±0.13^{NS} (3.41-5.50)
4	Albumin:Globulin ratio	0.714±0.49 (0.555-0.865)	0.835±0.40^{NS} (0.571-1.288)
5	Serum aspartate aminotransferase (IU/l)	67.90±5.53 (49.3-83.4)	57.91±3.67^{NS} (33.6-91.4)
6	Serum sodium (mEq/l)	139.93±2.24 (132.17-147.83)	143.03±2.13^{NS} (126.09-160.87)
7	Serum potassium (mEq/l)	4.90±0.28 (4.36-6.15)	5.44±0.16^{NS} (4.36-6.92)
8	Serum calcium (mg/dl)	8.36±0.40 (7.56-10.00)	8.20±0.40^{NS} (5.85-11.94)
9	Serum inorganic phosphorus (mg/dl)	5.52±0.36 (3.93-6.63)	4.59±0.19* (3.57-7.14)
10	Serum magnesium (mg/dl)	2.56±0.19 (2.00-3.18)	2.32±0.14^{NS} (1.56-4.00)
11	Serum glucose (mg/dl)	47.35±4.08 (36.50-63.00)	42.05±2.08^{NS} (31.0-62.0)
12	Blood urea nitrogen (mg/dl)	15.10±1.67 (9.6-20.6)	17.01±0.77^{NS} (12.8-24.1)
13	Serum creatinine (mg/dl)	1.56±0.10 (1.24-1.88)	1.55±0.06^{NS} (1.17-1.99)

*Significant (P<0.05) Ranges are given in brackets

NS - Non significant

values and their mean values were 4.40 ± 0.23 mEq/l (3.08 to 5.38 mEq/l) and 5.20 ± 0.77 mEq/l (4.36 to 6.92 mEq/l), respectively (Table 7).

All the other serum biochemical parameters did not differ significantly before and after treatment in this group (Table 7).

4.5.3 Serum biochemistry of Group II cows (*Tribulus terrestris* Linn treatment)

Serum biochemical parameters except serum glucose did not differ significantly before and after treatment in Group II cows (Table 8).

The post-treatment serum glucose values in Group II cows showed significant increase ($P<0.05$) when compared to pre-treatment values and their mean values were 46.33 ± 2.49 mg/dl (36.0 to 58.0 mg/dl) and 41.88 ± 3.1 mg/dl (36.0 to 62.0 mg/dl), respectively (Table 8).

4.5.4 Pre-treatment serum biochemistry of both the treatment groups (I & II)

The pre-treatment serum biochemical values of both the treatment groups did not differ significantly (Table 9).

4.5.5 Post-treatment serum biochemistry of both the treatment groups (I & II)

The post-treatment serum biochemical parameters except serum potassium did not differ significantly. (Table 10).

The mean post-treatment serum potassium of group I animals (4.40 ± 0.23 mEq/l) showed significant decrease when compared to group II animals (5.24 ± 0.39 mEq/l) (Table 10).

Table 7

Serum biochemical values of cows with udder oedema before and after treatment with Frusemide (Group I) (n = 7)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Total serum protein (g/dl)	8.00 ± 0.23	8.60 ± 0.37 NS
2	Serum albumin (g/dl)	3.61 ± 0.36	3.60 ± 0.12 NS
3	Serum globulin (g/dl)	4.36 ± 0.14	5.00 ± 0.38 NS
4	Albumin:Globulin ratio	0.838 ± 0.09	0.759 ± 0.08 NS
5	Serum aspartate aminotransferase (IU/l)	60.97 ± 5.63	59.71 ± 4.71 NS
6	Serum sodium (mEq/l)	141.61 ± 3.12	139.71 ± 1.74 NS
7	Serum potassium (mEq/l)	5.20 ± 0.77 (4.36 - 6.92)	4.40 ± 0.23* (3.08 - 5.38)
8	Serum calcium (mg/dl)	8.67 ± 0.77	8.18 ± 0.75 NS
9	Serum inorganic phosphorus (mg/dl)	4.49 ± 0.21	4.54 ± 0.29 NS
10	Serum magnesium (mg/dl)	2.17 ± 0.11	2.63 ± 0.24 NS
11	Serum glucose (mg/dl)	44.86 ± 3.25	46.43 ± 5.06 NS
12	Blood urea nitrogen (mg/dl)	15.09 ± 0.98	16.10 ± 1.66 NS
13	Serum creatinine (mg/dl)	1.45 ± 0.10	1.58 ± 0.07 NS

* Significant ($P < 0.05$)
NS - Non significant
Ranges are given in brackets

Table 8

Serum biochemical values of cows with udder oedema before and after treatment with *Tribulus terrestris* (Group II) (n = 9)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Total serum protein (g/dl)	8.23 ± 0.37	8.60 ± 0.33 NS
2	Serum albumin (g/dl)	3.86 ± 0.17	3.87 ± 0.24 NS
3	Serum globulin (g/dl)	4.37 ± 0.24	4.72 ± 0.25 NS
4	Albumin:Globulin ratio	0.894 ± 0.05	0.843 ± 0.07 NS
5	Serum aspartate aminotransferase (IU/l)	56.71 ± 5.29	58.59 ± 7.19 NS
6	Serum sodium (mEq/l)	143.48 ± 3.90	144.45 ± 2.27 NS
7	Serum potassium (mEq/l)	5.38 ± 0.25	5.24 ± 0.39 NS
8	Serum calcium (mg/dl)	8.11 ± 0.58	7.93 ± 0.29 NS
9	Serum inorganic phosphorus (mg/dl)	4.33 ± 0.24	5.01 ± 0.38 NS
10	Serum magnesium (mg/dl)	2.53 ± 0.25	2.60 ± 0.19 NS
11	Serum glucose (mg/dl)	41.88 ± 3.1 (36.00 - 62.00)	46.33 ± 2.49* (36.00 - 58.00)
12	Blood urea nitrogen (mg/dl)	18.06 ± 1.40	18.63 ± 1.76 NS
13	Serum creatinine (mg/dl)	1.62 ± 0.09	1.55 ± 0.08 NS

* Significant (P <0.05)
NS - Non significant
Ranges are given in brackets

Table 9

Comparative serum biochemical values before Frusemide and *Tribulus terrestris* Linn treatments in cows with udder oedema

Sl. No.	Parameters	Before treatment values (Mean ± SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Total serum protein (g/dl)	8.00±0.23	8.23±0.37 NS
2	Serum albumin (g/dl)	3.61±0.36	3.86±0.17 NS
3	Serum globulin (g/dl)	4.36±0.14	4.37±0.24 NS
4	Albumin:Globulin ratio	0.838±0.09	0.894±0.05 NS
5	Serum aspartate aminotransferase (IU/l)	60.97±5.63	56.71±5.29 NS
6	Serum sodium (mEq/l)	141.61±3.12	143.48±3.90 NS
7	Serum potassium (mEq/l)	5.20±0.77	5.38±0.25 NS
8	Serum calcium (mg/dl)	8.67±0.77	8.11±0.58 NS
9	Serum inorganic phosphorus (mg/dl)	4.49±0.21	4.33±0.24 NS
10	Serum magnesium (mg/dl)	2.17±0.11	2.53±0.25 NS
11	Serum glucose (mg/dl)	44.86±3.25	41.88±3.10 NS
12	Blood urea nitrogen (mg/dl)	15.09±0.98	18.06±1.40 NS
13	Serum creatinine (mg/dl)	1.45±0.10	1.62±0.09 NS

NS - Non significant

Table 10

Comparative serum biochemical values after Frusemide and *Tribulus terrestris* Linn treatments in cows with udder oedema

Sl. No.	Parameters	After treatment values (Mean ± SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Total serum protein (g/dl)	8.60±0.37	8.60±0.33 NS
2	Serum albumin (g/dl)	3.60±0.12	3.87±0.24 NS
3	Serum globulin (g/dl)	5.00±0.38	4.72±0.25 NS
4	Albumin:Globulin ratio	0.759±0.08	0.843±0.07 NS
5	Serum aspartate aminotransferase (IU/l)	59.71±4.71	58.59±7.19 NS
6	Serum sodium (mEq/l)	139.71±1.74	144.45±2.27 NS
7	Serum potassium (mEq/l)	4.40±0.23	5.24±0.39*
8	Serum calcium (mg/dl)	8.18±0.75	7.93±0.29 NS
9	Serum inorganic phosphorus (mg/dl)	4.54±0.29	5.01±0.38 NS
10	Serum magnesium (mg/dl)	2.63±0.24	2.60±0.19 NS
11	Serum glucose (mg/dl)	46.43±5.06	46.33±2.49 NS
12	Blood urea nitrogen (mg/dl)	16.10±1.66	18.63±1.76 NS
13	Serum creatinine (mg/dl)	1.58±0.07	1.55±0.08 NS

* - Significant ($P < 0.05$)

NS - Non significant

4.6 Urinalysis

4.6.1 Physical examination

The urine samples of both healthy control and cows with udder oedema before and after treatment were clear and slightly yellowish in colour. The specific gravity of urine did not differ significantly between control group and cows with udder oedema (pre-treatment) and their means were 1.028 ± 0.12 and 1.027 ± 0.15, respectively. There was no significant difference in specific gravity of urine before and after treatment in both groups (I & II). In group I, the specific gravity of urine before and after treatment were 1.027 ± 0.11 and 1.026 ± 0.13, respectively. In group II the specific gravity of urine before and after treatment were 1.028 ± 0.14 and 1.028 ± 0.17, respectively.

The pre-treatment specific gravity of urine in both the treatment groups did not differ significantly and the values of 1.027 ± 0.11 and 1.028 ± 0.14 were observed in group I and II, respectively.

The post-treatment specific gravity of urine in both the treatment groups did not differ significantly and the values of 1.026 ± 0.13 and 1.028 ± 0.17 were observed in group I and II, respectively.

4.6.2 Chemical examination

The pH of urine did not differ significantly between control and affected cows and their means were 8.20 ± 0.16 and 8.40 ± 0.15, respectively. There was no significant difference in pH of urine before and after treatment in both the groups (I & II). In group I, the mean pH of urine before and after treatment were 8.30 ± 0.16 and 8.20 ± 0.15, respectively. In group II, the mean pH of urine before and after treatment were 8.40 ± 0.16 and 8.50 ± 0.16, respectively.

The pre-treatment pH of urine in both the treatment groups did not differ significantly and the values of 8.30 ± 0.16 and 8.40 ± 0.16 were recorded in group I and II respectively.

The post-treatment pH of urine in both the treatment groups did not differ significantly and the values of 8.20 ± 0.15 and 8.50 ± 0.16 were recorded in group I and II, respectively.

Other pathological constituents like protein, ketone bodies, blood, glucose, bile salts and bile pigments were absent in control cows and cows with udder oedema in both the groups (before and after treatment).

4.7 Udder oedema scores

Subjective udder oedema scores were assessed before treatment in all the affected cows. The individual udder oedema scores ranged between two to five. The overall mean udder oedema score was 3.40 ± 0.31. The mean udder oedema scores for group I and group II separately were 3.60 ± 0.29 and 3.30 ± 0.33, respectively.

4.8 Udder measurements

Udder measurements like circumference of udder, circumference and length of teats and distance between teat tip and the ground were recorded in control group and cows with udder oedema before and after treatment (Tables 11, 12, 13, 14 and 15).

4.8.1 Circumference of udder

Cows with udder oedema showed significant increase ($P<0.01$) in the circumference of udder when compared to healthy control cows and their means were 129.30 ± 2.36 and 110.17 ± 2.83 cm, respectively (Table 11).

Group I cows with udder oedema showed significant reduction ($P<0.01$) in circumference of udder after treatment. The mean circumference of udder before and after treatment were 131.20 ± 3.47 and 111.80 ± 3.65 cm, respectively (Table 12).

Group II cows with udder oedema also showed significant decrease ($P<0.01$) in circumference of udder after treatment. The mean circumference of udder before and after treatment were 127.40 ± 3.28 and 108.30 ± 1.79 cm, respectively (Table 13).

The pre-treatment circumference of udder in both the treatment groups (I & II) did not show significant difference (Table 14).

The post-treatment circumference of udder in both the treatment groups (I & II) did not show significant difference (Table 15).

4.8.2 Circumference of teats

Circumference of both fore and hind teats of control cows and cows with udder oedema did not differ significantly (Table 11).

Circumference of teats showed significant decrease ($P<0.01$) after treatment in group I and group II. In group I, the before and after treatment mean circumference of the fore teats were 5.35 ± 0.24 and 5.05 ± 0.24 cm, respectively and the hind teats were 4.90 ± 0.22 and 4.60 ± 0.22 cm, respectively (Table 12). In group II, the before and after treatment mean circumference of the fore teats were 5.65 ± 0.25 and 5.30 ± 0.23 cm, respectively and that of the hind teats were 5.25 ± 0.29 and 4.90 ± 0.25 cm, respectively (Table 13).

The pre-treatment circumference of teats (fore and hind) in both the treatment groups (I & II) did not show significant difference (Table 14).

The post-treatment circumference of teats (fore and hind) in both the treatment groups (I & II) did not differ significantly (Table 15).

4.8.3 Length of teats

Length of teats of control cows and cows with udder oedema did not differ significantly (Table 11).

Length of both fore and hind teats showed significant increase ($P<0.01$) after treatment in group I and II.

In Group I, mean length of fore teats before and after treatment were 5.05 ± 0.14 and 5.60 ± 0.12 cm, respectively and of hind teats were 4.45 ± 0.14 and 5.00 ± 0.15 cm, respectively (Table 12).

In Group II, mean length of fore teats before and after treatment were 5.30 ± 0.19 and 5.75 ± 0.16 cm, respectively and of hind teats were 4.65 ± 0.21 and 5.10 ± 0.15 cm, respectively (Table 13).

The pre-treatment length of teats (fore and hind) in both the treatment groups (I & II) did not differ significantly (Table 14).

The post-treatment length of teats (fore and hind) in both treatment groups (I & II) did not differ significantly (Table 15).

4.8.4 Distance between teat tip and the ground

Distance between teat tip and the ground in cows with udder oedema showed significant decrease ($P<0.01$) when compared to control cows. The mean distance between teat tip and the ground of control cows and affected cows were 49.33 ± 1.26 and 38.50 ± 0.73 cm, respectively (Table 11).

Distance between teat tip and the ground significantly increased ($P<0.01$) after treatment in group I and group II. In group I, the mean distance between teat tip and the ground before and after treatment were 39.10 ± 1.37 and 46.30 ± 1.42 cm, respectively (Table 12). In group II, the mean distance between teat tip and the ground before and after treatment were 37.90 ± 0.53 and 45.20 ± 0.60 cm, respectively (Table 13).

The pre-treatment distance between teat tip and the ground in both the treatment groups did not differ significantly (Table 14).

Table 11

Udder measurements of healthy control and cows with udder oedema (Before treatment)

Sl. No.	Parameters	Mean ± SE values of healthy control (n=6)	Mean ± SE values of cows with udder oedema (n=20)
1	Circumference of udder (cm)	110.17 ± 2.83 (98-118)	129.30 ± 2.36** (118.0-153.0)
2	Circumference of teats (cm)		
	i) Fore teats	5.50 ± 0.26 (4.5-6.0)	5.50 ± 0.18^{NS} (4.5-7.0)
	ii) Hind teats	5.25 ± 0.28 (4.5-6.0)	5.08 ± 0.18^{NS} (4.0-7.0)
3	Length of teats (cm)		
	i) Fore teats	5.00 ± 0.18 (4.5-5.5)	5.18 ± 0.12^{NS} (4.5-6.0)
	ii) Hind teats	4.25 ± 0.11 (4.0-4.5)	4.55 ± 0.13^{NS} (3.5-6.0)
4	Distance between teat tip and the ground (cm)	49.33 ± 1.26 (46.53)	38.50 ± 0.73** (35-48)

** Significant ($P < 0.01$)

NS - Non significant

Ranges are given in brackets

Table 12

Udder measurements in cows with udder oedema before and after treatment with Frusemide (Group I) (n = 7)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Circumference of udder (cm)	131.20 ± 3.47	111.80 ± 3.65**
2	Circumference of teats (cm) i) Fore teats ii) Hind teats	 5.35 ± 0.24 4.90 ± 0.22	 5.05 ± 0.24** 4.60 ± 0.22**
3	Length of teats (cm) i) Fore teats ii) Hind teats	 5.05 ± 0.14 4.45 ± 0.14	 5.60 ± 0.12** 5.00 ± 0.15 **
4	Distance between teat tip and the ground (cm)	39.10 ± 1.37	46.30 ± 1.42**

** Significant (P <0.01)

Table 13

Udder measurements in cows with udder oedema before and after treatment with *Tribulus terrestris* Linn (Group II) (n = 9)

Sl. No.	Parameters	Before treatment (Mean ± SE)	After treatment (Mean ± SE)
1	Circumference of udder (cm)	127.40 ± 3.28	108.30 ± 1.79**
2	Circumference of teats (cm) i) Fore teats ii) Hind teats	 5.65 ± 0.25 5.25 ± 0.29	 5.30 ± 0.23** 4.90 ± 0.25**
3	Length of teats (cm) i) Fore teats ii) Hind teats	 5.30 ± 0.19 4.65 ± 0.21	 5.75 ± 0.16** 5.10 ± 0.15 **
4	Distance between teat tip and the ground (cm)	37.90 ± 0.53	45.20 ± 0.60**

** Significant (P <0.01)

Table 14

Comparative udder measurements before Frusemide and *Tribulus terrestris* Linn. treatments in cows with udder oedema

Sl. No.	Parameters	Before treatment values (Mean ±SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Circumference of udder (cm)	131.20 ± 3.47	127.40±3.28 NS
2	Circumference of teats (cm)		
	i) Fore teats	5.35 ± 0.24	5.65 ± 0.25 NS
	ii) Hind teats	4.90 ± 0.22	5.25 ± 0.29 NS
3	Length of teats (cm)		
	i) Fore teats	5.05 ± 0.14	5.30 ± 0.19 NS
	ii) Hind teats	4.45 ± 0.14	4.65 ± 0.21 NS
4	Distance between teat tip and the ground (cm)	39.10 ± 1.37	37.90 ± 0.53 NS

NS - Non significant

Table 15

Comparative udder measurements after Frusemide and *Tribulus terrestris* Linn. treatments in cows with udder oedema

Sl. No.	Parameters	After treatment values (Mean ±SE)	
		Frusemide group (n=7)	*Tribulus terrestris* Linn group (n=9)
1	Circumference of udder (cm)	118.0±3.65	108.30±1.79 NS
2	Circumference of teats (cm)		
	i) Fore teats	5.05 ± 0.24	5.30 ± 0.23 NS
	ii) Hind teats	4.60 ± 0.22	4.90 ± 0.25 NS
3	Length of teats (cm)		
	i) Fore teats	5.60 ± 0.12	5.75 ± 0.16 NS
	ii) Hind teats	5.00 ± 0.15	5.10 ± 0.15 NS
4	Distance between teat tip and the ground (cm)	46.30 ± 1.42	45.20 ± 0.60 NS

NS - Non significant

The post-treatment distance between teat tip and the ground in both the treatment groups did not differ significantly (Table 15).

4.9 Treatment

The mean number of days taken for complete recovery from udder oedema in cows which were treated with *Tribulus terrestris* Linn (4.11 ± 0.44 days) was less when compared to cows which were treated with Frusemide (4.44 ± 0.34 days).

4.9.1 Cost of treatment

i) Frusemide therapy:

Average body weight of affected cows = 350 kg

Dose rate of the frusemide = 1mg/kg BID I/M

Dosage required for an average cow = 350 x 1 x 2

= 700 mg

1 ampoule of Inj. Lasix® (2 ml) = 20 mg of frusemide

Total number of ampoules required/day = 700/20

= 35

Cost of 1 ampoule of Inj.Lasix® = Rs. 2.35/-

Total cost of drug/day = 35 x 2.35

= Rs. 82.25/-

Cost of therapy for 4.4 days = 82.25 x 4.4

= Rs. 361.90/-.

ii) *Tribulus terrestris* Linn therapy:

Total dose of fruits of *Tribulus terrestris* Linn per day = 100 g

Cost of medicine per day (100 g) = Rs. 5/-

Cost of therapy for 4.1 days = 5 x 4.1

= Rs. 20.50/-

The cost of treatment for udder oedema in cows with frusemide was approximately Rs.360/- per animal however, with *Tribulus terrestris* Linn it was approximately Rs.20/- per animal.

DISCUSSION

5. DISCUSSION

Udder oedema is an important problem for the dairy farmers. Though many theories are suggested, no definite etiology could be attributed for this condition. The epidemiology, clinical findings and efficacy of two lines of therapy for udder oedema are discussed.

5.1 History and Epidemiology

In the present study, majority of cows (18) developed udder oedema during the period of two days pre-partum to the day of calving. Two cows developed oedema eight to ten days pre-partum. This finding was in agreement with those of Conway *et al.* (1977) and Thakur *et al.* (1989).

The data obtained in the present study showed that udder oedema occurred mostly in first two calvings. Higher incidence was observed in primiparous animals (55 per cent) when compared to second calving (35 per cent) and subsequent calvings (10 per cent). This finding was consistent with those of Greenhalgh and Gardner (1958); Schmidt and Schultz (1959); Emery *et al.* (1969); Mitchell *et al.* (1976); Sigmund (1981) and Dorp *et al.* (1999). The lesser incidence of udder oedema in older ruminants when compared to the primiparous animals might be due to the better vascular circulation of the udder in older animals (Emery *et al.*, 1969 and Prasad *et al.*, 1999). On the contrary Vestweber and Al-Ani (1985) observed more incidence of udder oedema in Holstein cows in third and fourth calving.

The incidence of udder oedema was found to be high when the age at first calving increased in heifers and was in agreement with Dentine and McDaniel (1983) and Malvern *et al.* (1983). However, this observation was not supported by Nestor *et al.* (1988).

Incidence of severe udder oedema was observed in cows fed on more concentrate ration during pre-partum and was in accordance with those of Hemken *et al.* (1960) and Emery *et al.* (1969). On the contrary, Fountaine *et al.* (1949); Greenhalgh and Gardner (1958) and Schmidt and Schultz (1959) observed no correlation between udder oedema and pre-partum concentrate feeding.

Eventhough the affected cows were fed with more salt during last trimester of pregnancy and early post-partum period the mean serum sodium level was within the normal limit in these animals, on laboratory examination. Most of the domestic animals could tolerate a very large quantity of sodium intake provided they had adequate drinking water (Buck *et al.*, 1976). Thus in the present study, there was no correlation between excess salt feeding and udder oedema. This was in agreement with Vestweber *et al.* (1989). However in contrary to this; Hemken *et al.* (1969); Randall *et al.* (1974); Conway *et al.* (1977) and Jones *et al.* (1984) found that there was definite correlation between development of udder oedema and increased salt feeding.

Increased incidence of udder oedema observed in the present study was associated with lack of exercise during last trimester of pregnancy. This finding was consistent with McCuistion (1960) and Lamb *et al.* (1979).

Though genetic factors were also be claimed as one of the cause for udder oedema by several earlier workers, this was not highlighted in the present study because of the lack of familial history of animals studied.

5.2 Clinical findings

All the four quarters of udder were found to be oedematous in all animals; however, fore quarters showed severe oedema when compared to hind quarters. In most of the cases oedema extended upto the umbilicus, rarely it was confined to the udder only and very rarely extended upto the brisket region. These findings were in accordance with Al-Ani *et al.* (1985) and Thakur *et al.* (1989).

In majority of the cows, udder oedema slightly extended to the teats. The base of the teats were found to be drawn into the oedematous udder, thereby length of the teats were shortened in few animals which had no oedema on the teats. Extensive oedema distorted the position of the teats and the teats were close to the ground. The oedematous and shortened teats rendered milking very difficult. These findings were consistent with those of Vigue (1961a); Belloff and Diener (1963); Heidrich and Renk (1967) and Al-Ani and Vestweber (1984).

Clinical observations like pain, pale to pinkish colour of udder, cold to slightly warm and pitting on pressure of udder were in agreement with those of Heidrich and Renk (1967); Thakur *et al.* (1989) and Cook (1998).

The milk samples collected were apparently normal; however six animals showed mild haemagalactia with few blood clots in the milk. Similar findings were also observed by earlier workers like Vigue (1961a) and Heidrich and Renk (1967). They suggested that severe congestion and rupture of the capillaries in the oedematous udder were considered to be the cause for haemagalactia; however it was not unusual for animals in early lactation.

In the present study, California mastitis test (CMT) of milk was not undertaken. CMT was not a reliable indicator of mastitis during early lactation and late lactation period because of the physiological increase of cells at these times (Schalm, 1962). Milk samples from the affected cows showed no growth on bacteriological media. This finding was in agreement with the earlier workers like Sanders and Sanders (1981); Jones *et al.* (1984); Thakur *et al.* (1989); Prabhakar *et al.* (1991) and Grant (1996).

The normal body temperature, pulse and respiratory rates in all cows with udder oedema agreed with the findings of Grant (1996) and Prasad *et al.* (1999).

5.3 Complications of udder oedema

Out of six cows with haemagalactia, four were further complicated with mastitis. Mastitis as a complication in udder oedema was observed by Amstutz (1982); Vestweber and Al-Ani (1985); Nestor *et al.* (1988); Prabhakar *et al.* (1991); Rebhun (1995) and Prasad *et al.* (1999). Moreover, haemagalactia with blood clots could cause obstruction of teat canal and further it could lead to galactostasis (Heidrich and Renk, 1967). Failure of complete milking due to pain and mechanical pressure by oedema over the glandular part of the udder led to post-milking leakage and increased risk of mastitis (Rebhun, 1995). Severe pain could cause release of epinephrine which might inhibit the susceptibility of alveolar myoepithelium of udder to the influence of oxytocin leading to poor milk 'let down' (Linzell, 1955). Galactostasis due to blood clots and pain might be a contributory factor for the development of mastitis in the present study.

There was very severe oedema and development of tear in the udder between the fore-quarters in one cow. This finding was in concurrence with Al-Ani *et al.* (1985) and Thakur *et al.* (1989). They opined that it might be due to extensive stretching of udder skin as a result of severe oedema. In the present study, the wound got further complicated with maggots.

5.4 Haematology

Although mean value of mean corpuscular volume (MCV) was more in cows with udder oedema (56.43 ± 0.85 fl) when compared to control cows (52.35 ± 0.56 fl), the values were with in the normal range given by Jain (1986). Following parturition, more number of reticulocytes were released into the circulation which might be responsible for the increase in MCV values (Schalm *et al.*, 1975).

Other haematological parameters were within the normal level in cows with udder oedema. This was in agreement with those of Sanders and Sanders (1981) and Grant (1996).

The pre and post-treatment haematological values within and between the groups (I and II) were not significantly different.

5.5 Metabolic profile test (serum biochemistry)

5.5.1 Serum biochemistry of healthy control and cows with udder oedema (pre-treatment)

The serum inorganic phosphorus level in cows with udder oedema (4.59 ± 0.19 mg/dl) was significantly lower than the control cows (5.52 ± 0.36 mg/dl). This was not in agreement with Vestweber and Al-Ani (1984) and Vestweber *et al.* (1989).

Cows were in negative calcium balance soon after calving, due to increased flow of calcium through colostrum and milk (Payne, 1964 and Sato, 1978). High yielding cows were more prone to udder oedema (McCuistion, 1960). Hypocalcaemia would stimulate the secretion of parathyroid hormone and when calcium level gets restored in the blood the parathyroid hormone release will be inhibited (Radostits *et al.*, 1994). The decreased level of parathyroid hormone in recently calved cows may induce hypophosphataemia (Gupta and Rai, 1987). In the present study, the mean serum calcium level was within the normal range in cows with udder oedema (8.20 ± 0.40 mg/dl) and was in agreement with Jones *et al.* (1984) and Vestweber *et al.* (1989). The role of parathyroid hormone in producing mild hypophosphataemia in cows with normal calcium level should be further studied.

Total protein, albumin, globulin and Albumin : Globulin ratio (A:G ratio) in serum were found to be normal in cows affected with udder oedema. These findings were consistent with that of Kolk *et al.* (1991). However, Vestweber and Al-Ani (1984) observed slightly lower serum proteins during early post-partum period in both cows with or without udder oedema and claimed that if hypoproteinaemia was a factor in the development of udder oedema, a more generalized body oedema would have occurred. On the contrary Larson and Kendall (1957); Larson and Hays (1958); Nestor *et al.* (1988) and Rebhun (1995) have reported that hypoproteinaemia recorded in udder oedema was due to either hypoglobulinaemia or hypoalbuminaemia.

The normal serum albumin and A:G ratio indicated an apparently normal liver function. This suggests that liver does not play a role in the development of udder oedema. The mean serum aspartate aminotransferase (AST) value of healthy control and cows with udder oedema did not differ significantly. This observation reinforced the non-involvement of liver in udder oedema.

The normal serum glucose levels in both control and cows with udder oedema were in agreement with Vestweber *et al.* (1989).

The serum sodium and serum potassium levels in both control and affected cows were within the normal range and were consistent with Sanders and Sanders (1981); Vestweber and Al-Ani (1984); Vestweber *et al.* (1989); Kolk *et al.* (1991) and Cook (1998).

The serum magnesium level in cows with udder oedema was found to be normal and was in accordance with the earlier observations of Jones *et al.* (1984). However, Hicks and Pauli (1976) have observed simultaneous udder oedema and hypomagnesaemia in cows which might be due to the application of excess potassium fertilizer to the crop.

The serum creatinine and blood urea nitrogen (BUN) in cows with udder oedema were found to be normal. These findings were consistent with the observations of Vestweber *et al.* (1989). Serum creatinine was considered as a reliable indicator of kidney function (Benjamin, 1985). The normal serum creatinine and BUN values in cows with udder oedema in the present study indicated that there was no apparent involvement of kidney in udder oedema.

5.5.2 Serum biochemistry of Group I cows (Frusemide treatment)

In the present study, post-treatment mean serum potassium value (4.40 ± 0.23 mEq/l) was lower than pre-treatment value (5.20 ± 0.77 mEq/l) in cows with udder oedema (Group I). This finding was in accordance with the earlier observations of Vestweber *et al.* (1989). Jackson (1996) reported that there was a depletion of serum potassium in animals treated with frusemide as a diuretic. Hypokalaemia often resulted in muscular weakness, prolonged recumbency, anorexia, muscular tremors and coma in later stages (Radostits *et al.*, 1994). Tripathi (1999) opined that the serum potassium values were only a rough guide as the potassium primarily occur intracellularly. This suggests that the dose of frusemide in the present study (@ 1 mg/kg body weight intramuscularly twice daily) was adequate to induce diuresis without any untoward clinical signs of potassium depletion.

The pre and post-treatment serum sodium levels of cows (Group I) were normal in the present study. In contrary Vestweber *et al.* (1989) have reported that a significant increase in mean serum sodium level after 210 min of intravenous administration of 500 mg frusemide in cows affected with udder oedema.

The pre and post-treatment values of inorganic phosphorus, glucose, creatinine and urea nitrogen in serum were found to be normal. These findings were in agreement with that of Vestweber *et al.* (1989).

5.5.3 Serum biochemistry of Group II cows (*Tribulus terrestris* Linn treatment)

The post-treatment mean serum glucose value (46.33 ± 2.49 mg/dl) was higher than that of pre-treatment value (41.88 ± 3.10 mg/dl). Kirtikar and Basu (1975) reported that the fruits and roots of *Tribulus terrestris* Linnwere used to improve the appetite in human beings. The increased post-treatment serum glucose values observed in the present study might be pointing towards a similar effect in cows also.

The pre-treatment serum biochemical values did not differ significantly between groups I and II. However, the post-treatment mean serum potassium level of group I (4.40 ± 0.23 mEq/l) showed significant reduction when compared to group II (5.24 ± 0.39 mEq/l). This indicated that there was no potassium depletion in *Tribulus terrestris* Linn treated group. All the other post-treatment serum biochemical values did not differ significantly between group I and II.

5.6 Urinalysis

5.6.1 Physical Examination

The urine samples of control group and cows with udder oedema (pre and post-treatment) were clear and slightly yellowish in colour.

The normal specific gravity of urine in control group and cows with udder oedema was in conformity with the earlier finding of Vestweber *et al.* (1989).

The pre and post-treatment specific gravities of urine in affected cows (Group I) were normal and was in accordance with the earlier observation of Vestweber *et al.* (1989).

The pre and post treatment specific gravities of urine in affected cows (Group II) were within the normal range. These values were comparable to the pre and post treatment values of group I.

5.6.2 Chemical Examination

The normal alkaline pH of urine in control group and cows with udder oedema were comparable to the earlier reports (Vestweber *et al.*, 1989).

The pre and post-treatment pH of urine in the affected cows (Group I) were within normal range as reported by Vestweber *et al.* (1989).

The pre and post-treatment pH of urine in the group II animals were within normal ranges and were also comparable with values of group I animals.

In the present study, other pathological constituents like protein, ketone bodies, glucose, blood, bile salts and bile pigments were absent in both control and cows with udder oedema. The findings of the present study indicated that ketosis was not associated with udder oedema.

5.7 Udder oedema scores

Overall mean subjective oedema score (3.40 ± 0.31) of cows with udder oedema showed that the oedema was moderate to severe. Eventhough subjective oedema scoring by visual inspection was claimed as the best tool to assess the severity of udder oedema by Greenhalgh and Gardner (1958), it was liable for human errors. Because of this fact, udder measurements were also included in the present study to support the subjective oedema scoring system.

5.8 Udder measurements

5.8.1 Circumference of the udder (cm)

The increase in mean circumference of udder of cows with udder oedema was in agreement with Sigmund (1981).

There was significant reduction in the post-treatment mean circumference of the udder in both the treatment groups. This indicated that both line of treatments were effective in relieving udder oedema.

5.8.2 Circumference of the teats (cm)

Eventhough the circumference of teats did not show significant difference between the control group and cows with udder oedema, the post-treatment values of both groups showed a significant reduction. This indicated that there was mild extension of oedema to the teats.

5.8.3 Length of teats (cm)

Eventhough the mean length of the teats in control cows and the cows with udder oedema showed no significant difference, the post-treatment values showed a significant increase in both the treatment groups. This indicated that the teats were drawn little bit into the oedematous udder. This finding supported the clinical findings recorded by visual inspection.

5.8.4 Distance between teat tip and the ground (cm)

Decrease in distance between teat tip and the ground was observed in udder oedema cases. However, the distance between teat tip and the ground significantly increased after treatment. The sagging of udder during oedema could cause injury to the udder and make it more prone to mastitis. This parameter would be subjected for more bias, because the height of the animal would not be uniform. So less importance should be given to this parameter for assessing the severity of udder oedema.

5.9 Treatment

Frusemide was one of the most potent diuretic with rapid onset and short duration of action. It was used for the treatment of udder oedema with great

success (Ahlers, 1977 and Vestweber *et al.*, 1989). Prolonged frusemide therapy could lead to hypokalaemia (Jackson, 1996 and Tripathi, 1999). Eventhough the frusemide treated animals did not show clinical manifestations of hypokalaemia, prolonged therapy and over dosage would predispose to conditions like 'Downer cow syndrome'.

The mean duration of treatment for complete recovery from udder oedema was less in animals treated with *Tribulus terrestris* Linn (group II) when compared to animals treated with frusemide (group I). The cost of treatment was also less with *Tribulus terrestris* Linn (group II). However, it was reported that *Tribulus terrestris* Linn plant could cause liver damage and subsequent secondary photosensitization (Hungerford, 1990). In the present study, A:G ratio and AST values were within the normal limits suggesting that there was no hepatotoxicity after four days of *Tribulus terrestris* Linn therapy. Moreover, *Tribulus terrestris* Linn therapy did not induce any potassium depletion.

Conclusion

Udder oedema commonly occurred during the peri-parturient period in crossbred first-calf heifers which have genetically high milk production potential. Reduced fodder intake, increased concentrate feeding and lack of exercise during the last trimester of pregnancy might be responsible for this condition. The metabolic profile of affected cows in the present study did not suggest any specific predisposing or etiological factor. Although udder oedema occurred in high yielders during peripartum period, the normal metabolic profile confirmed that it was not a metabolic disease. The role of hormones, genetic factors etc., in the etio-pathogenesis of udder oedema needs further investigation. Though, udder oedema was considered as physiological, it might change to pathological if it persists for more than three to four days. Haemagalactia and mastitis are often associated with this condition. So timely diagnosis and treatment should be undertaken. Treatment with *Tribulus terrestris* Linn was cheap and effective without any side effects.

Further study is needed to find out the pharmacokinetic action of this plant in the veterinary field. Frusemide therapy was also effective but expensive and potassium supplementation might be necessary in case of prolonged therapy.

SUMMARY

6. SUMMARY

A study was conducted on udder oedema in crossbred cows. The objectives were to understand more about the epidemiology and etio-pathogenesis of this condition and to compare the efficacy of the indigenous plant *Tribulus terrestris* Linn with frusemide in the treatment of udder oedema cases.

Out of twenty cows affected with persistent udder oedema, four developed mastitis during the course of study. Remaining sixteen animals were randomly divided into two treatment groups viz., group I (Frusemide treatment group) with seven cows and group II (*Tribulus terrestris* Linn treatment group) with nine cows. Six apparently healthy cows maintained under identical field conditions served as the control group.

The haemogram, serum biochemistry, urinalysis and udder measurements of both healthy control and cows with udder oedema were compared. The pre and post-therapy values of both the treatment groups (I and II) were also compared.

Data collected from the affected animals indicated that udder oedema mostly occurred during the periparturient period of the first two calvings. Increased concentrates and decreased roughage feeding and lack of exercise during pre-partum period were some of the factors associated with the occurrence of udder oedema in cows.

On clinical examination, the affected animals were apparently normal except for the udder involvement. Mostly the udder oedema extended upto umbilicus, rarely upto the brisket in front and upto the escutcheon region.

Oedematous udder was pale and pinkish, cold to touch, pitting on pressure and also painful. Oedema at the base of teats and shortening of teats were

also observed. Milk was apparently normal in cows with udder oedema. However, during the experiment six animals showed haemagalactia and four among them were further complicated with mastitis. One animal showed a tear on the udder skin and this was further complicated with maggots.

Apart from a significant increase of mean corpuscular volume (MCV) all the other haematological paremeters did not differ significantly between control group and cows with udder oedema. The pre and post-treatment haematological values did not differ significantly in both the treatment groups.

Serum inorganic phosphorus showed a significant decrease in cows with udder oedema when compared to control cows. A decrease in serum potassium in frusemide treatment group and an increase in serum glucose in *Tribulus terrestris* Linn treatment group, were the prominent post-treatment biochemical changes.

The urine samples of both healthy control and cows with udder oedema (pre and post-treatment) were normal with respect to physical and chemical characters.

The overall mean subjective udder oedema score for the cows with udder oedema was 3.40 ± 0.31, which indicated moderate to severe udder oedema in the cases studied. The mean circumference of udder increased significantly and the mean distance between teat tip and the ground decreased significantly in cows with udder oedema. The circumference and length of the teats did not differ significantly between control group and the affected cows. In both the treatment groups, the post-treatment circumference of udder and teats showed significant reduction and the length of teats and the distance between teat tip and the ground showed significant increase when compared to pre-treatment values. These findings indicated recovery from the condition as a result of treatments instituted.

The mean duration of days required for complete recovery with *Tribulus terrestris* Linn was less when compared to frusemide treatment. Frusemide therapy

in udder oedema cases induced mild hypokalaemia without any clinical manifestations. *Tribulus terrestris* Linn therapy was cheaper and without any side effects when compared to the frusemide therapy.

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*Originals not seen

ANNEXURE

ANNEXURE-I

Case No.: Date:

Name and address of the owner	:	
Animal	:	
Species	:	
Breed	:	
Sex	:	
Age	:	
Colour	:	
History		
Present history	:	
Past history	:	
Breeding	:	Natural mating/Artificial insemination
Parity of animal	:	Primiparous/Pluriparous
Calving date	:	
Age at first calving	:	
Sex of the calf	:	
Weight of the calf	:	
Feeding (Quantity)	:	Concentrate : Roughage : Salt/mineral mixture:
General Clinical Examination	:	
System wise examination	:	
Special examination of udder	:	

Observations	Before treatment		After treatment	
1. Circumference (cm) and shape of udder				
2. Teat shape				
3. Circumference of teats (cm)	RF:	RH:	RF:	RH:
	LF:	LH:	LF:	LH:
4. Length of teats (cm)	RF:	RH:	RF:	RH:
	LF:	LH:	LF:	LH:

5. Distance between teat tip and the ground (cm) :

6. Palpation of udder and teats :

7. Extent of oedema :

8. Subjective oedema score :

9. Milk yield (lits) :

10. Clinical and laboratory examination of milk :

Urinalysis (Qualitative)	Before treatment	After treatment
a) Physical characters		
i) Colour	:	
ii) Transparency	:	
iii) Specific gravity	:	
b) Chemical characters		
i) pH	:	
ii) Glucose	:	
iii) Protein	:	
iv) Blood	:	
v) Ketone bodies	:	
vi) Bile salts	:	
vii) Bile pigments	:	

Complete Blood Count (CBC)	Before treatment	After treatment
1) Haemoglobin (g %)	:	
2) Packed cell volume (%)		
3) Total Erythrocyte count ($x10^6$/cmm)	:	
4) Erythrocytic indices		
i) Mean corpuscular volume (fl)	:	
ii) Mean corpuscular haemoglobin (pg)	:	
iii) Mean corpuscular haemoglobin concentration (%)	:	
5) Total leucocyte count ($x10^3$/cmm)	:	
6) Differential leucocyte count (absolute and relative)	:	

Serum biochemistry		Before treatment	After treatment
1) Total serum protein (g/dl)	:		
2) Serum albumin (g/dl)	:		
3) Serum globulin (g/dl)	:		
4) Albumin:Globulin ratio	:		
5) Serum aspartate aminotransferase (IU/l):			
6) Serum sodium (mEq/l)	:		
7) Serum potassium (mEq/l)	:		
8) Serum calcium (mg/dl)	:		
9) Serum inorganic phosphorus (mg/dl)	:		
10) Serum magnesium (mg/dl)	:		
11) Serum glucose (mg/dl)	:		
12) Blood urea nitrogen (mg/dl)	:		
13) Serum creatinine (mg/dl)	:		

Details of treatment :

Results of treatment :

METABOLIC PROFILE AND CLINICAL MANAGEMENT OF POST-PARTUM UDDER OEDEMA IN DAIRY CATTLE

By

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ABSTRACT OF A THESIS

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ABSTRACT

A study was conducted in the Department of Clinical Medicine, College of Veterinary and Animal Sciences, Mannuthy for a period of three semesters, during the year 1999 to 2000, to elucidate the etio-pathogenesis of the udder oedema in crossbred cows. The study included haemogram, metabolic profile test, urinalysis, udder measurements and comparison of the efficacy of treatments with *Tribulus terrestris* Linn and frusemide in udder oedema cases.

Twenty crossbred cows with persistent udder oedema were selected. Four cows developed mastitis during the observation period. The remaining sixteen animals were randomly divided into two groups viz. Group I with seven animals which were treated with frusemide and Group II with nine animals which were treated with *Tribulus terrestris* Linn. Six apparently healthy cows maintained under identical conditions served as the control group.

Udder oedema occurred mostly in first two calvings around peri-parturient period. The affected animals were clinically normal except for the involvement of udder. Oedema extended mostly upto umbilicus, pale to pinkish in colour, cold to touch, pitting on pressure and was painful. Oedema extending to the base of the teats and shortening of teats were also observed.

In the present study, haemagalactia, mastitis and maggot wound on the udder were observed as complications of udder oedema.

The sole haematological change observed in udder oedema cases was an increase in mean corpuscular volume (MCV). The serum biochemical estimation showed a decrease in the serum inorganic phosphorus value of cows with udder oedema when compared to control cows. The post-treatment serum biochemical values showed a decrease in serum potassium in frusemide treatment and an increase in serum glucose in *Tribulus terrestris* Linn treatment.

Urine samples from the affected cows did not show any pathological changes during the observation period.

The mean subjective udder oedema score was 3.40 ± 0.31. The udder measurements in cows with udder oedema like circumference of udder showed significant increase and the distance between teat tip and the ground showed significant decrease when compared to the control cows. The udder measurements of both groups became normal after the treatments.

Cows which were treated with *Tribulus terrestris* Linn took less number of days for complete recovery. This treatment was cheaper and effective without any side effects when compared to frusemide treatment. Frusemide treatment led to mild hypokalaemia without any clinical manifestations.