COMPARATIVE EVALUATION OF ORAL REHYDRATION THERAPY IN ADULT CATTLE

THESIS

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BY

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I hereby declare that the experimental research work and interpretation of the thesis entitled **COMPARATIVE EVALUATION OF ORAL REHYDRATION THERAPY IN ADULT CATTLE** or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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LIST OF ABBREVIATIONS

ml	Mililiter
kg	Kilogram
gm%	Gram per cent
gm/dl	Gram per deciliter
mmol/l	Milimol per liter
mg/dl	Miligram per deciliter
mEq/l	Miliequivalent per liter
gm	Gram
IV	Intravenous
mOsm/kg	Miliosmols per kilogram
ml/kg	Milliliter per kilogram
w/w	Weight to weight
%	Per cent
tsf	Tea spoonfull
@	At the rate of
mM/L	Milimole per liter
NaCl	Sodium Chloride
KCL	Potassium Chloride
$CaCl_2$	Calcium Chloride
mOsmol/kg	Miliosmols per kilogram
Na^+	Sodium ion
ORS	Oral rehydration solution
lb	Pound
gm/l	Gram per liter
mEq	Miliequivalant
^0F	Degree Fahrenheit
/min	Per minute
HCO_3	Bicarbonate
PCV	Packed Cell Volume
TLC	Total Leucocytes count

LIST OF ABBREVIATIONS

T.P.	Total Protein
TEC	Total erythrocyte count
Hb	Hemoglobin
Ca	Calcium ion
A:G	Albumin and globulin ratio
mg/l	Milligram per liter
H^+	Hydrogen ion
SCFAs	Short chain fatty acids
Cl^-	Chloride ion
Mg	Magnesium ion
K	Potassium ion
$NaHCO_3$	Sodium bicarbonate
mOsmol/l	Miliosmols per liter
ORT	Oral rehydration therapy
Rs.	Rupees
cm	Centimeter
Cumm	Cubicmilimeter
S.E.	Standard error
et al.	Other workers
Fig	Figure
inj	Injection
viz	As follows

INTRODUCTION

Dehydration from the Greek *hydor* (water) and the Latin prefix (indicating deprivation, removal and separation) occurs when more water and fluids are exiting the body than are entering the body. With about 75% of the body made up of water found inside cells, within blood vessels, and between cells, survival requires a rather sophisticated water management system. Although water is lost constantly throughout the day through breathing, sweating, urination and defecation. This can be replenish through the water in body by drinking fluids. The body can also shift water around to areas where it is more needed if dehydration begins to occur. Most occurrences of dehydration can be easily reversed by increasing fluid intake, but severe cases of dehydration require immediate medical attention.

Many diseases of animals cause dehydration. Common ones include ruminal and enteric diseases, acute mastitis, acute metritis, milk fever and ketosis. The worst consequence of dehydration is death. In animals which die of common diseases, it is often dehydration which ultimately kills them.

In less severe cases, dehydration delays the animal's recovery also. It also reduces the dry-matter intake, which increases the risk of complications – for example, left displacement of the abomasum (LDA) and hence, fluid therapy becomes the corner stone of treatment to save such animals.

Fluid therapy is a cornerstone of veterinary care. Fluid therapy in large animal practice is commonly undertaken, with two most likely scenarios being in a calf with diarrhea and a sick adult cow. Dehydration can be serious problem for both young animals and adults. Enteral nutrition always should be preferred to parenteral nutrition, because it is more effective, physiologic, practical and economic. Enteral nutrition is the state-of-the-art treatment for critically ill ruminants (Constable, 2003). The oral route for fluid administration should be used whenever possible, because oral solutions are cheaper and faster to administer than intravenous fluids and do not need to be sterile or pyrogen- free (Sen and Constable, 2013).

Fluid therapy in adult ruminants is often difficult to accomplish because large volumes are needed, animals must be restrained, proper therapy can be very time consuming, monitoring is often impossible and the large volume of fluids necessary to correct the dehydration is expensive. For these reasons, fluid

therapy is often avoided in adult ruminants, however there are clinical situations where either oral or intravenous fluids are necessary and cannot be avoided (Smith, 2005).

The degree of dehydration is potentially life threatening and procedures of intravenous fluid therapy and oral rumen large volume supplementation should be initiated immediately.

There are two things that dehydrated cow need, one is water, the other is electrolytes. A healthy cow just drinks what she needs and gets electrolytes from her feed. But a sick or weak one will not drink and eat as much as she needs too. Dehydration can then become an emergency. If untreated, it can cause a sequence of metabolic changes that can even become fatal.

The decision to give fluid is based on the clinician's determination of the degree of dehydration. In field situation, assessment of laboratory parameters such as hematocrit and total plasma protein are not immediately available and the clinician must use physical findings to determine hydration. Fluid administration remains a problem for most food animal practitioners not so much from the point of knowing the appropriate fluid to use but how to administer the fluid in an economic fashion and by an effective route. In clinics with animal pens, the idea of intravenous fluid administration is not out of the question because someone is on the premises to monitor the delivery. In the field, an intravenous fluid is occasionally given but only to the extent that the veterinarian has the time to baby-sit the animal and frequently the volume given is insufficient to correct the problem.

Oral electrolyte solutions have classically been used to replace fluid losses and correct electrolyte abnormalities in adult ruminants because they are cheap and easy to administer on-farm. Since most dehydrated cattle have a metabolic alkalosis, it is important to use a non-alkalinizing oral electrolyte solution that does not contain bicarbonate, acetate or propionate (Smith, 2005).

The rumen serves as a reservoir which releases consumed water to the body fluid compartments through an osmotic pressure gradient. As cells require fluid for metabolism, electrolytes and other nutrients exert osmotic pressure to continuously supply the cells with fluid for normal functions. A body fluid deficit results in reduced perfusion of fluid transferred nutrients to the cells for metabolism. Management of the water content of the rumen should be employed to maintain both normal rumen fluid volume as well as other body fluid reserves

to help cattle to combat the dehydrating effects from disease, environmental stress or transportation, water restriction (Ovrebo, 2010).

Oral administration can be done by using a full length orogastric tube and pumping in 20 to 50 litre of fluid, depending on rumen capacity and degree of dehydration. Non-chilled water when mixed with electrolytes is the preferred fluid choice and will replace the need for intravenous isotonic fluids for all but the severely dehydrated or toxic animal (Ovrebo, 2010).

Hydrating the cow orally, through a pump system, is the easiest means of rehydrating the cow on-farm, giving the cow the most vital nutrient - water.

It is therefore, decided to undertake a study to compare two different oral rehydration formulae for hydrating through a pump system, in adult cattle with the following objectives

OBJECTIVES

1. To study clinical, hematological & biochemical changes in dehydrated animals.
2. To compare the efficacy of two oral rehydration solutions in terms of their effects in correcting dehydration & electrolyte imbalance.
3. To estimate the cost economics of the therapy.

REVIEW OF LITERATURE

2.1 Oral Fluid Therapy

Donawick and Christie (1971) stated that, for maintenance of fluid losses, the route of administration may vary, depending on the severity of the case. Life threatening hypovolumia and acidosis must be rapidly corrected by intravenous administration of fluids and bicarbonates. They further expressed that, for mild cases of diarrhea, oral medication may be all that is necessary. However, if significant absorption of sodium ions from the intestinal tract is to occur, dextrose must be added to the orally administered electrolyte solution.

Breukink and Hajer (1974) prepared electrolyte solution composed of 29.4 gm sodium bicarbonate, 38 gm sodium chloride, 4.4 gm potassium chloride and 144 gm glucose per 10 liter of water to treat colibacillosis in calves. It was given to 18 calves for 6-8 times a day in a total daily dosage of 4-6 liters, after an initial I/V infusion of one liter of normal saline plus sufficient sodium bicarbonate (around 15-20 gm) to correct the acid base equilibrium. The result revealed that 12 calves suffering from diarrhea were recovered.

Dobson *et al.,* (1976) reported in experimental studies that in adult cattle, a net flow of water from rumen to plasma occurs whenever plasma osmolality exceeds rumen osmolality by greater than or equal to 20 mOsm/Kg; moreover, as rumen osmolality decreases, the rate of water movement from rumen into the plasma increases which means that to optimizing free water absorption rumen osmolality should be markedly hypo-osmotic.

Horvay *et al.,* (1976) treated calves with coli enteritis with a mixture of salt containing 0.15 gm potassium chloride, 0.25 gm calcium chloride, 4.3 gm sodium chloride, 30 gm glucose, 5 gm sodium bicarbonate and 5 gm of sodium citrate. This mixture was used with sulfotrim, however showed 86.56 per cent recovery with this combined treatment. Whereas the highest rate of recovery (91.62%) was observed by using combined treatment plus single injection of adrenocortical hormone. The combined treatment gave short recovery period than sulftrim alone having recovery rate 77.8 per cent.

Blood *et al.,* (1979) opined that rehydration therapy in diarrheic calves should be carried out with oral fluids. The oral fluid should be given in divided

doses every 2-4 hours. They proposed the composition of oral fluid as Formula No 1 : Sodium chloride 113.6 gm, potassium chloride 50.3 gm, sodium bicarbonate 108.9 gm , glucose 55.1 gm, glycine 223 gm. They recommended that 1000 ml of oral solution add 38.2 gm of the above dry mixture to 1 liter of water and it should be given at the rate of 100-140 ml/kg body weight in 6-8 divided doses.

Redaelli *et al.,* (1979) conducted an experimental study on the rehydration of calves suffering from diarrhea, stress like transport etc. These calves were rehydrated by giving drinking water or milk alone or with an antibiotic and a solution of sodium chloride, calcium gluconate, magnesium sulphate, monopotassium phosphate, sodium propionate, dextrose and 19 amino acids. The satisfactory weight gains and reduced mortality from diarrhea were recorded.

Click and Phillips (1981) evaluated a commercial preparation for oral therapy of diarhoea in neonatal calves. They compared administration of solution by suckling versus intubation. They observed that overall groups of calves (healthy suckle, healthy intubation, sick suckle and sick intubation) appeared to absorb beneficial quantities of nutrients, electrolyte and the fluid regardless of the method of administration. The products were containing the following ingredients at different concentration in different groups. Dextrose 56.75 w/w, Dried meat solubles 18.91% w/w, Magnesium sulphate 0.76w/w, Potassium chloride 3.60%, Sodium chloride 2.84%, Sodium bicarbonate 12.68, Calcium phosphate dibasic 1.33%, 100 gm of product dissolved in 1892 ml of water.

Green (1984) reported that all commercially available fluid and electrolyte replacement products are seriously deficient in energy and also observed that oral rehydration is the treatment of choice whenever the estimated degree of dehydration is 8 %. He formulated homemade high energy oral rehydration solution comprised of glucose 60 gm, beef consommé soup 320 gm, sodabicarb 2 tsf and sodium chloride 1 tsf each along with water up to 1.9 liter for prevention and treatment of calf diarrhea.

Roy *et al.,* (1984) evaluated oral fluids for treatment of diarrhea in kids by using two oral fluid containing sodium chloride, calcium gluconate, magnesium sulphate, potassium dihydrogen phosphate, dextrose and glycine in fluid I while fluid II contained sodium phosphate, sodium bicarbonate, glycine and glucose. It

was observed that administration of oral fluids caused improvement in the general appearance and condition of diarrheic kids. Gain in body weight of diarrheic kids on fluid administrations was 4.84±0.36 per cent with fluid I and 8.07±0.05 per cent with fluid II in 7 days.

Yeotekar (1988) compared efficacy of oral rehydration with parenteral rehydration therapy with inj. Ringer lactate in experimentally induced calf diarrhea. The oral rehydration formula the compassion of sodium chloride 1 tsf (5 gm approx.), potassium chloride 50 gm dissolve in 2 liters of water and given twice daily. inj. Ringer lactate was given @ 1200 ml I/V for 3 days to each calf. No significant difference was found between the efficacy of these two treatments towards the restoration of lost electrolyte and water.

Avery and Snyder (1990) suggested that the combined administration of sodium and glucose is beneficial because glucose facilitates sodium absorption via the small intestine, intestinal sodium/ glucose co-transport mechanism.

Carter and Grovum (1990) stated that the ruminal epithelium is capable of absorbing large volumes of water. The main force for water movement across the rumen wall is the gradient of osmolarity between ruminal fluid (which is normally iso-osmotic) and blood perfusing the ruminal epithelium.

Mohan *et al.,* (1990) used fluid therapy in neonatal diarrhea of buffalo calves. Out of 25 diarrheic calves, 18 (48.7%) gave well response when given oral fluid than other group of 25 calves to whom parenteral fluid therapy was given, 19 (51.3%) responded favorably. The difference in the response to dehydration by two different routes was found to be statistically non-significant. They suggested that both oral rehydration therapy and parenteral fluid therapy were equally effective, suggesting the use of oral route in field practice.

Naylor (1990) considered that the optimal oral electrolyte solution should have a sodium concentration between 60 and 120 mM/L, a potassium concentration between 10 and 20 mM/L, a chloride concentration between 40 and 80 mM/L, 40 – 80 mM/L of metabolized (non- bicarbonate) base, such as acetate or propionate and glucose as an energy source.

Rings (1994) stated that the most consistent sign of disease in cattle is anorexia and hence, hypokalemia is likely to develop because cattle store little

potassium in their body but continue to lose in urine and feces. If anorexia is more profound and likely to increase the prospect for hypokalemia, isotonic mixture containing NaCl and KCl can be offered safely to most sick cattle to accommodate this condition. He opined that oral fluids to adult ruminants should be delivered in isotonic range (280-300 mOsm/l) to enrich there movement and absorption.

Silanikove (1994) observed that the rumen is also involved in the regulation of water intake and in the capacity of ruminating animals to replenish the exact amount of water lost during dehydration. The gastrointestinal tract and related organs (salivary glands and liver), in addition to their function in nutrient digestion and absorption, are vitally important in maintaining water, electrolyte and acid-base homeostasis. The water ingested following rehydration (15-40 % of body weight) is first retained in the rumen. Thus, rumen volume may exceed the extracellular fluid volume and an osmotic gradient of 200-300 mOsmol kg (7-8 atm) between the rumen and blood may develop. Compared with the erythrocytes of other mammalian herbivores (Camelidae and Equidae), those of domestic ruminants are very susceptible to a lowered tonicity of the plasma, so buffering the rate of water absorption following rehydration is vital. Na+ absorption from the gut is very high and similar high rates of Na+ absorption were also found in various monogastric mammals. Utilization of gut water during dehydration causes a considerable Na+ load, the amount of Na+ absorbed from the gut per day exceeding by 600 % the amount of Na+ contributed by daily food in cattle. The increase in Na+ concentration in saliva during dehydration is of physiological importance, since it helps to moderate the rise in plasma osmolality. Consequently, the effectiveness of utilization of rumen fluid during dehydration depends on the capacity of the kidney to 'desalt' the water absorbed from the gut and on maintenance of salivary flow to the rumen.

Brooks *et al.,* (1996) suggested that the optimal oral electrolyte solution required a higher sodium concentration (120 to 130 mM/L) to rapidly correct extracellular electrolyte and fluid losses that typically develop in calves with diarrhea and dehydration.

Constable *et al.*, (1996) reported that oral electrolyte fluid administration causes slow and sustained increase in cardiac output and also plasma volume in dehydrated animals.

Bouda *et al*., (1997) observed that an ORS containing 42 g of sodium chloride, 40 g of sodium bicarbonate, 18 g potassium chloride and 200 g glucose dissolved in 10 liter of water was effective in rehydrating diarrheic calves with mild dehydration.

Alone *et al.,* (2000) induced diarrhea in 18 calves, divided in 3 groups. The control group (C) kept untreated, whereas the second group (T_1) was given Ringer's Lactate I/V in three divided doses per day for three days. The third group (T_2) was drenched with isotonic oral rehydration solution @ 1 liter for three days which contain 32.8 g of mixture comprised of sodium chloride 113.6 gm, potassium chloride 50.3 gm, sodium bicarbonate 108.9 gm, glucose 535.1 gm and glycine 223 gm and observed that T_2 was effective in correcting diarrheic electrolyte imbalance in view of its easy preparation, administration and cost economics under field condition.

Rajora and Pachauri (2000) categorized three groups of diarrheic calves with mild, moderate and severe degree of dehydration. The calves with mild dehydration were given ORS comprising of 20 g glucose, 3.5 g sodium chloride, 2.5 g sodium bicarbonate and 1.5 g potassium chloride in 1 litre of water at 12 hour interval for 3 days. The calves with moderate dehydration were administered 5 per cent solution of sodium bicarbonate (I/V) followed by ORS. The calves with severe dehydration were administered sodium bicarbonate (I/V) followed by administration of mixtures of isotonic saline and bicarbonate with 5% dextrose (I/V) followed by ORS. All the calves with mild and moderate dehydration showed recovery with the above rehydration therapy however, two of the severely dehydrated calves did not recover with the above rehydration therapy.

Constable (2003) reported that the optimal solution for oral administration to neonatal ruminants has a sodium concentration between 90 and 130 mmol/L; a potassium concentration between 10 and 20 mmol/L; a chloride concentration between 40 and 80 mmol/L; 40 to 80 mmol/L of metabolizable (nonbicarbonate) base, such as acetate or propionate; and glucose as an energy source. The optimal formulation for adult ruminants is unknown, but such a solution should contain sodium, potassium, calcium, magnesium, phosphate, and propionate to facilitate sodium absorption and to provide an additional source of energy to the animal. Provided that the osmolality of the rumen contents remains hypo-osmotic

to plasma, there will be a slow but sustained absorption of electrolytes and water in an oral electrolyte solution because of the reservoir function of the rumen. He further stated that hypophosphatemia is treated best by oral administration of feed-grade monosodium phosphate. Hypokalemia is treated best by oral administration of feed-grade KCl.

Morin (2004) opined that fluids can be administered by the oral (intraruminal) or IV route. The oral route is least expensive and is often adequate for cows with mild to moderate dehydration. Oral fluids should be hypotonic and contain sodium in order to create an osmotic gradient between ruminal fluid and blood and enable sustained absorption of fluid and electrolytes; hypertonic oral fluids must be avoided. A 600 kg (1,320 lb) cow with 6% dehydration needs to absorb 36 liters (approximately 9 gallons) of fluid to replace the deficit. This volume can be administered safely, but oral ingestion of larger volumes of hypotonic fluid might lead to hypothermia and intravascular hemolysis. Oral fluids are not sufficient for cows with severe dehydration, as they do not allow rapid resuscitation.

Smith (2005) stated that oral electrolyte solutions have classically been used to replace fluid losses and correct electrolyte abnormalities in adult ruminants, because they are affordable and easy to administer on-farm. Since most dehydrated cattle have either a normal blood pH or a metabolic alkalosis, it is important to choose an oral electrolyte solution that does not contain bicarbonate, acetate, or propionate, and therefore is not alkalinizing. Metabolic alkalosis of cattle is not corrected by administering acid, but instead by providing extracellular anions in relative excess to cations. In practice, this is accomplished with chloride-rich, high potassium solutions by simply adding NaCl (7 g/L), KCl (1.25 g/L) and $CaCl_2$ (0.5 g/L) to a liter of water (or 140 g NaCl, 25 g KCl, and 10 g $CaCl_2$ in 20 L or roughly 5 gallons of water), a homemade nonalkalinizing oral electrolyte solution for adult ruminants can be prepared that will effectively rehydrate animals without alkalinizing blood pH.

Smith (2005a) opined that oral fluids can be used successfully in cows that have mild to moderate dehydration by adding reagent-grade salts to filtered de ionized water either Ringer's, sodium chloride, or a ruminant electrolyte solution containing additional potassium and calcium fluids can be prepared quite economically.

Smith (2005b) recommended two systems of therapy such as Magrath pump (available from several on-line livestock supply companies) and the Nasco flexible cattle pump (available from Nasco). Both of these are designed to be used by a single person. They involve inserting a metal tube in the cow's mouth which can then be secured to the nose with a clamp. That way, the tube cannot slide in or out of the cow's mouth. The person can then let go of the tube and pump the 5 gallons of water into the cow before removing the nose clamp and taking the tube out. With either of these systems, one person can deliver 5 gallons of fluids within 2 to 3 minutes.

Rainger and Dart (2006) reviewed that enteral fluids are often considered to be a less expensive method of rehydrating veterinary patients than intravenous fluids. As untrained personnel are able to administer fluids without requiring repetitive intervention by highly trained personnel. They further reported that enteral fluids provides an alternative for treating mild to moderate dehydration in a variety of species and where the animals did not readily drink.

Choudhary (2007) stated that there are many diseases of animals in which disturbances of body fluids occur. These disturbances coincide with changes in electrolyte and acid base balance of the body. Further, she stated that fluid administration is an important supportive measure in such diseases. Judicious and timely use of fluid therapy can correct the abnormalities in water, electrolyte and acid-base balance and can save lives of animals.

Cure (2010) reported that for 5 per cent dehydration 30 liters, for 10 per cent dehydration 60 liters and for 15 per cent dehydration 90 liters of oral fluid volume required to correct the dehydration in adult cattle.

Ovrebo (2010) suggested that dehydrated adult cattle usually have a metabolic alkalosis and it is important to use non-alkalinizing fluids. Alkalosis is addressed by providing more extracellular anions relative to the excess of cations. Fluid preparations, whether oral or IV, need to contain sources of chloride electrolytes when administered to dehydrated cattle. Oral rehydration of adult cattle is sufficient in most cases where dehydration is less than 8% of body weight and the animal is not toxic. Oral administration by using a full length orogastic tube (14-feet tube marked at the 10-feet length to insure rumen placement) and pumping in 20 to 50 liters of fluid depending on rumen capacity

and degree of dehydration. Non-chilled water when mixed with electrolytes is the preferred fluid choice and will replace the need for intravenous isotonic fluids for all but the severely dehydrated or toxic animal. If hypokalemia is suspected, 20–40 mEq/L of potassium chloride should be added. Hypocalcemia is a common confounding problem in a lactating cow that is dehydrated and off feed. Adding 250–500 ml of 23% of calcium gluconate will address the issue. Adding 5% glucose per liter will supply energy. Quantities of fluid administered were dependent on the level of dehydration and degree of vascular expansion needed to maintain cell perfusion.

Lopes (2013) used indwelling nasogastric tube and administered a homemade electrolyte solution in a Bactrian camel (*Camelus bactriances*) developed for horses containing 135 mEq of Na, 95 mEq of Cl and 5 mEq of K with calculated osmolality of 280 mOsm per litter and ruminal fluid extracted from a healthy cow with a ruminal fistula. The electrolyte solution and ruminal fluid were transferred to a carboy and administered through a coiled fluid line. Enteral administration of fluids and ruminal content well tolerated and the camels appetite was markedly improved 24 hour after the beginning of this therapy. A total volume of 80 liter of ruminal fluid was administered over 2 days while 120 liter of electrolyte solution was administered over 5 days to the camel.

Jones and Navarre (2014) documented that in ruminants and camelids, large volumes of fluids may be administered into the rumen or first compartment, allowing for effective treatment of mild to moderate dehydration. In general, the animals most likely to benefit from oral fluid therapy are those that are mentally alert, have good gastrointestinal motility, and are less than 8% dehydrated. Animals not meeting these criteria are best managed with at least initial parenteral fluid resuscitation and correction of acid-base and electrolyte abnormalities. Oral fluid therapy represents an economical and effective means for replacing mild to moderate fluid and electrolyte deficits. In addition, oral therapy is indicated in cases of severe hypokalemia and hypophosphatemia, where intravenous administration carries a greater risk for complications and is frequently less effective than oral therapy. To achieve effective absorption of water, oral fluids must contain sufficient sodium to facilitate transport across the intestinal mucosa. Ideally oral solutions should contain at least 90 mmol/L of sodium. Ruminants with anorexia and gastrointestinal stasis frequently have low

concentrations of plasma potassium and chloride, making it important that oral replacement solutions contain extraphysiologic concentrations of these electrolytes. Oral electrolyte solution formula for adult ruminants 7 g NaCl, 1.5 g KCl and 1 g $CaCl_2$ dissolved in 1 liter of water.

Roussel (2014) mentioned that the rumen is an incredibly useful reservoir in which one may administer large volumes of water and rehydration solutions, and should be used whenever possible. For conditions where the gastrointestinal tract is functional, there is no reason not to administer intraluminal fluids along with intravenous fluids. The concentration of electrolytes in the solutions varies dramatically, and it should be emphasized that nonalkalinizing oral electrolyte solutions are indicated in adult ruminants. Products that contain bicarbonate or acetate are designed for calves with diarrhea that generally have a metabolic acidosis, and would not be appropriate for adult cattle in most cases. By simply adding NaCl (7 g/L), KCl (1.25 g/L), and $CaCl_2$ (0.5 g/L) to 1 L of water (or 140 g NaCl, 25 g KCl, and 10 g $CaCl_2$ in 20 L or roughly 5 gallons of water), a homemade nonalkalinizing oral electrolyte solution for adult ruminants can be prepared which effectively rehydrate animals without alkalinizing blood pH.

2.2 Clinical observations

Weeth *et al.,* (1962) studied effect of salt water dehydration on temperature, pulse and respiration of growing cattle and he observed during winter and summer dehydration the average pulse rates were lowered in growing cattle.

Watt (1965) noted typical signs of diarrheic dehydration as lassitude, sunken eyes, sluggish capillary refill time, tight hide bound skin which when pinched remain in a ridge, cold extremities and pale mucus membrane overlaid by a dirty brownish coloration. Frequently the temperature was subnormal. The pulse was impalpable and heart rate was either very fast, or slow and irregular. As the condition progressed the animal became unwilling to rise on its feet and was ataxic when raised.

Thornton *et al.*, (1972) suggested that clinical assessment of dehydration and diarrhea based on the loss of pliability of the skin of the neck, upper eyelid

and on the observed fecal consistency and can be classified as being slight, moderate and severe.

Boyd *et al.,* (1974) observed the values of rectal temperature (^{O}F), heart rate per minutes and respiration rate per minutes in normal calves as 101.5±0.7, 63±9 and 28±10 respectively. Whereas for diarrhoeic calves values were 100.9±2.0, 137±32 and 43±15 respectively.

Dallenga (1975) reported clinical signs as cold muzzle and extremities, subnormal temperature, sunken eyes, disturbed locomotion and watery feces indicating the need for electrolyte treatment. At the rate of 150 drop/min given 3 liters of solution containing 30 g sodium bicarbonate and 9 g sodium chloride followed by 14 g sodium bicarbonate, 12 g sodium chloride, 8 g potassium chloride and 100 g glucose in 3 liter distilled water subjected at the rate of 60 drops per minute to the diarrheic calves, with good results.

Tennant *et al.*, (1975) observed that each neonatal calf with diarrhea showed severe dehydration which was judged by the turger of skin and by the sunken appearance of eyes in the orbit. Calves were either weak or lethargic. Rectal temperature was almost elevated. There was varying degree of hypovolemic shock with heart rate varied from 40-120 per minute.

Rumesy and Bond (1976) carried out an experiment in adult beef cattle to evaluate changes due to deprived water and feed. Two trails were conducted with total of 12 heifer beef cattle and allowed them of deprived water and feed. Data reported that due to deprivation of water and feed rectal temperature declined significantly by 1.5% and respiration rate by 45% there was increased PCB by 21% and serum phosphorus by 43%. Deprivation of water reduced heart rate 19% and increased serum sodium and potassium by 12 and 23 % respectively, however, these changes were not significant. After reintroduction of water and feed all parameters came in normal physiological limit.

Bywater (1980) correlated degree of dehydration with clinical signs in 0-5 per cent dehydration. The symptoms were mild depression, and decreased loss of body weight and urine output. In 6 to 8 per cent body weight loss, there were sunken eyes, tight skin and depression but the animal was standing with further urine reduction. In 9 - 11 per cent there was body weight loss with increase in

above symptoms as cold extremities and recumbence. In 12 – 24 per cent, body weight loss was more and common symptoms was shock and death.

Kumar *et al.,* (1981) studied on 25 scouring buffalo calves having age up to 60 days to determine clinical manifestation, temperature, pulse rate and respiration rate. The increase in temperature, pulse rate and respiration rate up to 3-5 days was observed.

Gadge (1982) studied on diarrhea in neonatal calves and observed after 72 hours of treatment with parenteral or oral rehydration fluids, the respiration rate in all the treatment groups was reduced.

Sridhar *et al.,* (1988) observed debility, anorexia, lethargy, marked elevation of body temperature, pulse rate and respiration rate in diarrheic calves.

Constable *et al.,* (1998) suggested that altered hydration status can be estimated and quantified using eye position within orbit, extent of skin elasticity and degree of mucous membrane moistness.

Bhalerao *et al.,* (2000) documented that the duration of illness of three to four days in diarrheic calves . The rectal temperature, respiration rate and heart rate were elevated within normal range and values for respiration rate as ranging from 22-35/min in calves suffering from neonatal calf diarrhea.

Constable *et al.,* (2001) observed unaltered rectal temperature in dehydration and rehydration with oral electrolytes during the study on comparison of two oral electrolyte solutions for the treatment of dehydrated calves with experimentally induced diarrhea. In all groups serum calcium, protein were decreased after oral rehydration.

Kumar and Mandial (2002) studied clinical signs of colibacillosis in cross bred calves and found that, affected calves showed profuse diarrhea with loose fecal consistency, dullness, depression, reduced appetite and dehydration with sunken eyes and reduced skin elasticity. The mean value of body temperature in infected calves was 102.40±0.41 which decreased gradually on 5th day of treatment to 101.67 ± 0.20^{0}F**.** The significant ($p<0.05$) increase in respiration rate (31.33±0.98/min) and heart rate (106.67±2.51/min) were observed in the study.

Khan and Zaman (2007) studied on effects of rehydration solution on hematological and biochemical parameters in induced buffalo neonatal calf diarrhea and reported that that mean pulse and respiration rate differ non-significantly between the groups of dehydrated calves.

Radiostits *et al.,* (2007) documented the body temperature may increase slightly in the initial stage which is known as dehydration hyperthermia because of insufficient fluid to maintain the loss of heat by evaporation.

Davis (2013) documented that skin turgor or skin elasticity is a crude way of determining the interstitial compartment volume status. When assessing skin turgor its best to use the same location for consistency in technique. The lateral thorax or between the shoulder blades are good locations to assess skin turgor. With 5% dehydration the skin, when lifted, will return to it's normal position fairly quickly but slightly slower than normal. With 8% dehydration the skin returns to its normal position slower than 5% dehydration but faster than 12% dehydration. When the patient is 12% dehydrated the skin will remain tented and not return to normal position. Elasticity of the skin is affected by cachexia and obesity. It is possible to have a normally hydrated patient that has reduced skin elasticity due to cachexia; or a dehydrated patient that has normal skin elasticity as a result of being fat. Other signs consistent with dehydration include dry skin and mucus membranes, oliguria, and signs of compensatory peripheral vasoconstriction.

Roussel (2014) studied more than 500 cattle, wherein blood gas and electrolyte analysis were made from venous blood serum and found that dehydrated mature cattle were about twice more likely to have metabolic alkalosis than metabolic acidosis. If cattle with pneumonia, carbohydrate engorgement (rumen acidosis), and diarrhea were excluded, only 16% of dehydrated cattle had metabolic acidosis. In another study, approximately 60% of 350 sick cattle tested had pH values within the reference interval. However, many had compensated acidosis or alkalosis. Approximately 53% had abnormally elevated concentrations of HCO_3 whereas about 10% had decreased HCO_3 concentrations. Therefore, based simply on the fact that an animal is a mature bovid and is dehydrated, the probability that it has metabolic alkalosis is much greater than the probability that it has metabolic acidosis. By considering the clinical signs and diagnosis, further refinement of the assumption can be made. Gastrointestinal tract stasis and small intestinal or pyloric obstruction lead to

accumulation of chloride ions in the gastrointestinal tract, resulting in systemic alkalosis. Therefore, cattle with abomasal displacement or volvulus, vagal indigestion, and cecal displacement or torsion are usually alkalotic. Carbohydrate engorgement, urinary tract disease, small intestinal strangulation/obstruction, and enteritis/diarrhea, are conditions of mature cattle whereby metabolic acidosis is more common than metabolic alkalosis. Carbohydrate engorgement results in systemic acidosis because large amounts of volatile fatty acids and lactic acid are produced by bacterial fermentation.

2.3 Hematological study

2.3.1 Packed Cell Volume

Fisher and Fuente (1972) reported that PCV values in normal calves ranged from 35.50±3.5 to 42.5±1.7 per cent however reaches to 51.7± 9.8 per cent in the dying calves.

Tennant *et al.*, (1972) conducted the study in 28 diarrheic dehydrated calves and found significant increase in PCV per cent. The mean PCV was 45.3± 7.0 per cent with a range of 31.0-60.0 per cent against the normal range of 25.0-40.0 per cent.

Thornton *et al.*, (1973) reported PCV values in normal, slight, moderate and severe dehydrated calves as 35, 35, 36 and 46 per cent which indicate that there was significant increase in PCV value in severely dehydrated calves.

Boyd *et al.*, (1974) estimated packed cell volume, total leucocyte count, neutrophils and lymphocytes values in normal calves and observed values were 40.8±6.9 per cent, 9.12± 2.96x10^3 per cmm, 3.52±1.94 x10^3 per cmm and 5.36±1.84 x10^3 per cmm, respectively. In diarrheic dehydrated calves the non sustained levels were 54.2±8.0 per cent, 20.18± 8.94 x10^3 per cmm, 14.06±6.79 x10^3 per cmm and 5.02±1.93 x10^3 per cmm, respectively. PCV, TLC, neutrophils and lymphocytes values differ significantly between diarrheic calves able to stand and calves unable to stand.

Sodhi and Singh (1974) assessed changes in plasma values under normal condition and stress condition such as exercise load, dehydration and starvation and found that haematocrit values under all these condition increased

from that normal values. The mean value of PCV 32.1±1.8 and 36.4± 3.1in normal and in starvation and dehydration condition respectively was noted.

Benjamin (1981) suggested that packed cell volume provides information about the degree of dehydration. A low packed cell volume would suggest the need for blood transfusion rather than parenteral solutions. As hydration occurs the packed cell volume fall below normal. Also after hydration the total protein values also decreases.

Fettman and Phillips (1986) studied effect of 5 commercial oral replacement formulae on hematological values in healthy neonatal calves. It was observed that, there was non-significant (P > 0.05) effect of commercial product feeding with time or by treatment as compared with those in whole milk fed controls on hematological values of PCV and leucocyte count.

Rajora and Pachauri (2000) conducted hematological profile in 36 diarrheic calves and six apparently healthy controls and observed that PCV value was significantly (P<0.01) elevated to 43.33± 0.84, 51.67±0.67 and 55.67±1.12 per cent in calves having mild, moderate and severe dehydration, respectively in comparison to PCV of 36.17±2.023 per cent in healthy calves.

Kumar and Mandial (2002) studied hematological profile of cross bred calves for clinical colibacillosis and revealed significant (P<0.05) increase in packed cell volume (43.67±2.5%).

Davis (2013) mentioned that packed cell volume (PCV) and total protein (T.P.) are simple tests that can be used to evaluate hydration. PVC and T.P. are often elevated with dehydration. In case of anemia, the PCV may appear to be normal but this is only due to hemoconcentration.

2.3.2 Total Erythrocyte Count

Manoiu *et al.,* (1972) made hematological investigation on 74 calves of 2-15 days of age, in dehydrated condition consequent upon enteritis and observed that affected calves showed increased TEC, TLC,PCV, Hb and eosinophil count. They also showed decrease in serum Na, Ca and magnesium.

Sridhar *et al.,* (1988) studied clinic-pathological alteration in calf scour and revealed higher total erythrocyte count (8.39±0.26 million/cmm), and total

leucocyte count (12.71±0.90 thousand /cmm) which probably resulted from dehydration.

Nag *et al.,* (2007) evaluated therapeutic efficacy of polyherbal formulation containing *Cassia absus, Cuminum cyminum, Kalanchoe pinnata* and *Helicteres isora* in clinical cases of diarrhea in calves and found significant decrease in the values of total erythrocyte count in treatment calves.

Sukare (2007) evaluated the herbal antidiarrhoeal with oral rehydration in calf diarrhea and found decrease of total erythrocyte count in all the groups from 0 to 24 hours after treatment.

2.3.3 Hemoglobin

Bianca (1970) experimented on four cattle kept at 20℃ where each animal was subjected to deprivation of drinking water for three days, followed by rehydration, or overhydration brought by infusion of water into the rumen. Dehydration caused a 34% increase in blood viscosity, mainly due to loss of water from plasma but also from the loss of red cells, as evidenced by increases in mean corpuscular Hb concentration and red cell total solids. Osmotic fragility of erythrocytes and urinary specific gravity was increased. Rehydration by drinking produced cardiac acceleration and a sharp transient rise in the blood variables to above. These responses were absent in rehydration by infusion. After rehydration, osmotic fragility remained high for several hours. In two instances, rehydration by drinking led to intravascular haemolysis and haemoglobinuria. Overhydration caused marked diuresis and slight haemoconcentratjon. There were no obvious signs of water intoxication, but there were instances of haemolysis and haemoglobinuria.

Tennant *et al.,* (1975) in their studies on calf diarrhea observed that hemoglobin concentration was constantly elevated in most severe dehydrated calves.

Bijwal and Misra (1987) conducted the study on 12 cross bred cow calves less than one week of age in which enteric colibacillosis was produced by giving *E.coli* culture orally. Blood samples were collected for hematological analysis from all the calves before infection, following diarrhea and 24 hours after last treatment. The result reveled increases in Hb and PCV values as 13.60±

1.30 g/dl and 49.33± 4.51 per cent than that of base values of 9.21±0.64 g/dl and 31.83±1.37 per cent respectively.

Alone *et al.,* (2000) conducted studies on calf diarrhea with special reference to oral rehydration therapy, who reported increase in hemoglobin concentration in pre treatment groups and hemoglobin concentration decreased in treatment groups.

Sukare (2007) during evaluation of the herbal antidiarrhoeal with oral rehydration in calf diarrhea reported that there was decrease of hemoglobin concentration after the therapy in calves.

2.4 Biochemical study

2.4.1 Total protein

Thronton *et al.*, (1972) found no relationship between the degree of dehydration in calves with diarrhea and the serum protein concentration. Severely dehydrated calves had total serum protein levels which were almost identical to those of normally dehydrated calves. However, albumin globulin ratio was highest in severely dehydrated calves.

Barber and Doxey (1975) reported that serum protein ranges from 4.59 to 6.91 g/100 ml in healthy and diarrheic calves. The figure range for potassium, sodium and chloride recorded as 5.75 to 9.1 mEq/l, 133.6 to 142.6mEq/l and 99.7 to 111.3 mEq/l, respectively.

Lewis and Phillips (1978) observed that increased total plasma protein concentration in diarrheic calves as a result of dehydration.

Kumar *et al.,* (1981) conducted study on 25 scouring buffalo calves of different age groups up to 60 days of age to record the change in serum total protein. It was observed that, the mean serum total protein was ranging from 5.780±0.237 to 7.480±0.205 and 6.220±0.235 to 8.020±0.443 g/dl in healthy and infected buffalo calves, respectively which indicates an increase of total protein in scouring buffalo calves. Further, they opined that rise in serum total protein might be the result of dehydration and hemoconcentration.

Sridhar *et al.,* (1988) revealed increase in total protein concentration (gm/100ml), albumin (gm/100ml), globulin (gm/100ml) and albumin : globulin ratio in scouring calves as 7.55±0.24, 4.07±0.10, 3.48±0.12 (gm/100ml) and 1.17± 0.08, respectively.

Constable *et al.,* (2001) made comparison of two oral electrolyte solutions for the treatment of dehydrated calves with experimentally induced diarrhea and they found that in all the three treatment procedures similar decrease in serum total protein, albumin, calcium, phosphates, creatinine and urea nitrogen concentrations and hematocrit by 24th hours after treatment.

Avanza (2004) studied on experimentally dehydrated cows and reported that there was decrease in indices of hematocrit and total protein. This was caused by enteral administration of hydration solution, which lead to the expansion of plasma volume.

Atoji (2005) experimented fluid by nasogastric tube in goats and found the total solid concentration increased significantly in dehydration phase and decreased significantly in the fluid phase in the two treatments.

2.4.2 Serum Sodium

Dalton *et al.*, (1965) investigated effects of diarrhea and observed that diarrheic calves registered significant changes in the concentration of plasma sodium and potassium.

Watt (1965) observed plasma sodium concentration as 154.0 mEq/L and plasma potassium concentration as 6.1 mEq/L in severely dehydrated calves. In a normal calf, plasma sodium concentration was141.0 mEq/L and plasma potassium concentration was 4.1 mEq/Litre.

Donawick and Christie (1971) stated that for mild cases of diarrhea, oral administration of fluid may be all that is necessary. However, if significant absorption of sodium ions from the intestinal tract is to occur, dextrose must be added to orally administer electrolyte solution.

Alikutty and Rajamani (1972) observed that plasma sodium did not show marked change in mild cases of diarrhea but found declined in prolonged

cases of diarrhea. They also registered normal and subnormal potassium levels in majority of cases showing mild or moderate form of diarrhea.

Manoiu *et al.*, (1972) recorded decrease in A:G ratio, hypo or agammaglobulinaemia in 74 dehydrated calves consequent upon enteritis. It also showed decrease in serum sodium.

Horvay *et al.*, (1976) recorded decrease level of sodium (141.29mg/l) in calves suffering from coli enteritis than that of normal healthy calves (144.24 mg/l). Similarly there was increase in chloride level (100.01 mg/l) in calves suffering from coli enteritis than that of normal healthy calves (98.67 mg/l), but the potassium level did not show much alteration in healthy and in calves suffering from coli enteritis and recorded as 4.88 in healthy calves.

Scharrer *et al.,* (1983) reported that Na and Cl absorbed from the rumen and both ions are transported by active mechanism in the mucosal- serosal directions.

Deshpande *et al.,* (1993) reported that the mean serum sodium concentration was significantly lower in scouring calves (132.28±0.92mEq/l) as compared to normal healthy calves (138.14±1.19mEq/l) while serum potassium concentration was significantly higher (5.32±0.07 mEq/l) as compared to normal calves (4.14±0.15 mEq/l). The mean serum chloride concentration was also significantly higher in scouring calves (107.42±0.87 mEq/l) as compared to normal healthy calves (98.00±0.37 mEq/l). There was slight increase in the value of albumin (4.05±0.01 g/dl) and globulin (3.12±0.01 g/dl) in scouring calves than healthy calves who reported as 3.92±0.02 and 3.01±0.02 g/dl, respectively whereas, as A : G ratio in diarrheic calves and healthy ones was found to be 1.19±0.01 and 1.29±0.01. The mean serum total protein concentration was significantly higher in scouring calves (7.18±0.02 g/dl) as compared to normal healthy calves (6.93±0.01 g/dl).

Sehested *et al.,* (1996) explained that sodium is actively transported across bovine rumen epithelium and it interacts with SCFAs short chain fatty acids and chloride ions. The apical membrane of rumen epithelial cells expresses a SCFA and amiloride sensitive Na^+ -H^+ exchange that might be the main route for apical sodium transport in the presence of SCFAs (i.e. physiological conditions).

2.4.3 Serum Potassium

Fisher (1965) observed non-significant difference between plasma sodium concentration between calves and adults. However, the plasma potassium showed a higher concentration in calves than in adults.

Watt (1967) studied fluid therapy for dehydration in calves and found that plasma sodium and potassium level varies considerably in cases with mild diarrhea followed by marked alteration in terminal cases and further stated that in majority of cases sodium level decline where as potassium values elevated.

Scotto *et al.,* (1971) administered citric acid (53 g/100kg body weight) to two blocks of animals, one splenectomized and one intact with 0,40, 80 or 100 g KCL/100 kg body weight in water by stomach tube. In a second study animals received either no salts, 80 gm KCL, 63 gm NaCl or both KCL and NaCl with citric acid administered as before and serial blood samples were taken and plasma citric acid, Mg, K, Ca and Na measured, they found that plasma citric acid increased and generally reached to peak ½ hour after drenching, regardless of the treatment, the increase was related directly to the amount of salt administered within 24 hours plasma citric acid was within the normal range. Oral KCL and/or NaCl increased plasma Mg, Ca and Na in early periods post administration. Plasma K was depressed in early intervals in those animals receiving no salt or only NaCl. All plasma constituents were normal in 24 hours.

Boyd *et al.,* (1974) estimated serum sodium and potassium concentration in normal calves and the recorded values were 136±7.3mEq/l and 5.3±0.3mEq/l, respectively. In diarrheic calves the corresponding levels were 144.2±5.5mEq/l and 5.6±2.7mEq/l, respectively serum sodium concentration differed significantly between diarrheic and normal calves.

Massip (1979) studied biochemical changes associated with diarrhea in the calf. The mean plasma sodium concentration on day 3 and 5 were reported significantly lower than the mean concentrations in the calves at birth ($P<0.01$) as 129.0±2.9 and 126.0±6.2mEq/l, respectively. However, the mean plasma potassium concentration on 3rd and 5th day was significantly ($P<0.01$) higher than the mean concentrations in the calves at birth and reported as 6.4±0.4 and 5.20.1mEq/l, respectively.

Groutides and Michell (1990) reported that hypokalemia occurs commonly in anorectic adult ruminants particularly in lactating dairy cows because of the loss of potassium in the milk and severe hypokalemia causes muscular weakness and recumbence. Similar to calcium, oral administration of potassium is a mandatory component of fluid and electrolyte administration to lactating dairy cows.

Bali *et al.,* (2000) investigated 24 cases of *E coli* infected diarrheic calves which were dehydrated and observed decline in concentration of serum sodium and elevation of serum potassium and protein levels in diarrheic calves.

Constable (2003) suggested that oral potassium administration is the method of choice for treating hypokalemia. Practitioners routinely treat anorectic adult cattle with 30 to 60 g of feed –grade KCl twice at 12 hours interval in gelatin bolus.

Kaur *et al.,* (2006) investigated biochemistry in 32 diarrheic calves and revealed increase in mean plasma sodium and potassium level in diarrheic calves 139.33±5.98 and 5.19±0.26 mEq/l before treatment as compared to healthy control 128.40±7.64 and 4.51±0.29 mEq/l, respectively.

Radostits *et al.,* (2007) documented that since potassium is the major intracellular cation, the measurement of plasma or serum potassium is not a reliable indication of whole-body potassium status. Extremely low levels or high levels are usually indicative of a potassium imbalance, often associated with other electrolyte and acid-base imbalances. In severe alkalosis, for example, potassium leaves the extracellular space and becomes concentrated in the cells. This may result in low serum potassium levels when, in fact, there might not be potassium depletion of the body. Conversely, in severe metabolic acidosis of calves with acute diarrhea, the potassium leaves the cells and moves into the extracellular fluid. This results in hyperkalemia in some cases where the body potassium is normal or even decreased.

2.4.4 Serum Calcium

Constable (2003) opined that orally administered calcium is absorbed by a dose-dependent passive diffusion process across ruminal epithelium and a dose-independent calcium-binding protein mechanism in the small intestine that

is modulated by vitamin D. Passive diffusion across the ruminal epithelium occurs when the calcium concentration is greater than 1.5 mmol/L but is substantial when the calcium concentration in rumen fluid is greater than 6 mmol/L , which is approximately five times the normal value in plasma. Oral calcium solutions should be administered only to cattle that have normal swallowing ability, precluding their administration to animals with advanced clinical signs of hypocalcemia.

Ribeiro *et al.,* (2011) evaluated isotonic electrolyte solution administered by nasogastric tube in healthy adult cattle dehydrated experimentally enteral hydration caused reduction in values of hematocrit and total plasma protein demonstrating that there was expansion plasma volume they reported that enteral route is also an effective option to restore blood volume and correct dehydration in adult cattle. There was no difference ($P>0.05$) in the values and sodium chloride signaling that the composition of the electrolyte solution used in the study contained satisfactory values of said electrolyte. They further reported that however, by causing a decreases in potassium and calcium it should be used with caution in animals with hypokalemia and hyperkalemia.

Ribeiro *et al.,* (2013) investigated the effects of composition and volume of an isotonic electrolyte solution administered via small-bore nasogastric tube in continuous flow on body weight, waist circumference, moisture from feces, hematocrit, total protein, sodium, potassium, chloride, total calcium, ionized calcium, magnesium and urine specific gravity in healthy cattle experimentally or dehydrated. Four adult cattle, crossbred females were assessed and divided into two treatments in a randomized crossover. The electrolyte solution used in enteral SEHig treatments contained 5.27 g of NaCl, 3.78 g of $NaHCO_3$ and 0.3 g of KCl dissolved in 1,000 mL of water. Enteral hydration was administered at a dose of 10 L h^{-1} for 12 hours in continuous flow. Regardless of treatment, the infusion of electrolyte solution caused an increase in body weight and abdominal circumference, decrease in hematocrit, total plasma protein, potassium, total and ionized calcium, and polyuria and hyposthenuria.

2.4.5 Serum Chloride

Fisher (1965) compared surviving and dying diarrhoeic calves and found that mean concentration of chloride in surviving, dying and normal calves was 94.0±5.4, 92.3±4.0 and 100.3±3.5 mEq/l, respectively.

Watt (1965) documented plasma chloride level in a severely dehydrated calf as 123.0 mEq/l whereas, in normal healthy calf it was 102.0 mEq/l.

Care *et al.,* (1984) carried out in *vivo* and in *vitro* studies and reported that sodium, chloride and magnesium can be absorbed from the rumen in sheep and cows.

Bijwal and Misra (1987) induced experimentally enteric colibacillosis in calves and on biochemical evaluation observed that, the sodium level declined (139.00±1.60 mEq/l) significantly as compared to base values (143.66±0.55 mEq/l) and the potassium level slightly change from 5.01±0.26 to 4.88±0.11 mEq/l. While serum total protein and chloride remained unchaged as 7.01±0.24 g/dl and 99.50±1.22 mEq/l.

Tabaru *et al.,* (1990) evaluated the rumen as potential site of absorption in oral fluid therapy of adult cattle. Thirty of 40 L of test solutions with varying osmotic pressure (100, 200, 300 and 500 mOsmol/l pH 6.8) were prepared using different concentrations of electrolytes and VFAs and infused into the isolated and emptied ruminoretculum and the absorption rate of water and each components were studied for 3 hours. Marked absorption of water was observed with solutions more hypotonic than rumen fluid, the extent of which was more extensive with less osmotic pressure, the absorption rate as high as 47.6% was obtained with a solution 100 mOsmol in osmotic pressure and when hypertonic solution (500 mOsmol/L) was infused, however, water was transported on the contrary from from blood to rumen. Absorption rate of electrolytes such as Na, K and Cl were increased according to the elevation of osmolarities and their concentrations in the test solutions. AFAs were also absorbed in large quantities. These results indicate that the ruminal wall has a high absorptive function for water, electrolytes and VFAs when the osmolalities and the concentration of solutes in the ruminal fluid are maintained within a certain range.

Alone *et al.,* (2000) reported on serum electrolyte profile hyponatremia, hyperkalemia and non-significant change in serum chloride concentration in induced diarrhea in eighteen healthy calves with 8 per cent dehydration.

Constable *et al.,* (2001) studied the comparison of two oral electrolyte solutions for the treatment of dehydrated calves with experimentally induced diarrhea and observed decrease in chloride values.

Nag *et al.,* (2007) recorded significant elevation in the values of A:G ratio and serum sodium and reduction in serum total protein, albumin, globulins, chloride and potassium post therapy as compared to their levels before treatment in all clinical cases of calf diarrhea.

2.4.6 Blood Glucose

Ribeiro *et al.,* (2011) administered oral electrolyte solution through nasogastric intubation in six dehydrated adult cattle in two groups. With 4 gm NaCl, 1 gm KCl, 4 gm $NaHCO_3$ and 5 gm of dextrose per liter to one group and 8 gm NaCl, 0.5 gm $CaCl_2$ and 15 ml glycol propylene in 1000 ml of water to another. In both group of animals significant improvement in serum glucose level was observed after rehydration as both solutions contain dextrose and propylene glycol which readily got absorbed in rumen and converted to glucose in liver. Though Non-significant alterations in serum glucose level were reported.

MATERIAL AND METHODS

The present study was conducted to evaluate the effect of oral rehydration therapy in terms of its effects in correcting dehydration and electrolyte imbalance in dehydrated cattle.

3.1 Selection of animals

In the present study, 30 cattle with dehydration were selected from Gorakshan Sabha, Dhantoli, Nagpur. Assessment of clinical dehydration and its categorization was done on the basis of skin tent, eye position and characteristics of mucus membrane surfaces (Kopcha, 2008).

Category	Skin tent	Eye position	Mucous membranes
Mild (4-7%)	Slightly prolonged (2 to 3 seconds)	Slightly recessed	Moist, shiny not tacky
Moderate (8-10 %)	Prolonged (3 to 6 seconds)	Obviously sunken	Dull and tacky (slightly sticky)
Severe (>10 %)	Prolonged indefinitely (> 6 seconds)	Severely sunken	Dry surface

3.2 Clinical observations

Clinical observations were recorded on 0th, 24th and 48th hour of oral rehydration. The observations consist of examination of mucus membrane, eye position, skin tent test, body temperature, pulse, respiration rate, gait of animal, appetite etc.

3.3 Laboratory material

3.3.1 Chemicals and reagents

The laboratory chemicals viz., Sodium Chloride, Potassium Chloride, Calcium Chloride and Dextrose (M/s HiMedia Laboratories)* were used to prepare electrolyte solution. The standard diagnostic kits (M/s Avantor Performance Materials)** were used to estimate various serum biochemical's under study viz;

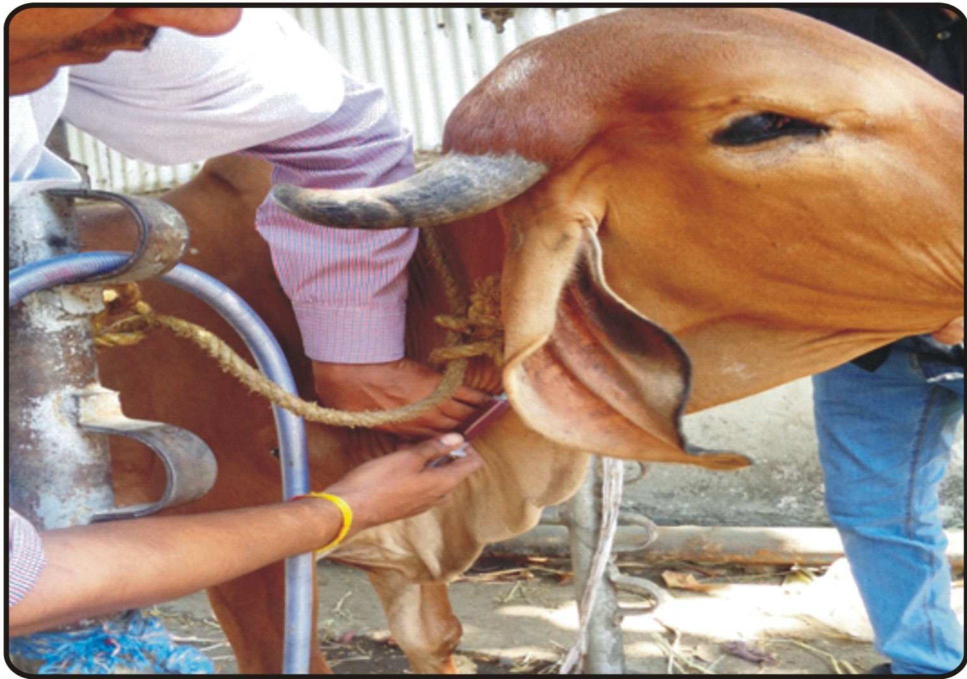

Plate 1. Blood sample collection

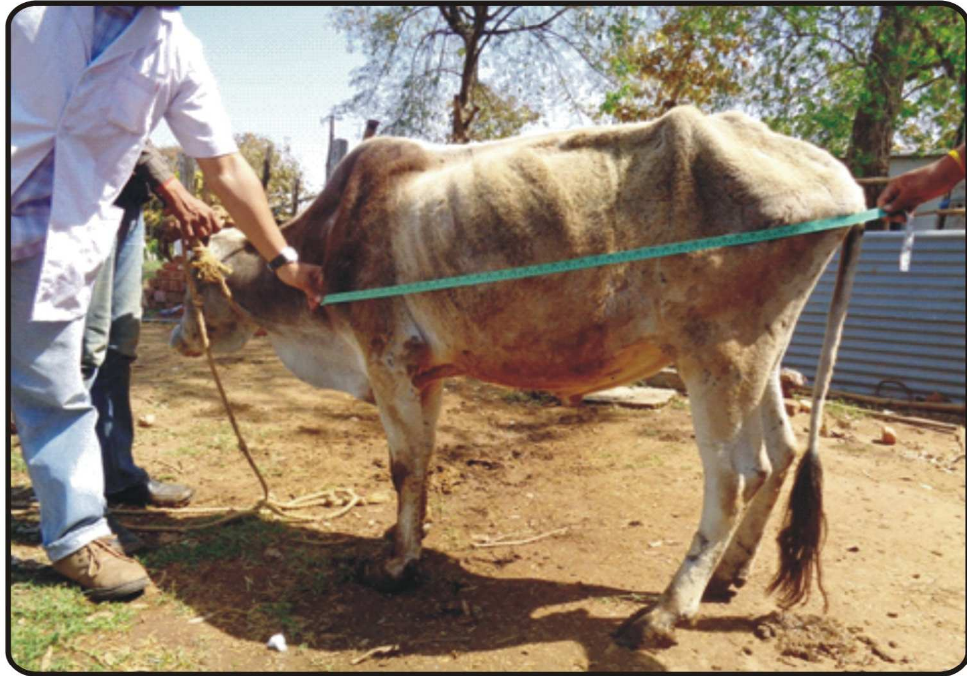

Plate 2. Measuring length of animal for calculation of weight

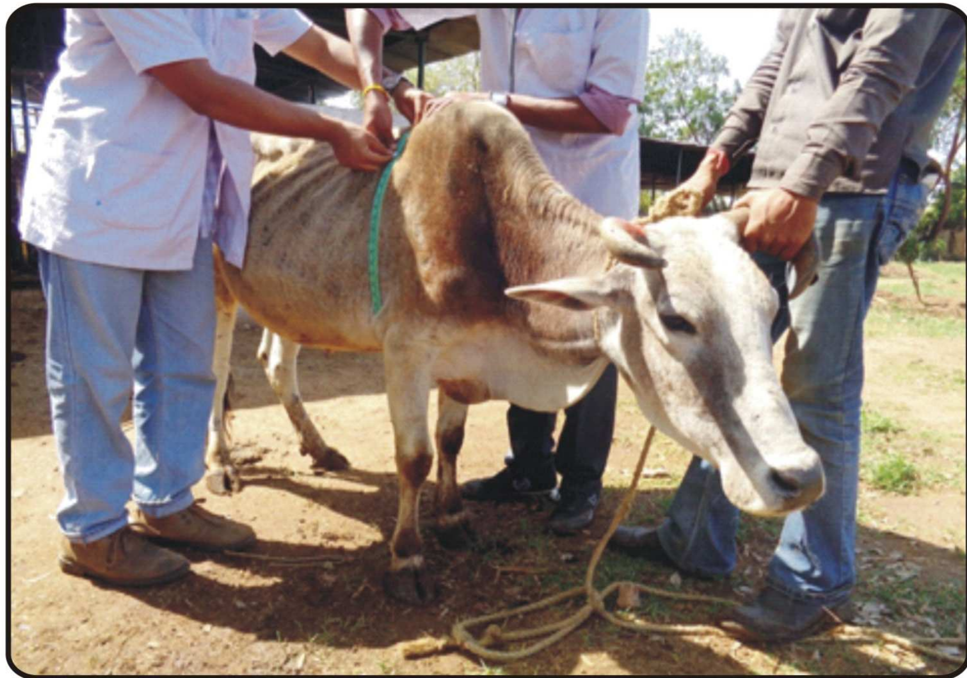

Plate 3. Measuring girth of animal for calculation of weight

i) Total Protein
ii) Serum Sodium
iii) Serum Potassium
iv) Serum Calcium
v) Serum Chloride
vi) Serum Glucose

3.4 Collection of samples

Blood was collected by veinpunctuncturing jugular vein (Plate 1) into to 2 ml EDTA vial for hematology and 4 ml in Clot activator for harvesting serum. The harvested serum separated for further study.

3.5 Methodology

3.5.1 Oral Rehydration Therapy

In the present study 30 dehydrated adult animals irrespective of sex, age and breed were selected from Gorakshan Sabha, Dhantoli, Nagpur and divided into following three groups each comprising of 10 animals.

* M/s HiMedia Laboratories Private Limited, Dindori, Nashik

**M/s Avantor Performance Materials India Limited, Surjkiund, Faridabad.

Groupwise treatment schedule

Group-I	Oral electrolyte solution prepared by dissolving 100 gms Dextrose, 140 gms NaCl, 25 gms KCl and 10 gms of $CaCl_2$ in 20 liters of water.
Group-II	Oral electrolyte solution prepared by dissolving 100 gms Dextrose, 140 gms NaCl,25 gms KCl in 20 liters of water.
Group-III	Oral electrolyte solution prepared by dissolving 100 gms Sugar, 140 gms Salt, 25 gms KCl in 20 liters of water.

The hematological and biochemical estimations were done on 0th, 24th & 48th hours of therapy.

The fluid requirement was evaluated on the basis of following formula;

- Body weight in Kg X Estimated dehydration percentage = Fluid deficit in liters
- The weight of the animal was calculated by the following formula (Plate 2 and 3).

Plate 4. Oral rehydration pump unit

Plate 5. Passing of oral rehydration unit probe

$$\text{Weight of animal (Kg)} = \frac{\text{Length (cm)} \times \text{Girth}^2\text{(cm)}}{10838}$$

Oral drench of electrolyte solution into rumen was done with the help of oral rehydration pump (Plate 4).

3.5.2 Procedure of oral rehydration

Animals were restrained in a travis. The length of the esophageal probe was measured upto the rumen. Esophageal probe was lubricated and held gently but firmly over the base of the tongue and passed into the oesophagus. Directed the tube into the ventral nasal passage and gently passed to the level of the pharynx and oesophagus (Plate 5). Observed for signs that the tube was present in the oesophagus and not the trachea. Passed the esophageal probe until it reaches the level of the rumen. Started the motor of pump so as to electrolyte solution should dispensed in rumen gently with intermittent forward & backward movement of esophageal probe so as to facilitate eructation of gases from rumen. After drenching of required electrolyte solution pump was stopped and withdrawn esophageal probe gently.

3.6 Haemato - Biochemical estimations

3.6.1 Estimation of Packed Cell Volume, Total Erythrocyte Count and Haemoglobin (gm%)

Hematological estimations viz. Hb, PCV, TEC were carried out using Hematology Analyzer (Horiba Make ABX Micros ESV-60) on principle of electrical impedance, flow cytometry, and fluorescent flow cytometry.

3.6.2 Estimation of Serum Total Protein (gm/dl)

Serum Total Protein was estimated by Biuret end point method (Vatzidis, 1977) using Auto Analyzer Slim (Star 21 Biochemical Auto Analyzer).

3.6.3 Estimation of Serum Sodium (mmol/L)

Microprocessor-controlled electrolyte system that uses ISE (Ion Selective Electrode) technology to make electrolyte measurements.

3.6.4 Estimation of Serum Potassium (mmol/l)

Microprocessor-controlled electrolyte system that uses ISE (Ion Selective Electrode) technology to make electrolyte measurements.

3.6.5 Estimation of Serum Calcium (mg/dl)

Serum Calcium was estimated by Arsenazo III method using auto analyzer slim (SEAC) (Bauer, 1981).

3.6.6 Estimation of Serum Chloride (mEq/l)

Serum chloride was estimated by Mercurous (II) thiocynate method using autoanalyzer.

3.6.7 Estimation of Serum Glucose (mg/dl)

Serum Glucose was estimated by DPGC – GOD – POD method using auto analyzer slim (SEAC) (Trinder, 1969).

3.7 Statistical analysis of data

Statistical analysis was carried out by using two way analysis of variance technique (Snedecor and Cochran, 1967).

Plate 6. Dehydrated adult cattle

Plate 7. Dry tacky mucus membrane with sunken eyeball in dehydrated animal

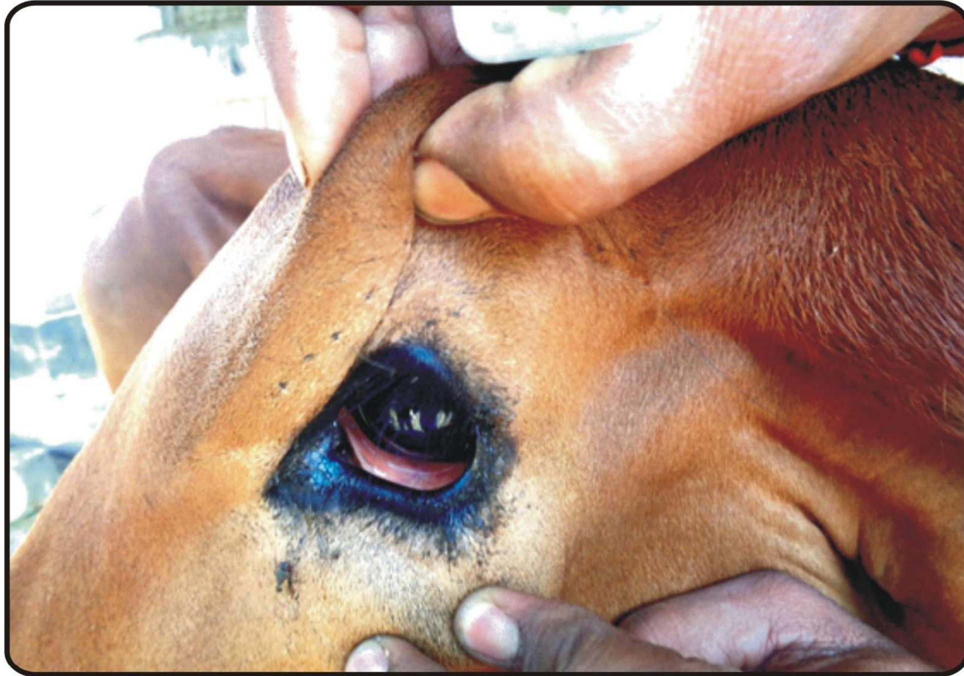

Plate 8. Eyeball recession of dehydrated cattle

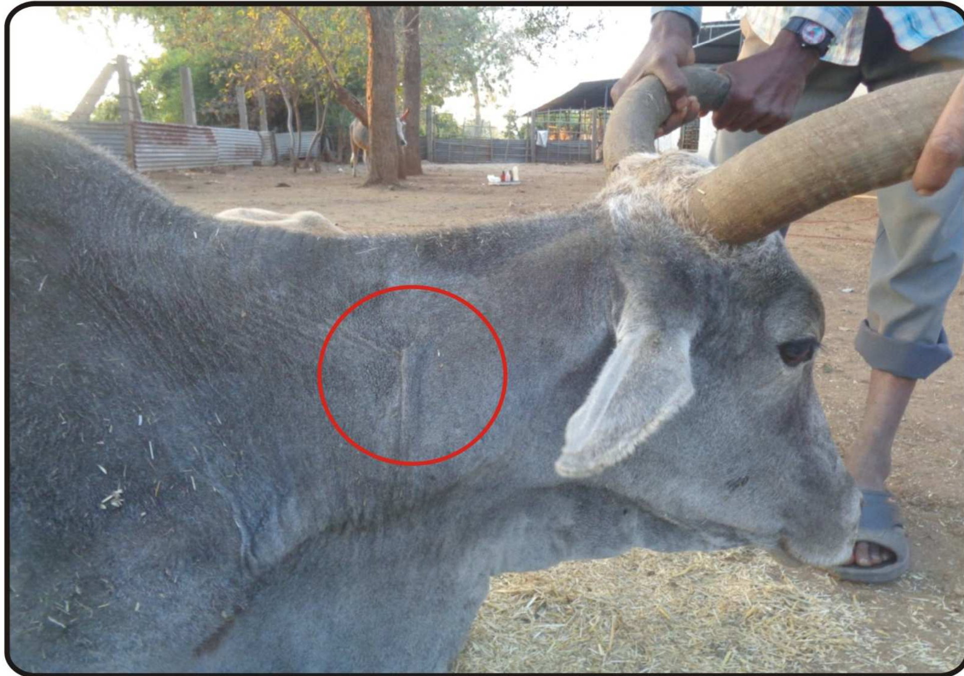

Plate 9. Prolonged skin tent in dehydrated animal

RESULTS AND DISCUSSION

The present study was conducted to evaluate oral rehydration therapy in terms of its effects in correcting dehydration and electrolyte imbalances in dehydrated cattle. In this study 30 clinically dehydrated adult animals of either sex from Gorakshan Sabha, Dhantoli, Nagpur were selected and divided in three groups (*viz*., Group-I, II and III) comprising 10 animals in each group. The three groups of dehydrated animals were subjected to three different combinations of electrolyte solution prepared on farm. The hematological and biochemical parameters were studied at 0th hour followed by 24th and 48th hours post-treatment.

4.1 Clinical Observations

In the present study dehydrated adult animals were found lethargic, dull and depressed (Plate 6). Some of them had sunken eyes, congested and tacky mucous membrane (Plate 7) along with prolonged skin tent indicating dehydration state of the animals. These findings corroborates with that of Constable *et al.,* (1998) who suggested that altered hydration status can be estimated and quantified using eye position within orbit, extent of skin elasticity and degree of mucous membrane moistness. The eye ball recession was also observed along with stiff, stumbling gait few of them were recumbent (Plate-8). The appetite was noted decreased and some of them were anorectic though one or two of them were with normal appetite at the onset of experiment. These findings are supported by Watt (1965) who noticed typical signs of diarrheic dehydration as lassitude, sunken eyes, sluggish capillary refill time, tight hide bound skin which when pinched remain in a ridge, cold extremities and pale mucus membrane overlaid by a dirty brownish coloration. Bywater (1980) correlated degree of dehydration with clinical signs. In 0-5 per cent dehydration noted loss in body weight, mild depression and decreased urine output. In 6 to 8 per cent dehydration more body weight loss, sunken eyes, tight skin and depression but the animal was still standing with further urine reduction. Sridhar *et al.,* (1988) also observed debility, anorexia, lethargy, marked elevation of body temperature, pulse rate and respiration rate in diarrheic calves having dehydration.

4.1.1 Skin tent test

This was assessed by pinching the skin at neck region of animals and noted the time required for the skin fold to disappear after release (Plate 9). The results and its analysis of variance presented in Table 1 and 2, respectively.

Table 1 Mean ± S. E. of skin tent (seconds) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	5.30^{bA} ± 0.60	2.00^{a} ± 0.54	0.20^{a} ± 0.20
II	5.70^{cA} ± 0.87	3.40^{b} ± 0.97	1.70^{a} ± 0.84
III	8.70^{cB} ± 0.88	3.90^{b} ± 0.48	2.40^{a} ± 0.54

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 2 Analysis of variance for skin tent in seconds

Source	Df	MS
Group	2	47.10**
Period	2	205.73**
Error	85	2.14

** = Significant at 1% level

The skin tent test and per cent dehydration are closely related to each other as the skin elasticity is primarily lost due to loss of fluid from the interstitial and intracellular spaces and hence, the skin tent is one of the criteria to ascertain the degree of dehydration. From Table 1 it can be observed that the average skin tent for animals of the Group-I at 0th hour was recorded as 5.30 ± 0.60 seconds which is considered as moderately dehydrated. Almost the same condition of animals from Group-II (5.70 ± 0.87 seconds) was observed as that of Group-I. However, higher values were recorded for Group-III (8.70 ± 0.88 seconds) which scaled under severe dehydration category. Hence, significant difference was observed between groups at 0th hour (Table 2). After 24 hours of experiment, the average time recorded for skin tent 2.00 ± 0.54 seconds for Group-I which comes

under mild dehydration category. However, in Group-II and III though average time reduced to 3.40 ± 0.97 and 3.90 ± 0.48 seconds respectively, it remained under moderate category only. The average values from Group-I and II after 48 hours of therapy reached to normal, however, the average of Group-III where initially severe dehydration was recorded which reduced to mild on 48th hour. When average values for 24th hour and 48th hour of recording were compared the differences were non-significant compared with critical difference.

But, when comparison was made within group and between period the difference was significant for all the three groups (Table 2). This indicates that the skin tent values were drastically reduced within 24 and 48 hours in each group. The rate of reduction (in seconds) was highest in group-III followed by Group-II and Group-I (Fig.1).

These findings were in line with those of Davis (2013) who observed that at 5% dehydration skin returned to normal position fairly quickly but slightly slower than normal. With 8% dehydration the skin returns to its normal position slower than 5% dehydration but faster than 12% dehydration. When the patient was 12% dehydrated skin remained tented and not return to normal position. Similar assessment of the degree of dehydration is reported by Rings (1994), Constable *et al.,* (2001). The results in the present study regarding skin tent is self explanatory regarding effectiveness of the three different combinations of oral electrolyte solutions used. The trend towards restoration of skin tent to normal observed in the present study can attributed to the therapy administered.

4.1.2 Body temperature (^{0}F)

Per rectal body temperature of all the animals under study were recorded at different interval and presented in Table 3 and its analysis of variance in Table 4 of different groups before and after therapy.

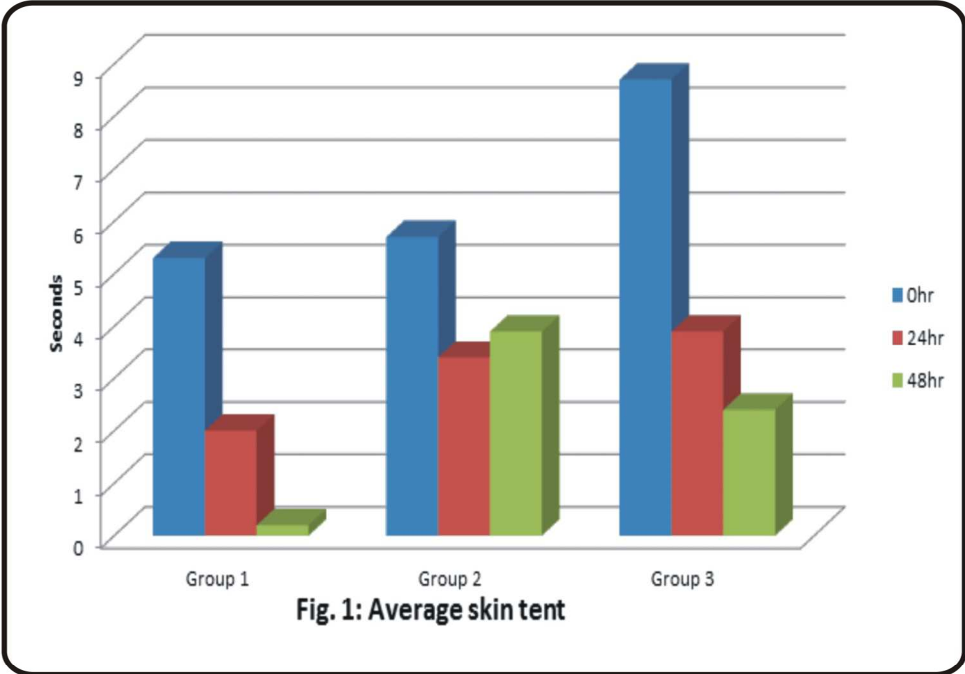

Fig. 1: Average skin tent

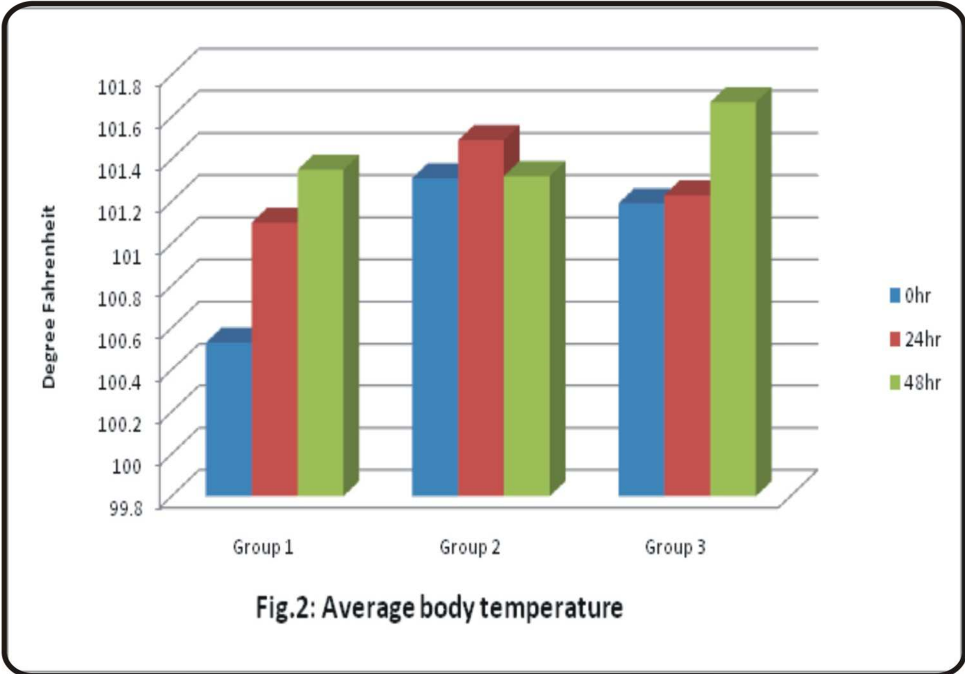

Fig.2: Average body temperature

Table 3 Mean ± S. E. of body temperature (^{0}F) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	100.53 ± 0.48	101.10 ± 0.32	101.35 ± 0.19
II	101.31 ± 0.32	101.49 ± 0.26	101.32 ± 0.19
III	101.19 ± 0.50	101.23 ± 0.30	101.67 ± 0.13

Table 4 Analysis of variance of body temperature (^{o}F)

Source	Df	MS
Group	2	1.40
Period	2	1.45
Error	85	1.05

Non-significant difference was observed for group effect as well as period effect (Table 4) and thus all the averages ranged between 100.53 ± 0.48^{0}F to 101.67 ± 0.13^{0}F.

In the present study non-significant difference was observed for group effect as well as period effect. It indicates that in all categories of dehydration the temperature remains statistically same, within normal limits at 0th, 24th and 48th hour of therapy (Fig.2). Similar findings were reported by Constable *et al.,* (2001) who noted unaltered rectal temperature in dehydrated calves. However, Radostitis *et al.,* (2007) reported that the body temperature increases slightly during initial stage of dehydration which is known as dehydration hyperthermia and is due to insufficient fluid to maintain the loss of heat by evaporation.

4.1.3 Pulse rate

During this study pulse rate of all the dehydrated animals at 0th ,24th , and 48th hour were recorded and depicted in Table 5 and its analysis of variance in Table 6.

It was observed that the pulse rate/minute decreases due to rehydration therapy as depicted in Table 5. When comparison was made between periods within Group it was observed that in Group-I due to rehydration the values were decreased at 24 hour though non significantly. While, in Group-II the average value of 60.60 ± 4.92 /minute had reduce down to 53.10 ± 2.06 /minute at 48th hours of reading. The critical difference exhibits significance. Same results were

obtained for Group-III as that of Group-II. This indicated that the reduction of average values were higher for Group-II and Group-III than Group-I (Fig. 3).

Table 5 Mean ± S. E. of pulse rate/minute in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	**24th**	**48th**
I	60.10^{A} ±4.56	60.80^{B} ±3.49	58.60^{B} ±2.07
II	60.60^{bA}±4.92b	54.90^{aA} ±3.39	53.10^{aA} ±2.06
III	73.10^{bB} ±5.83	65.80^{aC} ±2.58	62.40^{aC} ±2.29

Different column wise superscripts (small letter) within a group indicates significance
Different row wise superscripts (capital letter) within a period indicates significance

Table 6 Analysis of variance of pulse rate /minute

Source	Df	MS
Group	2	924.07**
Period	2	330.07*
Error	85	90.81

* = Significant at 5% level
** = Significant at 1% level

At 0th hour the average pulse rate /minute was recorded as highest in Group-III (73.10 ± 5.83/minute) compared to Group-II (60.60 ± 4.92/minute) and Group-I (60.10 ± 4.56/minute) which was statistically significant. After 24 hours of rehydration significant difference in average pulse rates were the highest for Group-III and lowest for the Group-II which were found significant considering critical differences.

The findings of the present study are in accordance with that of Weeth *et al.,* (1962) who documented that during winter and summer dehydration the average pulse rates were lowered in growing cattle. Khan and Zaman (2007) reported that that mean pulse and respiration rate differ non-significantly between the groups of dehydrated calves.

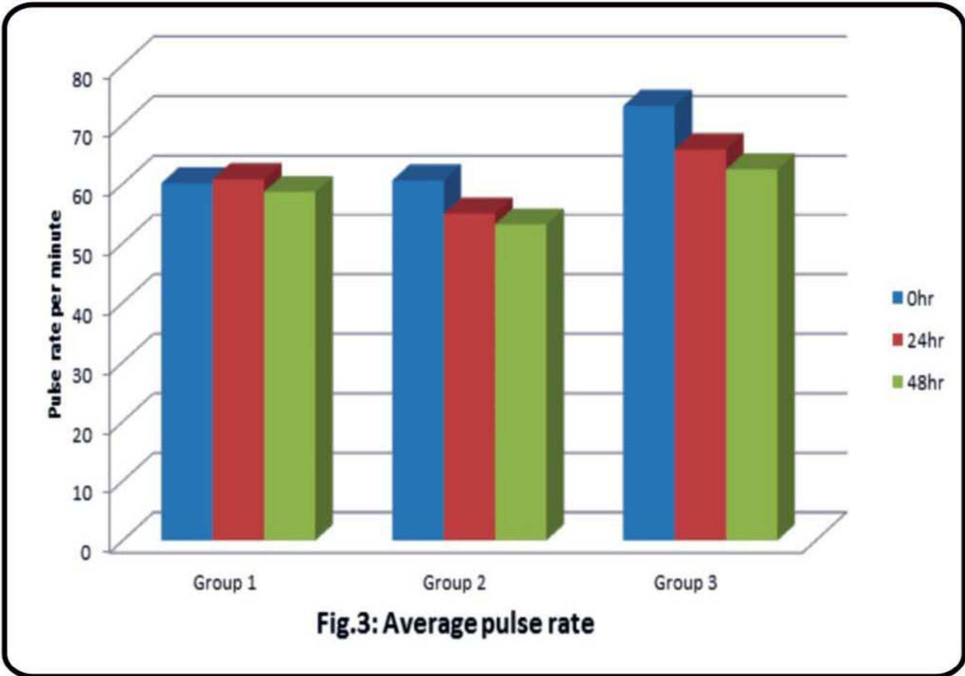

Fig.3: Average pulse rate

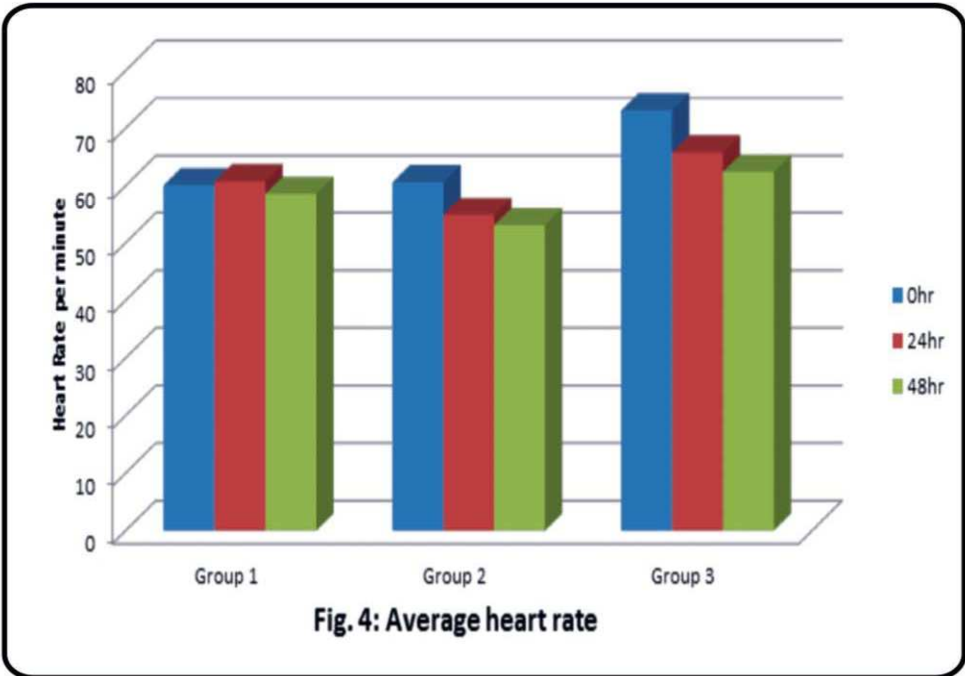

Fig. 4: Average heart rate

4.1.4 Heart rate

The heart rate was recorded and documented in the Table 7 and its analysis of variance in Table 8.

Table 7 Mean ± S. E. of heart rate /minute in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	60.10^{A} ±4.56	60.80^{B} ±3.49	58.60^{B} ±2.07
II	60.60^{bA} ±4.93	54.90^{aA} ±3.39	53.10^{aA} ±2.06
III	73.10^{bB} ±5.83	65.80^{aC} ±2.58	62.40^{aC} ±2.29

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 8 Analysis of variance of heart rate /minute

Source	Df	MS
Group	2	924.07**
Period	2	330.07*
Error	85	90.81

* = Significant at 5% level

** = Significant at 1% level

It depicts that there is decline in average heart rate values after oral rehydration therapy as that of pulse rate. On comparison between the period within group, it was recorded that the average values were increased but not statistically significant at 24th hour and again decreased at 48th hour for Group-I. Wherein, for Group-II the values were decreased significantly from 60.60 ± 4.93/minute at 0th hour comes down to 54.90 ± 3.39/minute at 24th hours and 53.10 ± 2.06 /minute at 48th hours. For Group-III, similar scenario reflected as 73.10 ± 5.83/minute at 0th hour decreases to 65.80 ± 2.58/minute at 24th hours

and again decreases to 62.40 ± 2.29/minute at 48th hours (Fig. 4). This indicated that the decrease in average heart rate values were higher for Group-II and III.

When comparison was made between the group within the periods the average heart rate was recorded highest for Group-III (73.10 ± 5.83/minute) compared to Group-II (60.60 ± 4.93/minute) and Group-I (60.10 ± 4.56/minute) at the 0th hour. At 24th hours after oral rehydration the significant difference was observed between Groups within period on the basis of critical differences. Similar scenario persisted up to 48th hours.

4.1.4 Respiration rate

Respiration rate of 30 dehydrated adult cattle was recorded at scheduled study intervals and depicted in Table 9. Similarly, the analysis of variance of averages of respiration rate is projected in Table 10.

The average respiration rate in all three groups ranged between 23.80 ± 2.76 to 20.20 ± 0.71/minute. Two way analysis of variance of average respiration rate depicts non-significant difference within group and within periods (Table 10). But, the average values for respiration rate decreased from 0th hour to 24th hours and continued decreasing till 48th hours of oral rehydration in Group-I and Group-II. While for Group-III the average values of respiration rate decreased from 0th to 24th but again increased at 48th hours of therapy.

Table 9 Mean ± S. E. of respiration rate /minute in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	21.60 ± 1.30	21.10 ± 0.84	20.20 ± 0.71
II	23.80 ± 2.76	21.00 ± 1.85	20.20 ± 0.99
III	21.40 ± 1.48	20.60 ± 0.81	21.60 ± 0.93

Table 10 Analysis of variance of respiration rate /minute

Source	Df	MS
Group	2	3.81
Period	2	22.41
Error	85	20.64

In the present study at the time of initiation of therapy the respiration rate was elevated which decreased during the treatment period (Fig.5). After 24th hour of treatment with oral electrolyte solution respiration rate in all the treatment groups was reduced. This is in agreement with that of Boyd *et al.,* (1974) who reported moderate increase in respiration rate in calves suffering from diarrhea and Gadge (1982) found non-significant increase in respiration rate of diarrheic calves.

Generally dehydrated animals have elevated respiration rate. However, Weeth *et al.,* (1962) reported respiration rate fluctuates more widely during dehydration. These findings are in agreement with Kumar *et al.,* (1981) and Sridhar *et al.,* (1988). Similar values for respiration rate as ranging from 22-35/min in calves suffering from neonatal calf diarrhea observed by Bhalerao *et al.,* (2000).

4.2. Hematological observations

For the hematological study blood was collected at different intervals before and after therapy in 2 ml EDTA container and the sample is processed using hematology analyzer.

4.2.1 Packed cell volume (%)

The packed cell volume was estimated at predetermined intervals in all the animals from different groups. The average values for packed cell volume (%) are presented in Table 11 and its analysis of variance in Table 12 for all the three groups and 3 periods.

Generally packed cell volume provides information about the degree of dehydration. From Table 11 it can be observed that in Group-I the reduction in packed cell volume (%) values were significant between 0th to 24th hours; but, non-significant between 24th to 48th hours. Contrary picture was recorded for

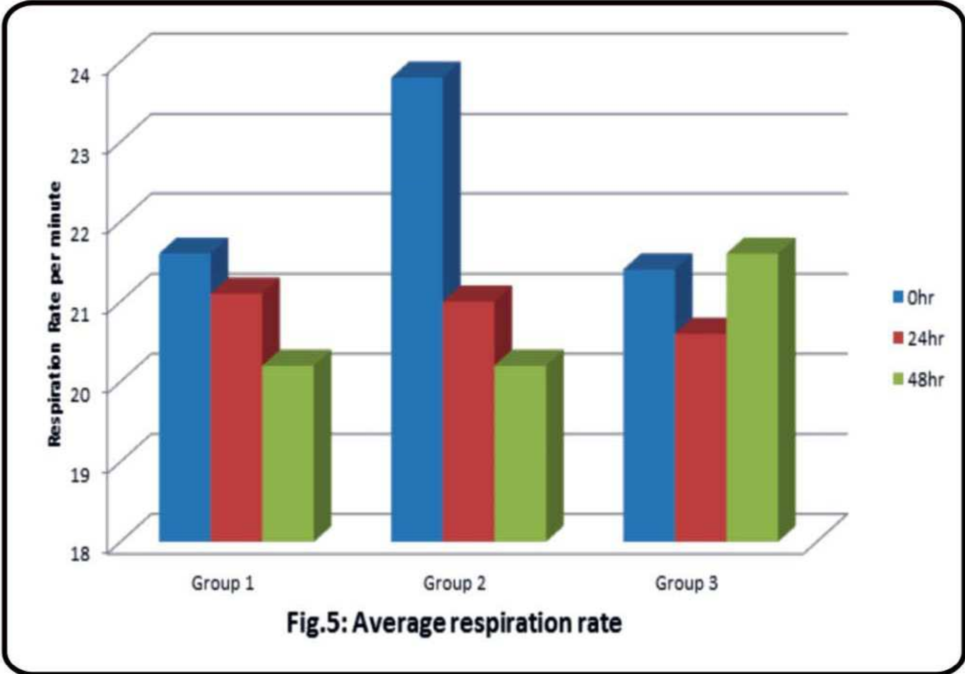

Fig.5: Average respiration rate

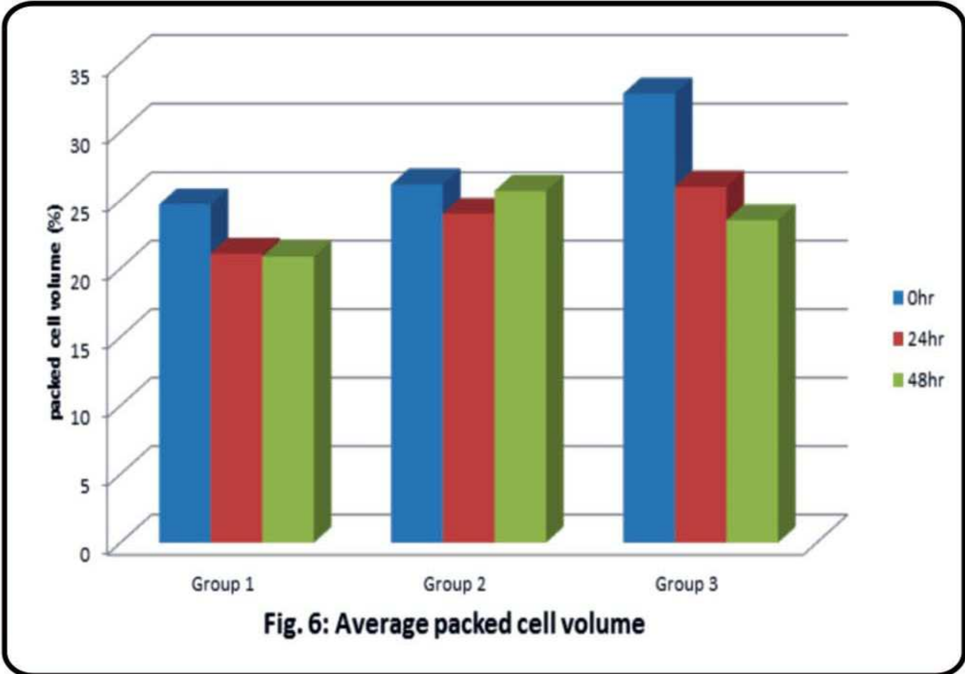

Fig. 6: Average packed cell volume

Group-II where significant reduction was observed from 0th to 24th hour and significant increase in packed cell volume (%) values from 24th to 48th hours indicating the dehydration persist at 48th hours. In group-III significant reduction was noticed 0th to 24th hours and from 24th to 48th hours (Fig. 6).

Table 11 Mean ± S. E. of packed cell volume (%) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	24.69^{bA} ± 0.89	21.08^{aA} ± 0.74	20.87^{aA} ± 0.89
II	26.15^{bA} ± 2.53	23.99^{aB} ± 2.54	25.68^{bC} ± 1.93
III	32.78^{cB} ± 1.65	25.99^{bC} ± 1.12	23.51^{aB} ± 0.92

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 12 Analysis of variance of packed cell volume (%)

Source	Df	MS
Group	2	205.89**
Period	2	190.34**
Error	85	20.34

** = Significant at 1% level

The packed cell volume (%) was one of the variables to assess the effect of rehydration. The average packed cell volume recorded for Group-I to Group-III for 0th hour was 24.69 ± 0.89, 26.15 ± 2.53 and 32.78 ± 1.65 %, respectively (Table 11). The difference noticed was significant at 1% level (Table 12) indicated that average packed cell volume (%) was highest in group-III and different from rest of the groups at statistical level when critical difference were considered. The recordings on 24th hours depicts that the averages were reduced significantly in all groups when compared with 0th hour and the averages still reduced at 48th hours.

In the present study estimated packed cell volume (%) was less than normal reference range which can be attributed to fact that the animals under study were of Gorakshan Sabha, Nagpur which were in poor body condition and also were anemic as they were rescued from intended to slaughter. Anemia appeared be a contributing factor for reduced packed cell volume in the animals under study. An elevated hematocrit often associated with dehydration, which is a decreased amount of water in the tissue may be due to diarrhea etc. These conditions reduce the volume of plasma causing a relative increase in red blood cells concentration in blood called as hemoconcentration.

Reduction in packed cell volume at 24th hours of oral rehydration indicates that the oral rehydration therapy was adequate; but, again at 48th hours it increased suggesting that further oral rehydration is required. In the present study initial packed cell volume was very low; but, after oral rehydration the packed cell volume further lowered which indicates that the efficacy of rehydration therapy of dehydrated animals. The findings of the present study are in general agreement with that of Benjamin (1981) who documented that as hydration occurs the packed cell volume (%) fall down indicating that the therapy is efficacious.

4.2.2 Total erythrocyte count (X 10^6/cumm)

The total erythrocyte count of animals from three groups at scheduled different study interval was conducted and presented in Table 13 with its ANOVA in Table 14.

In spite of non-significant difference for group effect as well as period effect (Table 14) the average values of total erythrocyte count (X 10^6/cumm) were decreased from 0th hour (5.20 ± 0.26 X 10^6/cumm) to 24th hour (4.63 ± 0.15 X 10^6/cumm) for Group-I. Similarly for Group-II average values for total erythrocyte count (X 10^6/cumm) at 0th hour were 5.41 ± 0.52 X 10^6/cumm decreased to 4.95 ± 0.51 X 10^6/cumm at 24th hour and again increased to 5.61 ± 0.36 X 10^6/cumm at 48th hour. On the contrary, for Group-III average values for total erythrocyte count (X 10^6/cumm) constantly decreased from 4.87 ± 0.36 X 10^6/cumm at 0th hour to 4.71 ± 0.29 X 10^6/cumm at 24th hour and again decreased to 4.59 ± 0.27 X 10^6/cumm at 48th hour (Fig.7).

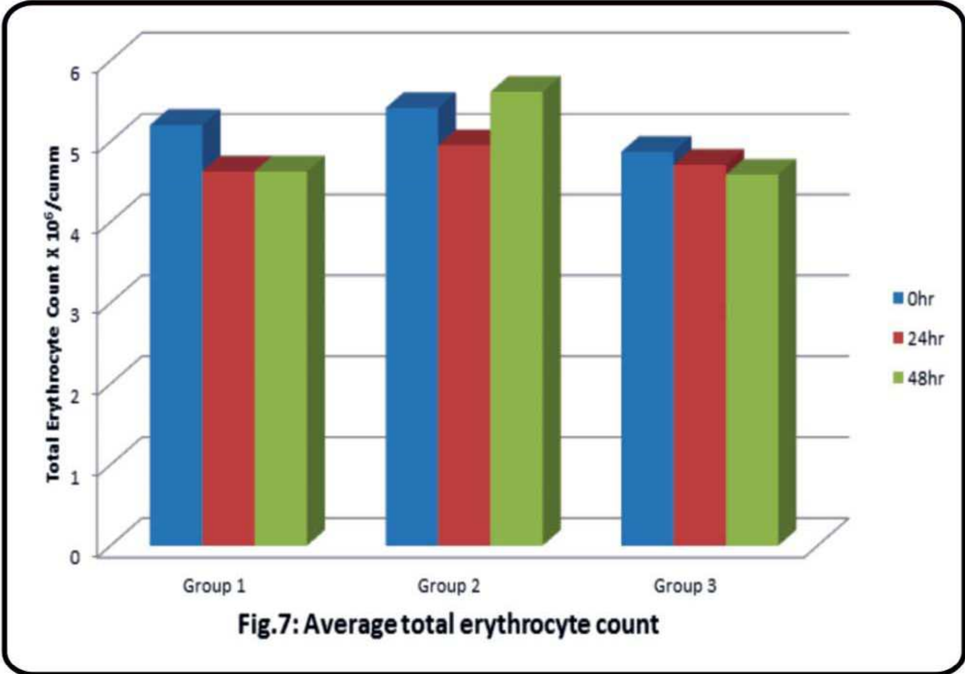

Fig.7: Average total erythrocyte count

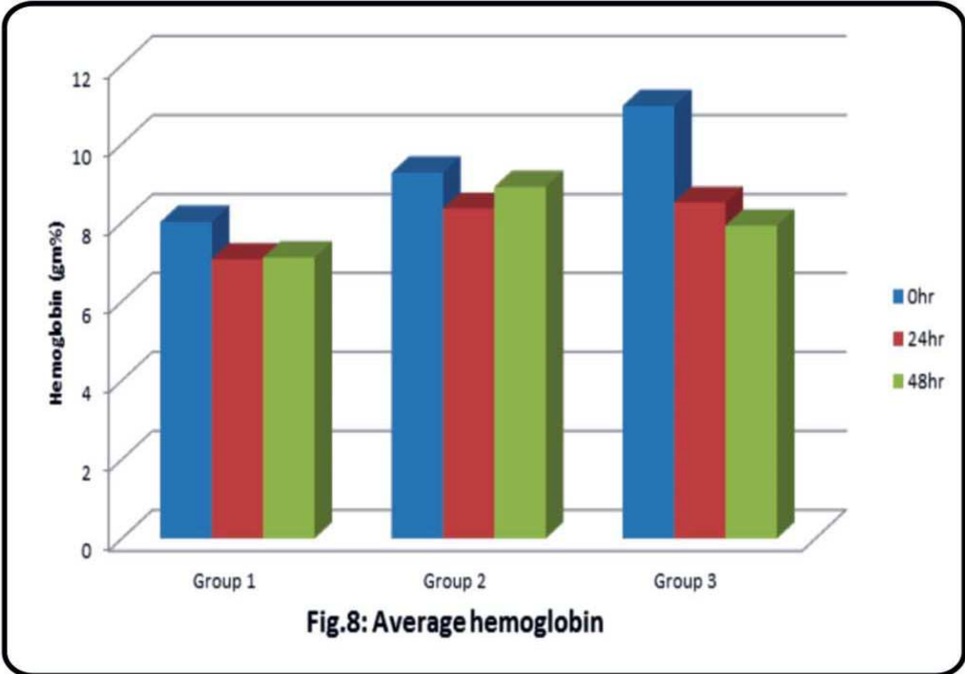

Fig.8: Average hemoglobin

Table 13 Mean ± S. E. of total erythrocyte count (X 10^6/cumm) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	5.20 ± 0.26	4.63 ± 0.15	4.63 ± 0.22
II	5.41 ± 0.52	4.95 ± 0.51	5.61 ± 0.36
III	4.87 ± 0.36	4.71 ± 0.29	4.59 ± 0.27

Table 14 Analysis of variance of total erythrocyte count (X 10^6/cumm)

Source	Df	MS
Group	2	3.09
Period	2	1.15
Error	85	1.023

When comparison was made between groups within period it was observed that when experiment was started the highest recorded value for 0th hour period was 5.41 ± 0.52 (X 10^6/cumm) in Group-II and the lowest 4.87 ± 0.36 (X 10^6/cumm) for Group-III. Though, the difference was observed between Groups at 0th hour; but, it was non-significant indicating the total erythrocyte count (X 10^6/cumm) was almost same for all the Groups. Similar trend of results were obtained when between Group values were considered for 24th and 48th hours.

In the present study the total erythrocyte count was on the lower side at 0th hour in all the groups as compared to the reference values indicating anemia. This may be due to the unproductive, debilated, weak animals received by Gorakshan Sabha. On judicious observation of Table 13 it is revealed that continuous decrease can be observed in total erythrocyte count at 24th and 48th hour after rehydration therapy in all the three groups. This indicates positive effect of rehydration therapy which resolved hemoconcentration and caused plasma volume to increase, which ultimately lead to decrease in total erythrocyte cell concentration per unit volume of blood. These findings are in agreement with

that of Nag *et al.,* (2007) who observed significant decrease in the value of total erythrocyte count in treatment values. Similarly Sukare (2007) observed decrease of total erythrocyte count in all the groups from 0 to 24 hours after treatment.

4.2.3 Hemoglobin (gm%)

The estimation of hemoglobin (gm%) was conducted in animals of all the three groups at 0th, 24th and 48th hour of oral rehydration therapy. Its averages are presented in Table 15 and its analysis of variance in Table 16.

Table 15 Mean ± S. E. of hemoglobin (gm%) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	8.01^{bA} ± 0.31	7.07^{aA} ± 0.26	7.11^{aA} ± 0.26
II	9.27^{bB} ± 0.74	8.35^{aB} ± 0.84	8.91^{abC} ± 0.56
III	10.96^{cC} ± 0.63	8.51^{bB} ± 0.41	7.92^{aB} ± 0.41

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table16 Analysis of variance of hemoglobin (gm%)

Source	Df	MS
Group	2	25.89**
Period	2	20.59**
Error	85	2.52

** = Significant at 1% level

From Table 15 (Fig.8) it can be noted that the average blood hemoglobin (gm%) for Group-I was 8.01 ± 0.31 gm% at 0th hour decreased to7.07 ± 0.26 gm% at 24th hours and slightly increased to 7.11 ± 0.26 gm% at 48th hours. Similar picture was observed in respect of Group-II wherein, 0th hour average

hemoglobin (gm%) value was 9.27 ± 0.74gm% which reduced to 8.35 ± 0.84 gm% at 24th hours and again increased to 8.91 ± 0.56 gm% at 48th hours. On the contrary, for Group-III the scenario is slight different, wherein at 0th hour average hemoglobin (gm%) values were 10.96 ± 0.63gm% which decreased to 8.51 ± 0.41gm% at 24th hour and continued decreasing to 7.92 ± 0.41gm% at 48th hours of experiment. In all the three Groups due to rehydration therapy the values improved significantly.

It can be postulated that because of hemoconcentration in dehydrated animals the estimated hemoglobin (%) was slightly increased at 0th hour, though was less than normal range. Subsequently by virtue of the rehydration therapy the said hemoconcentration resolved to some extent increasing plasma volume in circulation. This lead to decrease in erythrocyte concentration per unit of blood because of which hemoglobin estimation at 24th and 48th hours again decreased than that of 0th hour. It can be attributed to efficacy of rehydration therapy. In group II at 48th hour hemoglobin (%) was found increased which could be assigned to increase in total erythrocyte count when compared to 24th hours observation similar findings were also recorded by Alone *et al.,* (2000) who reported increase in hemoglobin concentration in pre treatment groups and hemoglobin concentration decreased in treatment groups. Further Sukare (2007) reported that the similar trend of hemoglobin concentration after the therapy in calves.

4.3 Biochemical observations

Biochemical estimations were carried out in all the animals under study at 0th hour to determine the changes incurred due to dehydration in animals. The same estimations were done at 24th and 48th hours after oral rehydration therapy to assess the efficacy of oral rehydration therapy in all animals.

4.3.1 Serum total protein(gm/dl)

The serum total protein levels estimated at stipulated time interval before and after therapy in all the animals under study and values presented in Table 17 and its analysis of variance in Table 18.

The average total protein (gm/dl) in the animals ranged between 4.96 ± 0.58 to 6.40 ± 0.12gm/dl in all the three groups and in all the three periods. The

two way analysis of variance indicated non-significant differences in average values of total protein within and between the groups and in the three periods. It can be observed from Table 17 that the average total protein (gm/dl) values decreased from 0th hour to 24th hours, that is 6.11 ± 0.10 to 5.89 ± 0.11gm/dl in Group-I, 6.15 ± 0.35 to 4.96 ± 0.58 gm/dl in Group-II and 6.15 ± 0.39 to 5.66 ± 0.43gm/dl for Group-III. Similarly, decrease in average total protein (gm/dl) value was observed at 48th hours readings that is 5.89 ± 0.11 to 5.77 ± 0.11gm/dl in Group-I and 5.66 ± 0.43 to 5.22 ± 0.41gm/dl in Group-III. However, increase was observed in Group-II that is 4.96 ± 0.58 to 6.40 ± 0.12gm/dl (Fig. 9).

Table 17 Mean ± S. E. of total protein (gm/dl) in dehydrated animals of different groups before and after therapy

Group	Period (hour)		
	0th	24th	48th
I	6.11 ± 0.10	5.89 ± 0.11	5.77 ± 0.11
II	6.15 ± 0.35	4.96 ± 0.58	6.40 ± 0.12
III	6.15 ± 0.39	5.66 ± 0.43	5.22 ± 0.41

Table 18 Analysis of variance of total protein (gm/dl)

Source	Df	MS
Group	2	0.46
Period	2	3.046
Error	85	0.98

On comparison between the groups within the period group-II (6.15 ± 0.35gm/dl) and Group-III (6.15 ± 0.39gm/dl) were comparable. Whereas, Group-I (6.11 ± 0.10gm/dl) was having lowest estimates at 0th hour. After 24th hour of oral rehydration average total protein (gm/dl) values decreased to 5.89 ± 0.11, 4.96 ± 0.58 and 5.66 ± 0.43gm/dl for Group-I, II and III, respectively. On 48th hours of experiment the average total protein (gm/dl) values for the Group-I was 5.77 ± 0.11gm/dl, for the Group-II (6.40 ± 0.12gm/dl) the highest and for the Group-III 5.22 ± 0.41gm/dl which was the lowest.

Generally in dehydration the hematocrit values and serum total protein values increases. In the present study increased level of serum protein is

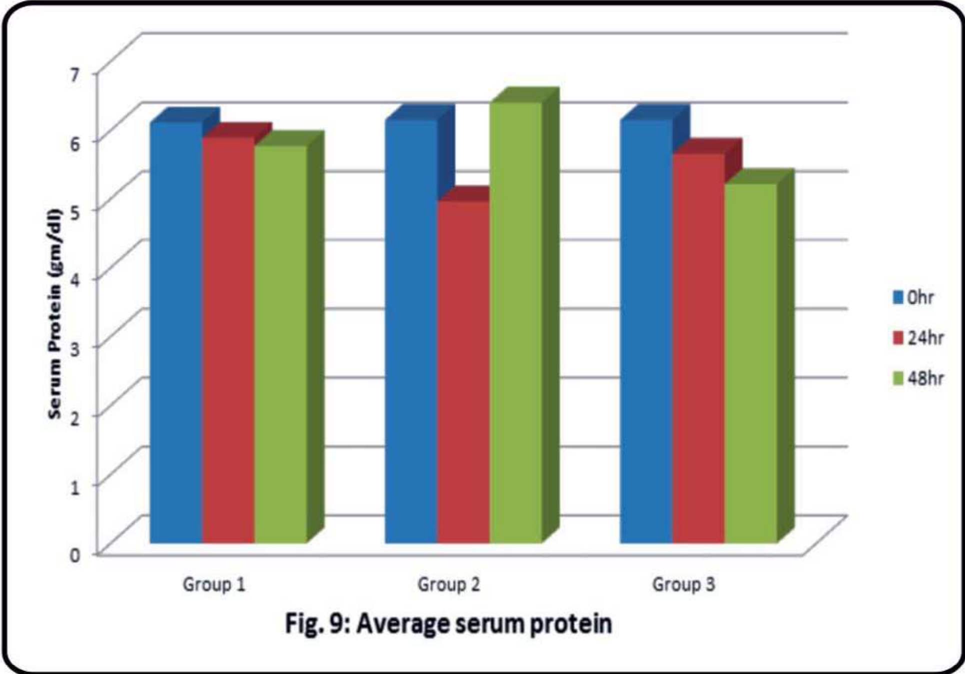

Fig. 9: Average serum protein

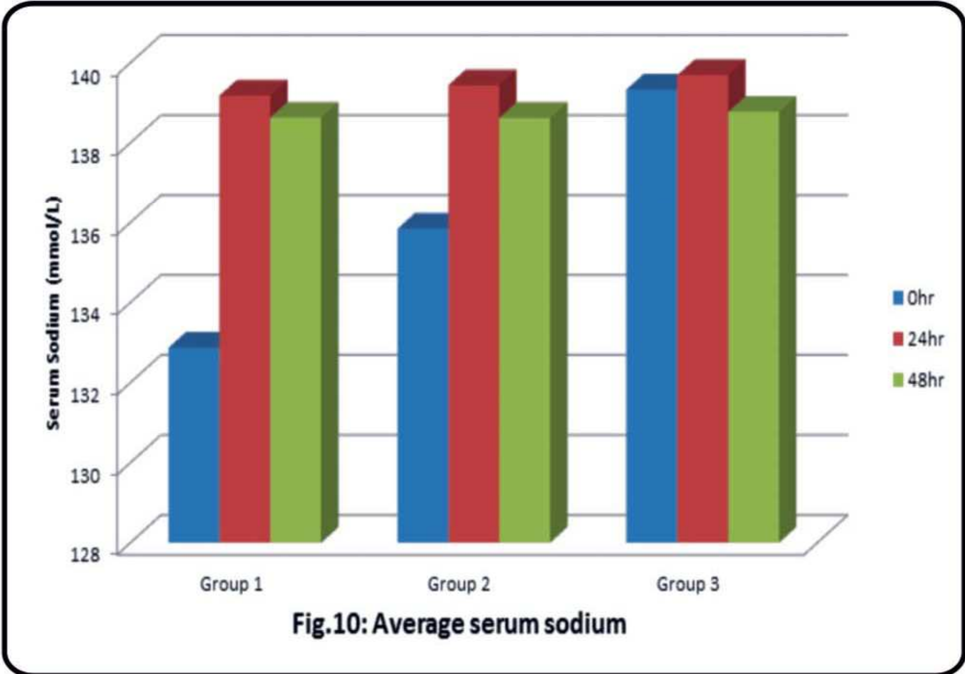

Fig.10: Average serum sodium

observed as a result of dehydration. This can be attributed to increased protein concentration per unit volume of blood due to dehydration. These protein values decreased after rehydration therapy at 24th and 48th hours in all the animals which might be due to increase in plasma volume which obviously lead to decrease in protein concentration per unit volume of blood. These findings corroborate with the findings of Constable *et al.,* (2001), Avanza (2004), Atoji (2005) and Bejamin (1981) who stated that during hydration with enteral administration there was decrease in the indices of total protein which was because of expansion of plasma volume. However, in animals from group II the values at 48th hour increased than that of 0th hour suggesting that further oral rehydration solution should have been administered.

4.3.2 <u>Serum sodium (mmol/L)</u>

Serum sodium study is the prime indicator of dehydration status of the animal. The serum sodium levels were estimated in all the animal at predicted time interval before and after oral rehydration therapy. The estimated values are presented in Table 19 with its analysis of variance in Table 20.

Table 19 Mean ± S. E. of serum sodium (mmol/l) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	$132.87^{aA} \pm 1.37$	$139.18^{b} \pm 0.51$	$138.63^{b} \pm 0.68$
II	$135.84^{aB} \pm 0.83$	$139.44^{b} \pm 0.90$	$138.62^{b} \pm 0.40$
III	$139.33^{abC} \pm 0.83$	$139.69^{b} \pm 1.06$	$138.77^{a} \pm 0.60$

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 20 Analysis of variance of serum sodium (mmol/l)

Source	Df	MS
Group	2	42.25**
Period	2	96.88**
Error	85	6.12

** = Significant at 1% level

Sodium, potassium and chloride are most important electrolytes in the body when imbalance of these important electrolytes occur, the electrochemical function of the body starts malfunctioning. The average serum sodium values for Group-I were recorded as 132.87 ± 1.37mmol/l at 0th hour which was improved to 139.18 ± 0.51mmol/l at 24th hours and 138.63 ± 0.68mmol/l at 48th hours after rehydration. In Group-II average serum sodium levels were 135.84 ± 0.83, 139.44 ± 0.90 and 138.62 ± 0.40mmol/l at 0th, 24th and 48th hours of study, respectively. Whereas, for animals of Group-III the average serum sodium values were noted on 0th hour as 139.33 ± 0.83 mmol/l, 24th hours 139.69 ± 1.06mmol/l and at 48th hours as 138.77 ± 0.60mmol/l. A decrease in serum sodium levels at 0th hour in the present study `could be due to reduction of extracellular fluid which leads to dehydration. Hyponatremia in the dehydrated animals might be due to an excessive secretion of sodium along with the water into the intestinal lumen. Same observations were reported by Dalton *et al.,* (1965). Similar findings of decrease in serum sodium level was reported by Manoiu *et al.,* (1972).

The estimated values indicate significant increase in serum sodium level in all the animals under study at 24th and 48th hours as a effect of oral rehydration therapy (Fig.10). In the present study to enhance gastrointestinal absorption of sodium, 5% dextrose was added to oral rehydration preparation. Same was suggested by Donawick and Christie (1971) who also used similar oral rehydration solution formula to improve the absorption of sodium in dehydrated animals.

The comparison was also made between Groups within period (Table 20). It was observed that at the start of the experiment itself the average serum sodium (mmol/l) values in cattle were significant at 1% level and hence, the critical differences showed significance. The average values for 24th and 48th

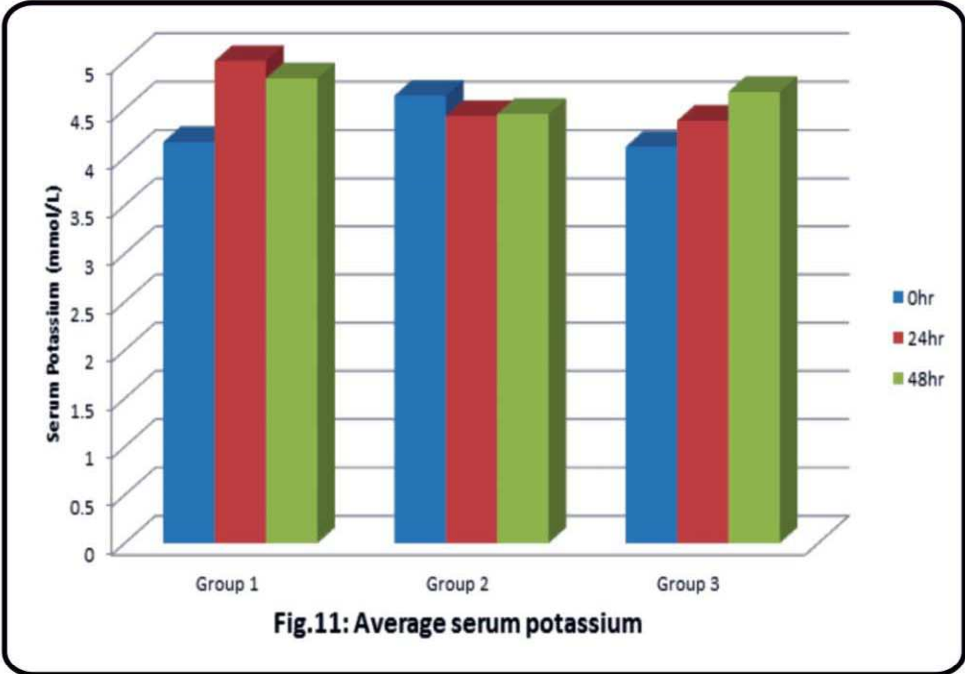

Fig.11: Average serum potassium

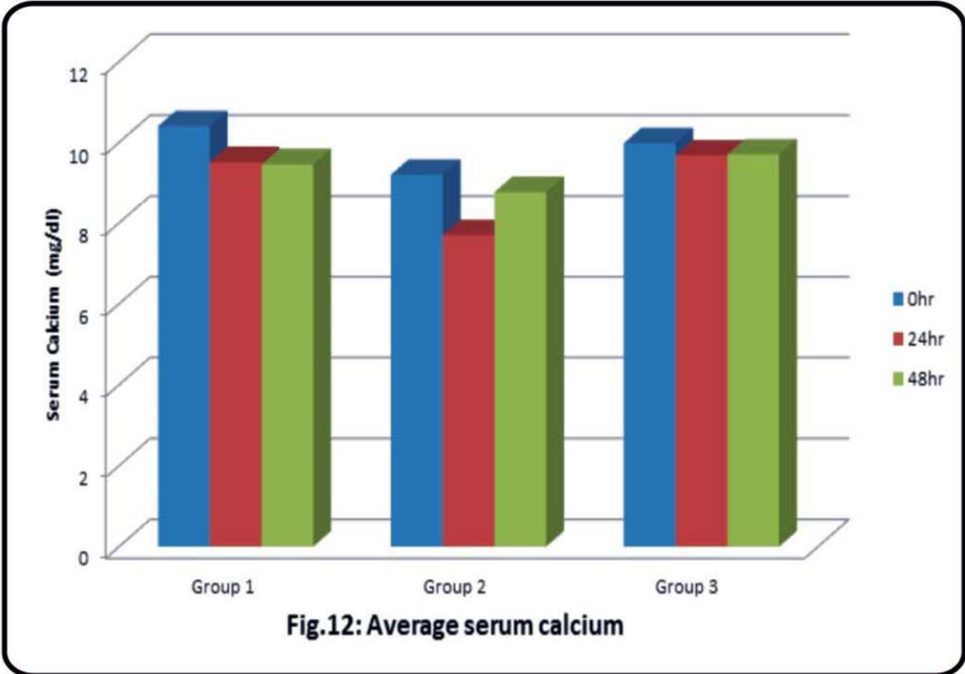

Fig.12: Average serum calcium

hours indicate no significance when comparison was made between Groups within period. Hence, all the values at 24th hour for different Groups were 139 mmol/l and for 48th hours 138 mmol/l. This indicated that due to rehydration the values after 24th hours reached towards normal, though average values were different at 0th hour.

4.3.3 Serum potassium (mmol/l)

Potassium plays an important role in regulating fluid balance in cell, mechanism of nerve impulse and in muscle contraction. During present investigation estimation of serum potassium was carried out in dehydrated animals under study at different pre decided time interval and estimated values presented in Table 21 with analysis of variance in Table 22.

Table 21 Mean ± S. E. of serum potassium (mmol/l) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	4.16 ± 0.15	5.00 ± 0.19	4.82 ± 0.11
II	4.64 ± 0.24	4.43 ± 0.11	4.45 ± 0.11
III	4.11 ± 0.34	4.38 ± 0.32	4.68 ± 0.21

Table 22 Analysis of variance of serum potassium (mmol/l)

Source	Df	MS
Group	2	0.55
Period	2	1.05
Error	85	0.47

The average serum potassium (mmol/l) values for Group-I were 4.16 ± 0.15mmol/l at 0th hour which increased to 5.00 ± 0.19mmol/l and 4.82 ± 0.11mmol/l at 24th and 48th hours of study. While, the average values for Group-II were 4.64 ± 0.24mmol/l at 0th hour reduced to 4.43 ± 0.11mmol/l at 24th hours and again increased to 4.45 ± 0.11mmol/l at 48th hours of therapy. Average

values for serum potassium (mmol/l) in respect of Group-III were 4.11 ± 0.34 mmol/l at 0th hour which increased to 4.38 ± 0.32mmol/l at 24th hours and to 4.68 ± 0.21mmol/l 48th hours of oral rehydration (Fig. 11). Though the variation was observed in average values of serum potassium (mmol/l) but it was within normal physiological range. The analysis of variance of serum potassium showed non-significant difference within periods (Table 22).

The comparison was also made between Groups within period. The Group differences within period indicated non-significant difference (Table 22). This showed that oral rehydration therapy has no statistical significant effect on serum potassium (mmol/l) level. Though, the difference is noticed in averages for different periods and different Groups. However, the differences were negligible.

Since potassium is the major intracellular cation, the measurement of plasma or serum potassium is not reliable indication of whole body potassium status. Extremely low or high levels are usually indicative of imbalance associated with electrolyte and acid base imbalance (Radostits *et al.,* 2007). The estimated serum potassium levels in the present investigation before and after oral rehydration therapy was observed to be within normal physiological range which indicates neither alkalosis nor acidosis was developed in animals and at the same time it reflected appropriate oral dosing of sodium through oral rehydration therapy.

4.3.4 Serum calcium (mg/dl)

Calcium is known as a bone building nutrient but it is also very important in fluid and electrolyte balance of the body. Serum calcium was also estimated in animals of all three groups before and after oral rehydration therapy and its averages were documented in Table 23 and its analysis of variance in Table 24.

It can be observed that average serum calcium (mg/dl) in Group-I were 10.40 ± 0.23mg/dl at 0th hour, 9.51 ± 0.14mg/dl at 24th hours and 9.46 ± 0.10mg/dl at 48th hours. In Group- II averages of serum calcium (mg/dl) were 9.20± 0.28, 7.70 ± 0.62 and 8.77 ± 0.18mg/dl at 0th, 24th and 48th hours of therapy. Whereas, in Group-III averages of serum calcium (mg/dl) were 9.98 ± 0.25mg/dl at 0th, 9.68 ± 0.22mg/dl at $24^{th}$and 9.70 ± 0.06mg/dl at 48th hours of therapy, respectively (Fig.12). The significant difference was observed within

groups between the periods at 1% level (Table 23) for Group-I and II. However, the differences were non-significant for Group-III.

Table 23 Mean ± S. E. of serum calcium (mg/dl) in dehydrated animals of different groups before and after therapy

Group	**Period (hour)**		
	0th	**24th**	**48th**
I	10.40^{bC} ± 0.23	9.51^{aB} ± 0.14	9.46^{aB} ± 0.10
II	9.20^{cA} ± 0.28	7.70^{aA} ± 0.62	8.77^{bA} ± 0.18
III	9.98^{B} ± 0.25	9.68^{B} ± 0.22	9.70^{B} ± 0.06

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 24 Analysis of variance of serum calcium (mg/dl)

Source	**Df**	**MS**
Group	2	15.18**
Period	2	6.09**
Error	85	0.69

** = Significant at 1% level

Significant differences within Groups were observed for all the three periods (Table 24). When the comparison between Groups and within period was made it was revealed that at 0th hour itself the average serum calcium (mg/dl) values were different. The highest average mean serum calcium (mg/dl) values were recorded in Group-I (10.40±0.23mg/dl) and the lowest were in Group-II (9.20±0.29mg/dl). After 24th hours of treatment the comparison of averages between Groups indicated significance because lowest value was recorded for Group-II (7.70±0.62mg/dl). After 48th hours of post treatment the average values was still differed for different Groups.

The estimated serum calcium indicated increase in level though within normal range in dehydrated animals before therapy i.e. at 0th hour. These observations are supported by the findings of Riberio *et al.,* (2013) who stated that dehydration leads to mild hypercalcemia. Calcium level rises due to the low amount of fluid in the blood. Dehydration can lead to imbalance of electrolyte in

blood stream. Unlike sodium and potassium which tend to decline with fluid loss on the other hand calcium can rise leading to hypercalcemia. After oral rehydration therapy serum calcium level was found to be decrease at 24th and 48th hours in all the animals under study. This indicate effectiveness of the therapy. These findings are supported by that of Constable *et al.,* (2001) who reported decrease in calcium level by administration of isotonic electrolyte solution in dehydrated calves. In spite inclusion of $CaCl_2$ in Group-I electrolyte solution trend of serum calcium levels was comparable in all the groups. In oral rehydration formula calcium chloride was included, which was drenched to animals from group-I; but, the estimated calcium levels at 24th and 48th hours in group I did not show elevation. This can be attributed to the low absorption of calcium salt from gastrointestinal tract.

4.3.5 Serum chloride (mEq/l)

The serum chloride is important anion and plays vital role in electrolyte balance. The estimation of serum chloride was carried out in all the animals before and after therapy and its averages are presented in Table 25 and its analysis of variance in Table 26.

Table 25 Mean ± S. E. of serum chloride (mEq/l) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	94.10^{aA} ± 3.10	105.97^{bB} ± 1.98	102.97^{bA} ± 1.27
II	102.51^{bB} ± 3.26	88.73^{aA} ± 4.56	111.91^{cC} ± 2.86
III	102.61^{aB} ± 2.46	109.64^{bC} ± 3.12	108.24^{bB} ± 1.63

Different column wise superscripts (small letter) within a group indicates significance

Different row wise superscripts (capital letter) within a period indicates significance

Table 26 Analysis of variance of serum chloride (mEq/l)

Source	df	MS
Group	2	336.48*
Period	2	527.73**
Error	85	76.56

* = Significance at 5% level

** = Significant at 1% level

Chloride is needed to maintain normal blood pH for metabolism. Kidney regulates the levels of chloride and sodium in the blood. In severe dehydration this ability is lost. The average values of chloride for Group- I were 94.10 ± 3.10 mEq/l at 0th hour increased to 105.97 ± 1.98 mEq/l at 24th hours and maintained to 102.97 ± 1.27 mEq/l at 48th hours. For Group-II the average values were 102.51 ± 3.26 mEq/l at 0th hour decreased to 88.73 ± 4.56 mEq/l at 24th hours and again increased to 111.91 ± 2.86mEq/l at 48th hours of therapy. Wherein, Group-III averages were 102.61 ± 2.46, 109.64 ± 3.12 and 108.24 ± 1.63 mEq/l at 0th, 24th and 48th hours of therapy, respectively (Fig.13). In respect of Group-III average values of serum chloride (mEq/l) were increased from 0th to 24th hours and again slightly decreased at 48th hours. This indicated that the trend of results were similar for Group-I and III but differed in Group-II.

The significance of difference between groups within period was at 5% level (Table 26). At 0th hour average values of serum chloride (mEq/l) for Group-I, II and III were 94.10 ± 3.10, 102.51 ± 3.26 and 102.61 ± 2.46 mEq/l, respectively. At 0th hour Group-I (94.10 ± 3.10 mEq/l) was the lowest and Group-II and III (102.51 ± 3.26 and 102.61 ± 2.46 mEq/l) were similar. The trend differed when Group averages were considered after 24th hours of treatment where the lowest value was recorded for Group-II (88.73±4.56 mEq/l). At 48th hours the trend again changed where the highest value was recorded for Group-II and lowest for Group-I. This showed that the average serum chloride (mEq/l) for all the Groups and all the periods was variable and hence, significance at 1% level was noticed in Table-26.

In dehydrated animals at 0th hour the chloride levels estimated towards lower side of the normal physiological range. In dehydration to maintain the

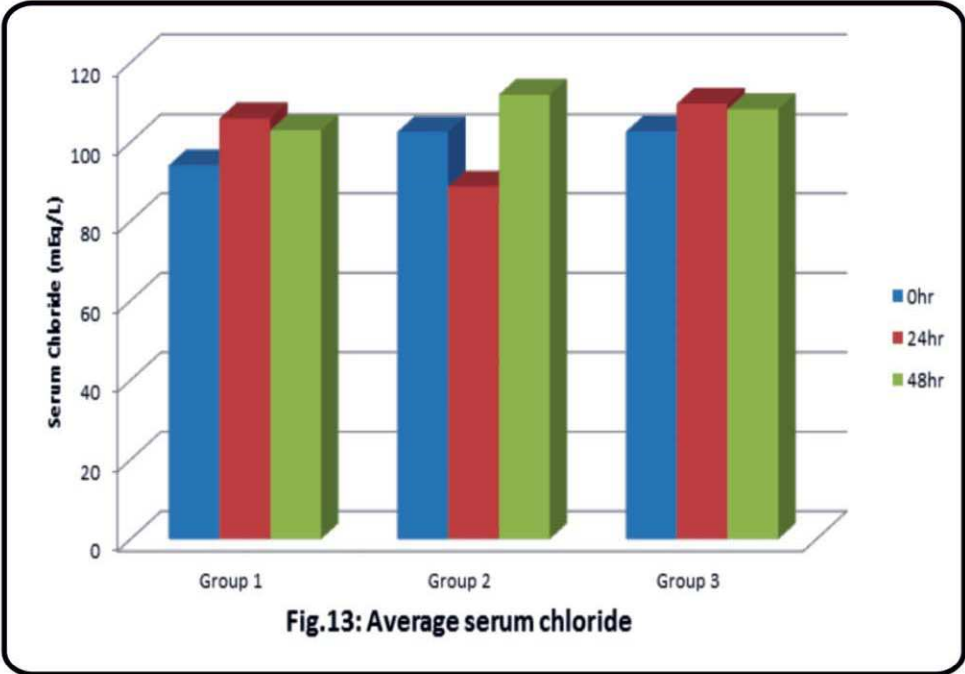

Fig.13: Average serum chloride

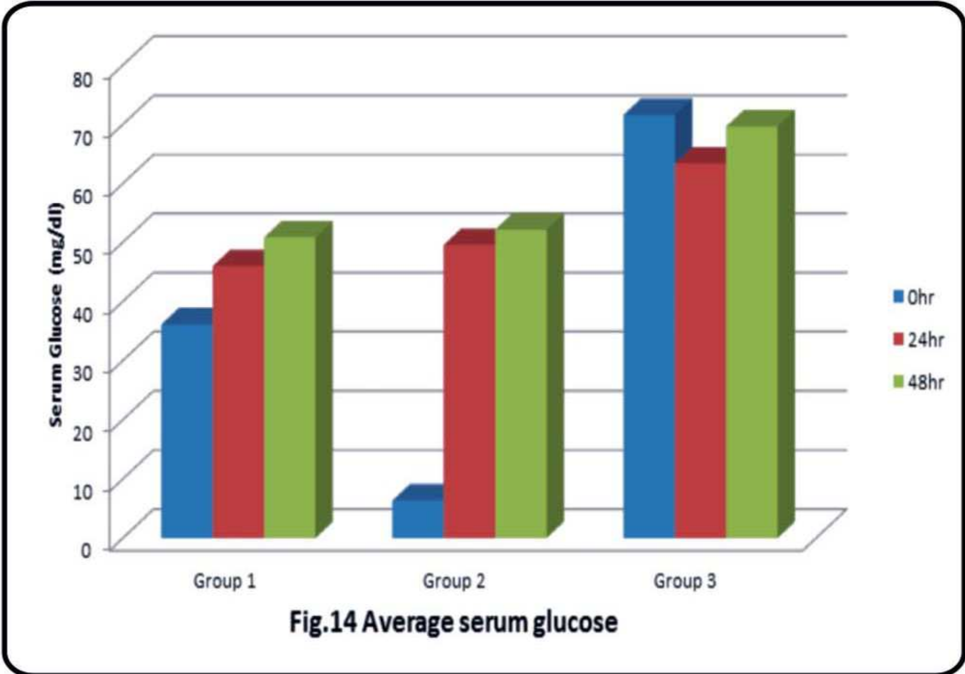

Fig.14 Average serum glucose

electro neutrality within electrolytes there is excretion of chloride along with sodium from the body.

After rehydration therapy the chloride levels found to increase and reaching to near normalcy indicating efficacy of therapy. Since oral rehydration solution containined both sodium and chloride, hence the excretion of chloride from body might have been restricted. The findings of the present study are in general agreement with that of Dalton *et al.,* (1965), Fisher (1965) and Bijwal and Mishra (1987) However, decrease in chloride values were observed by Constable *et al.,* (2001) and Atoji (2005).

4.3.6 <u>Serum glucose (mg/dl)</u>

During present investigation estimation of serum glucose was carried out in dehydrated animals under the study at different pre decided time interval before and after therapy and estimated average values are presented in Table 27 with analysis of variance in Table 28.

In the present study within the Groups between the period showed non-significance difference. While within the period between the Groups the differences were significant at 1% level.

In Group-I the average values for 0th, 24th and 48th hours were 36.10 ± 2.63, 45.94 ± 2.86 and 50.80 ± 2.94mg/dl. Though, the trend was of inclining fashion but at statistical level it was non-significant. In Group-II the trend noticed was haphazard. At initial level it was the highest, at 24th hours it was the lowest and increased at 48th hours. The same trend of results was observed for Group-III as well.

Group differences within period were statistically significant. At initial stages the lowest average was noticed in Group-I (36.10 ± 2.63 mg/dl) and highest in Group-III (71.58 ± 5.86 mg/dl) which was statistically significant. The result for 24th hours between Groups indicated the highest value in Group-III (63.37 ± 4.35 mg/dl) and lowest in Group-I (45.94 ± 2.86 mg/dl). Similar trend of results were noticed in all the three Groups after 48th hours of drenching (Fig. 14).

Table 27 Mean ± S. E. of serum glucose (mg/dl) in dehydrated animals of different groups before and after therapy

Group	Period (Hour)		
	0th	24th	48th
I	$36.10^{A} \pm 2.63$	$45.94^{A} \pm 2.86$	$50.80^{A} \pm 2.94$
II	$60.33^{B} \pm 6.16$	$49.54^{A} \pm 5.64$	$52.12^{A} \pm 6.95$
III	$71.58^{C} \pm 5.86$	$63.37^{B} \pm 4.35$	$69.63^{B} \pm 2.53$

Different row wise superscripts (capital letter) within a period indicates significance

Table 28 Analysis of variance of serum glucose (mg/dl)

Source	Df	MS
Group	2	4337.92**
Period	2	162.06
Error	85	195.40

** = Significant at 1% level

The glucose levels at 0th hour in dehydrated animals reveled not much variation except in animals from Group-I. This indicates that dehydration has no effect on blood glucose level. In Group-I at 0th hour marginal hypoglycemia was recorded, this may be because of a variable feeding timings. The dextrose was added to oral rehydration solution because glucose facilitates sodium absorption from the gut thereby enhancement of water absorption. However, inspite of dextrose incorporation in the solution the estimated glucose levels at 24th and 48th hour were within normal ranges. These findings are in agreement with that of Riberio *et al.,* (2013) who administered glucose at 5 gm per liter of solution and reported no effect on blood glucose indicating that the use of this substance in electrolyte solution administered enterally in adult cattle has no desired effect. Similar observation was also reported by Riberio *et al.,* (2011).

4.4 Economics

The cost economics was also the part of this study which was calculated. For determination of cost the maximum retail price of the chemical at the time of purchase was considered and the values were calculated. Similarly, regularly

used isotonic saline i.e. Ringer's Lactate was selected and the estimated cost was put for comparison.

4.4.1 Cost economics (Rs.)

Table 29 Average of cost

Group	Dehydration (%)	Cost of ORT (Rs)	Cost of IV therapy (Rs)	Amount saved	
				(Rs)	(%)
I	8.70 ± 0.40	180.34 ± 13.02	2340.06 ± 168.99	2159.72 ± 155.97	92.29
II	8.50 ± 0.34	106.08 ± 7.97	2713.14 ± 128.76	1607.06 ± 120.78	93.81
III	10.00 ± 0.00	20.56 ± 0.86	2325.54 ± 97.49	2304.99 ± 96.63	99.12

In the present study the electrolyte formulation used in oral rehydration therapy was prepared before administration. To compare homemade oral rehydration solution with marketly available fluids for rehydration, it was decided to consider isotonic solution. The isotonic fluid available in the market is to be administered by intravenous route.

It is pertinent to calculate the cost on the basis of ORT as well as assuming intravenous therapy (Table 29). In group I the average expenditure required for oral therapy was Rs. 180.34±13.02 which was highest as compare to Group-II & III where in the cost recorded as Rs. 106.08±7.97 & Rs.20.56±0.86, respectively. This indicates that the amount required for rehydration using oral therapy was less than Rs. 200.00 & that to of single dose. It is surprising to note that in Group-III where average dehydration per cent was 10.00±0.00 required a meager amount of Rs. 21.00. Had the rehydration therapy given intravenously considering isotonic fluid in market then the average cost would have been for Group-I & III was Rs. 2340.06±168.99, 2713.14±128.76 & 2325.54±97.49, respectively. This indicated that the average cost required using intravenous therapy would have been much higher than oral rehydration therapy. The amount would have saved due to change in therapy from intravenous to oral with homemade oral rehydration therapy could be Rs. 2159.72±155.97,

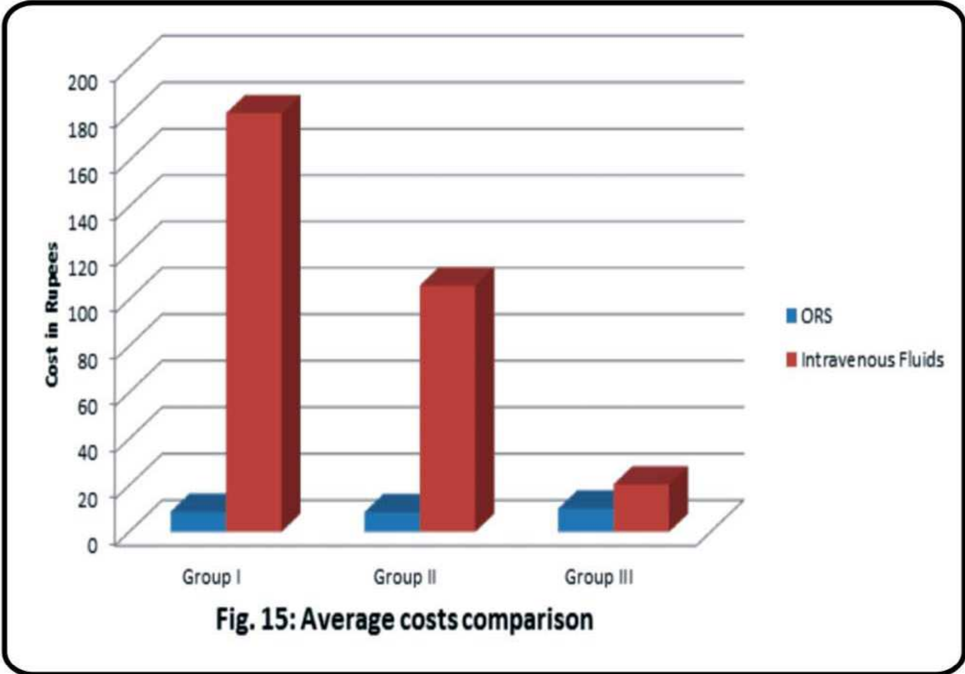

Fig. 15: Average costs comparison

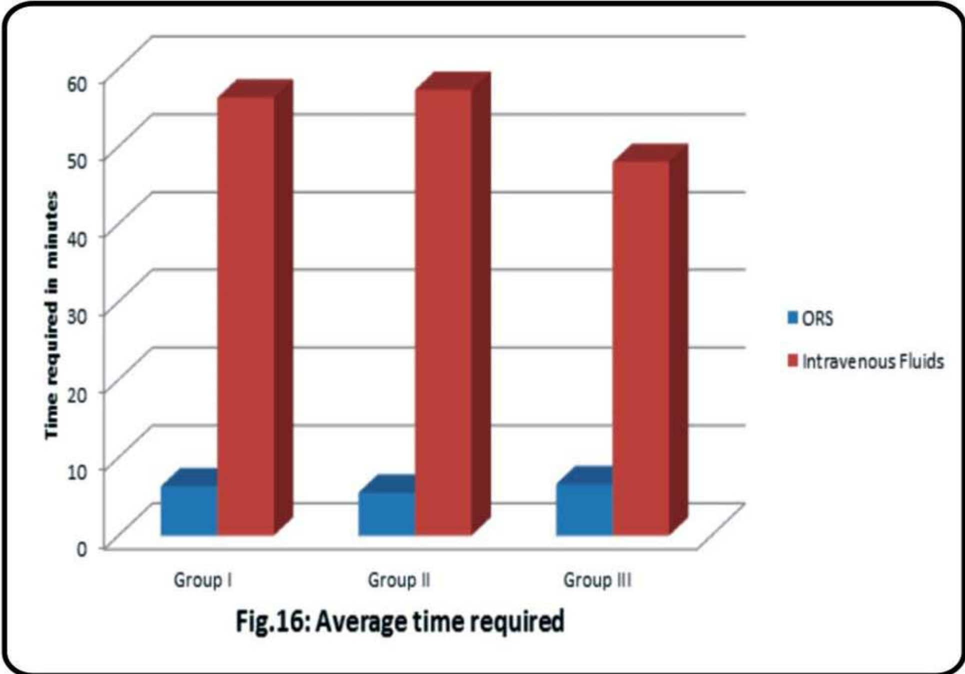

Fig.16: Average time required

1607.06±120.78 & 2304.99±96.63, respectively. The per cent expenditure saved to the maximum of 99.12% from Group-III. Perusal of Table 29 clearly indicate that the average cost required for oral rehydration solution compared to the average cost might have required of indigenous medicine using oral rehydration therapy as compared to the average cost might have required of similar market medicine using intravenous therapy was much less. Hence, it is suggested to use oral therapy for treating dehydration cases wherein the medicine is to be prepared purely indigenously. This will save the expenditure which ranges from 92.29 to 99.12 per cent.

4.4.2 Time saved (min)

Time is major constraint because majority of times the fluid therapy was avoided because of paucity of time in large animal practice and so it was decided to study and compare the time required for regularly used intravenous therapy and oral rehydration therapy . For oral rehydration therapy actual time required was recorded and for intravenous fluid therapy the standard infusion rate i.e.80ml/kg/hr was considered to estimate the time.

Table 30 Average of time

Group	Time for ORT (Minutes)	Time for IV therapy (Minutes)	Time saved	
			(Minutes)	(%)
I	6.30±0.56	56.25±2.64	49.95±3.12	88.80
II	5.50±0.45	57.26±2.19	51.76±2.56	90.39
III	6.60±0.37	48.00±0.00	41.40±0.37	86.25

Table 30 depicts the average time required for oral therapy comparing with intravenous therapy & also the time saved due to change in route of administration. The average time required ranged between 5.50±0.45 (Group-II) to 6.60±0.37 (Group-III) minutes when oral therapy was given. If the same markedly available medicine is given by intravenous route then the time required was ranging between 48.00±0.00 (Group-III) to 57.26±2.19 (Group-II) minutes. This shows that time required for oral therapy was much less than likely to be for intravenous therapy. The time saved due to oral therapy ranged between 86.25% (Group-III) to 90.39% (Group-II) due to change therapy from intravenous to oral.

SUMMARY AND CONCLUSIONS

The present study was conducted to evaluate the effect of oral rehydration therapy in terms of its effect in correcting dehydration and electrolyte imbalances in dehydrated cattle. In this study 30 clinically dehydrated adult animals of either sex from Gorakshan Sabha, Dhantoli, Nagpur were selected and divided in three treatment groups comprising 10 animals in each group. The three groups of dehydrated animals were subjected to the treatment with three different combinations of electrolyte solutions prepared on farm. Group-I was treated with oral electrolyte solutions prepared by dissolving 100 gms Dextrose, 140 gms NaCl, 25 gms KCl and 10 gms of $CaCl_2$ in 20 liters of water. Group-II was treated with oral electrolyte solution prepared by dissolving 100 gms Dextrose, 140 gms NaCl, 25 gms KCl in 20 liters of water. Group-III was treated with oral electrolyte solution prepared by dissolving 100 gms Sugar, 140 gms Salt, 25 gms KCl in 20 liters of water.

The fluid requirement was evaluated on the basis of formula i.e. Body weight in Kg X Estimated dehydration percentage = Fluid deficit in liters. The body weight of animals was determined by formulae i.e. Body weight(Kg) = Length(cm) X Girth^2(cm) /10838. The oral electrolyte solution was drenched to animals using Oral Rehydration Unit.

Clinical parameters i.e. mucus membrane, eye position, skin tent test, body temperature, pulse, respiration rate, gait of animal appetite were recorded on 0th, 24th and 48th hour of oral rehydration. Similarly hematobiochemical investigations were carried out at same intervals.

In the present study clinically cattle were found dehydrated, lethargic, dull and depressed. Some of them showed sunken eyes, congested and tacky mucous membrane along with prolonged skin tent. The eye ball recession was also observed along with stiff, stumbling gait and few of them were recumbent. The appetite was decreased, anorectic and one or two of them were with normal appetite at the onset of experiment.

The skin tent values had drastically reduced within 24 and 48 hours in each group. The rate of reduction (in seconds) was highest in group-III followed by Group-II and Group-I. In all classes of dehydration body temperature did not differ significantly at the onset of experiment and also on 24th and 48th hour of recording. It is observed that the pulse rate (/minute) decreases after rehydration

therapy. Similarly decline in average heart rate /minute values were recorded. Respiration rate was elevated at the time of initiation of therapy which decreased during the treatment period. The packed cell volume(%) was reduced significantly in all the groups at 24th and 48th hours as compared to 0th hour. The rate of reduction (in seconds) was highest in Group-III followed by Group-II and Group-I. Decrease in total erythrocyte count was noted on 24th and 48th hour after rehydration therapy in all the three groups under study. The total erythrocyte count was on the lower side at 0th hour in all the groups as compared to the reference values indicating anemia. As far as hemoglobin (gm%) values are concerned the values are decreased in all the groups upto 48 hrs. But, in Group I and II it increased slightly at 48 hrs. Due to dehydration increased protein concentration per unit volume of blood decreased after rehydration therapy at 24th and 48th hours in all the animals except in Group II it increased at 48 hrs. A decrease in serum sodium level at 0th hour in the present study could be attributed to dehydration. Increase in serum sodium level in all the animals under study at 24th and 48th hours was observed. The estimated serum potassium levels in the present investigation before and after oral rehydration therapy was observed to be within normal range. The analysis of variance of serum potassium showed non-significant difference within periods. Increased level of serum calcium though within normal range in dehydrated animals before therapy decreased at 24th and still continued to decline at 48th hours in Group I, whereas, slight increase was found in group II and III. In dehydrated animals estimated chloride levels at 0th hours was observed to be towards lower side of the normal range. After rehydration therapy the chloride levels were found to increase near normalcy. Dehydration has no effect on blood estimated glucose and the glucose levels at 24th and 48th hour were within normal ranges after oral rehydration therapy. The average cost required using intravenous therapy would have been much much higher than oral rehydration therapy. The time required for oral therapy was much less than likely to be for intravenous therapy.

Conclusions

1. Oral rehydration therapy with homemade formula is effective in correcting dehydration in cattle.
2. Oral rehydration therapy was found to be safe.
3. Oral rehydration therapy is recommended for animals suffering with mild dehydration.

4. Oral rehydration is economical vis-à-vis intravenous fluid therapy.
5. Oral rehydration saves the time of administration vis-à-vis fluid therapy.
6. Oral rehydration therapy can be undertaken by the livestock keepers if trained.

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VITA

The author Jadhav Yogesh Bhimrao was born on 10th June 1978 at Bawada, Taluka- Indapur District- Pune of Maharashtra. He had completed his schooling up to high school level at Shri Shivaji Vidyalaya, Bawada. During his S.S.C examination he got 84% marks after that he was admitted to Sadashivrao Mane High School, Akluj, Taluka- Malshirus, District- Solapur for Higher Secondary education. In the board examination of H.S.C. he got 81.50% marks.

After successful completion of higher secondary schooling he secured admission in the Bombay Veterinary College, Parel, Mumbai-12 for B.V.Sc. & A.H. degree programme. During the graduation tenure he has actively participated in various sports, cultural activities. He was the Students Council Secretary during year 2001. In college days he was the part of University Volleyball team and attended two state level competitions. In year 2002 he completed his graduation.

He started his professional carrier as a Veterinary Officer at Dudhaganga Co-Opertative Milk Union, Indapur in February 2003 and was involved in attending various clinical cases and involved extension activities. It was his work which brought him opportunity to work with national level leading organization National Dairy Development Board (NDDB), Anand, Gujrat. NDDB established company namely IndiaGen, author was the candidate who got selected for the post of Area Officer and posted at Islampur, Dist- Sangali where he was daily attending the infertility camps and extension camps. During this period he also worked under progeny testing programme DIPA and proven 2 bulls. In 2008 he got selected as Laboratory Technician in Maharashtra Animal & Fishery Sciences University, Nagpur and posted at KNP College of Veterinary Science, Shirwal. During this period he was working in the Department Of Surgery &Radiology.

In year 2013 MAFSU, permitted him to complete his post graduation and he got admitted for M.V.Sc. in the discipline of Veterinary Medicine at Nagpur Veterinary College, Nagpur. He completed his post graduation in First class. These fruitful years resulted in the submission of present thesis successfully. While prosecuting his post graduation he participated in N.S.S. camp. He considered himself lucky to have gained the love and affection of his superiors and entire staff of the department.

THESIS ABSTRACT

a)	Title of the thesis	:	**COMPARATIVE EVALUATION OF ORAL REHYDRATION THERAPY IN ADULT CATTLE**
b)	Full name of student	:	**Jadhav Yogesh Bhimrao**
c)	Name and Address of Major Advisor	:	**Dr. G. R. Bhojne** Assistant Professor,Department of Veterinary Clinical Medicine, Ethics & Jurisprudence, Nagpur Veterinary College, Nagpur.
d)	Degree to be awarded	:	**Master of Veterinary Science**
e)	Year of award of degree	:	**2015**
f)	Major Subject	:	**Veterinary Clinical Medicine, Ethics & Jurisprudence**
g)	Total number of pages in the thesis	:	**58**
h)	Number of words in the abstract	:	**460**
i)	Signature of Student	:	
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ABSTRACT

The present study was conducted to evaluate the effect of oral rehydration therapy in terms of its effects in correcting dehydration and electrolyte imbalances in dehydrated cattle. In this study 30 clinically dehydrated

adult animals of either sex from Gorakshan Sabha, Dhantoli, Nagpur were selected and divided in three groups comprising 10 animals in each group. Group-I was treated with oral electrolyte solution prepared by dissolving 100 gms Dextrose, 140 gms NaCl, 25 gms KCl and 10 gms of $CaCl_2$ in 20 liters of water. Group-II was treated with oral electrolyte solution of 100 gms Dextrose, 140 gms NaCl, 25 gms KCl dissolved in 20 liters of water. Group-III was treated with oral electrolyte solution of 100 gms Sugar, 140 gms Salt, 25 gms KCl dissolved in 20 liters of water.

The fluid requirement was evaluated on the basis of formula i.e. Body weight in Kg X Estimated dehydration percentage = Fluid deficit in liters and body weight of animals by formulae i.e. Body weight (Kg) = Length(cm) X Girth^2(cm) /10838. The oral electrolyte solution was drenched to animals using Oral Rehydration Unit.

In the present study clinically the cattle were found dehydrated, lethargic, dull and depressed. Also sunken eyes, congested and tacky mucous membrane along with prolonged skin tent and eye ball recession. The gait of animals was stiff, stumbling few of them were recumbent. Appetite was decreased, anorectic and some of them were with normal appetite.

Skin tent values had drastically reduced within 24 and 48 hours post-treatment in each group indicating successful rehydration. In all classes of dehydration the body temperature remained statistically non-significant throughout the study period. It is observed that the pulse rate /minute and heart rate/minute decreased after rehydration therapy. Respiration rate was elevated at the time of initiation of therapy which decreased during the treatment period. The packed cell volume (%), total erythrocyte count (x10^6/cumm) and hemoglobin (gm%) were reduced significantly in all the groups at 24th and 48th hours as compared to 0th hour. Due to dehydration increased protein concentration per unit volume of blood decreased after rehydration therapy at 24th and 48th hours in all the animals. The serum sodium (mmol/L) was lower or below reference range at 0th hour increased after oral rehydration and reached up to normal levels while serum potassium (mmol/L) was within normal range. In dehydrated animals at 0th hour estimated chloride levels were observed to be towards lower side of the normal range. After rehydration therapy chloride levels were found to rise and reached near normalcy indicating efficacy of therapy. Glucose levels did not differ

in dehydration and rehydration. The average cost required using intravenous therapy would have been much higher than oral rehydration therapy. The time required for oral therapy was much less than likely to be for intravenous therapy.

प्रबंध सारांश

अ.	प्रबंधाचे शिर्षक	:	**प्रौढ गोवंशामधे मौखीक पुनर्जलीकरण उपचाराचा तुलनात्मक अभ्यास**
ब.	विद्यार्थ्याचे पुर्ण नांव	:	**जाधव योगेश भिमराव**
क.	मार्गदर्शकाचे नांव पत्ता	:	**डॉ. जी. आर भोजने** सहाय्यक प्राध्यापक, पशुवैद्यकिय चिकित्सालयीन, नितीशास्त्र आणि न्यायवैद्यकशास्त्र विभाग, नागपूर पशुवैद्यक महाविद्यालय, नागपूर
ड.	प्रदान करण्यात येणारी पदवी	:	**स्नातकोत्तर पदवी (एम.व्ही.एस.सी.)**
इ.	पदवी प्रदानकरण्याचे वर्ष	:	२०१५
फ.	मुख्य विषय	:	**पशुवैद्यकिय चिकित्सालयीन, नितीशास्त्र आणि न्यायवैद्यकशास्त्र**
ग.	प्रबंधातील एकूण पृष्ठे	:	५८
ह.	सारांशातील एकूण शब्द	:	४२१
ई.	विद्यार्थ्याची सही	:	
ज.	अग्रेषित करणाऱ्या अधिकाऱ्याची सही, नांव आणि पत्ता	:	

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सदर अभ्यास हा गोवंशातील जनावरांच्या निर्जलीकरण व खनिजद्रव्य यांच्या असंतुलना मध्ये मौखीक देण्यात येणाऱ्या खनिजद्रव्य व पाणी यांच्या मिश्रणाचा प्रभाव

पाहण्यासाठी करण्यात आला. या अभ्यासामध्ये गोरक्षण सभा धंतोली नागपुर येथील निर्जलीकरणाने प्रभावीत ३० जनावरे त्यांचे लिंग विचारात न घेता निवडुन त्यांना १० चा एक अशा तीन गटामध्ये विभागण्यात आले. पहिल्या गटाला १०० ग्रॅम स्फटीक साखर, १४० ग्रॅम स्फटीक मीठ, २५ ग्रॅम पोट्याशियम क्लोराइड आणि १० ग्रॅम कॅल्शीयम क्लोराइड २० लीटर पाण्यात विरघळुन पाजले. दुसऱ्या गटात १०० ग्रॅम स्फटीक साखर, १४० ग्रॅम स्फटीक मीठ आणि २५ ग्रॅम पोट्याशियम क्लोराइड २० लीटर पाण्यात विरघळुन पाजले. तिसऱ्या गटासाठी १०० ग्रॅम घरगुती वापरातील साखर, १४० ग्रॅम घरगुती वापरातील मीठ आणि २५ ग्रॅम पोट्याशियम क्लोराइड २० लीटर पाण्यात विरघळुन पाजण्यात आले.

जनावरांचे जल वियोजन पुढील सुत्राने काढण्यात आले. शरीरातील द्रव्याची कमतरता (लीटर) = जनावराचे वजन (किलो) ग निर्जलीकरणाची शतावरी, तसेच शरीराचे वजन पुढील सुत्राने काढण्यात आले. जनावराचे वजन (किलो) = जनावराची लांबी (सेंटीमीटर) ग जनावराच्या छातीचा घेर^{२} / १०८३८. इलेक्ट्रोलाइटचे द्रावण जनावरांना निर्जलीकरण यंत्राच्या सहाय्याने मौखीक पाजण्यात आले.

सदर अभ्यासात निर्जलीकरणाने बाधीत जनावरे, मलुल उदासीन, सुस्तावलेली आढळुन आलीत. डोळयाचा पडदा लालसर, शुष्क व डोळे खोल गेलेले आढळले. डोळयाच्या पडद्याचा चिकटपणा, डोळयाचे बुबुळ व डोळयाचा पडदा यातील अंतर वाढणे तसेच त्वचेचा प्रदिर्घ तंबु अशी लक्षणे आढळली. जनावरांची चाल हेलकावे देत व ताठ शरीर करूण चालणारी होती तसेच काही जनावरे ऊठु न शकणारी होती. काही जनावरांची भुक सामान्य तर काहींची मंदावलेली आणि काहींनी अन्नत्याग केला होता.

उपचारा नंतर त्वचा तंबुला अद्रुष्य होण्यास लागणाऱ्या वेळेचे आकडे २४ तास व ४८ तासाला मोठ्या प्रमाणात कमी झालेले होते. यावरून जनावरांच्या शरीराचे पुनर्जलीकरण झालेले दिसत होते. अभ्यासाच्या कालावधी मधे सर्व जनावरांच्या शारीरीक तापमानाच्या नोंदीमध्ये कुठलाही बदल आढळला नाही. नाडीच्या ठोक्यांचा दर आणि ह्दयाच्या ठोक्यांचा दर हा पुनर्जलीकरणासोबत कमी झालेला आढळुन आला. श्वसन दर हा पुनर्जलीकरणामध्ये वाढलेला होता परंतु पुनर्जलीकरणासोबत कमी झाला. पॅक सेल व्हाल्युम(:), लाल पेशींची

संख्या ($१०^{६}$/क्युएमएम) आणि हिमोग्लोबीन (ग्रॅम:) यांच्या आकड्यामध्ये ० तासाच्या तुलनेत २४ तासाला आणि ४८ तासाला घट झालेली आढळली. रक्तजलामधील प्रथीनांचे ० तासाला निर्जलीकरणामध्ये वाढलेले होते ते पुनर्जलीकरणानंतर २४ तास व ४८ तासाला कमी झाले हे पुनर्जलीकरण झालेले दर्शविते. रक्तजलामधील सोडीयमची पातळी निर्जलीकरणामध्ये संदर्भीय पातळीच्या खाली किंवा पातळीवर होती ती पुनर्जलीकरणानंतर वाढुन संदर्भीय पातळीच्या बरोबर आली तसेच रक्तजलातील पोट्याशीयमची पातळी संदर्भीय पातळीच्या बरोबर आढळुन आली हे पुनर्जलीकरण झालेले दर्शवित होते. पुनर्जलीकरणानंतर रक्तजलातील क्लोरईडची पातळी वाढुन संदर्भीय पातळीच्या बरोबर आली हे पुनर्जलीकरण उपचाराची उपयोगीता दर्शविते. रक्तजलामधील शर्करा पातळी मध्ये निर्जलीकरण व पुनर्जलीकरणामध्ये कोणताही बदल दर्शवित नाही. शिरेद्वारे देण्यात येणाऱ्या उपचारापेक्षा मौखीक देण्यात येणाऱ्या उपचारासाठी लागणारा खर्च हा नगण्य होता. वेळेच्या संदर्भात सुद्धा मौखीक देण्यात येणाऱ्या उपचारासाठी लागणारा वेळ हा शिरेद्वारे येणाऱ्या उपचारासाठी लागणाऱ्या वेळे पेक्षा खुपच कमी होता.