



Electrolytes for Dairy Calves

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Topics include:

Causes of scouring
When to treat with electrolytes
Treatment strategies and calculating fluid needs
Recommendations for electrolyte composition

INTRODUCTION

Oral rehydration solutions are used to replenish fluids and electrolytes that are lost during the course of diarrhea. Also known as electrolytes, these solutions are a convenient way to treat calves with diarrhea. There are many brands of electrolytes on the market that offer treatment for diarrhea through rehydration and electrolyte replacement. These products, however, can be variable and the right one needs to be chosen for each individual dairy.

Oral rehydration therapies are designed to improve acid-base balance by providing electrolytes and water. Although they are generally easy to use, neonatal calf diarrhea is still a major cause of death and economic

loss in the dairy industry. According to NAHMS (2002), calf mortality averages 8.7% annually, of which 62.1% is due to scours. In past years, mortality due to scours averaged 60.5% in 1996 and 52.5% in 1991 indicating an expanding problem in the dairy industry.

Although convenient and easy to use, the capacity of oral rehydration use for treatment is limited when there is a lack of protocol on the farm. Farms should have a standard operating procedure for treatment of scouring calves that includes when to use oral rehydration solutions, how much to give and many other questions that can arise without proper protocol.

CAUSES OF SCOURING

There are two main types of scouring in neonatal calves: nutritional and pathogenic. Causes of nutritional scours can include changing brands of milk replacer, changing from waste milk to milk replacer, transport, weather, vaccinations, dehorning, etc. These types of scours are caused by stress and are usually temporary. Because there is no heavy damage to the intestinal villi, the condition of calves can improve even without treatment once the source of stress is removed. However, nutritional scours can cause as much water loss and dehydration as pathogenic scours and these calves should be monitored closely and possibly treated, especially if they are young.

Causes of pathogenic scours can include any bacteria or virus found on a farm and can vary between farms. Calves begin

showing clinical symptoms, such as diarrhea, from about one to three weeks of age. Infection can occur from contact with other calves, through workers while they are feeding or handling calves or through the environment. Common pathogens that cause enteric infections include rotavirus, coronavirus, *E. coli*, salmonella and cryptosporidia as well as many others.

After birth, passive immunity is obtained through colostrum ingestion; however this immunity decreases while the immune system of the calf slowly increases its own ability to produce a response to infection. Calves become vulnerable to infection when passive immunity has decreased but their own immune system has not yet fully strengthened.

WHEN SHOULD YOU TREAT WITH ELECTROLYTES?

Calves can lose 5 to 10% of their bodyweight in water within 1 day of scouring. Fluid loss in excess of 8% requires IV treatment, and over 14% loss can result in death (Figure 1). This is why it is extremely important to monitor calves daily and treat them quickly when signs of illness are observed. The amount of water lost by scouring calves can be approximated using symptoms such as skin tenting, gum condition, attitude, and ability to stand or suckle (Table 1).

To evaluate hydration using skin tenting, pinch a fold of skin (best done on the neck) and count the seconds it takes to flatten. Flattening of skin in less than 2 seconds indicates normal hydration. If skin takes 2 to 6 seconds to flatten, the calf is about 8% dehydrated. Over 6 seconds indicates severe dehydration above 10%. Gums can be evaluated by looking at their color and feeling them for moisture. Normal gums should be pink and damp but if gums are white and dry this indicates 8 to 10%

Table 1. Clinical symptoms that help evaluate amount of dehydration in calves.

Dehydration	Symptoms
5-6%	Diarrhea, no clinical signs, strong suckling reflex
6-8%	Mild depression, skin tenting 2-6 seconds, calf still suckling, sunken eyes, weak
8-10%	Calf depressed, laying down, eyes very sunken, dry gums, skin tenting >6 seconds
10-14%	Calf will not stand, cool extremities, skin won't flatten when tented, comatose
Over 14%	Death

Adapted from J. M. Naylor, Can. Vet. J. (1989).

dehydration. One of the best measures of estimated dehydration and illness in calves is their attitude during milk feeding. Calves may show no symptoms of dehydration but if they need encouragement to drink, monitor them closely for scouring or other illnesses.

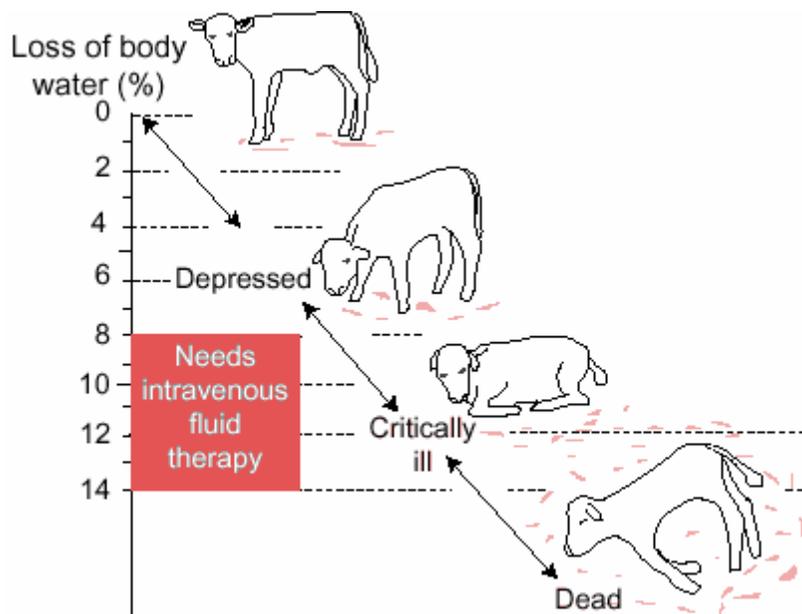


Figure 1. Visual representation of percent dehydration as related to clinical symptoms and health of calves. Adapted from M. A. Wattiaux (2005).

PROTOCOL

Establishing a protocol for dealing with sick calves is important to keep everyone consistent with each other. Because calves can lose so much water in a short period of time, it is necessary for all employees to be able to diagnose and treat calves quickly and efficiently to prevent mortality. Evaluation of calves should include scores given for scours, respiration and appearance.

Scoring of scours can be based on a 1 to 4 or 5 scale. The lowest number is usually better so a 1 should be normal feces, with the consistency of pudding. A 2 should be slightly less firm, such as yogurt. A 3 should be considered scours and have the consistency of maple syrup, loose to watery with a strong odor. If using a scale up to four, a 4 can then be anything more fluid than maple syrup, such as water. If using a scale up to five, a 4 should have the consistency of apple juice, however with fecal matter still seen. A 5 should be the consistency of water with no fecal matter or with mucous and/or blood.

Respiration should be scored on a 1 to 5 basis. A 1 should be normal breathing, no problems. A 2 should be slight cough, runny nose but regular breathing. A 3 should have a moderate cough and rapid breathing. A 4 should have a severe cough that is frequent with rapid breathing. A 5 should have a severe cough that is chronic with irregular breathing.

Appearance should be scored on a 1 to 5 basis with a 1 being alert and active. A 2 should have droopy ears and be slightly unresponsive. A 3 should be moderately depressed with head and ears drooping. A 4 should be depressed with drooping ears and

head and no interest in getting up. And a 5 should be flat on its side.

All scores should be added up for each day and when scores are over a certain number, the protocol should consist of taking a temperature reading, treating with oral rehydration solution and/or giving antibiotics. This will ensure proper consistent treatment for all calves and should decrease mortality.

Calculating the amount to feed. Although there is little detriment in feeding too much oral rehydration solution, feeding too little may not help alleviate dehydration and can prolong scouring. Although many farms do not weigh individual calves, approximate amounts to feed should be established. For example, small calves (or breeds other than Holstein) can be estimated at 60 lbs and fed less than high birth weight calves (110 lbs) or even medium size calves (80 lbs). To estimate how much to feed a calf:

- Multiply weight of calf by (dehydration percent/100). This will give you the pounds the calf needs to drink **IN ADDITION TO ITS MILK OR MILK REPLACER FEEDING**. Then divide by 2 to get quarts of liquid needed.
- Example: A 100-lb calf is dehydrated 6%. $100 \times 0.06 = 6 \text{ lb}$. $6 \text{ lb} / 2 = 3 \text{ quarts}$ need to be fed per day *in addition* to her usual milk (which would be 5 quarts if calf is fed at 10% of body weight). The total amount of fluids the the calf needs (milk plus the rehydration solution) is 8 quarts per day.

SHOULD MILK BE FED WHILE CALVES ARE SCOURING?

Different ways currently exist for feeding milk or milk replacer while feeding oral rehydration solution to scouring calves. One way is to cut milk out completely and only feed oral rehydration solution for the entire treatment period. Another way is to only feed the oral rehydration solution for 2 days then feed half and half with milk the last day. And the third way is to feed the rehydration solution and milk as well in separate feedings.

Calves need enough energy to maintain their weight as well as their immune system, especially when they are sick. Oral rehydration solutions cannot provide enough energy because they are limited in the amount of glucose that can be added in order to keep the osmolarity of the solution low. Therefore, feeding milk or milk replacer supplies more energy and protein, allowing calves to maintain weight.

One of the studies showing the benefit of milk feeding while treating with rehydration solution was conducted at the University of Illinois (Figure 2). Once scouring occurred, calves were placed onto 3 different treatments. Treatment 1 consisted of only rehydration solution fed for 2 days, after which milk was slowly incorporated back into the diet for 7 days. Treatment 2 consisted of a partial removal of milk during therapy, and treatment 3 was a full feeding of milk as well as rehydration solution for 7 days. Fecal scores did not differ between treatments and bodyweights were higher for the treatments that incorporated milk in some way, especially the treatment that fed a full allotment of milk for the entire treatment period.

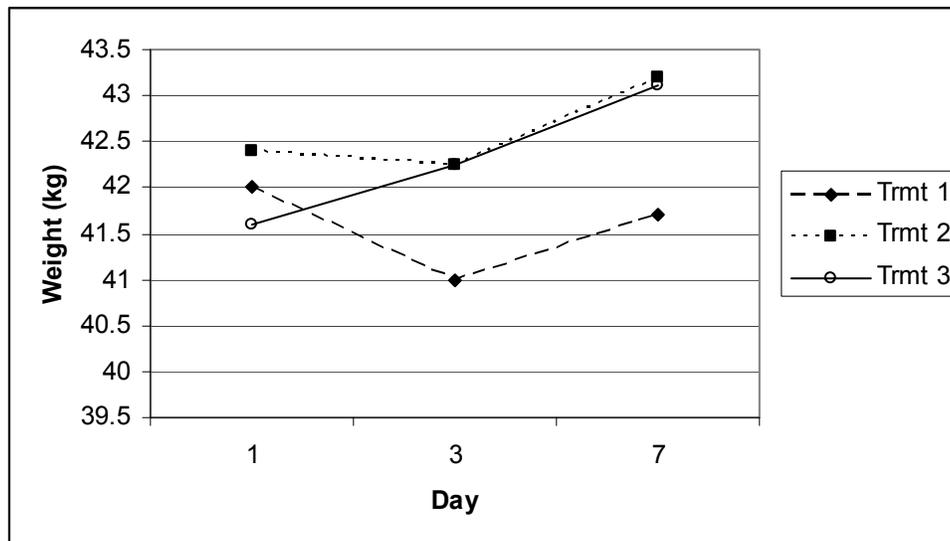


Figure 2. Treatment 1 was oral rehydration solution (ORS) only, treatment 2 was ORS with low feeding of milk and treatment 3 is equal ORS and milk feedings. Adapted from Garthwaite et al., 1994. *Journal of Dairy Science* 77:835-843.

SHOULD ANTIBIOTICS BE GIVEN?

If scouring becomes a regular occurrence a veterinarian should be consulted to determine the source and whether antibiotics are appropriate. Also, a few fecal samples should be taken and sent

to a diagnostic lab to evaluate the cause of enteric infection. This may help establish a preventative program and save time and labor in treatment of scouring calves.

WHAT SHOULD THE ORAL REHYDRATION SOLUTION CONTAIN?

First, an important distinction needs to be made between oral rehydration solutions used for treatment of scouring calves and those used for electrolyte supplementation. The latter are used to supplement extra electrolytes to older, usually weaned calves or cattle during times of stress from transport, weather and other situations that can cause loss of fluids and electrolytes. It is easy to mistake one type for another; however, if the directions require small amounts of powder being mixed into gallons of water, this indicates that the solution is only supplemental and should not be used for treatment of scours in preweaned calves.

One of the most important components of oral rehydration solutions is **water**. Water is the essential ingredient to a rehydration solution.

Sodium should be included in the solution at 70 to 145 mmol/L. Sodium is tightly regulated by the body and although low amounts of sodium in the body can cause problems (from diarrhea, for example), high amounts can also cause problems. If the sodium offered is too high, calves will need to drink more water to dilute these amounts; this extra water may not be available in the pen or they may be too weak to reach it. Sodium should also be at an average ratio of one to one with glucose to be absorbed efficiently.

Another important ingredient is an energy source such as **glucose** (dextrose may also be listed but it is only a different name for glucose). Glucose is transported

into the intestine on a one to one ratio with sodium and thus helps sodium absorption. However, no more than 200 mmol/L should be included because this may change the osmolarity of the solution. A solution with high osmolarity will draw water out of the intestine instead of into the intestine. When the amount of solutes is high on one side of a semi-permeable membrane, this causes water from the side with a low concentration to be drawn to dilute the contents of the side with a higher concentration. The same happens in the intestine. If the solution in the lumen of the small intestine is too high in solutes, water will come out of the body into the lumen to dilute the contents and end up being excreted instead of absorbed.

Glycine is a non-essential amino acid that is commonly added to oral rehydration solutions and has been shown to enhance absorption of glucose. To calculate the amount that should be included in the oral rehydration solution, the level of glycine should be added to the sodium level and the total should not exceed 145 mmol/L. The total of glycine and sodium should also equal a one to one ratio with glucose.

Alkalinizing agents are added to decrease metabolic acidosis and may also provide some energy. These are usually attached to sodium and include bicarbonate, citrate, lactate, acetate or propionate. One of the most common alkalinizing additions is bicarbonate, which should not be fed directly or within a few hours of whole milk. Bicarbonate and citrate inhibit the formation

of the casein curd in the abomasum. If feeding an oral rehydration solution with bicarbonate or citrate, it should be fed about 4 hours after milk feeding. Acetate is the most easily metabolized. Alkalinizing agents should be included at 50 to 80 mmol/L.

Oral rehydration solutions will also contain other electrolytes, especially **potassium** and **chloride**, as well as many minerals. Potassium and chloride are needed to maintain pH of the blood and for muscle contractions, especially in the heart. Although little research has concentrated on evaluating amounts of potassium and chloride needed to replenish electrolytes in scouring calves, the range of potassium found in most solutions is 20 to 30 mmol/L and chloride is 50 to 100 mmol/L.

Other additions can include **gelling agents** such as guar gum, pectin and others. These have not been shown to be largely beneficial nor detrimental. Oral rehydration solutions containing gelling agents reduce diarrhea within hours of feeding and may

coat inflamed intestinal mucosa. Slowing down the passage rate of the rehydration solution also may allow the intestine to absorb more nutrients. However, this may also reduce the body's ability to flush toxins out. More research is needed to determine the advantages and disadvantages of gelling agents.

Many rehydration solutions are also adding direct-fed microbials. These are bacteria that are meant to re-establish the correct ratios of gut microflora. Usually these probiotics consist of lactobacillus and bifidobacterium species, both of which work against E. coli and are beneficial to the intestinal environment. There is no published research at this time evaluating direct-fed microbial effects in rehydration solutions. An oral rehydration solution should be chosen based on its ability to provide correct levels of electrolytes and to rehydrate rather than whether it contains microbials.

MAKING YOUR OWN ORAL REHYDRATION SOLUTION

Although making your own oral rehydration solution can be relatively simple if all the ingredients are available, it is easier to buy one that is already made up correctly. If you are in a bind and need to make your own, remember not to use table sugar for the glucose portion of it. Table sugar, or sucrose, is a carbohydrate that cannot be metabolized by cattle because they do not have the enzyme to break it down. Adding sucrose may actually increase scouring and worsen dehydration.

Feeding calves plain water does not work either when the calf is infected with a virus or bacteria that have affected absorption in the intestine. Water "follows" sodium into the intestine and therefore, both

sodium and glucose need to be present for maximal water absorption. It is always best to have an oral rehydration solution on hand to treat scouring calves.

Homemade example for an oral rehydration solution from Feeding the Newborn Dairy Calf (1984):

- 1 tsp. low sodium salt
- 2 tsp. baking soda
- 1 $\frac{3}{4}$ oz. (1 packet) fruit pectin
- 1 can beef consommé

Add water to make 2 quarts. Feed at the rate of 1 pint per 10 pounds of bodyweight 3 to 4 times a day. Feed milk 2 to 3 hours before or after due to bicarbonate content.

CONVERSIONS

It can be difficult to compare oral rehydration solutions due to the different units that are used. Most solutions are expressed in percents; however others can be expressed in mmol/L, mg/ml or μ Eq. For ease of determining the quality of oral rehydration solutions, a conversion table is provided (Table 2).

To calculate from g/L to mmol/L, the molecular weight of each ingredient needs to be known. Take the amount given and then

divide by the respective molecular weight and multiply by 1000 (which will convert from mol to mmol). For example, if there is 3 g/L of sodium divide by 23 and then multiply by 1000. This equals 130 mmol/L. Other molecular weights are given below. Converting grams or percent to mmol/L is the best way to compare whether ratios of sodium to glucose are approximately one to one.

Table 2. Requirements of ingredient concentrations included in oral rehydration solutions in different units.

Ingredient	MW ¹ (g/mol)	Mmol/L	g/L
Glucose	180	< 200	< 36
Sodium	23	< 145	< 3.3
Glycine	75	< 145	< 10.9
Sodium bicarbonate	84	50 - 80	4.2 - 6.7
Sodium citrate	294	50 - 80	14.7 - 23.5
Sodium acetate	136	50 - 80	6.8 - 10.9
Potassium	39	20 - 30	0.8 - 1.2
Chloride	35	50 - 100	1.8 - 3.5

¹Molecular weight in grams per mole.
Useful conversion: 1 quart is approximately 1 liter (0.95 L).

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