Comparison of Commercial Oral Electrolyte Solutions for Scouring Calves

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As vets one of our main spring jobs is dealing with scouring calves. Rehydration is crucial for these neonates, and we are a go-to for advice on this topic. We need a solid understanding of the physiology of calf scouring and dehydration, as well as knowledge of what is in our products, before we can offer sound advice on the matter. Kristina sheds some light on oral rehydration in calves.

Calf diarrhoea remains the most common cause of death in both beef and dairy calves, and continues to be a major cause of economic loss to the cattle industry. The most common organisms causing scours in neonatal calves (≤21 days of age) include enterotoxigenic *E.coli*, rota- and coronaviruses, and *Cryptosporidium*. The majority of these organisms cause diarrhoea by producing severe damage to the enterocytes leading to villous atrophy and malabsorption. The duration of the resulting diarrhoea is dependent on the extent of the gut damage and the time taken for the enterocytes to regenerate and is not usually influenced by specific therapy against causal pathogens.

The pathophysiology of diarrhoea in neonatal calves is complex but regardless of the organism or mechanism involved, it increases the loss of water, electrolytes and buffer in the faeces of the scouring calf, and decreases milk consumption. This leads to dehydration, electrolyte imbalances, metabolic (strong ion) acidosis, accumulation of D-lactic acid in the blood, and negative energy balance.

As diarrhoea in neonatal calves is not always preventable, appropriate management of scouring calves is crucial to reduce animal losses and minimise animal welfare implications. Oral rehydration, originally developed for the treatment of cholera in humans, continues to be of major importance for treatment protocols for diarrhoea in young calves[1]. It is imperative to understand the requirements for oral rehydration or oral electrolyte solutions to make informed treatment recommendations. Due to the variety of products that are commercially available, veterinarians should put some thought into choosing the product they use in practice.

In general, electrolyte solutions should provide sufficient sodium to normalize the ECF, provide agents like glucose, citrate, acetate, propionate, or glycine that aid efficient absorption of electrolytes and water, provide alkalinising agents/ buffers (citrate, propionate, or bicarbonate) to correct acid-base imbalances, and provide energy and nutritional support[2].

Firstly, since sodium is the osmotic skeleton of the extracellular compartment, it must be present in adequate concentration in an oral electrolyte solution[1]. Studies have shown that solutions containing 120 mmol/L sodium are able to restore ECF volume and correct dehydration whereas solutions with much lower sodium concentrations (73mmol/L and 50mmol/L) are not[3]. Even though there is little evidence that solutions with high sodium concentrations are harmful, sodium concentrations much higher than 130 mmol/L could have an increased risk of causing salt toxicity (especially if calves don't have free access to water of good quality and palatability) and have been shown to slow down abomasal emptying[4].

Chloride and potassium are both lost in the faeces of scouring calves. Even though blood potassium levels can be paradoxically increased, due to extracellular accumulation of K+ due to metabolic acidosis, total body potassium concentrations are still decreased. Therefore, oral electrolyte products should contain a chloride concentration between 40 and 80 mmol/L and potassium concentrations between 10 and 30 mmol/L.

Another important ingredient is an energy source, such as glucose/ dextrose. This will also facilitate sodium absorption because sodium is co-transported with glucose from the intestinal lumen. Neutral amino acids, such as glycine, alanine, or glutamine, can also help with sodium absorption in the small intestine. Glutamine not only contributes to sodium absorption, it also assists recovery of villous structures and enterocyte function, as well as supporting renal function and acid excretion[5,6]. A glucose to sodium ratio of 1:1 to 1:3 is considered ideal; products with lower ratios will fail to ensure sufficient sodium absorption and products with higher ratios will also have a higher osmolality which will draw fluid into the intestinal lumen following an osmotic gradient rather than helping to correct dehydration.

Alkalinising agents including bicarbonate, citrate, lactate, acetate or propionate should be added to oral electrolyte solutions for calves because young ruminants with diarrhoea are more prone to severe metabolic acidosis and accumulation of D-lactic acid in the blood than other domestic species. Bicarbonate directly buffers

Comparison of Calf Oral Electrolyte Solutions Commercially Available in New Zealand

A summary of molar concentrations of selected nutrients in commercial electrolyte products designed for oral rehydration of scouring calves. The comparison provided here assumes that products are mixed with water according the manufacturer's directions. This list may not contain every available product. Where trade names appear, no discrimination is intended, and no endorsement by Massey University is implied.

Product	Company	Mixing Rate	Glucose/ Dextrose	Na+ (mmol/l)	K+ (mmol/L)	Cl- (mmol/L)	SID^ (mEq/L)	Alk Agent (mmol/L)	Glucose: Na+ ratio	Osmolarity	Energy~ (MJ/L)
Recommended values [1]			**380-420**	**90-130**	**10-30**	**40-80**	**60-80**	**50-80**	**1:1-3:1**	**500-600**	
Dexolyte	BAYER	80 g/2L	181	44	14	58	-0.07	0	4.14	298	0.52
Diarrest#	Virbac	248.5 g/2L	111	148	31	103	76	60	1.2	$	1.84
Electrolife	BAYER	82 g/2L	182.5	43.8	10.7	43.8	10.7	10.7	4.17	291.4	0.58
Enerlect*	Vetpak	50 g/L	218.6	68.4	21.4	53.5	36.3	22	3.2	417.2	0.67
Kryptade*	PVD Limited	80 g/2L	111.0	80.4	5.2	57.7	27.83	27.4	1.38	331	0.41
Revive#	Virbac	118.5 g/2L	111	136	40.7	102.7	73.88	51.6	1.35	514.94	0.75
Scourstop	Ethical Agents	60 g/1.5L	90.2	81.7	14.3	46.1	49.9	40.8	1.1	$	0.27
Vytrate Powder*	Jurox	64 g/2L	123.8	73.4	15.6	73.4	15.6	5	2.2	328	0.40
Vytrate Liquid*	Jurox	160 ml/2L	123.8	73	15.6	73	15.6	5	2.3	328	0.41
Vet Electrolyte	Vetpak	112.5 g/2L	246.3	61.66	20.14	81.88	0	18.44	3.99	431.7	0.75

Calculated using Microsoft Excel from information listed in the Index of Veterinary Specialties Annual 2017, and from product labels; only products and ingredients whose mixing rates are known were included.

*[1] Smith, 2009: Vet Clin Food Anim 25: p.55–72; ^SID= [Na]+[K]-[Cl]; ~Glucose, lactose & rice flour @ 16 kJ/g, acetate @ 0.9 kJ/mmol, citrate @ 2.1 kJ/mmol, propionate @ 1.5 kJ/mmol (Brooks et al 1996); *contains Glycine; Glycine included in energy and osmolarity; #contains lactose; lactose included in energy and osmolarity; $ label contained insufficient information to calculate concentration.*

H+ ions while precursors, such as acetate or propionate, need to be metabolized by the liver first. Acetate and propionate have several advantages over bicarbonate in that they a) facilitate sodium and water uptake whereas bicarbonate does not, b) produce energy when metabolized whereas bicarbonate does not, c) do not alkalinize the abomasum (low abomasal pH provides natural resistance against bacterial infections), and d) do not interfere with milk clotting and abomasal emptying[2]. The impact of oral bicarbonate on milk clotting and calf performance is not clear, but it is advisable to offer solutions containing bicarbonate 2-4 hours after the last milk feed. This does not need to be the case if non-bicarbonate alkalinising agents are used. Alkalinizing agents should be included at 50 to 80 mmol/L.

Another way of correcting metabolic acidosis in diarrhoeic calves is to offer solutions with a high strong ion difference (SID). This is based on the strong ion theory and postulates that a solution must deliver an excess of strong cations (Na+) relative to the concentration of strong anions (Cl-). The SID can be calculated as follows: [Na+] + [K+] - [Cl-] = SID. Studies consistently showed that products with high SID have higher alkalinizing properties than solutions with low SID[3,7]. The ideal oral rehydration solution should therefore contain at least 50 mmol/L alkalinizing agents and have a SID of 60-80 mEq/L. Solutions without alkalinizing agents or low SIDs should be avoided for the treatment of diarrhoea in young calves.

It is still common practice in numerous countries to put diarrhoeic calves on a "diet" and withhold milk for several feeds. However, there is no scientific evidence that milk feeding actually prolongs or worsens the course of diarrhoea in neonatal calves. Milk provides energy and nutrients that aid with the recovery of the intestinal mucosa, and milk withdrawal has been shown to lead to malnourishment and weight loss in scouring calves[8,9]. Clients should therefore be advised to continue milk feeding unless there is a known problem with milk quality that is contributing to diarrhoea.

Since there are a multitude of commercial oral electrolyte solutions with different electrolyte concentrations available it is important to adhere to the manufacturer's instructions when preparing and mixing solutions. In order to avoid hypernatremia/salt toxicity, always ensure that electrolytes are not fed more concentrated than recommended. Finally, unless stated on the label, oral electrolytes should not be added to milk.

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