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Transportphysiological examinations on isolated rumen epithelium of the sheep with regard to different osmotic gradients

The aim of this study was to investigate the effect of an increased mucosal osmotic pressure on the electrophysiological properties of the epithelium, especially on the tissue-conductance (G_t) and on the transport mechanisms of the rumen epithelium. In-vitro-studies were carried out with isolated rumen epithelia of sheep using the Ussing-chamber-method in order to determine the electrophysiological parameters and the transport rates of different ions. The sheep were previously fed either only with hay or with hay and concentrate.

The following results were obtained:

The increased osmotic pressure of the mucosal solution by mannitol caused a significant increase of the tissue-conductance (G_t), which is completely reversible after restoring isoosmotic conditions. The change of the conductance (ΔG_t) was proportional to the osmotic pressure.

The increase of the tissue-conductance is very likely restricted to the paracellular pathway, which is substantiated by the following findings:

- Unidirectional transport rates of $^{51}\text{Cr-EDTA}$ increased linearly with the osmotic dependent increase of G_t . $^{51}\text{Cr-EDTA}$ was used as a marker for paracellular permeability.
- J_{sm}^{Na} also shows a positive correlation with G_t .
- The potential-dependent (unidirectional) transport rates of sodium increased significantly and linearly with the elevated osmotic pressure (and G_t).

Important functions of the moderately tight rumen epithelium, „barrier“ and „transport of solutes“, were impaired by the increasing mucosal osmotic pressure. The rumen epithelium was unable to maintain the electrochemical gradients and exhibited a decreased net absorption of sodium with increasing osmotic pressure. This is based on two osmotic-dependent effects: The rise of the osmotic pressure causes on the one hand an increase of the seromucosal Na-transport, induced by the enhanced paracellular permeability. On the other hand there is a decrease of the electroneutral transcellular Na-transport in the mucosal-serosal direction, induced by an inhibition of the Na^+/H^+ -exchanger. The negative effect of the increasing osmotic pressure on the Na-transport is even more reinforced applying the physiological potential ($\text{PD}_t = +40 \text{ mV}$), which leads to a net secretion of Na.

Summary

The effects of an increasing osmotic pressure were completely reversible.

The osmotic-pressure-induced changes of the electrophysiological parameters and of the ion transport of the rumen epithelia were much smaller in concentrate-fed sheep compared with epithelia of hay-fed animals.