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FUNCTIONAL DEVELOPMENT OF THE RUMEN AND RUMINANT SYSTEM

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Ruminant animals have a complex digestive system. They have a four-chambered stomach consisting of rumen, reticulum, omasum and abomasum. Among them, rumen is the largest one and gives the major characteristic features of the ruminant system. Without this rumen, cows and other ruminants wouldn't be much competent in converting grasses into milk. Actually, rumen acts as fermentation vat, where degradation of cellulose-containing fibers takes place, which is otherwise non-digestible for the monogastric animals. Interestingly, the digestive system of the ruminants is just like the monogastric at the time of birth. With the advancement of time, this system converts to a mature ruminant system. This transition occurs through step by step with simultaneous anatomical and physiological changes. There are different factors which influence the transformation. It is important to study these factors and the process of rumen development so that the ruminant digestive system can be modulated according to need. It will help in maintaining animal welfare as well as making more profit for the farmer through better production. For that purpose, the phases of rumen development and their stimulants have been described briefly in this section.

Structure and function of rumen

The rumen is the first chamber of the stomach. It is also the largest part of the digestive tract making 70% of the stomach. Many fingerlike projections called papillae covers the inner wall of the rumen. The rumen of an adult cow can contain up to 100 liters of undigested food. It contracts at a certain interval and helps in the movement of ingesta to the next chamber. Its major function is mechanical digestion through breaking the feed and fermentation with the help of microorganisms present in it. It also sends back the feed to the mouth for remastication and expels out the gases produced in the rumen, through eructation. Rumen can digest cellulose and hemicelluloses present in the leaves and produces volatile fatty acids as a final product. But, rumen itself can't secrete any enzymes for this digestion. It is the microbes present in the rumen which help in fermentation of the feed particles. The microbial population of the rumen is majorly consisting of bacteria, protozoa and fungus. They digest the feed taken by the animal and convert it into microbial products. The animal takes these products for further digestion in the later part of the digestive tract and fulfills their need. In the newborn animals, digestive tract is just like a monogastric animal and doesn't contain any microbes. At that time the rumen is also small in size consisting of only 25% of the stomach and abomasum 70%. With the progression of time, it gains its characteristic features and become fully functional at six to eight weeks of age.

Phases of rumen development

As already discussed above, a transformation of rumen takes place after birth with the progression of time. A newborn calf capable of taking only milk; transforms into an animal which can digest grass, leaves and other feeds. This process occurs through four stages namely newborn phase, pre-ruminant phase, transitional phase and ruminant phase. The events that occur in these phases are described below.

Newborn phase

This phase lasts for 24 hours after birth. The rumen is very comparatively small in size and contains no microbial population. The papillae present in the rumen are also rudimentary. At this period the only diet is colostrum (the first milk) which contains a high level of immunoglobulins. The abomasum also doesn't secret acid or pepsinogen to prevent digestion. This helps the immunoglobulins to pass undigested. The intestine also can't affect them due to the presence of anti-trypsin in colostrum. As a result, the antibodies present in

the colostrum are absorbed directly from the intestine and goes to the blood. This provides natural passive immunity to the newborn animal. This is very important as it helps in gaining disease resistant power. But, this direct absorptive capacity of intestine remains for only 24-48 hours after birth and disrupted if milk is provided. So, only colostrum should be fed to the newborn. If proper colostrum feeding is hampered, there will be a decline in immunity. It can result in acute infection like "joint-ill" and "naval-ill".

Pre-ruminant digestion

This period lasts from one day to 21 days. The principal food for this period is milk, though in the later part of this phase solid feed is also taken. Suckling of milk promotes the secretion of saliva. Saliva contains an enzyme called esterase which promotes hydrolysis of milk lipids. But, this milk bypasses the rumen and reticulum and directly goes to the abomasum. It stimulates the secretion of the abomasum and further digestion of milk components.

Transitional Phase

Duration of this period is 3-8 weeks. In this period the large volume of milk is taken and digested as described above. But simultaneously, roughages are also taken in the large amount. They are responsible for the development of salivary gland as well as rumen and reticulum. The salivary gland starts increasing in size and rumen starts acquiring microbes. Microbial fermentation of feed particles especially roughage produces volatile fatty acids (VFA). These VFAs are necessary for the development of papillae of the rumen. Gases are also produced and eructation function is started. Bulks of the roughage are responsible for muscular development. At the end of this period, rumen will be quite developed capable of fermentation. Finally, the intermediary metabolism will also shift from glucose to VFAs and blood glucose level is also become less insulin sensitive.

Ruminant digestion

Starting from the transitional phase his phase lasts up to adulthood. With the decline in milk production by the cow, the calf becomes more dependent on other feeds. The stomach attains motility and fermentation starts at full phase. In a word, rumen acts like an adult one.

Ingredients to initiate rumen development

Rumen development is defined as the development of the epithelium and it is critical to successful weaning and good calf growth rates. There are five key ingredients that are required to initiate rumen development:

Bacteria

Rumen bacteria are absent when a calf is born and are introduced as the calf begins to eat calf starter concentrates. Bacteria help the digestive process. Bacterial end products of digestion (VFAs) cause significant changes in the rumen. The type of VFA produced is crucial. Calf starter contains carbohydrates in the form of starch which is fermented by bacteria that produce propionic and butyric acids. In contrast, when forages are digested the primary end product is acetic acid. Acetic and propionic acids are absorbed through the rumen wall and are converted into metabolites that the calf uses as energy sources. Butyric acid is not absorbed through the rumen wall and is instead converted into an energy source used by cells in the rumen wall (Fig.1). The production of VFAs lowers the pH of the rumen and establishes an ideal growing environment for bacteria, especially for bacteria that digest starch and produce propionic and butyric acids. Addition of yeast culture in a dairy calf starter at 2% enhances dry matter intake and growth and slightly improves rumen development in dairy calves.

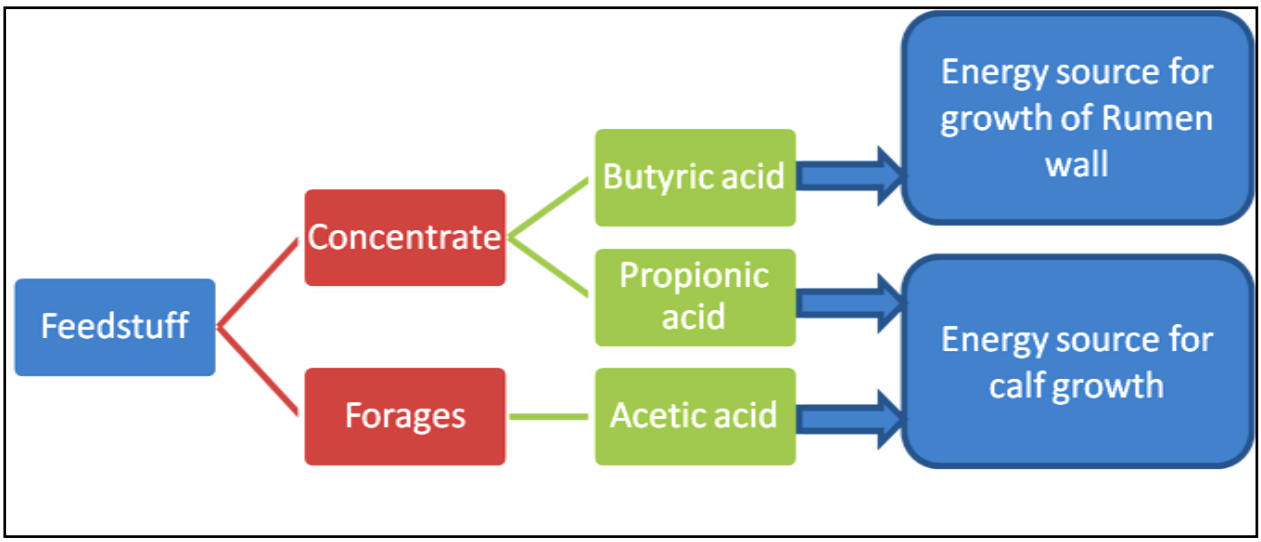

Fig. 1: Effects of VFAs in rumen development

Liquid in the rumen

Liquid in the rumen provides an ideal environment, combined with the absence of oxygen, for the rapid growth of bacteria. As milk bypasses the rumen, it does not provide enough liquid for optimal rumen development and therefore the calf must have access to 'free water'. Offering water from three days of age helps to increase calf weight gain, promotes starter intake and reduces the incidence of scour. Several studies have proved that rumen development may be affected by liquid feed type and composition.

Muscular movement

Feedstuffs that enter the rumen must be able to leave it. Therefore the development of rumen activity, such as contractions, pressure and regurgitation, is necessary. This muscular movement also helps mix the feedstuffs. When the calf is born, the rumen has little muscular activity, few contractions and no regurgitation. As the calf's dry feed intake increases, rumen contractions begin. If calves are fed milk, hay, and starter from shortly after birth, normal rumen contractions can be detected as early as three weeks of age. In contrast, if calves are only fed milk, normal rumen contractions may not be measurable for extended periods.

Absorptive ability of tissue

From a structural point of view, the rumen is made up of two layers: the muscular and the epithelial, the latter is responsible for the absorption of VFAs.

At birth, the epithelium does not have any ability to absorb. It is the production and subsequent absorption of VFAs in the rumen, from the fermentation of starter feedstuff that stimulates epithelium development by increasing the surface area through the development of the epithelium into finger-like projections called papillae. It has been seen that feeding greater amounts of non-structural carbohydrates increases the surface for absorption of the rumen epithelium in calves.

Availability of feedstuff in the rumen

The key factor to promote early rumen development, and thereby early weaning, is dry feed intake. As concentrates are fermented to propionate and butyrate, they are a good choice to ensure early rumen development. Offer clean, fresh, starter at three days of age which is both highly palatable and meets the nutrient recommendations for dairy beef calves.

Chopped hay provided to calf also help in the development of the rumen. The type of processed feed included in calf starters also affects intake, feed efficiency, growth, blood VFA concentrations, and rumen parameters in ruminally developing calves. The particle size of feed is also very important regarding this aspect.

Conclusions

Feeding of an animal should be taken care not only for the survival of the animal but also for better production and profit. Rumen plays an important function in digestion of ruminant animals and makes the difference from monogastric animals. Development of rumen is also a significant process through the animal gets its ruminant status. Factors affecting rumen development are important in the modification of rumen functions. It can be used for the benefit of the animal as well as the benefit of the farmer.

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