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Review

Synthesis of Microbial Protein in Rumen and the Influence of Different Factors on this Process

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ABSTRACT

The article describes the basics of the synthesis of microbial protein in the rumen and the factors which influence this process. Literature data and our own research found that the following factors influence synthesis of microbial protein in the rumen of ruminants: dry matter intake, the role of nitrogen compounds, energy supply from fermentative (enzymic) processes in the rumen, correlation of rough forage to concentrates in feed, environment of the rumen (pH), the rate of passage of forage masses and the duration of presence of forage masses in the rumen, and the role of the vitamins and minerals. All these factors have a direct effect on the synthesis of microbial protein in the rumen. Therefore, in this article each factor has separate discussion.

Key Words: Rumen, proteolysis, microbial protein, bacterial mass, infusoriums

ÖZET

RUMENDE MİKROBİYEL PROTEİN SENTEZİ VE BU SÜREÇ ÜZERİNE ÇEŞİTLİ FAKTÖRLERİN ETKİSİ

Bu makalede rumende mikrobiyel protein sentezinin temelleri ve bu işlemleri etkileyen faktörler tanımlanmaktadır. Literatür bildirimleri ve kendi yürüttüğümüz araştırmaların sonuçları, aşağıda sıralanan faktörlerin ruminantlarda rumendeki mikrobiyel protein sentezini etkilediğini göstermektedir: alınan kuru madde miktarı, nitrojen bileşiklerinin rolü, rumendeki fermentatif (enzimatik) işlemlerden sağlanan enerji, kaba ve konsantre yem arası ilişki, rumen pH'sı, yem geçiş hızı ve yemin rumende bekleme süresi, vitamin ve minerallerin rolü. Tüm bu faktörler rumende mikrobiyel protein sentezi üzerine direkt etkilidirler. Dolayısı ile her bir faktör ayrı olarak ele alınmıştır.

Anahtar Kelimeler: Rumen, proteolisis, mikrobiyel protein, bakteriyel kütle, infüzorya

Introduction

Microbial protein synthesized in ruminant's rumen facilitates the creation of amino acids. Microbial protein provides ruminants 2/3 of their requirements in amino acids. Despite the fact that 25% (AFRC, 1992; Kurilov, 1989) of ruminants' needs for protein are satisfied by non-protein nitrogen, the most important source

of amino acids is microbial protein. Feeding animals with black seeds and legumes enriches the synthesis of microbial protein with methionine and lysine. Carbohydrates are one of the important organic sources for synthesis of microbial protein. Therefore, most scientists calculate synthesis level in relation to carbohydrates, not to organic matter digested in rumen (Hoover and Stokes, 1991; Korshunov, 1989). The level of microbial protein synthesis varies depending on different animal species and different kinds of feed. For example, the ratio changes depending on feeding: ratio (correlation) after dry-lot feeding values as 13 gr/100gr of organic matter, concentrate and dry-lot feed – 17.6 gr/100 gr of organic matter, concentrate feed – 13.2 gr/100 gr of organic matter (digested in rumen) (Aliyev, 1997; Bach et al., 2005; Loginov, 1988). In other words, the average level of microbial synthesis makes 14.8 gr per each 100 gr of organic matter digested in rumen. According to these data, the level of microbial protein synthesis per 100 gr of organic matter digested in rumen is 13 gr of raw microbial protein (Korshunov and Kurilov, 1985).

The level of synthesis of microbial protein in relation to the level of carbohydrates digested in rumen is considered as proportional (Nocek and Russell, 1988; NRC, 1996). It is also indicates that high content of concentrated feed in feed has a negative effect on synthesis level of microbial protein and reduces acidity (pH) of rumen. In addition, feeding animals with low-quality forage reduces the level of synthesis, because the influence on digestibility of carbohydrates in rumen of such feed. The level of degradability of organic matters in rumen is studied by the nylon bags method (in situ). This method determined that the nitrogen level in organic matter digested in rumen after feeding changes depending on the time interval. It should be noted that according to the different composition of feed (roughage (fibrous) feed, concentrated feed) the synthesis of microbial protein is increased by increasing quantity and diversity of bacteria (NRC, 1996).

The main goal of this proposal is the study of factors that influence synthesis of microbial protein in rumen (Aliyeva, 1988; Iskenderov, 1992; Stern et al., 2006).

Influence of dry matter adoption

However, with increasing amounts of dry matter in the feed, the amount of organic matter digested in the rumen is reduced. This means that excessive consumption of dry matter has a negative effect on the microorganisms in the rumen. It should be also noted that the addition of dry feed, barley and cereals to the feed ration of animals the level of synthesis of microbial protein (Clark et al., 1992; Djouvinov and Todorov, 1994). Degradability of organic matters and the rate of passage of forage masses in the rumen of animals kept on such diets are high enough. Therefore, the high content of starch in feed (barley) causes a positive correlative link between organic matter digested in the rumen and the level of microbial protein synthesis. In this research increasing microbial protein in the small intestine is explained as due to increasing dry matter intake and accelerating of the rate of passage of food masses through the rumen (Djouvinov and Todorov, 1994)

The role of nitrogen compounds

Rumen microorganisms act normally if the level of raw protein in feed is more than 11%. To ensure the growth and progression of rumen microorganisms it is important to use feed with nitrogen compounds added. Degradability of feed protein in the rumen is important for meeting the needs of ruminants in protein. On other hand, nitrogenous compounds play an important role in meeting the needs of ruminants for protein. Modern protein systems indicate that microorganisms' requirement for nitrogen is satisfied by a degrading protein in the rumen, yielding oxidized amino acids and nitrogen. The research shows that the presence of saponin and substances in the feed increases the synthesis of microbial protein and the degradation of nitrogen compounds in the rumen is reduced (AFRC, 1992; ARC, 1984; Hoover and Stokes, 1991).

The content of protein in grass is more than in cereals. For example, 40% of the protein in grass is degraded in rumen or in artificial rumen (in vitro experiments).

Experiments determined that each 100 gr of organic compounds allocates 2 gr of digestible nitrogen, and this ensures the normal activity of microorganisms. The rate of synthesis of microbial protein in rumen declines depending on the amount of cereals in the feed.

Energy supply for the fermentation process

The growth of microorganisms in the rumen directly depends on the energy supply. Microorganisms are able to synthesize protein at a high level if animals receive high-quality forage. The level of synthesis of microbial protein is not raised by the addition of low-quality forage.

It was noted that the synthesis of microbial protein in the rumen of animals receiving forage ration with concentrated additives compared with animals receiving a balanced forage (GFE, 2001).

Carbohydrates degraded in the rumen provide rumen's microorganisms with required ATF. Thus, the level of microbial nitrogen is directly related to carbohydrate metabolism. The level of fermentation of water-soluble sugars and starch within 2 hours after forage intake is very high. After 4 hours the amount of metabolites is reduced. Thus, in the next 4 hours after feeding soluble starch and sugars satisfy the needs of rumen microbes for energy and ATP (ARC, 1984). After this period provision of microorganisms with energy is due to degradation of cellulose and hemicellulose. Cellulose and hemicellulose begin to degrade in the rumen and this period continues about 96 hours, and during this period microorganisms meet their needs in ATP. Thus, the balanced feeding of animals regulates the normal synthesis of microbial protein in the rumen. Feeding ruminants with grass or concentrated forage cannot provide the normal synthesis of microbial protein in the rumen (Aliyeva, 1988).

Influence of ratio of roughage to cereals in the feed on synthesis of microbial protein

Initially, it was noted that in comparison with animals receiving roughage and concentrated forage the synthesis of microbial protein is higher than in animals receiving only roughage. Various forage additives create conditions for high-level synthesis of microbial protein and complete satisfaction of energy needs (Stern et al., 2006).

There are other research results. For example, a high amount of carbohydrates contributes high absorption of ammonium nitrogen by microorganisms (Iskenderov, 1992; Kurilov, 1989). According to Hoover and Stokes (1991) regulation of the level of synthesis of microbial protein can change the level of degradation of carbohydrates in forage.

It was determined that the presence of decomposable proteins and non-structured carbohydrates in the feed has a positive effect on the growth of microorganisms in the rumen (Aliyeva, 1988; Korshunov, 1989; Stern et al., 2006).

According to Stern et al. (2006), the growth of microorganisms in the rumen of sheep fed with grass and concentrated forage is higher than in the rumen of sheep fed only with grass or concentrated forage. Concentration of non-nitrogen protein usually is high in mixed forage (grass and concentrated forage), because the presence of non-nitrogen protein in composition of roughage is more than in concentrated forage (Korshunov, 1989; Korshunov and Kurilov, 1985; Kurilov, 1989). It is also important to note that the protein in the concentrated forage degrades in the rumen and turns to peptides and amino acids, and they are the main raw material for the synthesis of the microbial protein. This proves again that the presence of roughage and concentrated forage in the animal's feed allows microbes in the rumen effectively to use peptides and amino acids for growth.

The synthesis of microbial protein in the rumen is higher if the amount of degraded carbohydrates is 30%. Increasing the amount of degraded carbohydrates to 70% reduces synthesis of microbial protein in the rumen. The presence of 70% of concentrated forage decreases intake of the microbial protein in the small intestine of animals. The main reason for this is that a small amount of non-structural carbohydrates in the forage weakens the

fermentation in the rumen (Aliyeva, 1988; Iskenderov, 1992; Nocek and Russell, 1988).

Increasing the roughage in the feed increases intake of dry matter. This in turn, leads to the secretion of saliva and increase the acidity (pH) of the rumen. As a result, the rate of passage of forage through the rumen decreases and this affects the growth of microorganisms and the fermentation process (Calsamiglia et al, 2002; Veth and Kolver, 2001).

Influence of rumen's environment (degree of acidity)

One of the important factors affecting on the level of synthesis of microbial protein in the rumen is acidity of the forage (pH) (Calsamiglia et al., 2002; Nocek and Russell, 1988; Veth and Kolver, 2001).

Influence of regulation of nitrogen and energy balance in the forage

Degradation of the protein in the forage improves digestibility of ammonium nitrogen and energy supply (Aliyev, 1997; Kurilov, 1989).

Stern observed that addition of hay (Stern et al., 2006), barley, canola and synthetic nitrogenous matters in the forage reduces digestibility of nitrogen and degradability of organic matters. This research shows that in the rumen of sheep which receive natural forage (hay, barley, canola) the amount of nitrogen (Calsamiglia et al., 2002) and carbohydrates was in the middle level, and this, in turn, creates conditions for optimum digestibility of these substances by microorganisms, that is fractional hydrolysis of starch and protein sources creates conditions for increasing the passage of microbial protein to duodenum.

The rate of passage and residence time of food masses in the rumen

Of one important factor influencing the level of synthesis of microbial protein in the rumen is the rate of passage of food masses through the rumen. Passage of food masses through the rumen at high speed increases the amount of microorganisms without high energy consumption. According to AFRC (1992) data increasing the rate from 0.02 to 0.08 hours increases the level of synthesis of microbial protein in the rumen to 20%. The presence of dry matter in the forage increases the rate of passage of food masses through the rumen and the level of synthesis of microbial protein in the rumen.

The role of minerals and vitamins

Rumen microbes need trace amounts of vitamins as well as nitrogen and carbohydrates (Hoover and Stokes, 1991; Stern et al., 2006). It was determined that sulfur in the forage content influences the growth and development of microorganisms. Rumen microbes use sulfur for the synthesis of methionine and cysteine. In forage the quantity of amino acids should be 0.11-0.20%, which satisfies the needs of livestock for those amino acids. Insufficient amount of sulfur in forage reduces the level of synthesis of microbial protein in the rumen. This happens because of addition of synthetic nitrogenous substances in the forage (Hoover and Stokes, 1991).

Another important element for the synthesis of ATP and rumen microbes is phosphorus. Insufficient amount of phosphorus reduces the level of synthesis of microbial protein in the rumen (NRC, 1996). Stern noted the role of vitamins on growth and development of microorganisms in the rumen (Stern et al., 2006).

Conclusion

The level of synthesis of microbial protein depends on source of carbohydrates and digested nitrogen. But improvement of the level of synthesis of microbial protein in the rumen needs sufficient presence of minerals and vitamins in the forage. Increasing the synthesis of the microbial protein in the rumen is characterized by the presence of peptides and amino acids in the forage.

Preparation of feed (i.e., using roughage and concentrated forage in combination) increases the level of the synthesis of microbial protein in the ruminant's rumen.

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