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PROTEIN SOURCE IN DIETS FOR RUMINANT NUTRITION

D. Ružić-Muslić, M.P. Petrović, M.M. Petrović, Z. Bijelić, V. Caro-Petrović, N. Maksimović, V. Mandić

Institute for Animal Husbandry, Belgrade-Zemun, 11080, Serbia
Corresponding author: muslic.ruzic@.gmail.com
Review paper

Abstract: The rapid increase in human population leads to increased demand for animal protein. On the other hand, the deficit of protein feeds in the market and rising costs are the most significant obstacles facing animal production. Therefore, most researches have focused on improving the status and utilization of different protein sources in order to reduce costs and maintain optimum performance of animals. The results of our study showed that lambs of MIS population, of average body weight of 18.0 kg, fed diets with different protein sources: sunflower meal, soybean meal, fish meal, realized average daily gain: 0.169, 0.205 and 0.227 kg, respectively. Conversion of dry matter in analogue treatments was: 4.54, 3.71 and 3.30 (kg/kg of gain) and total protein (g/kg): 732, 596 and 549, respectively. It is evident that the fish meal as a protein source improves the growth and utilization of food in lambs. However, given that the European Commission has banned the use of fish meal in diets for animal nutrition, nutritionists' imperative is to investigate the possibility of using "unconventional" sources of protein (peas, beans, lupins) in diets for ruminant nutrition. The aim of this study was to compare the effects of different sources of protein in diets on production performance of ruminants.

Key words: protein sources, ruminants, daily gain, feed conversion

Introduction

Dietary proteins that reach the small intestine of ruminants consist of two protein fractions: microbial and protein undegradable at the rumen level. Microbial protein is produced by the action of the rumen flora, which breaks down the dietary protein to peptides, amino acids and ammonia, after which these materials are used for the synthesis of own proteins *(Ružić-Muslić, 2006)*. In the course of the decomposition and synthesis some losses occur (typically about 20%, but sometimes higher). Thus, reduced amount of amino acids reaches the location where digestion and adoption of proteins occur, which means that the needs of high

yielding meat breeds cannot be satisfied by the microbial protein synthesis from the usual sources of protein and energy (*Ružić-Muslić et al., 2007d, 2011b*). Therefore, in order to ensure optimal pool of amino acids for a particular production, it is necessary to provide protein fraction which avoids degradation of the protein in the rumen (undegradable protein) (*Ružić-Muslić et al., 2007, 2011a).*

According to *Grubić et al. (1991)*, for each level of productivity it is necessary to ensure certain optimal ratio between the proteins that are degraded in the front-stomach / rumen under the action of microorganisms (biodegradable protein-RP), and of proteins which avoid degradation (NP - undegradable protein). The simplest method to influence the extent and rate of degradation of a protein in rumen consists in choosing the correct source of protein *(Grubić et al., 1992). Zeremski (1989)* states that the use of animal-based nutrients that have a low degradability of protein in the reticulum-rumen plays an important role in the utilization of the production potential and intensive fattening of lambs. Protein from these nutrients are considered highly valuable because they contain the essential amino acids necessary for the growth and development of lambs. As an excellent source of high quality protein that is slowly degraded in the rumen are the following: fish meal, meat and bone meal, blood meal and soy meal.

Bearing in mind that the European Commission has banned the use of fishmeal in diets for animals, research has focused on studying the effects of using soybean, sunflower and "unconventional" sources of protein in diets for ruminant nutrition.

Effect of protein source on performance of ruminants

Nutrients whose proteins pass through the reticulum-rumen to a greater extent non-degraded and reach the duodenum, cause greater weight gain in lambs, with the presence of sufficient energy *(Zeremski, 1989).* This was confirmed in studies of *Ružić-Muslić* (*2006, 2007d*) where the protein source has very significantly ($P<0.01$) influenced the ultimate/final result of fattening expressed as average daily gain, and final body weight of fattened lambs, with the best performance achieved by lambs in the treatment with fishmeal.

Table 1. Production performance of fattening lambs (Ružić-Muslić, 2006)

Traits	Protein source		
	Sunflower meal (SWM)	Soybean meal (SBM)	Fish meal (FM)
Initial body weight, kg	18.12±1.03	18.08±1.19	18.17±1.03
Initial age, days	60	60	60
Final body weight, kg	30.78^{a}±1.53	33.52±2.32	35.17^{b}±3.67
Total gain, kg	12.70^{a}±0.61	15.40±1.99	17.00^{b}±2.83
Average daily gain, kg	0.169±0.01	0.205^{a}±0.03	0.227^{b}±0.03
Use of dry matter, kg / kg gain	4.54	3.71	3.30
Use of total proteins, g/ kg gain	732	596	549
Use of NEM, MJ/kg gain	33.77	29.37	26.25

The difference between a and b is significant at the level of ($P<0.01$)

Results similar to ours, in terms of the effect of protein sources on production performance of fattened lambs were obtained by *Orskov et al. (1971), Miller (1978), Grubić et al. (1991), Walz et al. (1998), Beermann et al. (1986).*

Orskov et al. (1971) have established in their study performed on fattening male lambs of 15-50 kg, that with an increase in the proportion of fish meal in the diet from 1 to 6 and 12%, the average daily gain: 0.191, 0.270 and 0.330 kg, respectively.

Miller (1978) states that with the increase of the share of fish meal in diets for lambs of body weight 15-25 kg, their weight gain increases. Treatments were as follows: I control group (2.5% urea), II-2.5% fish meal +1.87% urea, III-5.5% fish meal + 1.25% urea and IV-10% fish meal. Daily weight gain of the treatments was: 0.250, 0.300, 0.330 and 0.350 kg, respectively.

Walz et al. (1998) has examined the impact of iso-protein diets (13% CP) without and with 3% fish meal, on the intensity of growth of lambs of average weight about 25.0 kg. Average daily gain in these treatments was: 0.171 and 0.206 kg.

Researches by *Beermann et al. (1986)* have shown that the replacement of soybean meal with 3% fish meal in diets for crossbred lambs Suffolk x Dorset has resulted in increased daily gain and improved feed conversion (0.441 kg and 3.52 kg) compared to (0.350 kg and 3.90 kg) as realized by animals in the treatment without fish meal.

It is evident that the fish meal, as a protein source, improves growth and feed efficiency in lambs. The explanation lies in the fact that the microbial protein is insufficient to meet metabolic requirements in amino acids necessary for growth of animals, so the use of a protein source with a high content of undegradable protein, results in superior performance.

However, given that the European Commission has banned the use of meat and bone meal and their by-products in diets for farm animals, in order to ensure safe food for consumers, the main source of protein in intensive ruminant production systems is soybean meal. However, its high price, orientation on import, fluctuations in the production, distribution as genetically modified food, have increased consumer interest in alternative sources of protein.

In recent years, the production of sunflower as oil crops has increased (due to the ability to adapt to different soil and climatic conditions), and at the same time production of sunflower meal as a by-product. It contains 36-46% of crude protein and 13-15% of crude fiber *Schingoethe et al., 1977; Nishino et al., 1980)* and it is extensively degraded in the rumen (*NRC, 1985)*. It has a higher content of methionine in comparison to other sources of protein, but is deficient in lysine (*Steen, 1989; Villamide and San Juan, 1998)*. The high fiber content is responsible for limited use in the diet for young ruminants. Therefore, to improve fiber degradation in the rumen the enzyme preparations are used. From the standpoint of the effect of different protein sources on the performance of fattening goats, *Titi (2003*) has examined the effects of three protein sources (soybean meal, sunflower meal, sunflower meal with fibrolytic enzyme supplementation) on the performance of Shami kids of average body weight of 17.0 kg, and has recorded the final body mass values: 30.23 kg, 29.68 kg and 36.38 kg, the average daily gain values: 0.155 kg, 0.142 kg and 0.221 kg, and feed conversion of 6.61, 7.59 and 4.70 kg/kg gain, respectively. Therefore, the use of sunflower meal with fibrolytic enzyme supplementation has caused significantly ($P < 0.05$) higher weight gain and better feed conversion, compared to the other two treatments. Superiority of this treatment is based on the fact that fibrolytic enzymes reduce fiber content and improve dry matter digestibility, which results in the provision of sufficient energy for growth of rumen microflora (*Lewis et al., 1995).* At the same time, kids who consumed soybean and sunflower meal were not significantly different in terms of production performance, although the numerical value of the gain in treatment with soybean meal was slightly higher (0.155: 0.142 kg). The slight difference may be the result of a higher fiber content of sunflower meal and lesser digestion capacity due to incomplete functioning of the rumen (*Schingoethe et al., 1977; Nishino et al*., *1980*). Also, the concentration of energy (MJ/kg of dry matter), and the amino acid composition of protein undegradable at the rumen level of soybean meal is much more favorable than in sunflower meal. However, these differences are not significant and the results indicate that sunflower meal can be used as a substitute for soybean meal in ruminant nutrition (*Stake et al., 1973; Schingoethe et al., 1977; Nishino et al., 1980; Steen, 1989; Isobel et al., 1990; Schingoethe et al., 1996; Economides, 1998; Economides and Koumas,1999).*

A further search for alternative sources of protein has led to increased interest in the use of legumes in ruminant nutrition. Leguminous grains have a high protein content, a considerable concentration of energy and calcium. Their proteins

are highly degradable in the rumen. By comparing some of them, it can be concluded that there is a higher content of proteins in lupine (324-381 g/kg of dry matter), compared to beans (301 g/kg dry matter) and peas (246 g/kg dry matter) *(Degussa, 2006)*. In terms of crude fat content, beans and peas contain from 15-20 g/kg dry matter *(Jezierny et al., 2007*), whereas the lupine has 57-88 g/kg dry matter *(DLG, 1999)*. In regard to starch, beans and peas have from 422-451 and 478-534 g/kg of dry matter, respectively (*Jezierny, 2009*), while lupine contains 42-101 g/kg of dry matter *(Jezierny, 2010)*. Lignin content is low and ranges from 1 to 7 and 6-9 g/kg of dry matter, respectively *(Salgadet et al., 2002a; Jezierny, 2010*). The proteins of peas and beans contain higher proportions of lysine (70 and 80 g of crude protein, respectively) compared to the soybean meal protein (69 g/kg of CP) and lupine (51-54 g/kg CP) *(Degussa, 2006)*.

Di Francia et al. (2007) have assessed the effect of partial replacement of soybean cake with extruded peas in the diet of cows during the first 100 days of lactation, and found that peas construe an attractive source of protein (GMO formulations free) in diets for cows whose production is based on organic principles. The protein content of the peas is about 25-26 % of dry matter. In terms of the amino acid profile, high lysine and low tryptophan content as compared to soybean meal *(Gatel, 1994*). The protein fraction is easily degradable in the rumen while the starch content is outstanding (more than 40 % DM), soluble and easily degradable (*Nocek and Tamminga, 1991). Lanza et al. (2003*) have conducted a comparative study in order to compare the effects of soybean meal and peas (39 and 18 % in the mixture), on fattening performance and meat quality of Barbaresa lambs. Protein source showed no significant impact on average daily gain (0.218, 0.29 and 0.250, respectively), feed conversion ratio (4.7, 4.8 and 4.1 kg, respectively), dressing percentage (50.1, 50.8 and 51.2 %, respectively), as well as the physical and chemical properties of *M. longissimus dorsi*. Obviously, in all diets, protein fraction was sufficient to meet the requirements of lambs in amino acids.

Morbidini et al. (2005) has examined the influence of soybean meal and beans on the performance of Italian Merino lambs. It was found that the use of beans in the diet resulted in a depressive effect on the performance of lambs. The explanation lies in the increasing content of NPN compounds and anti-nutritional factors. Hence, the recommendations for the period upon the early weaning of lambs is: the use of the rumen undegradable protein in the diet, given that in this period, the rumen is not a fully functional protein synthesis and is less efficient. In addition, for the same reason, in this period, the animals are not able to neutralize the possible anti-nutritive factors. The negative side of legume grains is that many of them contain anti-nutritional factors (lecithin, trypsin inhibitors, tannins, saponins, phytase).

Similar studies were conducted by *Cutrignelli et al. (2008b*) on two groups of bulls, average age of 129 days, fed diets based on bean and soybean meal,

weighing up to 620 kg. Source of protein has not significantly affected other parameters, except body weight (173 and 186 kg, in treatment with beans and soybean meal, respectively). The chemical composition of the *Muscullus longissimus thoracis*, amino acid composition, cholesterol content and sensory profile were not affected by the tested treatment. These results show that the beans can be used as an alternative source of protein, with no adverse effects on the biological effectiveness of growth, feed conversion index and meat quality of ruminants.

In view of these results, on the one hand, and instruction to observe and consider the share of undegradable protein, in addition to digestibility, when choosing a source of protein for ruminant rations, the following figure shows the representation of this fraction in individual sources of protein.

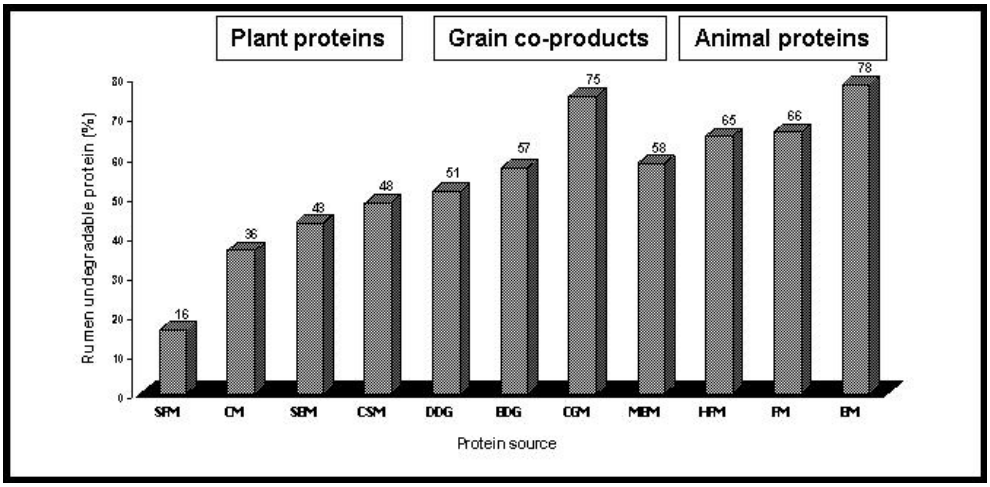

Figure 1. Rumen undegradable protein (%) of various protein sources including: sunflower meal (SFM), canola meal (CM), soybean meal (SBM), cottonseed meal (CSM), distillers dried grains with solubles (DDG), brewers dried grains (BDG), corn gluten meal (CGM), meat and bone meal (MBM), hydrolyzed feather meal (HFM), fish meal (FM) and blood meal (BM) adapted from NRC (2001).

Conclusion

Protein is a critical nutrient for young growing animals and most expensive component of food.

When choosing protein sources in diets of growing ruminants, an important criterion is the share of undegradable protein.

Fish meal is an excellent protein source that is slowly degraded in the rumen and has an excellent amino acid profile. However, due to the prohibition of its use by the European Commission, it is imperative to find other sources.

The high price of soybean, import orientation, fluctuations in the production, distribution as genetically modified food, have increased the consumer interest in alternative sources of protein.

Use of sunflower meal supplemented with fibrolytic enzymes in diets for ruminants resulted in optimal performance, compared with soybean meal.

Peas, beans, lupine can be used as an alternative source of protein without adverse impacts on biological efficiency of growth, feed conversion and meat quality of ruminants.

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Izvori proteina u obrocima za ishranu preživara

D.Ružić-Muslić, M.P.Petrović, M. M. Petrović, Z.Bijelić, V.Caro-Petrović, N. Maksimović, V. Mandić

Rezime

Brz porast ljudske populacije uslovljava povećanu potražnju za animalnim proteinima. Sa druge strane, deficit proteinskih hraniva na tržištu i porast troškova su najznačajnije prepreke sa kojima se suočava animalna proizvodnja. Zbog toga, većina istraživanja je usmerena na poboljšanje statusa i iskorišćavanja različitih izvora proteina, u cilju smanjenja troškova i održavanja optimalnih performansi životinja. Rezultati naših istraživanja su pokazali da su jagnjad MIS populacije, prosečne telesne mase 18,0 kg, hranjena obrocima sa različitim izvorima proteina: suncokretova sačma; sojina sačma, riblje brašno, ostvarila prosečan dnevni prirast: 0,169 : 0,205 : 0,227 kg, respektivno. Konverzija suve materije na analognim tretmanima, je iznosila: 4,54 : 3,71 : 3,30 (kg/kg prirasta) a ukupnih proteina (g/kg): 732 : 596: 549. Evidentno je da riblje brašno, kao izvor proteina, poboljšava rast i iskorišćavanje hrane kod jagnjadi. Međutim, obzirom da je Evropska komisija zabranila korišćenje ribljeg brašna u obrocima za ishranu životinja, imperativ nutricionista je ispitivanje mogućnosti korišćenjea"nekonvencionalnih" izvora proteina (grašak, pasulj, lupina) u obrocima za ishranu preživara. Cilj ovog

rada je da se uporede efekti različitih izvora proteina u obrocima na proizvodne performanse preživara.

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