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Full Length Research Paper

Heat treated soybeans in the nutrition of high producing dairy cows

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The main objective of this research was to study the effect of rations containing full-fat extruded soybeans or fat-extracted heat treated soybean meal, in the nutrition of dairy cows during the period of middle lactation. The study was carried out with two groups of 15 Holstein cows. The animal's health was controlled on the basis of body condition score, results in production, general condition of animals and some of the most important biochemical parameters of blood serum. In the case of nutrition based on rations where the total amount of soybeans was extruded or where it was partially replaced with fat-extracted heat treated soybean meal, the production of 4% fat corrected milk was 28.43 and 28.78 kg. Observed differences were not statistically significant ($p > 0.05$). The differences in the achieved average content of milk fat (3.38 and 3.45%) and protein (3.48 and 3.48%) were not statistically significant ($p > 0.05$). Results of this work shows that the partial replacement of full-fat extruded soybeans with soybeans based products with lower oil content gave better production results of cows during the period of middle lactation.

Key words: Soybeans, dairy cows, biochemical parameters of blood, ruminal content.

INTRODUCTION

Nowadays, the main problem in the nutrition of high producing dairy cows is the provision of the amount of energy and protein required. As a result of this, soybean is one of the most important feeds, due to its high protein content and high concentration of essential amino acids. Soybean is also a source of lipids (Radivojević et al., 2008). Effects of soybeans usage in milk production depend on the composition of the total ration and on the method of soybeans processing (Adamović et al., 1990; Adamović and Grubić, 1998; Nešić et al., 2001; Radomir, 2001). However, the presence of various harmful ingredients is not the primary reason for processing of soybeans for ruminant nutrition. Rather, it is intended to increase the by-pass protein content. In ruminant nutrition, high content of lipids in some feeds is not just a source of energy but may also be a cause for unfavorable influence on the rumen bacteria and protozoa.

Several authors have reported on the effect of soybean processing in animal nutrition on the production and chemical composition of milk (Dijk et al., 1983; Ruegsegger et al., 1985; Leonard and Block, 1988; Socha, 1991; Grummer and Rabelo, 2000). Some authors have reported that milk production is primary pointed (Adamović et al., 1990; Scott et al., 1991; Solomon et al., 2000; Nešić et al., 2001; Radomir, 2001), while others found that it affected the chemical composition of milk (Adamović and Grubić, 1998; Eifert et al., 2006; Šamanc et al., 2006). Other authors have focused on the problem of high polyunsaturated fatty acids content in soybeans, especially in relation to milk fat depression syndrome (Reddy et al., 1994; Doreau and Chilliard, 1997; Grubić and Adamović, 1998; Jenkins, 2002; Bauman and Lock, 2006; Grubić et al., 2007). Some studies have focused on important parameters of metabolism such as milk urea nitrogen (MUN), bio-chemical parameters of blood and parameters of intra-

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Table 1. Parameters of homogeneity in control and experimental group of cows prior to beginning of trial.

Parameter	Group			
	Control		Experimental	
	Mean	Standand deviation	Mean	Standand deviation
Production of milk before the trial (kg/day)	34.40	4.171	34.20	5.784
DIM at the beginning of trial	166.73	52.193	156.60	62.919
Lactation	1.67	1.047	1.80	0.941
BCS prior to beginning of trial	2.88	0.229	2.85	0.184

ruminal environment, pH of the rumen content, mobility and number of protozoa (Lee et al., 1978; Adamović et al., 1990; Williams and Coleman, 1992; Jouany, 1996; Amaral-Phillips, 2000; Solomon et al., 2000; Hristov et al., 2004; Ipharraguerre et al., 2005; Šamanc et al., 2006). The main objective of this work was to study the effect of including full-fat extruded soybeans and fat-extracted heat treated soybean meal in feed rations on the nutrition of dairy cows during the period of middle lactation.

MATERIALS AND METHODS

Basis of research

The main aim of this study was to partially replace extruded full fat soybeans (20.82%, crude fat) with heat treated fat-extracted soybeans - Biopro 60 (Oils and proteins Factory Bioprotein, 2008). It is a product with very similar traits with soybean meal processed by the expellers. Its content of crude fat is not higher than 10.71%. In the procedure of soybeans processing, the first step is milling of the grains, followed by steam treatment at 60 to 70°C, under pressure of 300 kPa for 5 min. After that, it is subjected to more intensive parameters (90 to 130°C, 600 kPa, 30 min). The last step in soybeans processing is the mechanical removal of oil and milling of soybeans based by-product. The main hypothesis of this study was that the production of milk would not decrease when there is lower content of soybeans oil in the ration. This is based on fact that despite the decreased amount of energy in the ration, the unfavorable effects of high amount of polyunsaturated fatty acids on the rumen bacteria and protozoa is avoided.

Animals used for the experiment

For the trial, two groups of Holstein cows were formed in each group containing 15 cows. Factors which were taken into account for homogeneity between the two groups were days in milk (DIM), lactation by order of succession, previous milk production and body condition score (BCS) (Edmonson et al., 1989). Mentioned data are presented in Table 1. Considering mentioned parameters, statistically significant differences were not detected ($p > 0.05$).

Nutrition of cows

The rations were formulated using the software Nutrient Requirements of Dairy Cattle V 1.0 (National Research Council, 2001). Rations were formulated for the production of 26 kg of milk, and milk fat content of 3.5%. Data on the rations are presented in Table 2.

The total amount of soybeans consumed a day was 1.6 kg. One part of this was full fat extruded soybeans (0.6 kg), and was part of the mixed portion of the ration. The rest of the soybeans were distributed manually. Cows that were producing more than 26 kg of milk, and cows with lower BCS, received some extra amount of concentrated feed. The main part of the total ration (alfalfa hay and haylage, corn silage, concentrated feed), including the 0.6 kg of full fat extruded soybeans, was distributed by mix van. The concentrated feed was made up of cracked corn grain (38.70%), wheat grain meal (10.00%), extruded full-fat soybeans (5.00%), sunflower meal (39.70%), dehydrated alfalfa (3.00%), di-calcium phosphate (0.90%), lime stone (1.10%), salt (0.60%) and premix of vitamins and minerals (1.00%).

Barns for cows and control of milk production

During the trial, cows were housed in barns, tied to beds by chains. They were milked twice a day, in the morning and in the evening by the Milk Master equipment (De Laval, 2008). The production of milk was controlled according to standard and regular procedures (ICAR, 2002). During the complete trial (56 days), there were 8 controls of milk production. Milk samples were obtained for chemical analysis using MK V Milk Meter equipment (Waikato Milking Systems NZ Ltd, 2002). Analysis of the chemical composition of milk was carried out using Milko Scan 104/SN which is based on the principles of infrared spectral analysis (Foss Electric, 2002).

The parameters of metabolism

At the end of the trial, analysis carried out included some of the important biochemical parameters in blood samples, MUN, pH of the rumen content and evaluation of protozoa activity in the rumen. For blood analysis, blood samples were obtained from vena jugularis, about three hours after the morning feeding. Glucose content of blood was determined with Precision Xtra Plus. The content of calcium was determined by the o-Cresolphthalein method (Sarker and Chanhan, 1967). The content of inorganic phosphates was analyzed by the UV method (Henry, 1974; Tietz, 1983). The BUN content was analyzed by the enzymatic kinetic method (Tietz, 1986).

For determination of the concentration of urea in milk, samples were stored for 24 h at 4°C. They were then centrifuged at 3,000 rpm for 10 min. The milk fat was separated on the surface and removed with a vacuum pump. Two to three drops of lab ferment (chymosine) were added to 10 ml of the defatted milk and homogenized on vortex and incubated at 37°C for 30 min. The sample was centrifuged again at 3,000 rpm for 10 min to remove casein as a sediment. The urea concentration in the clear supernatant (milk serum) was determined by the enzymatic kinetic method (Tietz, 1986), and by the Vet Screen analyzer (Biochemical Systems International Srl, 2010).

Table 2. Composition of ration for dairy cows in trial.

Feed (kg)	Group	
	Control	Experimental
Alfalfa hay	3.00	3.00
Alfalfa haylage	4.00	4.00
Corn silage (30-35% DM)	20.00	20.00
Extruded full fat soybeans	1.60	0.60
Soybeans meal "*Biopro* 60"		1.00
Mixture of concentrated feeds (18% CP)	6.00	6.00
Sodium bicarbonate	0.07	0.07
DM (kg/day)	18.40	18.30
CP (DM%)	16.90	16.80
RDP (DM%)	12.30	11.60
RUP (DM%)	4.60	5.20
NDF (DM%)	36.90	36.90
Forage NDF (%DM)	28.60	28.60
ADF (DM%)	25.50	25.30
NFC (DM%)	36.50	37.20
NEL (MJ/kg DM)	6.70	6.61
Calcium (DM) %	0.80	0.80
Phosphorus (DM%)	0.50	0.50
Crude fat (DM%)	4.60	4.10

DM, Dry matter; CP, crude protein; RDP, rumen degradable protein; RUP, rumen undegradible protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; NFC, nonfiber carbohydrates; NEL, net energy of lactation.

For analyses of the rumen content, samples were taken from the rumen three hours after the morning feeding. The pH was measured using a digital pH meter. The number of small, medium and large protozoa, as well as their mobility was determined using an optical microscope (medium magnification).

Data analysis

For statistical analysis, data were analysed using PASW Statistics 18 software (SPSS Inc, 2010).

RESULTS

The results of the research are presented in Table 3. Results of the BCS were very similar in the two groups of cows. At the beginning of the trial, the mean BCS of the cows was slightly low when compared to recommend-dations for this stage of lactation. Later, during the trial, the BCS improved in both groups (up to optimal values). The difference in milk production were not significant ($p > 0.05$). The results obtained were similar in both groups. It was quite similar, considering the amount of 4% fat corrected milk ($p > 0.05$). Also, the differences in milk fat and protein content were not significant ($p > 0.05$). The content of protein in milk was the same in both groups (3.48%) but the content of fat in milk was higher in the experimental group (3.45%) than in the control group (3.38%). However, the difference in milk fat content was not statistically significant ($p > 0.05$). The content of glucose in blood was higher in the experimental group (2.59 mmol/L) than in the control group (2.36 mmol/L) and this difference was statistically significant ($p < 0.05$). Differences in the calcium content (2.64 mmol/L in the control group and 2.70 mmol/L in the experimental group) and phosphorus content in blood (2.10 mmol/L in the control group and 2.20 mmol/L in experimental group) were not statistically significant ($p > 0.05$). The content of urea in blood was higher in the control group than in the experimental group (2.40 versus 2.33 mmol/L) and a similar trend was also observed in the urea content in milk (4.04 versus 3.66 mmol/L). Differences in urea content were not statistically significant either in blood or in milk ($p > 0.05$). Mobility of protozoa in rumen was significantly lower ($p < 0.05$) in the control group (1.80) than in the experimental group (2.00). The differences in number of protozoa in rumen were not statistically signi-ficant ($p > 0.05$), irrespective of size. However, the number of small protozoa was lower in the control group than in the experimental group (6.60 versus 8.60). This trend was also observed for the medium sized protozoa (7.47 versus 8.93) and the large protozoa (3.67 versus 4.80). Difference in pH value of rumen content was significantly lower ($p < 0.05$) in the control group (6.69) than in the experimental group (6.83).

If the content of protein in milk is greater or equal to 32 g/L, and milk fat content is not higher than 45 g/L, then

Table 3. Results of various analysis carried out on experimental and control group of cows at the end of the trial.

Parameter	Group			
	Control		Experimental	
	Mean	Standand deviation	Mean	Standand deviation
BCS	3.03	0.160	3.02	0.176
Production of milk (kg/day)	31.49	4.994	31.47	4.982
Milk fat content (%)	3.38	0.466	3.45	0.384
Milk protein content (%)	3.48	0.227	3.48	0.285
Protein : fat ratio	1.045	0.130	1.013	0.074
FCM (kg)	28.43	4.271	28.78	3.934
Glucose content in blood (mmol/L)	2.36[a]	0.275	2.59[a]	0.292
Calcium content in blood (mmol/L)	2.64	0.302	2.70	0.215
Phosphorus content in blood (mmol/L)	2.10	0.632	2.20	0.493
Urea in blood (mmol/L)	2.40	0.632	2.33	1.046
Urea in milk (mmol/L)	4.04	0.495	3.66	0.841
Mobility of Protozoa	1.80[b]	0.561	2.00[b]	0.000
Number of small Protozoa	6.60	2.586	8.60	2.501
Number of medium Protozoa	7.47	3.357	8.93	2.939
Number of large Protozoa	3.67	2.059	4.80	1.821
pH of rumen content	6.69[c]	0.194	6.83[c]	0.089

a, b, c: $p < 0.05$

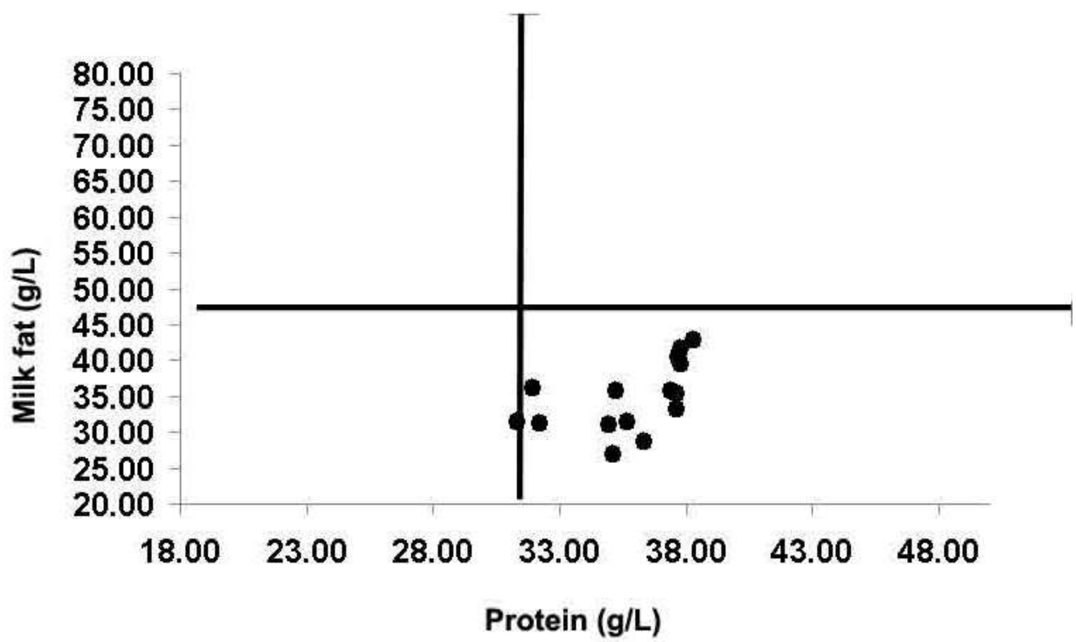

Figure 1. Protein : fat ration in milk of control group.

the ration is probably good with respect to the requirements of cows (Šamanc et al., 2006). In this work as seen from Figures 1 and 2, most of the cows had enough energy in the ration, and there were no significant differences between the two groups.

The protein : urea ratio in milk are presented in Figures 3 and 4. They show that the diet of the cows was quite suitable with regards to their energy and protein needs, and also suitably balanced with respect to the energy-protein ratio (Samanc et al., 2006). If the urea content in milk is lower than 4 mmol/L and protein is higher than 32.0 g/L, it can be concluded that the feed satisfies the nutritional requirements of the cow. If there is a little decrease in the amount of energy, the urea content in

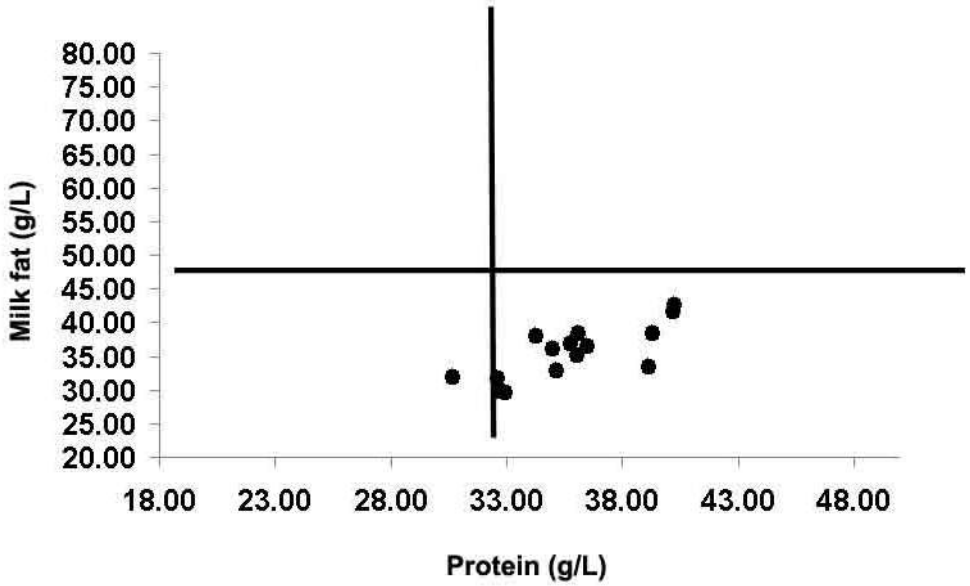

Figure 2. Protein : fat ration in milk of experimental group.

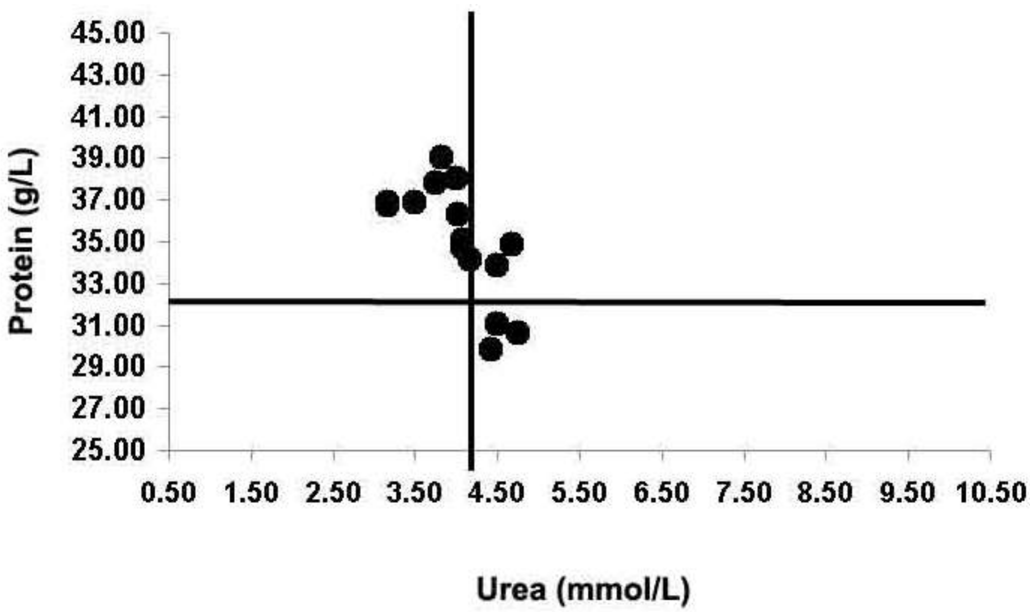

Figure 3. Comparison of protein and urea content in milk of control group**.**

milk increases over 4 mmol/L, while the protein content remains the same (>32.0 g/L). It is quite common for sudden changes to occur in the ratio of feeds, especially during the summer when the amount of protein can increase while crude fiber and energy decreases. In situations where the ration does not supply enough energy, but the amount of protein is optimal, the concentration of urea in milk will be between 5 and 10 mmol/L, while the protein content will be a little lower than 32.0 g/L. If the concentration of urea in milk is below 4 mmol/L, and the protein content is higher than 32.0 g/L, it is certain that both protein and energy content in the ration has decreased, which may lead to some metabolic disorders.

DISCUSSION

Extrusion is a very aggressive process considering its effect on intracellular organelles in soybean grain, where

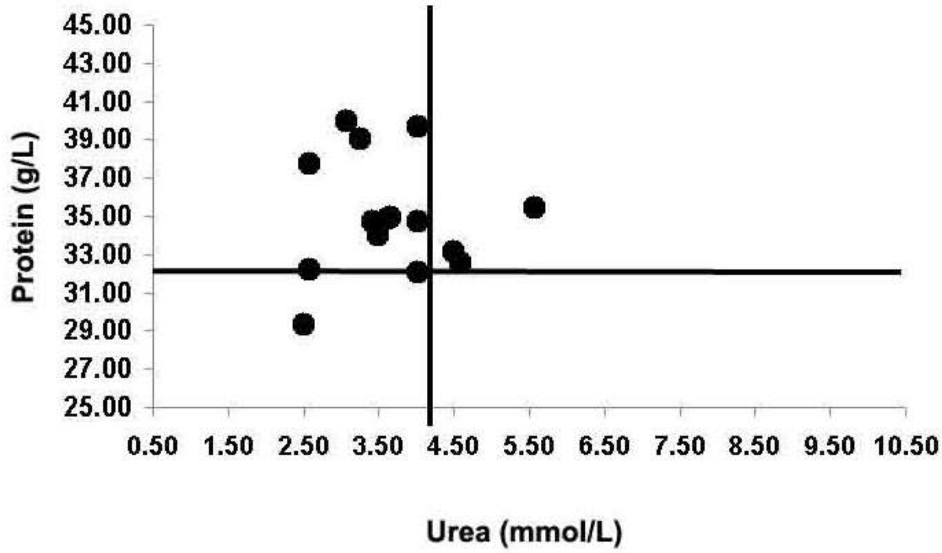

Figure 4. Comparison of protein and urea content in milk of experimental group.

the main part of oil is stored. After consuming extruded soybeans, a lot of oil can be released inside the rumen rapidly. The main ingredients of this oil are poly-unsaturated fatty acids which may have a negative effect on microbial activity, and above all, on bacteria that are important in metabolizing celluloses and methane such as *Bacteroides succinogenes*, *Butyrivibrio fibrisolvens*, *Methanobacterium ruminantium* and *Methanobacterium mobilis* (Bryant, 1970). The direct effect of such changes is increase in hydrogen ion concentration which leads to alteration of intraruminal fermentation for a higher propionic acid production, so, the final effect is decrease in milk fat content (Grubić and Adamović, 1998). This explains the observation that very similar amounts of milk were produced in both groups, and the higher content of milk fat in the experimental group, despite the difference in energy concentration in the rations based on extruded full fat soybeans when compared to the rations which contained both heat treated and fat extracted soybean meal ("*Biopro* 60").

Scott et al. (1991), reported similar milk production when cows were fed with rations based on heat treated or extruded soybeans, in comparison with rations based on expeller soybean meal. Socha (1991) has reviewed literature on replacing expeller soybean meal with heat treated full fat soybeans in the dairy cows rations from 16 publications. The average increase in milk production reported was 1.6 kg for rations based on heat treated soybeans and 1.30 kg for extruded soybeans. Recalculated on 4% fat corrected milk, the values obtained were 2.0 and 0.6 kg, respectively. In both groups, there was a similar decrease in milk protein (-0.07 and -0.06%) but the milk fat content results were different. An increase of 0.06% in milk fat was observed for cows fed on heat treated soybeans, while there was a decrease of 0.17% in milk fat of cows fed on rations based on extruded soybeans. Solomon et al. (2000) reported an increase in milk production by 7 to 10% for cows fed on extruded full fat soybean ration. Ruegsegger et al. (1985) investigated the effects of extruded vs. crumbled raw soybeans (equal amounts, 1.4 to 1.8 kg), and found that including extruded soybeans in the rations of fresh cows resulted in significantly higher milk production and small changes in milk fat content. Leonard and Block (1988) investigated the effects of two amounts (3.36 and 5.80 kg) and two types of soybean based feeds (raw and heat treated) on primiparous fresh cows. There were no significant differences in milk production as a result of soybeans processing or protein content in the rations, but the FCM amount was significantly higher ($p < 0.05$) when the higher amount of soybeans was consumed. In addition, some positive significant effects ($p < 0.05$) of the amount of soybean consumed with milk fat content were detected. Dijk et al. (1983) found increased milk production and significantly lower content of milk fat when cows were fed on 2.3 kg of extruded soybeans when compared to cows fed on the same amount of raw soybeans, while the amounts of FCM were not significantly different.

Some authors in Serbia have reported better results when fresh cows were fed on extruded full fat soybeans in comparison with heat treated soybeans (Nešić et al., 2001; Radomir, 2001). However, it should be noted that milk production of fresh cows is highly influenced by nutrition during the previous lactation and dry-off period.

Ipharraguerre et al. (2005) have carried out research on cows with rumen fistula. The amount of milk produced and FCM (3.5% of milk fat) were significantly higher when the rations were based on expeller soybean meal (22.6 and 25.2 kg), when compared to cows fed on heat treated full fat soybeans (22.5 and 24.7 kg). Effects of expeller soybean meal based ration had higher content of milk fat and protein (4.24 and 3.63%) when compared to heat treated full fat soybean based ration (4.05 and 3.46%). In addition, the content of acetate in the rumen was higher when the ration was based on expeller soybean meal. However, differences in the chemical composition of milk and acetate content in the rumen were not significant.

Jenkins (2002) claims that polyunsaturated fatty acids in intraruminal environment can be attached to cell membranes of certain microorganisms, which leads to cellular damage because of disruption of phospholipid components of cell membrane. Some microbial species are more susceptibe to this sort of damage. It leads to a disturbance in carbohydrate fermentation and ratio of acetate and propionate concentrations, which finally leads to disruption of fiber digestion. In addition to well established models of unfavorable effects of polyunsaturated fatty acids, some authors (Doreau and Chilliard, 1997) suggest that decreased accessibility of calcium ions in the rumen content is one of the reasons for reduced activity of cellulolytic bacteria. This is because calcium ions are important for the attachment of some species of bacteria to the cell walls of consumed plant materials and their degraded products in the rumen. According to results obtained by Reddy et al. (1994), the amount of free fatty acids released from extruded soybeans in the rumen is higher when compared to heat treated soybeans and raw soybeans as well. In same work, some very unfavorable effects of extruded soybeans on fiber digestibility were observed which were more severe when compared to heat treated soybeans and raw soybeans. Eifert et al. (2006) detected a decrease in milk fat content, from 3.34 to 3.13% when soybean oil was included in the mixture of concentrated feed. Also, the milk protein : fat ratio increased from 0.940 to 1.000. In the present work, similar trends were observed because the milk protein : fat ratio in the control group was higher than in the experimental group, but this difference was not significant ($p > 0.05$). The optimal values for milk protein : fat ratios are between 0.8 and 1.0 (Adamović and Grubić, 1998). Grummer and Rabelo (2000) reported increased amount of produced and FCM milk of 1.5 to 2.3 kg as a result of replacement of solvent extracted soybean meal by heat treated soybeans, but with reduced milk protein content (0.1%). They found similar results for rations based on solvent extracted soybean meal and extruded soybeans.

The issue of the validity of balancing rations with respect to protein and fat content as well as protein and fat ratio is well explained by the simple model suggested by Šamanc et al. (2006). However, somewhat inferior protein : fat ratio in a group of cows fed only extruded full fat soybeans, suggest that there is a moderated process of food digestion in the rumen and some metabolic disorders.

Grubić et al. (2007) suggested that decreased milk fat content can be a consequence of pure silage quality, pure mixed ration or because of high level of vegetable oils in ration (rations with high amount of extruded full fat soybeans). Bauman and Lock, (2006) emphasized that rations with high amount of fish or vegetable oils can cause milk fat depression.

Unsuitable intraruminal environment, as a result of decreased microbial activity due to excessive oil, may lead to lack of energy and consequently decreased transformation of ammonia to proteins. Final consequence of this is increased level of blood and milk urea nitrogen (BUN and MUN). Most recommendations for optimal concentration of milk urea nitrogen are between 12 and 18 mg/dl or in a wider range of 8 to 25 mg/dl for individual values (Amaral-Phillips, 2000). If those values are recalculated to urea concentration in milk, then the optimal range is between 4.3 and 6.4 mmol/L or 2.9 and 8.9 mmol/L for the wider range (Amaral-Phillips, 2000). The values obtained during the trial were optimal. Some authors have reported increased urea content in milk when cows were fed extruded full fat soybeans based rations (Solomon et al., 2000). In the present work, the urea content in milk was lower in the group where cows consumed the smaller quantity of soybean oil. Microbial activity was higher in the rumen of cows in this group. Such intraruminal environment was closer to optimal values, considering the most important physiological parameters, therefore ammonia utilization in the rumen was improved. It is clear that this was the main reason and prerequisite for the optimal milk protein content and concentration of urea in blood and milk as well.

From the protein : urea ratio in milk presented in Figures 3 and 4, it can be concluded that the diet of the cows was quite suitable with regards to their energy and protein needs as well as being suitably balanced with regards to the energy and protein ratio. During trials on cows with rumen fistula, Ipharraguerre et al. (2005) observed many advantages of expeller soybeans based nutrition over heat treated full fat soybeans. Although the differences were not significant in the milk of cows fed with expeller soybean meal, MUN content was lower when compared to a group fed on heat treated full fat soybeans (16.4 and 16.7 mg/dl).

In the present work, the content of glucose, phosphorus and urea in blood was carried out towards the end of the trial. These important biochemical parameters were analyzed due to their significance as indicators of possible mistakes in cattle nutrition. Concentration of glucose in the second group was significantly higher ($p < 0.05$). Adamović et al. (1990) compared ratios based on different soybeans feeds, and they found higher concentration of glucose in blood of cows fed with heated full fat soybeans (3.25 mmol/L) in comparison with cows fed with soybean meal (2.67 mmol/L).

Concentration of calcium in blood was slightly higher when compared to optimal values in the range of 2.2 to

2.5 mmol/L (NRC, 2001), but there was no significant difference between the groups. In Comparison with optimal values in the range of 1.3 to 2.6 mmol/L (NRC, 2001), concentrations of phosphorus were acceptable, and the differences between groups were not significant. In a work carried out by Adamović et al. (1990), rations for cows based on heat treated full fat soybeans and soybean meal were compared. The differences regarding calcium and phosphorus content in blood was not significant.

Lee et al. (1978) suggest that the optimal value of concentration of urea in the blood of lactating dairy cows is 9.53 mg/100 ml (standard deviation 4.84). In the present work , values for concentration of urea in blood were optimal and difference between groups was not significant ($p > 0.05$).

Williams and Coleman (1992) found that rumen ciliate protozoa have high capacity for protein degradation. Therefore, these protozoa are important in the process of ruminal recycling of microbial nitrogen (Jouany, 1996). However, the content and composition of fat in the ration can drastically alter the number and activity of protozoa in the rumen. Some *in vitro* research (Hristov et al., 2004), indicates that long chain polyunsaturated fatty acids, combined with medium chain saturated fatty acids, can cause a decrease of protozoa number in the rumen as well as utilization of ammonia nitrogen in the rumen, when rations of cows are based on high amounts of grains. In our research, all parameters of the rumen protozoa activity were much better in groups where cows consumed rations with lower quantities of extruded full fat soybeans. Furthermore, the difference in mobility of protozoa was significant ($p < 0.05$). The pH of the rumen content was within the optimal range, but the difference between groups was statistically significant ($p < 0.05$).

Partial substitution of extruded full fat soybeans with expeller soybean meal, is not the cause of lower milk production and also not the cause of decreased content of milk fat. Although, this approach to diet formulation leads to decreased content of fat in the ration, it is not the basis for the lack of energy. The main reason for this is that it avoids the unfavorable effects of the rapid release of oil from extruded soybeans in the rumen. This type of ration can promote better healthy cows, optimal reproduction parameters and higher milk production. Based on the results obtained from this work, it is recommended that additional research should be carried out, to investigate the possibility of replacing higher amounts of extruded full fat soybeans with the expeller based soybeans products. It would be incorrect to use full fat soybeans as an energy source in the rations for dairy cows. Rather, problems of energy deficit should be solved by special procedures of carbohydrate feed processing (e.g. ensiled corn grain, molasses with a standardized content of sugar, etc.). A second approach to solve the lack of energy problem could be the usage of fats that are protected from degradation in the rumen.

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