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VARIATION OF PROTEIN, CELLULOSE AND MINERAL CONTENTS OF LUCERNE AS INFLUENCED BY CULTIVAR AND CUT

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Abstract: Lucerne is the most important source of protein, fiber, and mineral substances in ruminant nutrition. The objective of this study was to chemically analyze the new lucerne cultivars for the levels of protein, fiber, oil and mineral substances during the year (4 cuts). According to the results, the cultivars differed significantly in their crude protein, fiber, and mineral matter contents. The crude protein content was significantly higher in the first cutting than in the others, while the fiber content was significantly increased in the second and third cuts, i.e. in the warmest part of the year. The P and K contents were the highest in the first and the lowest in the fourth cutting, while the Ca and Na levels did not vary significantly over the year.

Key words: lucerne, protein, fiber, mineral substances, cultivar, cutting

Introduction

Lucerne is very highly regarded as a forage crop both in Serbia and the rest of the world, because it is a rich source of protein, cellulose, mineral substances, and vitamins in animal nutrition, especially in the case of ruminants. Digestibility and crude protein content are the two main components of lucerne quality. The digestibility of lucerne organic matter depends mostly on protein, cellulose, and lignin contents. Lignin is practically indigestible, so increased lignification of the cell wall in the later stages of lucerne development results in a progressively reduced digestibility coefficient as the plants age.

The protein content of lucerne dry matter varies between 18 and 25% and depends on the stage of plant development, cultivar, and the method of preparation *(Katic et al., 2006)*. With its hay yield of 14 t ha^{-1} (20 t ha^{-1} when irrigated), lucerne is the largest producer of protein per unit area. Its output is 2.650-3.100 kg ha^{-1} *(Katić, 2001)*, which is three times more than what maize grown for grain yields, one and a half times more than what soybean produces, and double the output of

maize used for silage. Nutritional value is regarded as synonymous with protein content, because lucerne digestibility depends on protein levels. However, when determining the nutritive value of this plant, we need to take into account not only crude protein content but cellulose content as well. The crude cellulose content of lucerne is negatively correlated with digestibility and increases with plant age. Neutral detergent fiber (NDF) is indicative of dry matter consumption in lucerne. The higher the NDF content is, the lower plant quality and consumption by livestock will be. Acid detergent fiber (ADF) content indicates potential production energy, and any major increase in ADF is indicative of lowered energy, i.e. poorer quality. The forms of energy obtained from cellulose hay are not used efficiently in livestock nutrition. This is why the value of quality lucerne exceeds the estimates obtained by analyzing the concentration of digestible nutrients. Lucerne quality is reflected in greater consumption, faster digestion, and more efficient conversion of digestible energy into production energy *(Marten et al., 1988)*.

Richness in mineral substances is a special quality of lucerne. The mineral matter content of lucerne is 9.87 *(Katić et al., 2001)* and the plant is rich in calcium (1.4-1.9 %) *(Lanyon and Griffith, 1988)*. Lucerne is not only a rich source of minerals but these minerals are organically bound and less prone to interaction with other ions, do not form insoluble complexes, have greater digestibility, and are absorbed more easily, all of which increases the nutritive value of this crop.

Lucerne's fatty matter content is low, 1.78% on average *(Katić et al., 2005)*, and varies little from one Cultivar to another. In addition to containing highly nutritive matter, lucerne also has in it antinutritional substances, which is something that should be taken into account when utilizing and preparing this crop.

The most important antinutritional factors in lucerne are: a high concentration of Ca and a low one of P (Ca/P ratio); high levels of isoflavonoids – estrogen activity (livestock sterility); presence of lignin, which reduces consumption and digestibility of the plant; nitrate concentration (> 0.2%); and protease inhibitors and saponin (reducing nonruminant growth).

The objective of this paper was to determine dry matter chemical composition in five lucerne cultivars in the course of a year (4 cuttings). Another objective was to assess digestible dry matter content, dry matter consumption, and feed relative value.

Materials and Methods

Forage quality was studied using five lucerne cultivars developed at the Institute of Field and Vegetable Crops in Novi Sad using different breeding methods and directions.

Field trials with five replicates were conducted in 2005/2006 at the Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad. For

chemical analyses the samples were taken in the second year of crop life (2006) from the second and fourth replicates of the four cuts (40 samples). The samples were cut at 5 cm height and the sampled area was around 0.02 m^2, amounting to 500 g of green forage. Herbage materials were dried at 60˚C for about 48 hours. Chemical analyses were carried out using the standard methods. Proteins were determined by the Kjeldahl procedure, fats were extracted with diethyl ether and ash was determined by incineration. Calcium, sodium and potassium were determined by flame photometry, phosphorus by colorimetry. Nitrogen free content (NFE) was calculated as follows: 100 - (CP + ash + oil + fibre). Filter bag technique (Ankom Technology) was used for measuring neutral detergent fiber (NDF) and acid detergent fiber (ADF). NDF and ADF analyses were done with a Fiber Analyzer Ankom 2001. All analyses were performed in a laboratory of Animal Husbandry Department of Faculty of Agriculture in Novi Sad. Feed quality was assessed on the basis of the following parameters according to Anderson et al. (1994): digestible dry matter (DDM): DDM (%) = 88.9 - (% ADF x 0.779); relative feeding value (RFV): (DDM x CDM)/1.29; and consumption of dry matter (CDM): CDM = 120 / % NDF.

The two-factor analysis of variance was used with cultivar as factor A and cut as factor B. The LSD test was used for testing the significance of differences.

Results and Discussion

The new cultivars differed significantly in their crude protein content. Niagara, Mediana and Danka had higher crude protein levels than NS Alfa and Banat VS (Table 2).

Table 1. Variation of lucerne cultivars in protein, fibre content, oil and NFE (g kg $^{-1}$) during 2006 (4 cuts)

Cultivar		Proteins	NDF	ADF	Oil	NFE
Niagara		187.8	486.7	375.4	3.68	304.3
Banat VS		176.8	481.7	375.9	3.55	312.3
Mediana		190.3	472.0	389.7	3.62	296.7
NS Alfa		173.3	477.3	395.2	3.94	284.5
Danka		193.7	454.3	374.4	4.08	293.5
LSD	0.05	10.6	14.0	13.0	0.3	4.6
	0.01	14.2	18.0	17.0	0.5	6.5

Over the year, crude protein content of lucerne dry matter varied significantly. The highest levels were recorded in the first and fourth cuts and the lowest in the cut developing during the driest and warmest part of the year. This is a result of faster lucerne development and cutting in the later stages of plant

development (the first cutting was performed 45 days after the equinox, the second 42 days following the first, the third after 27 days, and the fourth 36 days after that *Katic et al. (2008)*.

The cultivars differed significantly in their fiber content. The highest NDF content was found in the cultivars Niagara and Banat VS, while the highest levels of ADF were observed in NS Alfa and Mediana. Highest dry matter consumption (lowest NDF content), was found in cultivars Danka, Mediana and NS Alfa. The lowest ADF content (highest dry matter energy value) was recorded in the cultivars Danka, Banat VS and Niagara. The NDF and ADF levels were also indicative of lucerne cutting in later developmental stages in the third cut. The significantly higher dry matter fiber content of lucerne developing in warm conditions is connected with faster biosynthesis of cellulose and lignin, what is related to greater day length and illumination *(Marten et al., 1988)*.

During the year, the lowest dry matter NDF content was found in the first cut and the highest in the third (Table 2).

Table 2. Seasonal variation of protein, fibre content, oil and NFE in lucerne (g kg $^{-1}$) during 2006

Cut		Proteins	NDF	ADF	Oil	NFE
1		196.9	411.9	320.9	3.89	331.5
2		187.2	499.3	401.6	3.71	278.6
3		171.1	508.3	409.3	3.56	299.3
4		185.6	478.2	396.7	3.94	283.6
	0.05	9.2	12.0	12.0	0.3	4.1
LSD	0.01	12.3	16.0	16.0	0.4	5.8

Mineral matter content is important for livestock development and progress, and lucerne is a rich source of mineral substances. The highest mineral matter content was found in the first cut and the lowest in the third (the warmest part of the year).

Table 3. Variation of lucerne cultivars in mineral elements during 2006 (4 cuts)

Cultivar		Ash g kg $^{-1}$	Ca %	P %	Na %	K %
Niagara		9.57	1.54	0.41	0.130	3.97
Banat VS		9.95	1.53	0.39	0.131	3.72
Mediana		8.72	1.53	0.34	0.094	3.70
NS Alfa		10.76	1.38	0.37	0.065	4.36
Danka		9.76	1.51	0.38	0.121	4.01
	0.05	1.6	0.2	0.0468	0.0468	0.463
LSD	0.01	2.2	0.3	0.0634	0.0634	0.633

Mineral substances are more abundant in the earlier stages of growth, i.e. in the leaves, which is another reason why leaves need to be preserved during the preparation, storage and utilization of lucerne hay.

Among minerals, lucerne is a rich source of calcium, which is necessary for the formation of skeleton in livestock. There were no differences in Ca content among the cultivars in the present study. Over the year, the highest Ca content was observed in the first cut (1.55 g kg^{-1}) and the lowest in the third (1.41 g kg^{-1}). These findings are in agreement with those of *Lanyon and Griffith (1988)*. P content varied within the expected range – 0.4 %. The highest P levels were recorded in the cultivar Niagara and in the first cut (0.43%) (Table 3). Lucerne was not able to fulfill all of livestock's requirement for P, because the optimum ratio of Ca to P is 2:1, and in the present study this ratio ranged from 5:1 to 3.5:1. This imbalance should be amended by introducing into the animal diet nutrients with a lower Ca content. Na content in this study ranged from 0.087 to 0.122%, which is close to the reference values for lucerne. Higher Na levels were found in Niagara and Banat VS and Na content did not vary significantly over the year. K content exceeded the reference values (2.5%) and was the highest in the cultivar NS Alfa. In the course of the year, the highest K content was observed in the furst cutting and the lowest in the third (Table 4).

Table 4. Seasonal variation of mineral elements in lucerne during 2006

Cut		Ash g kg^{-1}	Ca %	P %	Na %	K %
1		10.81	1.55	0.43	0.109	4.44
2		9.88	1.52	0.38	0.115	3.74
3		8.38	1.41	0.37	0.122	3.77
4		9.93	1.52	0.32	0.087	3.87
LSD	0.05	1.4	0.2	0.04	0.04	0.41
	0.01	1.9	0.3	0.06	0.06	0.57

K content depends not only on the cultivar but also on environmental conditions and is reduced in lucerne growing and developing in warmer weather. NFE content is an indicator of sugar content in lucerne. Banat VS and Niagara had the highest sugar levels of all the cultivars in the study. The highest NFE levels were recorded in the first cut and the lowest in the second. The NFE values we observed were somewhat lower than the reference ones.

Table 5. Quality of lucerne dry matter according to *Anderson et al. (1994)*

Cultivar	ADF	NDF	DDM	CDM	RFV	Cut	ADF	NDF	DDM	CDM	RFV
Niagara	37.54	48.67	60	2.5	114	1	32.09	41.19	64	2.9	144
Banat VS	37.59	48.17	60	2.5	115	2	40.16	49.93	58	2.4	107
Mediana	38.97	47.20	59	2.5	115	3	40.93	50.83	57	2.4	104
NS Alfa	39.52	47.73	58	2.5	113	4	39.67	47.82	58	2.5	113
Danka	37.44	45.43	60	2.6	122						

The sugar (energy) content of lucerne is lower than needed and this has to be corrected by incorporating into the livestock diet nutrients rich in sugar. Dry matter digestibility ranged from 58% in NS Alfa to 60% in Niagara, Banat VS and Danka (Table 5).

The best consumption index according to *Anderson et al. (1994)* was found in the Cultivar Danka (2.6). Over the years, the highest digestibility was observed in the first cut (64%) and the lowest in the third (57%). Relative feed value varied from 104 to 144 as per *Anderson et al. (1994)*. The cultivars differed little in this regard, while the differences among the cuts were much larger.

Conclusion

The protein, cellulose and mineral matter contents of lucerne vary according to cultivar and cut. The levels of crude protein, fats, and mineral substances are higher in the spring and autumn, i.e. in the moderately warm parts of the year.

The highest fibre (cellulose) content was observed during the warmest part of the year (middle of the summer).

Lucerne is a rich source of protein and can fulfill all of livestock's needs in this regard. Its cellulose content exceeds livestock's requirement for fiber, while the mineral matter content fully meets animal needs. The Ca content is excessive, since the Ca to P ratio in lucerne is 5:1, as compared to the optimum ratio of 2:1. Na and P levels in the crop completely fulfill the needs of livestock.

Variranje sadržaja proteina, strukturnih ugljenih hidrata, ulja i mineralnih materija u lucerki

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Lucerka je najznačajniji izvor proteina, strukturnih ugljenih hidrata i mineralnih materija u ishrani preživara. Cilj rada je bio da se hemijskim analizama odredi sadržaj proteina, strukturnih ugljenih hidrata, ulja i mineralnih materija kod novih sorti lucerke u toku godine (I-IV otkos). Sorte su se značajno razlikovale u sadržaju sirovih proteina, strukturnih ugljenih hidrata, i mineralnih materija. Značajno veći sadržaj sirovih proteina je dobijen u prvom otkosu, a strukturnih ugljenih hidrata u drugom i trećem otkosu, u najtoplijem delu godine. Sadržaj P i K je bio najveći u prvom, a najmanji u četvrtom otkosu, a sadržaj Ca i Na se nije značajno menjao tokom godine. Najsvarljiviju suvu materiju ima prvi otkos (64%), a najmanju treći (57%). Konzumiranje suve materije bilo bi najveće u prvom otkosu, 2,9 % od telesne mase, a najmanje u II i III otkosu (2,4%). Relativna

vrednost hraniva je najveća u prvom otkosu 144, a najmanja u trećem 103. Kvalitet suve materije lucerke zavisi od većeg broja parametara koje treba oceniti i odrediti njihovu međusobnu povezanost. U hladnijim i vlažnim ekološkim uslovima veći je sadržaj sirovih proteina, ulja i mineralnih materija (I otkos), a u toplim i suvim je veći sadržaj strukturnih ugljenih hidrata (II i III otkos).

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