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THE EFFECT OF HAY-MAKING PROCEDURES ON THE RUMINAL PROTEIN DEGRADABILITY OF HAY

UTJECAJ POSTUPAKA SUŠENJA SIJENA NA RAZGRADLJIVOST BJELANČEVINA SIJENA U BURAGU

J. Verbič, D. Babnik[1]

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SUMMARY

Protein degradability of grass, wilted grass, oven dried grass and corresponding hays were studied using the nylon bag method. Fresh (frozen) grass (F), material which was wilted for 5, 7, and 26 h and then frozen (W_5, W_7, W_{26}), material dried in laboratory oven at 40 and 60°C (D_{40} and D_{60}), sun cured hay (H), hay dried in shadow (H_{shadow}) and hay exposed to sun rays for 20 ($H_{sun\ 20}$) or 40 ($H_{sun\ 40}$) days were compared in Experiment 1. In Experiment 2 a comparison of fresh and prewilted grass dried in the laboratory oven at 40 and 60°C (FD_{40}, WD_{40}, FD_{60} and WD_{60}) grass dried hay-rack (FHR), wilted grass dried in a hay-rack (WHR) and barn dried wilted grass (WBD) was made. During the first stage of wilting (7 h) the effective protein degradability (EPD) slightly increased (by about 40 g kg^{-1}). Later (26 h) it decreased but it was not clear if the decrease was due to direct effect of wilting or to particle losses. EPD of H was lower than in H_{shadow} (666.0 *vs.* 715.2 g kg^{-1}) and lower in WHR than in WBD (752.9 *vs.* 792.5 g kg^{-1}). The exposure of hay to sun rays did not markedly alter the EPD which were, in H, H_{sun20} and H_{sun40}, 666.0, 666.2 and 645.6 g kg^{-1}) respectively. EPD of samples dried at 40°C was consistently higher than samples dried at 60°C (715.0 vs. 685.8, 814.5 vs. 792.6 and 775.2 vs. 755.5 g kg^{-1}). It was concluded that a difference of about 50 g kg^{-1} in EPD can be attributed to various preservation methods of hay.

INTRODUCTION

It has been known for a long time that forage protein undergoes considerable changes during the wilting period. Due to the action of plant proteases the proteins are broken down to free amino acids (Kemble and Macpherson, 1954; Kemble, 1956). Results of Brady (1960) indicate that the extent of proteolysis and final distribution of nitrogen fractions depends mainly on the rapidity with which the moisture is lost during the wilting period. In the case of quick wilting the proteolysis is less extensive and the major and products of protein breakdown comprise the amino acids and some volatile N compounds while in slow wilting also the amide-N can represent a considerable proportion of total N. On the other hand, a part of soluble protein

[1] Dr. Jože Verbič and Dr. Drago Babnik, Kmetijski inštitut Slovenije, Hacquetova 2, 1000 Ljubljana, Slovenija

can be bound to the fibre during the wilting period. Mangan et al. (1991) found out that with good weather conditons a considerable proportion of Fraction 1 protein, which represents the most abundant soluble leaf protein, can be recovered as a fibre bound protein in the silage. Adverse wilting conditions or ensiling of unwilted material caused degradation of its prevailing part. Therefore, the soluble protein concentration in hay is expected to be the result of two contradicting processes: a) proteolysis due to the action of plant proteases and b) binding of soluble protein to fibre. Both processes depend on weather conditions during the wilting.

It is less clear, how the proteolytic activity during the wilting of forage affects the rumen degradable protein fraction. The aim of the present work was to investigate whether the protein degradability of hay in the rumen could be altered by the procedures in hay making. Some procedures were investigated in the field conditions, some of them in laboratory.

MATERIAL AND METHODS

Material

Experiment 1

The first cut of the grass-clover mixture (0.823 *Dactylis glomerata,* 0.139 *Trifolium repens,* 0.038 other grasses and forbs in DM) was mown on 23 May 1994. Samples of fresh (F) and wilted (W_5, W_7, W_{26}) material were taken immediately after mowing and 5, 7 and 26 h later and stored at -20 °C until degradability determinations. The material was turned over manually to increase the wilting rate. The sample of hay (H) was collected from the meadow 77 h after mowing. A part of it was exposed in a thin layer to sun rays for 20 (H_{sun20}) or 40 ($H_{sun\ 40}$) days. One sample of fresh material was dried in the shadow (H_{shadow}). The samples of fresh material were also dried in air forced ovens at 40 (D_{40}) and 60 (D_{60}) °C.

Experiment 2

The first cut forage from the intensive meadow was mown on 17 May 1993. The main species represented in the forage were *Lolium perenne, Trifolium repens, Poa pratensis, Festuca pratensis, Taraxacum officinale, Capsella bursa-pastoris* and *Dactylis glomerata.* One batch of fresh material (188 g DM kg^{-1}) was drierd in hay-rack (FHR). Samples of fresh material were also dried in an air forced oven at 40 (FD_{40}) and 60 (FD_{60}) °C. Another batch was wilted on the meadow for 31 h to achieve 574 g DM kg^{-1}. Then some of the wilted material was barn dried (WBD), some was dried in a hay-rack (WHR) and two samples were dried in an air forced oven at 40 (WD_{40}) or 60 (WD_{60}) °C.

Chemical analyses

Total nitrogen was measured in fresh samples by Kjeldahl method according to Naumann and Bassler (1976). Crude protein concentrations were calculated as N conc. x 6.25. Neutral detergent insoluble (NDIN) and acid detergent insoluble (ADIN) N concentrations were determined according to Goerng and Van Soest (1970).

Protein dergadability and estimation of digestible undegradable protein concentration

Protein degradability was determined by the nylon bag method as described by Ørskov et al. (1980). Dry samples for the *in situ* degradability were ground through a 5 mm screen. Fresh samples (F. W_5, W_7, W_{26}) were first chopped using a farm chopper (theoretical chop length 5 mm). Particles longer than 10 mm were then reduced by scissors. About 3 g (Experiment 1) or 7 g DM (Experiment 2) of samples were put into a nylon bag of size 100 x 75 mm (Experiment 1) or 200 x 120 mm (Experiment 2), immersed into water (39 °C) and then incubated in the rumen of two sheep (Experiment 1) or two cows (Experiment 2) for 3, 6, 12, 24, 48 or 72 hours. Bags with samples were then washed in a domestic washing machine. Solubility (A) was determined by incubating the bags with samples in the hot water (39 °C) for 30 min before washing in the washing machine. Data on protein degradability were fitted to exponential equation ($p=a+b\ (1-e^{-ct})$ for $t>t_0$) taking into account lag phase ($p=A$ for $t<t_0$) as described by McDonald (1981). Effective degradability was calculated on the basis of degradability characteristics and theoretical outflow rate $k=0.05\ h^{-1}$ using the equation $EPD = a+bc/(c+k)\ e^{-(c+k)to}$ (McDonald, 1981).

Digestible undegradable protein (DUP) concentrations were calculated from the concentrations of undegradable dietary protein (UDP) and ADIN as DUP = 0.9 x (UDP - 6.25 ADIN)

Statistical analyses

The data were analysed by the analysis of variance using the statistical program Statgraphics (STSC, 1991).

RESULTS AND DISCUSSION

Changes of protein fractions during the wilting and drying period

In the first stage of wilting (from F to W_7) the crude protein concentration tended to increase, later it decreased (W_{26}) and was the lowest in hay (H, table 5). The slight increase of crude protein concentration during the first 7 h was probably due to respiration which is considered to cause, first of all, the losses of soluble carbohydrates and therefore to increase the concentration of crude protein. Relatively low concentrations of crude protein in W_{26} and H were probably a consequence of particle losses of material with higher CP concentration, especially leaves of white clover. The characteristics of protein degradability, which are presented in Table 1 and 2, should be therefore interpreted with caution, since they comprise not only the chemical changes of protein during wilting but also the changes due to mechanical losses.

Table 1. Solubility (A) and cumulative protein degradability in the rumen at different incubation times (Experiment 1)
Tablica 1. Topivost (A) i kumulativna razgradljivost bjelančevina u buragu kod različitih vremena inkubacije (pokus 1)

Treatment Postupak	Protein degradability in g kg^{-1} Razgradljivost bjelančevina u g kg^{-1}						
	A	3h	6h	12h	24h	48h	72h
F	308.2^{b}	391.4^{a}	427.0^{a}	742.9^{de}	812.0^{cd}	856.9^{c}	892.2^{ef}
W_5	270.2^{a}	421.2^{b}	504.2^{bc}	752.8^{e}	836.9^{e}	859.0^{c}	910.3^{g}
W_7	368.2^{c}	416.6^{b}	558.1^{def}	758.4^{e}	824.1^{de}	882.9^{d}	900.9^{fg}
W_{26}	301.1^{ab}	440.1^{bc}	498.2^{b}	689.2^{ab}	803.5^{cd}	846.4^{c}	871.4^{c}
H	384.9^{cd}	445.1^{c}	522.2^{bcd}	718.6^{cd}	766.7^{ab}	823.7^{b}	859.6^{b}
H_{shadow}	417.4^{d}	505.1^{d}	593.0^{fg}	763.0^{e}	822.9^{de}	857.6^{c}	886.5^{de}
$H_{sun\ 20}$	396.2^{cd}	483.0^{d}	525.7^{bcd}	696.4^{bc}	774.6^{b}	817.2^{b}	857.2^{ab}
$H_{sun\ 40}$	371.7^{c}	436.3^{bc}	541.5^{cde}	664.5^{a}	745.3^{a}	796.2^{a}	846.5^{a}
D_{40}	518.8^{e}	587.5^{e}	604.4^{g}	711.6^{bc}	799.9^{c}	851.3^{c}	883.1^{de}
D_{60}	398.5^{cd}	450.0^{c}	570.8^{efg}	707.4^{bc}	806.9^{cd}	848.4^{c}	876.9^{cd}
s.e.m.	11.6	8.4	14.2	9.5	7.8	5.3	3.9
Sig.	0.001	0.001	0.001	0.001	0.001	0.001	0.001

- values sharing the same superscript do not differ significantly (P>0.05)
- jednako označene vrijednosti među sobom se ne razlikuju značajno (p>0.05)

treatments - postupci:
- F - fresh (frozen) material - svjež (zamrznut) materijal
- W_5, W_7, W_{26} - material after 5, 7 or 26 h of wilting - materijal nakon 5, 7 ili 26 sati venenja
- H - sun cured hay - sijeno prirodno sušeno na suncu
- H_{shadow} - hay dried in shadow - sijeno sušeno u sjeni
- $H_{sun\ 20}$, $H_{sun\ 40}$ - hay exposed to sun rays for 20 or 40 days - sijeno izloženo sunčanim zrakama 20 ili 40 dana
- D_{40}, D_{60} - material dried in laboratory oven at 40 or 60 °C - materijal sušen u laboratorijskom sušioniku na 40 ili 60°C

It can be assumed that little or no particle losses occurred during the first 7 h of wilting. From the results in Table 1 it was evident that during the first stage of wilting (7 h) the protein degradability at all incubation times increased. Differences were the most pronounced and significant at shorter incubation times (3 and 6 h). Changes were also reflected in effective protein degradability which increased from 659.1 in F to 700.8 g kg^{-1} in W_7 (Table 2). Due to further wilting (W_{26}) the effective protein degradability was reduced to 660.2 g kg^{-1}. Generally, the results support the finding of Mangan et al. (1991) that wilting increases the fiber-associated protein fraction. However, as already mentioned, the decrease in protein degradability can also be the consequence of particle losses during the wilting.

Table 2. Protein degradability characteristics of fresh and wilted grass, hays and dried grass from Experiment 1.
Tablica 2. Karakteristike razgradnje bjelančevina svježe i uvele trave, sijena i osušene trave iz prvog pokusa

Treatment Postupak	Degradability characteristics Karakteristike razgradnje							
	B	PD	c	t_0	a	b	RSD	EPD
	g kg^{-1}	g kg^{-1}	h^{-1}	h	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}
F	570.0	878.2	0.1095	2.2	154.5	723.7	61.0	659.1
W_5	617.0	887.2	0.1168	0.9	199.8	687.4	39.1	682.7
W_7	516.4	884.6	0.1292	2.3	193.3	691.3	23.2	700.8
W_{26}	564.5	865.6	0.0912	0.3	285.3	580.3	24.3	660.2
H	453.4	838.3	0.1059	1.8	287.9	550.4	32.9	666.0
H_{shadow}	452.7	870.1	0.1180	1.3	341.7	528.4	21.7	715.2
$H_{sun\,20}$	446.1	842.3	0.0861	0.9	360.8	481.5	27.5	666.2
$H_{sun\,40}$	450.8	822.5	0.0880	1.0	331.6	490.9	23.2	645.6
D_{40}	363.8	882.6	0.0594	0.1	515.8	366.8	16.7	715.0
D_{60}	463.6	862.1	0.1048	1.8	304.2	557.9	13.0	685.8

a, b, c - coefficients form the equation $p = a + b\,(1-e^{-ct})$ where c represents degradation rate, B - Slowly degradable protein fraction, PD - potential protein degradability (a+b), t_0 - lag time, RSD - residual standard deviation, EPD - effective protein degradability calculated using rumen outflow rate k = 0.05 h^{-1}

a, b, c - koeficijenti iz jednadžbe $p = a + b\,(1-e^{-ct})$ gdje c predstavlja brzinu razgradnje, B - sporo razgradljive bjelančevine, PD - potencijalna razgradjivost bjelančevina (a+b), t_0 - vrijeme zaostatka, RSD - standardna devijacija ostatka, EPD - efektivna razgradljivost bjelančevina izračunata na osnovi brzine otjecanja digesta k = 0.05 h^{-1}

treatments are defined in table 1 - postupci su definirani na tablici 1

During wilting the concentration of undegradable dietary protein (UDP) declined (Table 5). In W_5 and W_7 the decline was due to the increase in protein degradability while in W_{26} it was the consequence of lower crude protein concentration.

Protein degradability of hay and factors which affect it

The protein degradability of sun cured hay (H) from Experiment 1 was at all incubation times significantly lower than in hay which was dried in shadow (H_{shadov}) (Table 1, Figure. 2). However, the direct effect of the drying method was confounded by the effect of particle losses, which were eliminated in H_{shadow}, but not in H. Therefore, we can not argue that the higher effective protein degradability in H_{shadow} (715.2 vs. 666.0 g kg^{-1}, Table 2) was due to considerably slower moisture losses (Figure 1), although it was the most possible reason for it.

More clear were the results from Experiment 2 where the same wilted material was barn dried (WBD) or dried in a hay-rack (WHR). There were no particle losses in either of the drying methods. However, the WHR expressed significantly lower protein solubility and degradability at 3, 6, 12 and 24 h (Table 3, Figure 3). The effective degradability was about 5% lower in WHR than in WBD (752.9 vs. 792.5 g kg^{-1}, Table 4). The difference was also reflected in UDP and estimated digestible UDP concentration, which were lower in WBD (Table 6).

Table 3. Solubility and cumulative protein degradability in the rumen at different incubation times (Experiment 2)
Tablica 3. Topivost (A) i kumulativna razgradnja bjelančevina u buragu kod različitih vremena inkubacije (pokus 2)

Treatments Postupci	Protein degradability in g kg^{-1} Razgradnja bjelančevina g kg^{-1}						
	A	3h	6h	12h	24h	48h	72h
WBD	404.8^{b}	435.5^{b}	704.8^{c}	864.0^{c}	921.0^{c}	940.3	946.0
WHR	404.5^{a}	393.0^{a}	616.3^{a}	811.5^{a}	897.5^{a}	942.5	939.0
FHR	526.5^{d}	513.3^{c}	685.3^{b}	848.0^{b}	924.0^{c}	942.3	937.5
FD_{40}	562.8^{e}	594.3^{d}	768.8^{d}	854.8^{bc}	917.8^{bc}	941.3	940.3
FD_{60}	489.5^{c}	506.8^{c}	675.3^{b}	858.8^{bc}	918.0^{bc}	939.5	935.8
WD_{40}	431.5^{b}	430.3^{b}	676.8^{b}	816.5^{a}	924.0^{c}	945.5	940.0
W_{60}	409.8^{a}	421.5^{b}	620.3^{a}	808.3^{a}	909.5^{b}	940.0	936.5
s.e.m.	4.0	5.5	4.5	4.2	3.1	2.7	2.5
sig.	0.001	0.001	0.001	0.001	0.001	n.s.	n.s.

- values sharing the same superscript do not differ significantly (P>0.05)
- jednako označene vrijednosti među sobom se ne razlikuju značajno (p>0.05)

treatments - postupci:
- WBD - grass wilted in the meadow and the barn dried - trava provela na livadi a poslije dosušena provjetravanjem
- WHR - grass wilted in the meadow and then dried on the hay-rack - trava provela na livadi a poslije dosušena na kozolcu
- FHR - fresh grass dried in the hay-rack - svježa trava osušena na kozolcu
- FD_{40}, FD_{60} - fresh grass dried in laboratory oven at 40 or 60°C - svježa trava osušena u laboratorijskom sušioniku na 40 ili 60°C
- WD_{40}, WD_{60} - wilted grass dried in laboratory oven at 40 or 60 °C - uvela trava dosušena u laboratorijskom sušioniku na 40 ili 60°C

Table 4. Protein degradability characteristics of fresh and wilted grass, hays and dried grass from Experiment 2.
Tablica 4. Karakteristike razgradnje bjelančevina svježe i uvele trave, sijena i osušene trave iz drugog pokusa

	Degradability characteristics - Karakteristike razgrađivanja							
	B	PDG	c	t_0	a	b	RSD	EPDG
	g kg^{-1}	g kg^{-1}	h^{-1}	h	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}
WBD	493.9	934.7	0.2403	3.0	-84.5	1019.2	14.0	792.5
WHR	527.7	932.2	0.1671	3.1	48.4	883.8	14.1	752.9
FHR	413.5	940.0	0.1707	3.2	228.9	711.1	3.6	799.4
FD_{40}	375.0	937.8	0.1534	2.4	398.5	540.4	26.9	814.5
FD_{60}	446.3	935.8	0.1783	2.8	198.5	737.3	9.0	792.6
WD_{40}	505.2	936.7	0.1842	2.9	74.0	862.7	22.5	775.2
WD_{60}	524.7	934.5	0.1563	2.8	119.0	815.5	6.2	755.5

all terms are defined in tables 2 and 3 - svi pojmovi su definirani na tablicama 2 i 3

Table 5. Concentrations of crude protein, proportions of neutral detergent insoluble and acid detergent insoluble N (NDIN and ADIN) and concentrations of undegraded (UDP) and digestible undegraded dietary protein (DUDP) in feeds from Experiment 1

Tablica 5. Koncentracije sirovih bjelančevina, proporcionalno u neutralnom detergentu i u kiselom detergentu netopivog N (NDIN i ADIN) i koncentracije nerazgradljivih (UDP) i probavljivih nerazgradljivih (DUDP) bjelančevina u krmivima iz prvog pokusa

	Crude protein Sirove bjelančevine	NDIN	ADIN	UDP[1]	DUDP[2]
	(g kg^{-1} DM) (g kg^{-1} ST)	(g kg^{-1} total N) (g kg^{-1} ukupnog N)	(g kg^{-1} total N) (g kg^{-1} ukupnog N)	(g kg^{-1} DM) (g kg^{-1} ST)	(g kg^{-1} DM) (g kg^{-1} ST)
F	105.7	-	-	36.0	-
W_5	110.5	-	-	35.0	-
W_7	116.6	-	-	34.9	-
W_{26}	100.0	-	-	34.0	-
H	90.8	275	117	30.3	17.7
H_{shadow}	110.5	226	96	31.5	18.8
$H_{sun\ 20}$	93.5	261	107	31.2	19.1
$H_{sun\ 40}$	92.1	285	115	32.6	19.8
D_{40}	119.2	299	136	34.0	16.0
D_{60}	110.8	423	130	34.8	18.4

[1] UDP = (crude protein x (1000 - EPD))/1000
UDP = (sirove bjelančevine x (1000 - EPD))/1000
[2] DUDP 0.9 x (UDP - ADIN g kg^{-1} DM)x6.25)
DUDP = 0.9 x (UDP - ADIN (g kg^{-1} ST) x 6.25)

treatments are defined in table 1 - postupci su definirani na tablici 1

Table 6. Concentrations of crude protein, proportions of neutral detergent insoluble and acid detergent insoluble N (NDIN and ADIN) and concentrations of undegraded (UDP) and digestible undegraded dietary protein (DUDP) in feeds from Experiment 2

Tablica 6. Koncentracije sirovih bjelančevina, proporcionalno u neutralnom detergentu i u kiselom detergentu netopivog N (NDIN i ADIN) i koncentracije nerazgradljivih (UDP) i probavljivih nerazgradljivih (DUDP) bjelančevine u krmivima iz drugog pokusa

	Crude protein Sirove bjelančevine	NDIN	ADIN	UDP[1]	DUDP[2]
	(g kg^{-1} DM) (g kg^{-1} ST)	(g kg^{-1} total N) (g kg^{-1} ukupnog N)	(g kg^{-1} total N) (g kg^{-1} ukupnog N)	(g kg^{-1} DM) (g kg^{-1} ST)	(g kg^{-1} DM) (g kg^{-1} ST)
WBD	161.2	217	52	33.4	22.5
WHR	159.2	300	68	39.3	25.6
FHR	158.4	255	64	31.8	19.5
FD_{40}	168.0	150	56	31.2	19.7
FD_{60}	167-8	223	59	34.8	22.4
WD_{40}	161.3	242	54	36.3	24.7
WD_{60}	158.4	253	66	38.7	25.4

[1] UDP = (crude protein x (1000 - EPD))/1000
UDP = (sirove bjelančevine x (1000 - EPD))/1000
[2] DUDP 0.9 x (UDP - ADIN g kg^{-1} DM)x6.25)
DUDP = 0.9 x (UDP - ADIN (g kg^{-1} ST) x 6.25)
Treatments are defined in table 2 - Postupci su definirani na tablici 2

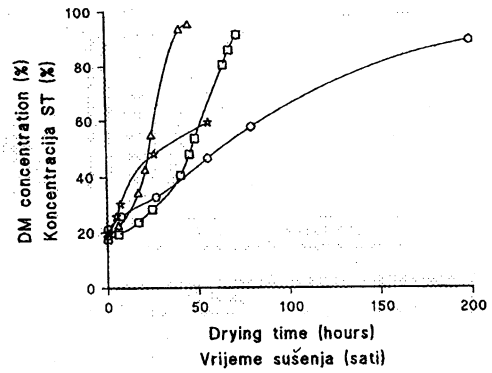

Figure 1. Changes of dry matter concentration during drying in the sun (☆), in the shadow (O) and in laboratory oven at 40 (□) or 60 (Δ) °C (Experiment 1)

Grafikon 1. Promjene u koncentraciji suhe tvari kod sušenja na suncu (☆), u sjeni (O) i u laboratorijskom sušioniku na 40 (□) ili 60 (Δ) °C (pokus 1)

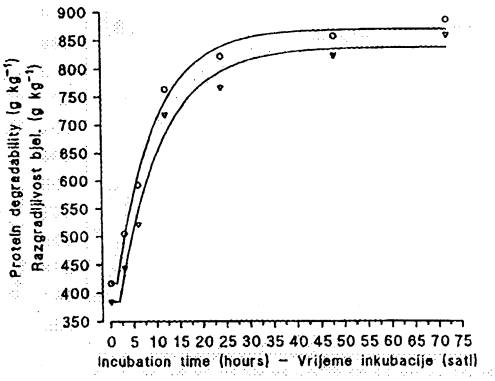

Figure 2. Protein degradability of hay dried in the sun (▽) or in the shadow (O) (Experiment 1)

Grafikon 2. Razgradljivost bjelančevina sijena sušenog na suncu (▽) ili u sjeni (O) (pokus 1)

Compared to the wilted material (WHR) the drying of fresh (unwilted) grass in hay-rack (FHR, Experiment 2) resulted in markedly higher soluble protein fraction (526.5 vs 404.5 g kg^{-1}) and higher protein degradability up to 24 h incubation time (Table 3, Figure 3). Since both samples contained similar amounts of crude protein (Table 6) it can be assumed that the difference was not due to particle losses during the wilting period. Lower effective

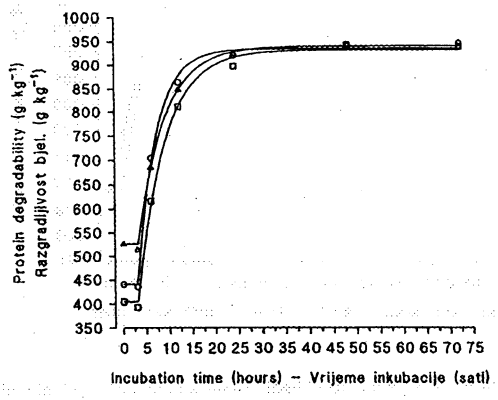

Figure 3. Protein degradability of barn dried hay (WBD, O), hay dried in a hay rack (WHR, □) and fresh grass dried in a hay rack (FHR, Δ) (Experiment 2)

Grafikon 3. Razgradljivost bjelančevina sijena sušenog s provjetravanjem (WBD, O), sijena sušenog na kozolcu (WHR, □) i svježe trave osušene na kozolcu (FHR, Δ) (pokus 2)

protein degradability in WHR compared to FHR (752.9 vs. 799.4 g kg^{-1}) was probably the consequence of more rapid moisture losses during the sun- curing, which was considered to play an important role in reducing the proteolysis.

The exposure of hay to sun rays seems to have only a minor effect on the protein degradability. Compared to hay sample (H) which was stored in shadow the exposure to sun rays for 40 days (H_{sun} 40) reduced the degradability at 12 h incubation time and onwards. The effective protein degradability was in H and $H_{sun\ 20}$ similar (666.0 and 666.2 g kg^{-1}) while in $H_{sun\ 40}$ it was slightly lower (645.6 g kg^{-1}).

Simulation of drying conditions in the laboratory

The results of both experiments showed that the drying temperature affects the extent of protein degradability as well as the course of its degradation in the rumen (Tables 1, 2, 3, 4 and Figure 4). Samples which were dried at 40°C (D_{40}, FD_{40}, WD_{40}) had higher protein solubility and higher degradability at shorter incubation times (3 and 6 h) than samples dried at 60°C. Effective protein degradability in samples dried at 40°C were 23.6 g kg

^{1} higher on average than in samples dried at 60 °C. From Figure 1 it is evident that at 40°C the moisture was lost at considerably slower rate than at 60°C and that can be one of the reasons for higher protein degradability. However, the temperature can also affect the protein degradability directly. The temperature of 40°C is close to the value which was found to be the optimal for the action of plant proteases (45 °C, Brady, 1961) while at higher temperatures they can be deactivated (Jones et al., 1995). On the basis of the results from artificially dried grass we can speculate about the reasons for higher protein degradability in barn-dried hay compared to the hay-rack dried hay. It is possible that in WBD a slight increase in temperature during the night period, when the hay was not aerated, enhanced the plant proteases and increased the protein degradability. Additional studies to distinguish between the direct and indirect effect of temperature on protein degradability are needed to clarify what is going on during barn drying, especially when the sun heated air is used.

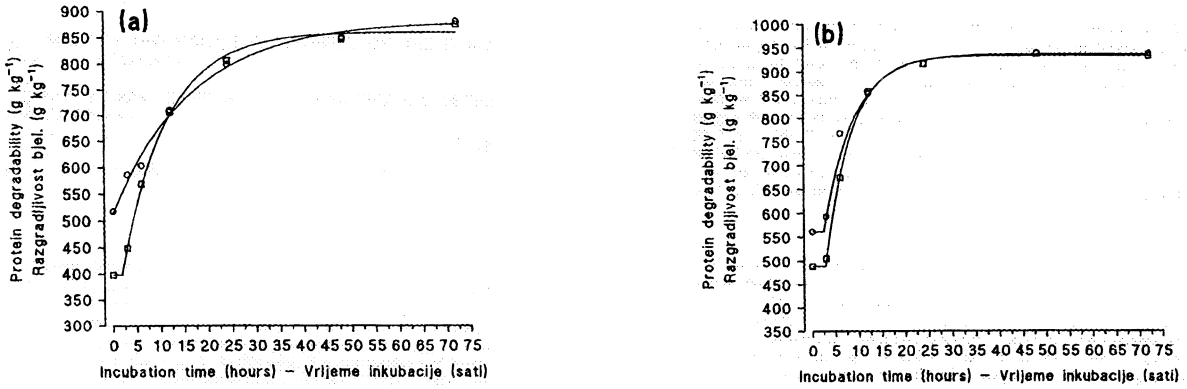

Figure 4. Protein degradability of samples dried in laboratory oven at 40 (D_{40}, O) or 60 (D_{60}, □) °C in the first (a) or second (b) experiment

Grafikon 4. Razgradljivost bjelančevina uzoraka trave osušenih na 40 (D_{40}, O) ili 60 (D_{60}, □) °C u prvom (a) i u drugom (b) pokusu

CONCLUSIONS

The results of this study have confirmed that hay-making procedures affect the ruminal protein degradability of hay. A difference of about 50 g kg^{-1} in effective protein degradability can be attributed to various preservation methods. Although the difference was about two times lower than the expected difference between the intensively and extensively used meadows, it can not be neglected.

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SAŽETAK

Razgradljivost bjelančevina trava, uvele trave, trave osušene u laboratorijskom sušioniku i odgovarajućeg sijena proučavana je metodom najlonskih vrećica. U prvom pokusu komparativno je istraživana svježa (zamrznuta) trava (F), zamrznut materijal koji je venuo 5, 7 odnosno 26 sati (W_5, W_7, W_{26}), materijal osušen u laboratorijskom sušioniku kod 40 i 60°C (D_{40} i D_{60}), sijeno prirodno sušeno na suncu (H), sijeno sušeno u sjeni (H_{shadow}) i sijeno izloženo sunčanim zrakama 20 ($H_{sun\ 20}$) ili 40 ($H_{sun\ 40}$) dana .U drugom pokusu uspoređivane su svježa trava i uvela trava dosušena u laboratorijskom sušioniku kod 40 odnosno 60°C (FD_{40}, WD_{40}, FD_{60} i WD_{60}), svježa trava osušena u sušnici za sijeno (FHR), uvela trava dosušena u sušnici za sijeno (WHR) i uvela trava dosušena provjetravanjem (WBD). U početnom razdoblju venjenja (7 sati) efektivna razgradljivost bjelančevina (EPD) malo je porasla (za oko 40 g kg^{-1}). Kasnije kod dužeg vremena venjenja (26 sati) ona se smanjila, međutim nije sasvim jasno da li se razgradljivost smanjila zbog direktnog utjecaja venjenja ili zbog mehaničkih gubitaka tijekom sušenja. Efektivna razgradljivost bjelančevina u H bila je manja nego u H_{shadow} (666.0 prema 715.2 g kg^{-1}) i u WHR manja nego u WBD (752.9 prema 792.5 g kg^{-1}). Kod sijena izloženog sunčanim zrakama $H_{sun\ 20}$ (666.2 g kg^{-1}) i $H_{sun\ 40}$ (645.6 g kg^{-1}) EPD se nije bitno razlikovao od prirodno sušenog sijena H (666.0 g kg^{-1}). EPD kod uzoraka sušenih na 40°C bila je dosljedno veća nego kod odgovarajućih uzoraka sušenih na 60°C (715.0 prema 685.8, 814.5 prema 792.6 i 775.2 prema 755.5 g kg^{-1}). Može se zaključiti da različiti postupci kod sušenja sijena doprinose oko 50 g kg^{-1} varijabilnosti u EPD.