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Adam RADKOWSKI[1] and Iwona RADKOWSKA[2]

ESTIMATION OF NUTRITIONAL VALUE OF THE SILAGES FROM SELECTED GRASS-LEGUME MIXTURES UTILIZED IN ECOLOGICAL AGRICULTURE

OCENA WARTOŚCI POKARMOWEJ KISZONEK Z WYBRANYCH MIESZANEK TRAWIASTO-MOTYLKOWYCH STOSOWANYCH W ROLNICTWIE EKOLOGICZNYM

Abstract: This work presents the evaluation of the chemical composition and nutritive value of silages prepared from the selected grass-legume mixtures, which are recommended for the meadow sowing in ecological farms. Prepared plant material was subjected to the analysis of the basic chemical composition by the standard method, the analysis of NDF, ADF and ADL content using ANKOM Fiber Analyser according to the method of Goering and Van Soest. The nutritive value was evaluated in the INRA 1988 units using Winwar 1.6 software (DJG). The estimation was done on the basis of tabular coefficients of forage distribution in the rumen and intestines. The content of organic components was very diversified, what can be the result of the differentiated share of grasses and legumes in the examined silages.

The samples of silages collected from the examined mixtures were characterized with significantly higher mean contents of the investigated organic components than did the silage from the control object *ie* perennial sward. In the examined silages from the grass-legume mixtures the growth of the content of raw ash – by 53 %, total protein – by 46 % and raw fat – by 69 % (mean values for all mixtures) in comparison with the respective values of the control object was noticed. On the other hand, these silages were characterized with 14 % lower crude fiber content, 8, 21 and 25 % lower level of ADF (acid detergent fiber), ADL (acid detergent lignin) and NDF (neutral detergent fiber), respectively. It indicates that grass-legume plants of new highly productive cultivars are very important factor affecting the forage quality. High concentration of nutrients in silages derived from the examined mixtures in comparison with the silage from the perennial sward suggests that they are excellent material for the perennial meadow undersowing.

Keywords: silages, organic components, nutritive value

In recent years there is an increasing consumer concern about ecological food, what is strictly connected with the requirement for the proper method of its production. In

[1] Department of Grassland Management, Institute of Plant Production, Agricultural University of Krakow, al. A. Mickiewicza 21, 31–120 Kraków, Poland, phone: +48 12 662 43 61, fax: +48 12 633 62 45, email: rrradkow@cyf-kr.edu.pl

[2] National Research Institute of Animal Production Balice n. Krakow, ul. Krakowska 1, 32–083 Balice, Poland, phone: +48 66 608 12 49, email: iradkowska@izoo.krakow.pl

ecological farms with animal production the forages from ecological cultivations need to be utilized. The bulk fodders derived from grasslands are of a great importance, especially in the cattle feeding. As green forages, silages and hay constitute the basis of ruminant feeding they should be characterized with high quality and high nutritive value, should be microbiologically clean and free of microtoxins [1, 2].

The meadow and pasture sward in ecological farms is characterized with high diversity, the herbs contribute in the improvement of the forage palatability and influence the digestive tract activity of animals. Moreover, due to the content of legumes which are able to fix the nitrogen from the atmosphere, they are valuable source of this element for the other plants, what allows to significantly limit the level of mineral, nitrogen fertilization. The production efficiency in the eco-farms is highly affected by the environmental conditions, feeding technology used, kind of forages as well as breeding material. Good forage resource, the utilization of the proper preservation technique and the quality of the grass sward in the meadows and pastures are fundamental for the high yields of the dairy cows [3]. Reference data indicate that the silages from the meadow grasses in the ecological farms are poor in calcium, phosphorus, magnesium, manganese, zinc and beta carotene in the context of the requirements of ruminants. As a result this deficiency need to be supplemented with the vitamin preparations. The conditions of the grasslands and the quality of bulky fodder directly influence the conditions of the animals, their well-being, yielding and the quality of animal production, what is of great importance in the ecological agriculture more interested in the quality than in the maximization of the production [4].

The aim and scope of the study

The aim of the conducted study was to compare the chemical composition and the forage value of the silages derived from the grass-legume mixtures and from the perennial meadow sward. The following variants were taken into account:

Variant 1 – control object, silages derived from the perennial sward of the meadows typical for the farms of the investigated area. It constituted the initial material for the comparison with the other variants.

Variant 2 – silage derived from the mixture of the following composition: late perennial ryegrass (t) 45 %, late perennial ryegrass (d) 30 %, timothy grass 10 %, intermediate perennial ryegrass (d) 10 %, white clover 5 %.

Variant 3 – silage derived from the mixture of the following composition: meadow fescue 25 %, early perennial ryegrass 10 %, intermediate perennial ryegrass 10 %, late perennial ryegrass 10 %, smooth-stalked meadowgrass 10 %, red fescue 10 %, white clover 10 %, red clover 10 %, timothy grass 5 %.

Variant 4 – silage prepared from the mixture of the following composition: red clover 30 %, meadow fescue 30 %, early-intermediate perennial ryegrass 20 %, timothy grass 20 %.

Variant 5 – silage derived from the mixture of the following composition: lucerne 80 %, meadow fescue 15 %, timothy grass 5 %.

Variant 6 – silage derived from the mixture of the following composition: westerwold (dutch) ryegrass 80 %, persian clover 20 %.

Variant 7 – silage derived from the mixture of the following composition: intermediate perennial ryegrass (t) 40 %, late perennial ryegrass (t) 35 %, red clover 20 %, white clover 5 %.

The scope of the study included the estimation of the mixture kind influence on the content of nutrients in the silage.

Materials and methods

The field experiment was conducted in the years 2006–2008 in the private, individual farms in Silesia province, located at the altitude of 300–320 m.

The experiment of a sward character, was located in the brown, acidic soil (pH_{KCl} = 5.0–5.2) of a V soil quality class. The soil was characterized with a medium content of the assimilable potassium, manganese and zinc and low level of the assimilable phosphorus and copper.

During the vegetation (April–September) the average rainfall amounted to 338.1; 375.4 and 320.3 mm, respectively in the year 2006, 2007 and 2008, whereas average air temperatures reached the values of 15.2 ^{o}C; 14.3 ^{o}C and 14.9 ^{o}C, respectively.

The meadows were fertilized with a cattle manure in a single dose of 25 Mg (ton) · ha^{-1} used ones in the early spring. The content of chemical components of the manure was as follows: dry matter – 24.2 %; total N – 0.52 %; P – 0.15 %; K – 0.57 %; Ca – 0.28 %; Mg – 0.08 %; Na – 0.07 %.

25 Mg dose of manure provided: 130 kg of total nitrogen, 38 kg of phosphorus, 143 kg of potassium, 70 kg of calcium, 20 kg of magnesium and 18 kg of sodium.

The area of each field amounted to 500 m^2. The silages were derived from the first swath of the meadow flora. The plant material was collected in two stages, the first included mowing of the plants at the turn of earing and flowering stage of grasses with a rotary mower, than the green fodder was slightly dried by one-time turning it over. The fodder was raked 30 minutes before picking up. The material was collected using constant-chamber baler, then it was transported to the storage place and wrapped using bale wrapper. The average time from the bale forming to its wrapping with foil did not exceed 4 hours.

Before grazing the samples of silages were collected for the chemical analysis, which comprise the determination of the fundamental components by the Weenden method [5], pH using pH-meter, the ammonium level by the Conway method [6]. The content of organic acids was evaluated using the Varian 3400 type gas chromatograph. The nutritive value was evaluated in the INRA 1988 units using Winwar 1.6 software (DJG). The estimation was done on the basis of tabular coefficients of forage distribution in the rumen and intestines. The obtained results were subjected to the analysis of variance, and the significance of differences was estimated on the basis of Duncan test at the significance level of α = 0.05.

Results and discussion

As it is well known, silages and hay silage are first of all the source of protein in the feeding dose for dairy cows and cows during drying off as well as for young cattle [7]. The total protein content in the selected silages was diversified and fluctuated in the range of 96.2 – 251.6 g · kg^{-1} d.m. (Table 1). The highest value was determined in the silage derived from the mixture of the following composition: lucerne 80 %, meadow fescue 15 %, timothy grass 5 %. The data found in literature suggest that forage of good quality should contain 140–160 g of protein in kg of dry matter [8]. In that light it can be concluded that the level of protein in the absolutely dry matter of the control object was insufficient. On the other hand, all silages derived from the objects seven with new grass-legume mixtures were characterized with the values exceeding the optimal level of this component in the absolutely dry matter. The evaluation of the raw fat content in the dry matter provided information that its level was on average 66 % higher in the silages derived from the investigated mixtures than in the control material. Average raw fat content in the silages of high quality is estimated to be 40.0 g · kg^{-1} d.m. [5]. The content of this component in the examined silages was variable and fluctuated in the range of 33.7–62.2 g · kg^{-1} d.m., with the mean value of 53.5 g · kg^{-1} d.m. determined for the silages derived from the grass-legume mixtures. Fat in a feeding dose not only increases the energy concentration but also improves its palatability and utilization, constitutes the source of fat-soluble vitamins (A, D and E) and *polyunsaturated fatty acids* (PUFA). This component is of great importance as highly effective animals require high energy food.

The silages derived from the grass-legume mixtures were characterized with significantly lower level of raw fiber, which was on average 14 % lower than the value observed for the control object. The level of ADF (*acid detergent fiber*), ADL (*acid detergent lignin*) and NDF (*neutral detergent fiber*) fiber fractions were also higher in the control material and were not utilized by ruminants. It is assumed that 230–260 g g · kg^{-1} d.m. is the optimal raw fiber content in the dry matter of a food dose destined for the lactating cows. The respective optimal values for NDF, ADF and ADL fractions are: 420–500 g · kg^{-1} d.m., 240–290 g · kg^{-1} d.m. and 20–30 g · kg^{-1} d.m. [9]. It is worth to emphasize that components of the cell membranes after their bacterial decomposition are substantial energy source for ruminants. NDF content in a food ration gives the information about the forage utilization ability (the higher value the lower intake), whereas the content of *acid detergent fiber* (ADF) determines its digestability (the higher ADF content the lower digestability).

The content of organic acids is an important indicator of the quality and feeding value of silages [10].

Silage of good quality should be characterized with 4.2 pH reaction. The lower pH value (and the higher acidity), the higher content of lactic acid is stated in the silage. On the other hand, pH level equal or exceeding 5.0 is linked with the presence of butyric acid [11]. However, our research did not confirm this relationship. The high quality silage should contain lactic and acetic acid, the latter being present in the smaller

Table 1

Chemical composition of silages (means for three years of investigations)

Specification	Variant							SD	V [%]
	1	2	3	4	5	6	7		
	[g · kg^{-1} d.m.]								
pH	4.78 b*	4.41 a	4.51 a	4.60 a	4.78 b	4.79 b	4.57 a	0.15	3.27
Raw ash	84.2 a	159.3 b	153.7 b	151.7 b	177.0 c	150.1 b	159.8 b	148.0	29.5
Total protein	96.2 a	190.3 b	191.1 b	221.4 bc	251.6 c	210.4 bc	213.0 bc	196.3	48.7
Crude fiber	338.6 c	294.8 b	290.4 b	288.8 ab	281.6 a	293.3 b	296.2 b	297.7	18.7
Raw fat	35.2 a	55.9 b	61.8 c	62.2 c	33.7 a	56.2 b	50.9 b	50.8	11.8
Non-nitrogen extract	445.9 c	299.7 b	302.9 b	276.0 a	256.0 a	289.9 ab	280.1 ab	307.2	63.2
ADF	398.6 b	366.0 a	375.4 b	360.8 a	365.8 a	352.5 a	370.4 ab	369.9	14.6
ADL	72.8 b	51.1 a	53.7 a	50.6 a	84.1 c	47.5 a	58.0 ab	59.7	13.6
NDF	633.3 c	495.4 ab	499.1 ab	467.8 ab	395.0 a	513.0 b	490.1 ab	499.1	70.8
Lactic acid	10.12 b	10.04 b	8.23 ab	7.14 a	11.16 c	8.39 ab	11.86 c	9.56	1.70
Acetic acid	7.25 d	4.62 c	1.71 a	3.18 b	4.27 c	4.33 c	4.24 c	4.23	1,67
Butyric acid	—	—	—	0.29 a	0.33 a	—	—	0.31	0.03
Points in Flieg-Zimmer scale	74	86	98	66	72	80	92	—	—
Total note	good	very good	very good	good	good	good	very good	—	—
Content of N-NH_3 in total N [%]	4.70 a	6.32 b	8.31 c	8.54 c	10.52 d	7.94 bc	6.76 b	1.86	24.54
UFL [kg^{-1} d.m.]	0.705 a	0.771 b	0.783 b	0.786 b	0.789 b	0.776 b	0.761 b	0.03	3.79
UVF [kg^{-1} d.m.]	0.610 a	0.696 a	0.709 ab	0.711 ab	0.720 b	0.700 a	0.685 a	0.04	5.38
PDIN [g · kg^{-1} d.m.]	55 a	109 ab	112 ab	127 ab	145 b	121 ab	125 ab	28.31	24.96
PDIE [g · kg^{-1} d.m.]	55 a	60 ab	62 ab	69 ab	72 b	63 ab	65 ab	5.65	8.87

* Means marked with the same letter are not statistically different following verification with the Duncan test (P = 0.05). ADF (*acid detergent fiber*), ADL (*acid detergent lignin*) and NDF (*neutral detergent fiber*), UFL – *Feed Unit for Lactation* (1700 kcal EN), UVF – *Meat production Unit* (1820 kcal EN), PDIE – *protein digested* in the small intestine supplied by rumen-undegraded dietary protein plus protein digested in the small intestine supplied by microbial protein from rumen-fermented organic matter, PDIN – *protein digested* in the small intestine supplied by rumen-undegraded dietary protein plus protein digested in the small intestine supplied by microbial protein from rumen-degraded protein.

quantities. The presence of butyric acid indicates the low quality and the level of 10 g · kg^{-1} d.m. very low quality of silage.

The lactic acid content, the most desirable in silages, ranged from 7.14 to 11.86 g · kg^{-1} d.m. The acetic acid level was changeable and fluctuated in the range of 1.71–7.25 g · kg^{-1} d.m. Butyric acid was present in two variants in quantities of

0.29–0.33 g · kg^{-1} d.m., what in a consequence substantially determined lower total note of these silages. It possibly could be linked with too high share of legumes in the silages.

The content of ammonia nitrogen is an indicator of the depth of proteolysis and protein degradation processes. The content of N-NH_3 expressed in relation to the total nitrogen level determines the silage quality. The investigated silages were characterized with diversified level of this component which was equal to 4.70–10.52 %. These values were consistent with the required values and indicate high quality of silages as the N-NH_3 to total N ratio is taken into account.

As the energy value is taken into consideration the examined silages were not very diversified: UFL (V = 3.8 %) and UVF (V = 5.4 %). Higher level of diversification was stated in the case of the protein value which amounted to 55–145 for PDIN (V = 25.0 %) and 55–72 g · kg^{-1} d.m. for PDIE (V = 8.9 %). The mean value of this parameter in the silages from the investigated mixtures was higher when compared with the control object by 55 % for PDIN and 16 % for PDIE.

Analyzing the content of organic components it can be observed that lower values were determined for the silages from the perennial sward. The silages prepared from the grass-legume mixtures are characterized with very high quality what is reflected in their relatively high nutritive value. The kind of green fodders utilized for the preparation of silages has also some influence on the silage consumption. Zielinska et al [12] in their research reported higher degree of dry matter consumption and higher milk production for cows fed silages from legumes and their mixtures with grasses when compared with the silages prepared from grasses alone.

Conclusions

1. It was stated, that utilized grass-legume mixtures were characterized with significantly higher content of organic and mineral components when compared with the control object.

2. The content of total protein and raw fat in silages derived from the grass-legume mixtures was respectively 46 and 69 % higher than the respective values noticed for the control object.

3. UFL and UVF values of silages from the examined mixtures were respectively 9 and 13 % higher when compared to the control object. The PDIN and PDIE values were higher by 55 and 16 %, respectively.

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OCENA WARTOŚCI POKARMOWEJ KISZONEK Z WYBRANYCH MIESZANEK TRAWIASTO-MOTYLKOWYCH STOSOWANYCH W ROLNICTWIE EKOLOGICZNYM

[1] Zakład Łąkarstwa, Instytut Produkcji Roślinnej
Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie
[2] Instytut Zootechniki – Państwowy Instytut Badawczy w Balicach koło Krakowa

Abstrakt: W pracy przedstawiono ocenę składu chemicznego i wartości paszowej kiszonek z wybranych mieszanek trawiasto-motylkowych, które zalecane są do obsiewu łąk w rolnictwie ekologicznym. W przygotowanym materiale roślinnym oznaczono podstawowy skład chemiczny metodą standardową, analizy na zawartość NDF, ADF i ADL przeprowadzono za pomocą aparatu ANKOM Fiber Analyser, według metody zaproponowanej przez Goeringa i Van Soesta. Wartość pokarmową wyznaczono w jednostkach systemu INRA 1988 za pomocą programu komputerowego Winwar, wersja 1.6. firmy DJG. Do wyceny posłużono się tabelarycznymi współczynnikami rozkładu pasz w żwaczu oraz jelitach. Zawartość składników organicznych i mineralnych wykazywała dużą zmienność, co może wynikać ze zróżnicowanego udziału traw i roślin motylkowatych w badanych kiszonkach.

Próbki kiszonek pobrane z badanych mieszanek odznaczały się znacznym wzrostem średniej zawartości badanych składników organicznych w porównaniu z obiektem kontrolnym, jakim była kiszonka z wieloletniej runi. W badanych kiszonkach pochodzących z mieszanek trawiasto-motylkowych wykazano wzrost zawartości (uśredniono zawartości wszystkich mieszanek): popiołu surowego o 53 %, białka ogólnego o 46 %, tłuszczu surowego o 69 % w porównaniu z obiektem kontrolnym. Z kolei przy zawartości włókna surowego odnotowano spadek o 14 %, a frakcji włókna ADF (kwaśne włókno detergentowe), ADL (kwaśna lignina), NDF (neutralne włókno detergentowe) odpowiednio o 8 %; 21 % i 25 % w stosunku do obiektu kontrolnego. Wskazuje to, że bardzo ważnym czynnikiem wpływającym na jakość kiszonek są rośliny trawiasto-motylkowe, składające się z nowych odmian wysoko wydajnych. Duża koncentracja składników pokarmowych zawarta w kiszonkach pochodzących z badanych mieszanek w porównaniu z kiszonką z runi wieloletniej przemawia za faktem wykonania podsiewu tymi mieszankami łąk wieloletnich.

Słowa kluczowe: kiszonki, składniki organiczne, wartość pokarmowa