ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 17, No. 8 2010

Iwona RADKOWSKA[1] and Adam RADKOWSKI[2]

NUTRITIVE VALUE OF MEADOW SWARD SILAGES DEPENDING ON THE TYPE OF FERTILIZATION

WARTOŚĆ POKARMOWA KISZONEK Z RUNI ŁĄKOWEJ W ZALEŻNOŚCI OD RODZAJU NAWOŻENIA

Summary: The aim of the conducted studies was an estimation of the quality and nutritive value of silages derived from the meadow sward as affected by the kind of fertilization used. The following variants were taken into account: the control object without fertilization, NPK mineral fertilization, fertilization with manure and fertilization with liquid manure.

The conducted fertilization resulted in the significant growth of the mean organic matter and total protein content, what in turn influenced the higher nutritive value expressed as UFL, UVF, PDIN and PDIE in comparison to the non-fertilized object. Treatment with natural fertilizers affected the increased level of organic matter and total protein by 4 and 21 %, respectively when compared with the respective values found for the silages derived from the control object. Furthermore, the increment of nutritive value amounted to 13 % – UFL, 17 % – UVF, 13 % – PDIN and 11 % – PDIE. In that light, it can be stated that organic fertilization contributes in the increase of the silage quality. The highest growth of the total protein content was observed in the silage derived from the manure fertilized object. On the basis of this observation, it can be stated that properly chosen organic fertilization helps to achieve high quality silages.

Keywords: fertilization, silages, quality and nutritive value

The period of winter feeding in Poland lasts for about 200 days. Thus the production of preserved forages is necessary, which enable the uniform and fully-valuable animal feeding during the whole year [1, 2]. In many farms, because of the necessity of the reduction of costs and because of the high nutritive value, pasture forages constitute a basis of the summer feeding of cows. Above 70 % of the yield from the permanent grasslands is collected in the form of hay and pasture green forage, but only 5 % of this is ensilaged. This phenomenon is disadvantageous, because when compared with hay

[1] National Research Institute of Animal Production Balice, ul. Krakowska 1, 32–083 Balice, Poland, phone 666 08 11 49, email: iradkowska@izoo.krakow.pl

[2] Department of Grassland, Agricultural University of Krakow, al. A. Mickiewicza 21, 31–120 Kraków, Poland, phone 012 662 43 61, fax 012 633 62 45, email: rrradkow@cyf-kr.edu.pl

silage is characterized with lower level of losses of the nutrients and at the same time higher nutritive value [3]. Silages are fully-valuable and the cheapest forages in the winter feeding of ruminants, especially in the case of simplified feeding systems [4, 5]. The quality of the silage is determined by many chemical and physical parameters. The most important are: the content of saccharides and buffering substances, the dry matter level, soil structure and pollutions [6, 7]. Many of this factors is influenced by the kind of utilized fertilization, especially nitrogen, which negatively affects the ensilage process.

The aim and scope of the study

The aim of the study was to evaluate the quality of the obtained silage in term of the utilized fertilization system. The estimation comprised mainly the determination of the effect of the applied fertilization on the level of collected nutrients in the silage. Three kinds of fertilization were applied to accomplish the goal. Four variant were taken into account in the experiment, ie:

Variant 1 – the control object, the silage derived from the non-fertilized sward,
Variant 2 – the silage derived from the minerally fertilized object – NPK,
Variant 3 – the silage derived from the object fertilized with manure,
Variant 4 – the silage derived from the object fertilized with liquid manure.

Materials and methods

The field experiment was conducted in the years 2006–2008 in the private, individual farm in Solca, in the Gmina Pilica administrative district, within Zawiercie County, Silesia province, located on the altitude of 320 m. One-factor experiment was located on the brown, acidic soil (pH_{KCl} amounted to 5.2) of a V quality class. The soil contained medium level of assimilable potassium, manganese and zinc and was poor in assimilable phosphorus and copper.

During the vegetation period (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; 14.3 and 14.9 ^{o}C, respectively.

The kind of fertilization was a determining factor in the study. In the fertilization of the meadow in the variant with the mineral fertilization the following fertilization was used: after the first regrowth – 80 kg N · ha^{-1} and after the II regrowth – 60 kg N · ha^{-1} in the form of ammonium saltpetre, phosphorus once in the spring in the amount of 120 kg P_2O_5 · ha^{-1} as a triple superphosphate and potassium after the first and second regrowth – 60 kg K_2O · ha^{-1} for each regrowth as 57 % potassium salt. In the variant fertilized with manure the cattle manure in a dose of 25 Mg · ha^{-1} was applied in the early spring. The content of chemical components in manure was as follows: dry matter – 24.2 %; total N – 0.52 %; P – 0.15 %; K – 0.57 %; Ca – 0.28 %; Mg – 0.08 and Na – 0.07 %.

In a 25 Mg of manure the following levels of components were derived: total N – 130 kg, P – 38 kg, K – 143 kg, Ca – 70 kg, Mg – 20 kg and Na – 18 kg.

As it come to the variant fertilized with liquid manure, the cattle liquid manure in an amount of 20 $m^3 \cdot ha^{-1}$ was applied, which was divided on a two equal doses for a first and second regrowth. Liquid manure contained: dry matter – 6.7 %; total N – 0.66 %; P – 0.14 %; K – 0.27 %; Ca – 0.24 %; Mg – 0.11 % and Na – 0.08 %. Thus with a dose 10 m^3 of liquid manure the following amounts of components were provided: total N – 66 kg, P – 14 kg, K – 27 kg, Ca – 24 kg, Mg – 11 kg and Na – 8 kg.

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 [8], pH using pH-meter, the ammonium level by the Conway method [9].

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 $\alpha = 0.05$.

Results and discussion

The estimation of the quality and real nutritive value of the silages is basic for the proper utilization of these material in the cattle feeding. The complex evaluation of the silage quality includes the determination of:

– chemical factors of quality, which describe the correctness of the fermentation proceeding and are important indicators of the chemical characteristic of the silage quality (pH, lactic, acetic, butyric and valeric acid, the share of $N\text{-}NH_3$ in relation to the total protein, NDF, ADF, ADL),

– the nutritive value expressed in the feed unit for lactation (UFL) or meet production unit (UVF) and the content of the protein digested in the intestines [10].

The chemical characteristic of the silage quality includes the estimation of the fundamental chemical composition (what enables the estimation of the silage nutritive value). The knowledge of the content of structural carbohydrates (NDF, ADF and ADL) is also very important in the evaluation of the silage quality [11].

The study revealed the impact of the applied fertilization on the content of organic components and nutritive value of the meadow sward (Table 1). The concentration of the particular components in silages was diversified and affected by the kind of fertilization used. Utilized in the investigation fertilization had various effect on the content of selected components. Among all examined components the highest

diversification was found for the level of total protein (V = 21.7 %), and its content ranged from 7.40 to 11.40 g · kg^{-1}. Mineral fertilization and treatment with manure affected a significant growth of the organic mass content when compared with the control object – the differences amounted to respectively 10 and 8 %. Fertilization with minerals, manure and liquid manure resulted in the significant decrease of the crude fiber in silages derived from the meadow sward (by 10, 8 and 4 %) in relation to the control object. As a result of mineral fertilization and application of manure a significant increase of the raw fat content was determined, which concentration raised by 9 and 6 % in comparison with the silage prepared from the meadow sward collected from the non-fertilized object. In the case of the object fertilized with liquid manure a 10 % decrease in the concentration of this component was noticed.

Table 1

The chemical composition of the silages as affected by the fertilization kind (means for three years)

Specification	Variant			
	Control	Mineral fertilization	Manure	Liquid manure
pH	6.04 a*	6.03 a	6.16 ab	6.49 b
[g · kg^{-1} dry matter]				
Organic matter	74.0 a	81.9 b	80.4 b	74.0 a
Total protein	74.0 a	110.0 b	114.0 b	79.7 ab
Crude fiber	389.5 b	349.6 a	357.4 ab	373.2 b
Raw fat	28.5 a	31.2 b	30.3 b	25.8 a
Non-nitrogen extract	434.1 ab	427.3 a	417.8 a	447.4 b
ADF	445.3 b	409.0 a	405.5 a	451.8 b
ADL	59.0 a	67.4 b	56.1 a	77.3 b
NDF	705.6 b	645.0 a	642.6 a	680.3 b
Lactic acid	2.34 a	4.98 b	6.63 c	2.85 a
Acetic acid	9.80 b	8.66 ab	7.85 a	9.10 b
Content of N-NH_3 in total N [%]	0.039 a	0.054 ab	0.078 b	0.047 ab
UFL [kg^{-1} d.m.]	0.647 a	0.744 b	0.748 b	0.749 b
UVF [kg^{-1} d.m.]	0.547 a	0.658 b	0.664 b	0.665 b
PDIN [kg^{-1} d.m.]	49 a	73 b	78 b	51 a
PDIE [kg^{-1} d.m.]	67 a	81 b	81 b	71 ab

* 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, UVF – Meat production Unit, 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.

As it was mentioned before, the knowledge of the content of structural carbohydrates (NDF, ADF and ADL) is of a great importance in the evaluation of the silage quality. As a result of the mineral fertilization and fertilization with manure significant reduction in the content of the ADF (*acid detergent fiber*) fraction was observed, which amounted to 8 and 9 %, respectively, in relation to the non-fertilized object. The concentration of the ADL (*acid detergent lignin*) decreased only in the object fertilized with manure (5 % in relation to the control object). On the other hand, the content of NDF (*neutral detergent fiber*) was 9.9 and 4 % lower in the objects treated with mineral fertilizer, manure and liquid manure than the NDF level in the control field.

The pH value, the concentration of the organic acids, the share of ammoniacal nitrogen in the total nitrogen content are among the most important factors characterizing the proceeding of the fermentation processes [3]. The silage acidity (pH) indicates the intensity of the fermentation processes [12]. The pH level in the examined silages fluctuated in the range of 6.03–6.49 in dependence on the fertilization variant.

The content of organic acids formed during the ensilage process was diversified. In this experiment the content of lactic acid ranged from 2.34 to 6.63 $g \cdot kg^{-1}$ dry matter and was very diversified (V = 47.2 %). The level of acetic acid fluctuated in the range of 7.85–9.80 $g \cdot kg^{-1}$ dry matter (V = 9.2 %). The content of ammoniacal nitrogen in analysed variants was low what indicates good quality of the silages as regards $N\text{-}NH_3$ content in relation to the total nitrogen.

As regards the energetic value the investigated forages were characterized with the similar UFL and UVF values. However, as a consequence of the applied mineral fertilization, manure and liquid manure 14, 13 and 14 % growth of the UFL value in relation to the control object was noticed. The respective differences stated for the UVF level between the fertilized objects and non-fertilized object were equal to 18, 17 and 18 %.

On the contrary, the protein value was more diversified and fluctuated in the range of 49–78 for PDIN (V = 23.7 %) and 67–81 $g \cdot kg^{-1}$ d.m. for PDIE (V = 9.5 %). It was on average 20 % (PDIN) and 13 % (PDIE) higher in the fertilized object than the values determined for the control object.

Conclusions

1. The application of natural fertilizers, especially manure, had a great impact on the chemical composition of the examined silages. The positive effect of fertilization was found in the case of the content of total protein, raw fat, ADF, ADL and NDF fractions of fiber.

2. As regards the nutritive value the studied silages were characterized with similar UFL and UVF values. On the contrary, the protein value was significantly higher under the treatment with manure and mineral fertilizers. The fertilization with liquid manure had lower impact on the nutritive value.

References

[1] Haigh P.M.: *Effluent production from grass silages treated with additives and made in large-scale bunker silos*. Grass Forage Sci. 1999, **54**, 208–218.

[2] Han K.J., Collins M., Vanzant E.S. and Dougherty C.T.: *Charakteristics of baled silage made from first and second harvests of wilted and severely wilted forages*. Grass Forage Sci. 2006, **61**, 22–31.
[3] Nowak J. and Šařec P.: *Wybrane czynniki decydujące o jakości kiszonek w belach cylindrycznych*. Post. Nauk Rol. 2001, **5**, 95–110.
[4] Haigh P.M.: *A note of relationship between oven and toluene determined dry matter concentrations in big-bale grass silages*. Irish J. Agricult. Food Res. 1995, **63**(1), 189–191.
[5] Lingvall P.: *The bale silage technology. Factors influencing fermentation, hygienic quality, storage stability and production costs*. XIIIth Int. Silage Conf., Auchincruive, Scotland 2002, 162–163.
[6] Gudmundsson B.: *The influence of number of layers in big bales on silage quality when stored outdoors on shady and sanny sides of buildings*. Proc. 326th The Nordic Association of Agr. Scientists (NJF) Production and utilization of silage, Lillehammer, Norway 2001, 125–127.
[7] Weinberg Z.G. and Ashbell G.: *Enginering aspects of ensiling*. Biochem. Eng. J. 2003, **13**, 181–188.
[8] Kamiński J., Borowiec F., Furgał K., Barteczko J., Kowalski Z., Pyś J.B., Siuta A., Pisulewski P. and Lehman B.: Ćwiczenia z żywienia zwierząt i paszoznawstwa. Skrypt, AR w Krakowie, Kraków 1995.
[9] Conway E.J.: Microdiffusions Analysis and Volumetric Error. Crosby Locwood, London 1962.
[10] Podkówka W. and Potkański A.: *Wpływ czynników chemicznych i fizycznych na przydatność pasz do zakiszania*. Post. Nauk Rol. 1993, **40**, 29–42.
[11] Rhein R.T., Coblentz W.K., Turner J.E., Rosenkrans Jr.C.F., Ogden R.K. and Kellog D.W.: *Aerobic stability of wheat and orchardgrass round-bale silage during winter*. J. Dairy Sci. 2005, **88**, 1815–1826.
[12] Nowak J.: *Wpływ rodzaju i wilgotności zbieranej paszy na jakość kiszonki w belach cylindrycznych*. Post. Nauk Rol. 2000, **5**, 119–135.

WARTOŚĆ POKARMOWA KISZONEK Z RUNI ŁĄKOWEJ W ZALEŻNOŚCI OD RODZAJU NAWOŻENIA

[1] Instytut Zootechniki – Państwowy Instytut Badawczy
[2] Katedra Łąkarstwa, Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie

Abstrakt: Celem podjętych badań było określenie jakości i wartości pokarmowej kiszonek pochodzących z runi łąkowej w zależności od zastosowanego nawożenia. W doświadczeniu przyjęto następujące warianty: obiekt kontrolny bez nawożenia, nawożenie mineralne NPK, nawożenie obornikiem i gnojowicą.

W wyniku zastosowanego nawożenia stwierdzono znaczny wzrost średniej zawartości substancji organicznej i białka ogólnego, co przyczyniło się do wzrostu wartości pokarmowej wyrażonej w wartościach parametrów JPM, JPŻ, BTJN oraz BTJE w porównaniu z obiektem nienawożonym. Nawożenie organiczne spowodowało wzrost zawartości substancji organicznej i białka ogólnego odpowiednio o 4 i 21 % w porównaniu z zawartością w kiszonce pochodzącej z obiektu nienawożonego. Z kolei wartość pokarmowa pod wpływem tego nawożenia wzrosła o 13 % JPM, 17 % JPŻ, 13 % BTJN i 11 % BTJE. Stwierdza się, iż nawożenie organiczne przyczynia się do wzrostu jakości kiszonek. Największy wzrost zawartości białka ogólnego odnotowano w kiszonce pochodzącej z obiektu nawożonego obornikiem. Wobec powyższego można stwierdzić, iż odpowiednio dobrane nawożenie organiczne pozwala osiągnąć kiszonki dobrej jakości.

Słowa kluczowe: nawożenie, kiszonki, jakość i wartość pokarmowa