ISSN 1392-3196
Žemdirbystė=Agriculture, vol. 99, No. 1 (2012), p. 3–8
UDK 591.5:636.085

Importance of non-leguminous forbs in animal nutrition and their ensiling properties: a review

Branko LUKAČ[1], Branko KRAMBERGER[2], Vladimir MEGLIČ[1], Jože VERBIČ[1]

[1]Agricultural Institute of Slovenia
Hacquetova 17, SI-1000 Ljubljana, Slovenia
E-mail: branko.lukac@kis.si

[2]University of Maribor, Faculty of Agriculture and Life Sciences
Pivola 10, SI-2311 Hoče, Slovenia

Abstract

Changing of grassland utilisation towards organic farming and expected climatic changes lead to an increasing biodiversity of grassland with an increasing proportion of non-leguminous forbs (NLF) in sward. Together with the increasing consumer's awareness of healthy food and its origin, forbs are becoming an important constituent of diets for ruminants. As forage, some of them are rich in protein, energy and minerals and have healing properties with the special dietary value. Due to the mechanical losses during hay curing, the ensiling provides a promising option for conserving the yield of biodiverse NLF rich grassland. The review of literature shows that only a few samples of NLF contain a sufficient amount of water soluble carbohydrates (WSC) for proper fermentation of fresh material. It seems that besides WSC and buffering capacity there are other important factors affecting the fermentation process, like secondary plant metabolites. Our knowledge about the effects of secondary metabolites on the fermentation of silage is still scarce and therefore more research on fermentation properties of NLF is needed along with the adaptation of the existing conservation methods of species-rich forage or the development of the new ones.

Key words: animal nutrition, biodiversity, ensilability properties, non-leguminous forbs.

Introduction

One of the main challenges faced by the modern management of semi-natural grasslands is to maintain a species-rich sward of high nutritive value for domestic animals. The ideal semi-natural meadow consists of: 50–60% grasses, 10–30% legumes and 10–30% non-leguminous forbs (NLF) (Buchgraber et al., 1994). During the last decades, NLF have become a more and more valued functional group of grassland plants, especially due to their contribution to biodiversity of the grasslands.

Cutting, livestock grazing and other traditional methods of forage utilization were used for managing habitats which are maintained by human intervention throughout the history in Europe (Pykälä, 2000). However, during the last 50–100 years, the number of plant species associated with semi-natural grassland has declined (Dahlstrom et al., 2008). The reason for the decline lies in the abandonment of the traditional methods of grassland management (Peeters, Janssens, 1998) and in the introduction of more intensive grassland management procedures as is intensive N fertilization. Nitrogen fertilization could reduce the amount of forbs by 6.8–7.9% (Butkuvienė, 2009).

Introduction of organic farming as a result of awareness of negative processes in the development of agriculture could maintain or improve grassland biodiversity (Frieben, Köpke, 1996; Hopkins, Hrabě, 2001). Organic grassland farming and sustainable agricultural systems need grasslands able to produce more or less stable yield within seasons and over several years (Kadziulis, Kadziuliene, 2005). Increased biodiversity of grasslands can also be expected due to the climatic changes. Warmer and drier climate leads to higher biodiversity (Wohlgemuth, 1998). With an increasing temperature in the future, for 6.4°C as expected by 2100 (Harle et al., 2007), we can anticipate an increase of biodiversity in grassland areas along with temperate climatic conditions and expansion of plant species with deeper roots, such as legumes and NLF.

It seems that climate changes will lead to the extensification of agriculture in certain areas, e.g., Southern Europe (Olesen, Bindi, 2002). Extensification on grassland is associated with a decrease in the number of cuts, which increases the biodiversity of meadows (Zechmeister et al., 2003).

With the expected increase in biological diversity and higher proportion of NLF in botanical composition, we need to find appropriate methods for improving cultivation and harvesting of forage from these species-rich grasslands. Most of the NLF are highly susceptible to mechanical damage during the preparation of sun cured hay, which can lead to major mineral and yield losses (Groβ, Riebe, 1974). Because of 40% slower drying in comparison to grasses (Höhn, 1988) NLF are less suitable for hay production than grasses. Johnson et al. (1993) have stated that in comparison to the hay of an average quality, animals prefer good quality silage. Silages from species-rich grasslands should therefore be a better alternative than hay.

Currently available knowledge about the NLF in terms of growth and their persistence in the sward is relatively poor. Even less is known about their ensiling properties, nutritive value and their possible undesirable side effects on animal health, which could have an impact on their use in the animal production, especially in organic farming (Smidt, Brimer, 2005; Søegaard et al., 2008).

Ensiling of the NLF can be difficult because of their high buffering capacity, low levels of soluble carbohydrates and secondary metabolites which may express antibiotic activity. There is little information available in the literature about the concentrations of these compounds in NLF, about their role in animal nutrition and effects on the fermentation of silages. Consequently, the aims of the present work were (i) to explain the role of common NLF in animal nutrition and (ii) to collect the existing information about effects of non-leguminous forbs on the fermentative properties of silage.

The role of non-leguminous forbs in animal nutrition

In recent decades, scientists have discovered huge importance of many grassland NLF in the ecological and aesthetic senses; however, NLF can also be important because they contain compounds of high nutritive value (Kramberger, Klemenčič, 2003). Isselstein and Daniel (1996) found comparable or even higher levels of nitrogen compounds in several NLF (at spring cut in herbage of *Polygonum bistorta* L., *Heracleum sphondylium* L. and at summer cut in *Taraxacum officinale* Weber, *Geranium pretense* L.) in comparison with *Lolium perenne* L. Similar results for common plant species from species-rich alpine pastures (*Achillea millefolium* L., *Alchemilla vulgaris* L., *Galium verum* L., *Heracleum sphondylium* L., *Leontodon hispidus* L., and *Polygonum bistorta* L.) were reported by Bassignana (1998), Marinas et al. (2003) and Bovolenta et al. (2008).

Moreover, review of the literature shows relatively high concentration of crude protein (CP) in different NLF, although there are large differences between individual NLF species (79–217 g kg^{-1} dry matter (DM), Table). On species-rich meadows and pastures some NLF, e.g., *Alchemilla vulgaris* L. and *Leontodon hispidus* L., have shown the same or even higher energy content and organic matter digestibility as grasses, but they were not as high as in *Trifolium repens* L. (Bovolenta et al., 2008). However, it is necessary to emphasize that such comparisons are sometimes rather difficult, because chemical analysis or *in vitro* digestibility of feed does not always give a real picture about actual nutritive value of NLF as was shown by Derrick et al. (1993).

In addition, several researchers have found that NLF contain higher levels of minerals in comparison to some grasses and legumes (Wilman, Derrick, 1994; Fisher, Baker, 1996; Bassignana, 1998; Daccord et al., 2001; Kuusela, Hytti, 2001; Harrington et al., 2006). Misztal and Zarzycki (2008) have discovered that the mineral content in hay from species-rich meadows depends on the proportion of NLF and that the concentration of minerals from such meadows can satisfy the needs of extensively reared animals.

Younie et al. (2001) have shown an improved supply with minerals (K, Na, Mg, Cu) and vitamin B_{12} in sheep fed with *Cichorium intybus* L. A better supply with Ca and Mg was also found in sheep fed with *Plantago lanceolata* L. and *Taraxacum officinale* Weber in comparison to *Lolium perenne* L. The relatively high concentrations of Mg and Ca in *Cichorium intybus* L. and *Plantago lanceolata* L. may reduce the risk of grass tetany on mixed species pastures (Sanderson et al., 2003). In the study of Tallowin and Jefferson (1999), hay from most of the species-rich semi-natural grasslands had an inadequate phosphorus and magnesium content to sustain high growth rates in ruminant livestock; therefore, attention should also be given to other factors in the grassland management, which contribute to the mineral content in plants, e.g., mineral availability in soil or soil pH (Whitehead, 2000).

The use of plants or their extracts for treatment of gastro-intestinal parasites in humans and livestock were known already in the ancient times (Waller et al., 2001). Plant secondary metabolites can affect animal health either positively or negatively (Weiβbach, 1998). Good examples of compounds, with potentially positive impact on animal health, are condensed tannins known as bloat preventers due to their protein-binding role. They may also help to prevent parasite burdens in grazing animals (Marley et al., 2003). Niezen et al. (1995) have reported that lambs grazing on *Hedysarum coronarium* L. and *Lotus pedunculatus* Cav. with high content of condensed tannins reduced parasite burdens up to 50%. Conversely, in another pasture experiment it has been difficult to relate anti parasitic effect to actual amounts of condensed tannins (Niezen et al., 1998). *Plantago lanceolata* L. contains an anti-microbial and possibly, anti-nematicidal agent, aucubin, which may help to reduce parasite burdens in sheep (Niezen et al., 1998). However, Robertson et al. (1995), Knight et al. (1996) and Niezen et al. (1998) were unsuccessful to prove this effect on internal parasites in grazing trials. Smidt and Brimer (2005) mentioned that some Danish organic farmers maintain special "medicine fields" on which sick animals are allowed to graze. Therefore, for the development of organic livestock where the use of prescription medicines for animals is very restricted, it could be important that the effects of NLF and their compounds on the inhibition of internal parasites in ruminants would also be investigated in grazing trials.

With the increasing consumer awareness of healthier food and its origin, feeding of domestic animals is also gaining on importance. Animal diets influence not only the quantity of animal products, but also significantly affect milk and meat traits such as color, flavor and fatty acid composition (Vasta et al., 2008). For example, exposure of sheep to *Chrysanthemum coronarium* L. altered milk and cheese fatty acid composition (Cabiddu et al., 2005), especially the concentrations of vaccenic and conjugated linoleic acid. The concentrations of the above mentioned fatty acids were higher in the milk of sheep which were given *Chrysanthemum coronarium* L. than in milk of sheep grazing pure grasses or grass legume mixtures. The variability can be at least partially attributed to the composition of plant material. Clapham et al. (2005) found that plantain and chicory cultivars tend to have higher concentrations of linoleic acid and α-linoleic acid than grasses. If a comparison of grasses and NLF from grazing pastures is made, dicotyledones are richer in aromatic terpenes (Vasta et al., 2008). They pass through the animal into milk with some minor alterations and give a special sensory profile to milk and other dairy products. If no supplementary feed is given to an animal on pasture during periods of vegetation deficit, milk is richer in aromatic compounds due to the higher proportion of plants such as *Rumex* L., *Mentha* L., *Galium* L. or *Asperula* L. in diets. These compounds can be useful tracers of feeding system of dairy goats and ewes (Vasta et al., 2008).

Milk is an important source of fat soluble vitamins, such as retinol (vitamin A) and tocopherol (vitamin E). The vitamin content of milk depends on the animal diet. The levels of retinol and tocopherols are higher in the milk from cows fed with silage than from those fed with hay. Differences are considered to appear due to the higher losses of provitamins A and tocopherols during hay drying and storage (Kalač, 2011). From the aspect of adding an additional value to the animal products and maintaining the botanical diversity, occasional ensiling of species-rich grasslands may be an attractive option. In low quantities (<40%) silage from semi-natural grassland can be included in the diet of lactating dairy cows without reducing their production (Bruinenberg et al., 2006).

Taraxacin in *Taraxacum officinale* Weber, a very desirable NLF in pastures because of high protein content, gives an undesirable flavor to milk and can cause a diarrhea when consumed in high quantities (Stählin, 1971). *Taraxacum officanale* Weber also contains many phenolic compounds (PC): terpenoids, flavonoids and tannins (Gessner, 1974; Pahlow, 1982). Phenolic compounds and their degradation products are known to interact positively or negatively with ruminal microorganisms. In high concentrations they have anti-nutritive effect due to reduced bioavailability of protein and minerals. On the other hand, moderate concentrations of PCs prevent bloat; increase the flow of non-ammonia nitrogen and essential amino acids from the rumen to the intestine. (O'Connell, Fox, 2001).

Animals prefer to consume *Heracleum sphondylium* L. leaves which are usually non phototoxic. Weimarck and Nilsson (1980) reported that leaves of *Heracleum sphondylium* subspecies sphondylium and sibiricum are usually non-phototoxic. Variation was observed within subspecies granatense and ternatum. The subspecies alpinum, transsilvanicum, pyrenaicum montanum and orsinii were moderately to strongly phototoxic. Another example of secondary metabolite with negative effects is anemonin in *Ranunculus acris* L., which gives an unpleasant taste to the plant. Anemonin is present in plants throughout the buttercup family, but in lower quantities. Ingestion of large amounts of fresh buttercups results in red-yellow milk with unpleasant or bitter taste. In worse cases of animal anemonin poisoning, diarrhea, hematuria, weight loss, cramps and occasional death can occur (Stählin, 1971; Buchgraber et al., 1994). *Ranunculus acris* L. is only one of many non-leguminous forbs with pronounced harmful effect in animal nutrition. Consequently, the main goal in managing semi-natural biodiverse grassland for forage production, e.g., organic livestock production, should be maintaining the sward with adequate proportion of NLF of high agronomic, nutritive and medicinal potential. According to Younie and Baars (2005) such NLF are *Cichorium intybus* L., *Plantago lanceolata* L., *Achillea millefolium* L. and *Sanguisorba officinalis* L. In addition to that, there are many other, although not sufficiently described, NLF with potential positive role in animal nutrition and health found in the species-rich semi-natural grassland.

Properties of non-leguminous forbs for ensiling

Hay still represents a major agronomic product of cut, or cut and grazed semi-natural grasslands (Tallowin, Jefferson, 1999). Species-rich swards with high proportion of NLF are often problematic for silage production because of dubious fermentation quality, depending on many interrelated factors. The main reason for undesired fermentation characteristics is considered to be high buffering capacity (BC) which is probably derived from plant organic acids. Other possible reasons are high mineral and low water soluble carbohydrate (WSC) concentrations as well as some secondary plant metabolites (Wyss, Vogel, 1999).

In general, high concentrations of WSC in the material for ensiling lead to a better fermentation (Wilkinson, 2005). It is generally recommended that fresh material should contain at least 25 g WSC kg^{-1} DM (Lundén Petterson, Lindgren, 1990). Taking into account that fresh material contains about 200 g DM kg^{-1} the adequate concentration on DM basis would be 125 g kg^{-1}. The content of WSC in forage depends on plant species, growth stage, weather conditions, light intensity, fertilization and diurnal variation (McDonald et al., 1991). In the common grasses used for silage, such as *Lolium perenne* L., WSC can reach values above 300 g kg^{-1} DM (McDonald et al., 1991). Generally, such high levels of WSC were not observed in various species of NLF (Table). Literature review has showed that the highest level of WSC in the first cut NLF was just above 150 g kg^{-1} DM. The highest values are found in individual samples of *Ranunculus repens* L., *Ranunculus bulbosus* L., *Plantago lanceolata* L., *Heracleum sphondylium* L., *Taraxacum officinale* Weber, and *Anthriscus sylvestris* (L.) Hoffm.

Table. Impact of growth stage on the concentration of water soluble carbohydrates (WSC) and crude protein (CP) in various NLF species at first cut

Species	Stage of growth	WSC g kg^{-1} DM	CP g kg^{-1} DM	Reference
1	2	3	4	5
Achillea millefolium	beginning of flowering	140.0	79.0	Isselstein, Daniel, 1996
	vegetative	114.3	110.1	Weiβbach, 1998
	beginning of flowering	68.1	117.4	
	flowering	59.6	152.7	
	flowering	94.0	131.0	Lukač et al., 2010
	flowering	110.0	117.0	
	flowering	133.0	100.0	
Centaurea jacea	beginning of flowering	143.0	150.0	Isselstein, Daniel, 1996
	beginning of flowering	86.0	140.0	Mainz, Isselstein, 1995
	beginning of flowering	109.3	102.3	Weiβbach, 1998
	flowering	109.7	96.1	Weiβbach, 1998
Galium mollugo	flowering	102.0	107.0	Lukač et al., 2010
	flowering	97.0	112.0	
Geranium pretense	vegetative	138.8	149.5	Weiβbach, 1998
	flowering	104.6	139.2	
Heracleum sphondylium	vegetative	80.0	217.0	Isselstein, Daniel, 1996
	vegetative	104.0	203.0	Mainz, Isselstein, 1995
	vegetative	161.9	128.3	Weiβbach, 1998
	flowering	155.6	124.2	

Table continued

1	2	3	4	5
Knautia arvensis	flowering	129.0	87.0	Lukač et al., 2010
	flowering	118.0	98.0	
	flowering	121.0	117.0	
Ranunculus bulbosus	flowering	168.0	112.0	Lukač et al., 2010
Plantago lanceolata	vegetative	120.0	138.0	Isselstein, Daniel, 1996
	flowering	139.1	94.1	Weiβbach, 1998
	flowering	135.5	79.4	
	flowering	107.0	136.0	Lukač et al., 2010
	flowering	164.0	140.0	
	flowering	122.0	107.0	
	flowering	144.0	115.0	
Pimpinela saxifraga	flowering	157.0	99.0	Lukač et al., 2010
Ranunculus repens	beginning of flowering	201.3	147.0	Weiβbach, 1998
	flowering	170.0	146.0	Isselstein, Daniel, 1996
	flowering	142.0	125.0	Mainz, Isselstein, 1995
	flowering	210.0	118.0	Lukač et al., 2010
	end of flowering	164.8	96.2	Weiβbach, 1998
Rumex acetosa	flowering	118.2	161.6	Weiβbach, 1998
	flowering	121.0	118.2	Isselstein, Daniel, 1996
	flowering	93.0	148.0	
	flowering	56.0	133.0	Mainz, Isselstein, 1995
Taraxacum officinale	beginning of flowering	201.8	164.6	Weiβbach, 1998
	flowering	117.6	179.7	Isselstein, Daniel, 1996
	flowering	279.0	174.2	
	seed ripening	188.0	113.0	

BC – buffering capacity, CP – crude protein, DM – dry matter, NLF – non-leguminous forbs, WSC – water soluble carbohydrates

According to Isselstein and Daniel (1996) the values of WSC in the second cut of *Achillea millefolium* L., *Ranunculus repens* L., *Heracleum sphondylium* L. and *Anthriscus sylvestris* (L.) Hoffm. were just above 100 g kg^{-1} DM, which is considerably lower than in the first cut. Also WSC values of only about 100 g kg^{-1} DM were found in the second cut of *Ranunculus repens* L. (Mainz, Isselstein, 1995), *Heracleum sphondylium* L., *Anthriscus sylvestris* (L.) Hoffm. and *Plantago lanceolata* L. (Wyss, Vogel, 1999). It can be concluded that the WSC in NLF are generally higher at spring cut than in the following cuts of the growing season. However, it is difficult to make a comparison, since only a small number of comparable data are available. Great diversity in WSC concentration within the same species has been reported, indicating that information on ensiling properties of individual species cannot be generalized. It should also be borne in mind that plant material from permanent grasslands is usually a mixture of grasses, legumes, and NLF. Therefore their ensiling properties depend not only on properties of individual groups but also on their proportions in a sward.

Buffering capacity and secondary metabolites

Wilkinson (2003) was relatively unsuccessful when he tried to ensile *Symphitum officinale* L. in laboratory silos. According to his opinion, there were several possible reasons for unsatisfactory fermentation, especially low WSC concentration and high BC. High BC in plants might have been associated with high concentrations of organic acids which are responsible for most of the buffering effect in plants (Playne, McDonald, 1966). Other possible reasons are high concentrations of ash and nitrogen compounds, although high values of nitrogen compounds have relatively low impact on BC at ensiling (McDonald et al., 1991). Weiβbach (1998) also concluded that concentration of CP in NLF is not always directly associated with the high BC.

In an ensiling experiment with nine NLF Isselstein and Daniel (1996) found that all silages indicated satisfactory quality after 90 days of fermentation. Plants differed in CP, WSC value and BC, but the correlation between these parameters and silage quality was weak. The results indicate that, beside WSC and BC, there are other important factors affecting the fermentation process. On the basis of WSC content we can predict the quality of silage from common grasses (Jones, 1970); however, it seems that it is hard to predict the same for NLF. The reason for such observations might be in the secondary metabolites which can also have an impact on microorganism activity. In the experiment with the grass-NLF mixtures of *Polygonum bistorta* L., *Geranium pratense* L., *Anthriscus sylvestris* (L.) Hoffm. (Daniel, 1998), the production of acetic and lactic acid during the fermentation was strongly reduced even though the quality of silages was estimated as satisfactory. According to the author, the reasons for restricted fermentation were secondary metabolites such as tannins in *Polygonum bistorta* L. and gallic acid in *Geranium pratense* L. These compounds may induce a rapid decrease of pH at the beginning of fermentation, inhibit the fermentation, and lower the decomposition of protein. The impact of secondary metabolites on the fermentation of silages was also noticed with *Plantago lanceolata* L. and *Rumex acetosa* L. in the experiments of Isselstein and Daniel (1996). Despite the fact that both plant species contained a sufficient amount of WSC, the concentrations of lactic acid in silages were low indicating the restricted fermentation. High level of oxalic acid in *Rumex acetosa* L. causes rapid decrease in pH. Consequently, the fermentation is limited as well as the growth and development of undesirable bacteria and yeast (Isselstein, Daniel, 1996; Weiβbach, 1998).

In the experiments of Isselstein and Daniel (1996), silage from *Plantago lanceolata* L. was pleasantly aromatic despite the high pH value and without any noticeable deterioration even 90 days after ensiling. According to Weiβbach (1998), the reason for limited fermentation was in the glycoside aucubin which inhibited degradation of protein.

Conclusions

1. In scientific literature little information is available on ensiling properties of non-leguminous forbs (NLF) ensiled separately or in mixtures with grasses and legumes.

2. Researchers were mainly focused on nutritive value and not so much on ensiling properties of NLF. On the basis of literature review, we can conclude that NLF have a great impact on the nutritive value of forage and also on the fermentation processes during ensiling. In both cases the secondary metabolites have a crucial role.

3. The knowledge about secondary metabolites and their impacts on forage quality and quality of animal products on the level of individual NLF species is poor. Even poorer is the knowledge about the suitable proportion of individual NLF in the species-rich swards used for silage production. These are the main reasons for supporting NLF research and adapting the existing conservation methods for species-rich swards or developing new ones.

Acknowledgements

This work was co-funded by the Slovenian Research Agency – ARRS; PhD scholarship of Branko Lukač.

Received 02 09 2011
Accepted 27 12 2011

References

Bassignana M. Evolution of the quality of different species in a subalpine summer pasture: proceedings of the 17th General Meeting of the European Grassland Federation. – Debrecen, Hungary, 1998, p. 1011–1016

Bovolenta S., Spanghero M., Dovier S., Orlandi D., Clementel F. Chemical composition and net energy content of alpine pasture species during the grazing season // Animal Feed Science and Technology. – 2008, vol. 146, iss. 1, p. 178–191

Bruinenberg M. H., Geerts R. H. E. M., Struik P. C., Valk H. Dairy cow performance on silage from semi natural grassland // NJAS-Wageningen Journal of Life Sciences. – 2006, vol. 54, No. 1, p. 95–110

Buchgraber K., Deutsch A., Gindl G. Zeitgemässe Grünland-Bewirtschaftung. – Graz, Austria, 1994, 194 p. (in German)

Butkuvienė E. The effect of long-term pasture resowing and other different improvement methods on the sward yield and quality (summary) // Žemdirbystė=Agriculture. – 2009, vol. 96, No. 2, p. 151–164 (in Lithuanian)

Cabiddu A., Decandia M., Addis M., Piredda G., Pirisi A., Molle G. Managing Mediterranean pastures in order to enhance the level of beneficial acids in sheep milk // Small Ruminant Research. – 2005, vol. 59, iss. 2, p. 169–180

Clapham W. M., Foster J. G., Neel J. P. S., Fedders J. M. Fatty acid composition of traditional and novel forages // Journal of Agriculture and Food Chemistry. – 2005, vol. 53, No. 26, p. 10068–10073

Daccord R., Arrigo Y., Kessler J. Nährwert von Wiesenpflanzen: Gehalt an Ca, P, Mg und K // Agrarforschung. – 2001, vol. 8, iss. 7, p. 264–269 (in German)

Dahlstrom A., Lennartsson T., Wissman J. Biodiversity and traditional land use in south-central Sweden: the significance of management timing // Environment and History. – 2008, vol. 14, No. 3, p. 385–403

Daniel P. Gäreignung von Kräutern des Wirtschaftsgrünlandes: 42. Jahrestagung der Aggf. – Gieβen, Deutschland, 1998, p. 15–21. <http://www.lfl.bayern.de/ipz/gruenland/37130/42_aggf_1998_alles.pdf> [accessed 01 02 2012] (in German)

Derrick R. W., Moseley G., Wilman D. Intake, by sheep, and digestibility of chickweed, dandelion, dock, ribwort and spurrey, compared with perennial ryegrass // Journal of Agricultural Science. – 1993, vol. 120, iss. 1, p. 51–61

Fisher G. E. J., Baker L. J. The chemical composition of forb species in grassland: proceedings of the 16th general meeting of the European Grassland Federation. – Grado, Italy, 1996, p. 429–432

Frieben B., Köpke U. Effects of farming system on biodiversity: proceedings of First Workshop of European Network for Scientific Coordination in Organic Farming (ENOF). – Bonn, Germany, 1996, p. 11–21

Gessner O. Die Gift- und Arznepflanzen von Mitteluropa. – Heidelberg, Germany, 1974, 582 p. (in German)

Groβ F., Riebe K. Gärfutter, Betribswirtschaft, Erzeugung, Verfütterung. – Stuttgart, Germany, 1974, 216 p. (in German)

Harle K. J., Howden S. M., Hunt L. P., Dunlop M. The potential impact of climate change on the Australian wool industry by 2030 // Agricultural Systems. – 2007, vol. 93, iss. 1–3, p. 61–89

Harrington K. C., Thatcher A., Kemp P. D. Mineral composition and nutritive value of some common pasture weeds // New Zealand Plant Protection. – 2006, vol. 59, p. 261–265. <http://www.nzpps.org/journal/59/nzpp_592610.pdf> [accessed 03 02 2011]

Hopkins A., Hrabě F. Organic grassland farming and nature conservation: proceedings of the International Occasional Symposium of the European Grassland Federation. – Witzenhausen, Germany, 2001, p. 91–106

Höhn E. Abtrocknung und Ernteverlust von kräuterreichen Wiesen // Schweize Landwirtschaftliche Forschrift. – 1988, vol. 27, No. 2, p. 181–189 (in German)

Isselstein J., Daniel P. The ensilability of grassland forbs: proceedings of the 16th general Meeting of the European Grassland Federation. – Grado, Italy, 1996, p. 451–455

Johnson A. T., Schoming G. W., Vandersall J. H. et al. Silage system for very small farms // Journal of Sustainable Agriculture. – 1993, vol. 2, iss. 4, p. 47–66

Jones D. I. H. The ensiling characteristics of different herbage species and varieties // The Journal of Agricultural Science. – 1970, vol. 75, iss. 2, p. 293–300

Kadziulis L., Kadziuliene Z. Impact of grazing regime on legume-based swards for low-input farming: proceedings of the 13th International Occasional Symposium of the European Grassland Federation. – Tartu, Estonia, 2005, p. 235–239

Kalač P. The effects of silage feeding on some sensory and health attributes of cow's milk: a review // Food Chemistry. – 2011, vol. 125, iss. 2, p. 307–317

Knight T. L., Moss R. A., Fraser T. J., Rowarth J. S., Burton R. N. Effect of pasture species on internal parasites of lambs: proceedings of the New Zealand Grassland Association. – Oamaru, New Zealand, 1996, vol. 58, p. 59–62

Kramberger B., Klemenčič S. Effect of harvest date on the chemical composition and nutritive value of *Cerastium holosteoides* // Grass and Forage Science. – 2003, vol. 58, iss. 1, p. 12–16

Kuusela E., Hytti N. Effect of dicot weeds on nutritive value of pasture herbage in organic farming: proceedings of International Occasional Symposium of the European Grassland Federation. – Witzenhausen, Germany, 2001, p. 110–112

Lukač B., Žnidaršič T., Verbič J., Verbič J., Kramberger B. Nutritive value of some forbs from permanent grasslands (summary): Mednarodno posvetovanje o prehrani domačih živali Zadravčevi-Erjavčevi dnevi. – Radenci, Slovenia, 2010, p. 275–283. <http://www.kis.si/files/janezj2/zed_2010/hranilna_vrednost_nekaterih_zeli_s_trajnega.pdf> [accessed 01 03 2011] (in Slovenian)

Lundén Petterson K., Lindgren S. The influence of the carbohydrate fraction and additives on silage quality // Grass and Forage Science. – 1990, vol. 45, iss. 3, p. 223–233

Mainz A., Isselstein J. Gäreignung und Gärqualitat verbreiteter Grunlandkräuter: 39. Jahrestagung der Aggf. – Weihenstephan, Deutschland, 1995, p. 187–190. <http://www.lfl.bayern.de/ipz/gruenland/37130/39_aggf_1995_alles.pdf> [accessed 05 03 2011] (in German)

Marinas A., García-Gonzáles R., Fondevila M. The nutritive value of five pasture species occurring in the summer grazing ranges of the Pyrenees // Animal Science. – 2003, vol. 76, iss. 3, p. 461–469

Marley C. L, Cook R., Keatinge R., Barrett J., Lampkin N. H. The effect of birdsfoot trefoil (*Lotus corniculatus*) and chicory (*Cichorium intybus*) on parasite intensities and performance of lambs naturally infected with helminth parasites // Veterinary Parasitology. – 2003, vol. 112, iss. 1–2, p. 147–155

McDonald P., Henderson A. R., Heron S. J. E. The biochemistry of silage (2nd ed.). – Marlow, UK, 1991, 340 p.

Misztal A., Zarzycki J. The effect of botanical composition on mineral content in hay from extensively managed montain grasslands: proceedings of the 22th General Meeting of the European Grassland Federation. – Uppsala, Sweden, 2008, p. 483–485

Niezen J. H., Robertson H. A., Waghorn G. C., Charleston W. A. G. Production, faecal egg counts and worm burdens of ewe lambs which grazed six contrasting forages // Veterinary Parasitology. – 1998, vol. 80, iss. 1, p. 15–27

Niezen J. H., Robertson H. A., Waghorn G. C., Charleston W. A. G. Growth and gastrointestinal nematode parasitism in lambs grazing either lucerne *(Medicago sativa)* or sulla (*Hedysarum coronarium*) which contains condensed tannins. – 1995, vol. 125, iss. 2, p. 281–289

O'Connell J. E., Fox P. F. Significance and applications of phenolic compounds in the production and quality of milk and dairy products: a review // International Dairy Journal. – 2001, vol. 11, iss. 3, p. 103–120

Olesen J. E., Bindi M. Consequences of climate change for European agricultural productivity, land use and policy // European Journal of Agronomy. – 2002, vol. 16, p. 239–262

Pahlow M. Das groβe Buch der Heilpflanzen. Gesund durch die Heilkräfte der Natur. – München, Germany, 1982, 499 p. (in German)

Peeters A., Janssens F. Species-rich grasslands: diagnostic, restoration and use in intensive livestock production system: proceedings of the 17th general meeting of the European Grassland Federation. – Debrecen, Hungary, 1998, p. 375–393

Playne M. J., McDonald P. The buffering constituents of herbage and of silage // Journal of the Science of Food and Agriculture. – 1966, vol. 17, iss. 6, p. 264–268

Pykälä J. Mitigating human effects on European biodiversity through traditional animal husbandry // Conservation Biology. – 2000, vol. 14, iss. 3, p. 705–712

Robertson H. A., Niezen J. H., Waghorn G. C., Charleston W. A. G., Jinlong M. The effect of six herbages on liveweight gain, wool growth and faecal egg count of parasitised ewe lambs // New Zealand Society of Animal Production. – 1995, vol. 55, p. 199–201

Sanderson M. A., Labreveux M., Hall H. M., Elwinger F. Nutritive value of chicory and English plantain forage // Crop Science. – 2003, vol. 43, p. 1797–1804

Smidt N. W., Brimer L. The use of herbs in pastures: an interview survey among bio-dynamic and organic farmers with dairy cattle // Agriculture and Human Values. – 2005, vol. 22, No. 3, p. 355–363

Stählin A. Gütezahlen von Pflanzenarten in frischem Grundfutter. – Frankfurt am Main, Germany, 1971, 152 p. (in German)

Søegaard K., Eriksen J., Askegaard M. Herbs in grasslands – effect of slurry and grazing/cutting on species composition and nutritive value: proceedings of the 22th general meeting of the European Grassland Federation. – Uppsala, Sweden, 2008, p. 200–202

Tallowin J. R. B., Jefferson R. G. Hay production from lowland semi-natural grasslands: a review of implications for ruminant livestock systems // Grass and Forage Science. – 1999, vol. 54, iss. 2, p. 99–115

Vasta V., Nudda A., Cannas A., Lanza M., Priolo A. Alternative feed resources and their effects on the quality of meat and milk from small ruminants // Animal Feed Science and Technology. – 2008, vol. 147, iss. 1, p. 223–246

Waller P. J., Bernes G., Thamsborg S. M., Sukura A., Richter S. H., Ingebrigtsen K., Höglund J. Plants as de-worming agents of livestock in the nordic countries: historical perspective, popular beliefs and prospects for the future // Acta Veterinaria Scandinavica. – 2001, vol. 42, No. 1, p. 31–44

Weimarck G., Nilsson E. Phototoxicity in *Heracleum sphondylium* // Planta Medica. – 1980, vol. 38, No. 3, p. 97–111

Weißbach F. Untersuchungen über die Beeinflussung des Gärungsverlaufes bei der Bereitung von Silage durch Wiesenkräuter verschiedener Spezies im Aufwuchs extensiv genutzter Wiesen. – Braunschweig, Germany, 1998, 99 p. (in German)

Whitehead D. C. Nutrient elements in grassland. Soil–plant–animal relationships. – Wallingford, USA, 2000, 369 p.

Wilkinson J. M. A laboratory evaluation of comfrey (*Symphytum officinale* L.) as a forage crop for ensilage // Animal Feed Science and Technology. – 2003, vol. 104, No. 1, p. 227–233

Wilkinson J. M. Silage. – Lincoln, USA, 2005, 254 p.

Wilman D., Derrick R. W. Concentration and availability to sheep of N, P, K, Ca, Mg and Na in chickweed, dandelion, dock, ribwort and spurrey compared with perennial ryegrass // The Journal of Agricultural Science. – 1994, vol. 22, iss. 2, p. 217–223

Wohlgemuth T. Modelling floristic species richness on a regional scale: a case study in Switzerland // Biodiversity and Conservation. – 1998, vol. 7, iss. 2, p. 159–177

Wyss U., Vogel R. Siliereignung von Kräuter aus intensiven Beständen // Agrarforschung. – 1999, vol. 6, iss. 5, p. 185–188 (in German)

Younie D., Baars T. Organic grassland: principles, practices and potential: developments opportunities perspectives. – New Hampshire, USA, 2005, p. 207–213. <http://www.google.com/books?hl=sl&lr=&id=37R5WvEsdW8C&oi=fnd&pg=PA207&ots=w1_fcKiQaW&sig=UNs8JZlyrUTF-Jv33xOF1cnz38#v=onepage&q=&f=false> [accessed 16 02 2011]

Younie D., Umrani A. P., Gray D., Coutts M. Effect of chicory or perennial ryegrass diets on mineral status of lambs: proceedings of the International Occasional Symposium of the European Grassland Federation. – Witzenhausen, Germany, 2001, p. 278–280

Zechmeister H. G., Schmitzberger I., Streuer B., Peterseil J., Wrbka T. The influence of land-use practices and economics on plant species richness in meadows // Biological Conservation. – 2003, vol. 114, iss. 2, p. 165–177

ISSN 1392-3196
Žemdirbystė=Agriculture, vol. 99, No. 1 (2012), p. 3–8
UDK 591.5:636.085

Nepupinių įvairiažolių svarba siloso savybėms ir gyvulių mitybai: apžvalga

B. Lukač[1], B. Kramberger[2], V. Meglič[1], J. Verbič[1]

[1]Slovėnijos žemės ūkio institutas

[2]Mariboro universiteto Žemės ūkio ir gyvybės mokslų fakultetas, Slovėnija

Santrauka

Žolynų naudojimo pokyčiai taikant organinę žemdirbystę ir tikėtini klimato pokyčiai lemia žolynų bioįvairovės ir nepupinių įvairiažolių dalies žolyne didėjimą. Kintant vartotojų sampratai apie sveiką maistą ir jo kilmę, įvairiažolės tampa svarbia sudėtine atrajojančių galvijų raciono dalimi. Kaip pašaras, kai kurios įvairiažolės turi didelį kiekį baltymų, energijos bei mineralų ir pasižymi gydomosiomis savybėmis bei specifine mitybine verte. Šieno ruošimo metu patiriama mechaninių nuostolių, o silosavimas suteikia galimybę užkonservuoti žolynų, pasižyminčių nepupinių įvairiažolių įvairove, derlių. Pateikiama literatūros apžvalga rodo, kad tik keli nepupinių įvairiažolių ėminiai turi pakankamą kiekį vandenyje tirpių angliavandenių (VTA) tinkamai žalios masės fermentacijai. Tikėtina, kad be VTA bei buferinės gebos egzistuoja ir kiti svarbūs veiksniai, veikiantys fermentacijos procesą, pavyzdžiui, augalų antriniai metabolitai. Vis dar nepakanka žinių apie antrinių metabolitų įtaką siloso fermentacijai, todėl reikėtų daugiau nepupinių įvairiažolių fermentacijos savybių tyrimų, taikant esamus pašaro, sudaryto iš įvairių rūšių augalų, konservavimo būdus arba kuriant naujus.

Reikšminiai žodžiai: gyvulių mityba, bioįvairovė, silosavimas, nepupinės įvairiažolės.