Chemical composition of galega mixtures silages

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Abstract. According to the near-infrared reflectance spectroscopy data, the chemical composition of fodder galega (*Galega orientalis* Lam.) is more valuable forage than traditional fodder plants such as the red clover and timothy at budding-early flowering stage. Due to the high concentration of total protein (231 g kg^{-1}) and some amino acids (asp, glu, phenylala), galega fresh mass could be used as a substitute for the soybean cake for 1.4–2.9 kg equivalent amounts. The mean of asp, glu and phenylala content in galega DM constitutes 68.22–56.37 % of their concentration in soybean cake. The high total protein concentration of fodder galega which was determined indicated that this crop could be used for increasing the protein content of livestock rations and successfully replace soybean cake, which is imported and expensive.

For supplying livestock with succulent forage during the year and for producing high quality silage, galega mixtures with grasses containing many water-soluble carbohydrates could be ensiled. Possibilities of ensiling mixtures of early flowering stage fodder galega (1:1) with orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), wheat grass (*Elytrigia repens* L.), milk stage maize and sugar beet leaves were studied at Research Station and Training Farm of Lithuanian University of Agriculture. The addition of 0.3% FPC to galega-maize silage had no significant influence on DM (225 and 214 g kg^{-1}), mineral element concentration and pH value (4.7 and 4.4) as compared to galega-maize silage without preservatives. The results of ensiling indicate that the quality of pure galega and galega-wheat grass silage was poor quality due to an unbalanced ratio of protein and water-soluble carbohydrates. Fodder galega appears suitable for ensiling with a grass component (orchardgrass, timothy or maize) which accumulated not less than 30% DM.

Key words: chemical composition, galega, grasses, silage, maize, sugar beet

INTRODUCTION

The cultivation of fodder grasses, particularly legumes, which compose only 20–30% of the annual forage ration of livestock, has great significance for attaining a sufficient amount of forage, as well as forage with enough protein content. In the climatic conditions of Lithuania, fresh fodder needs to be made into silage or another kind of forage to supply cattle with succulent forage during the year.

Legume species fodder galega (*Galega orientalis* L.) is characterized as a high protein-rich (14–26%) crop, especially at budding-flowering stages, and is suitable for composing different sorts of forage: silage, hay, haylage, ground hay, etc. (Baranovskij & Kurak 1990; Baranauskas et al., 1998; Adamovics, 2000). A high level of feed value and mineral content, abundance of non-fallen leaflets, and soft and non-wooden stems are characteristic to galega at this stage. Delayed harvest of galega or other fodder crops has resulted in the decrease of nutritious materials due to increasing cellulose content and diminishing synthesis of protein and other feed materials (Chamberlain & Wilkinson, 1996; Juraitis, 1998). Chemical composition of fodder galega was compared with soybean meal for the purpose of finding an indigenous and economical substitute for imported and expensive soybean meal.

Protein-rich flowering galega could be dried up to 40–55% moisture content and ensilaged to supply crude forage during the year. The quality of silage was influenced by moisture content of the ensiled mass (Yahaga et al., 2001; Marco et al., 2002). Ensilage mass, if too dry (60% and more DM), and pressed badly, could become hot and increase losses of dry matter. In the case of low DM content, the *Clostridium* spp., anaerobic bacteria, which cause butyric fermentation, start to grow, resulting in the decomposition of saccharose and protein into butyric acid and ammonium. These compounds increased pH up to 5.0 and decreased silage quality. The high silage moisture content led to increased acetic acid content and pH value, therefore diminishing the fermentation process and quality of silage. The optimal recommended DM content of ensilage mass is 28–30% (Jeroch et al., 1999).

The quality and fermentation of silage are influenced not only by DM yield but also protein content. The silages of pure maize or grasses have been the main forage fed to livestock in many countries in winter (Steidlová & Kalač, 2002), However, the deficiency of the dietary amines content reduced the feed value of these pure silages, and could be improved by adding protein–rich legumes into the silage mass (Mikulionienė & Stankevičius, 2002). Addition of grasses solved the deficiency of water-soluble carbohydrates (WSCs) in legumes (Cozzi et al., 2002). WSCs are indispensable for silage fermentation and implementation. Ensilaging plants that are protein-rich, but with low saccharose content, didn't produce the sufficient amount of lactic acid, therefore silage acidity increased from 6.0 to 5.0 pH; acetic and butyric acids content also increased. These processes determined decomposition of silage. Therefore high quality silage could be produced in case of profitable carbohydrate and protein ratios. As Jeroch et al. (1999) reported, the minimal WSCs level must not be less than 100–140 g kg^{-1} DM. The protein content of galega (18–23%) is twice that of maize, but maize exceeded galega by 2–4 times in WSCs.

The objective of this work is a survey of possibilities of ensiling galega with various grasses and leaves of sugar beet, to produce high quality and feed value silage. Mixtures of galega (1:1) with good-ensiling crops: maize, orchardgrass, timothy, wheat grass and leaves of sugar beet, were examined in order to determine the most profitable.

MATERIALS AND METHODS

Silage preparation

Results of all researched crops: fodder galega (*Galega orientalis* L.), red clover and grasses (orchardgrass *Dactylis glomerata* L., timothy *Phleum pratense* L., wheat grass *Elytrigia repens* L.) were harvested during the budding-early flowering stage in late August at the Research Station of the Lithuanian University of Agriculture. The crops samples were collected from experimental plots which consisted of four replications in a randomised split-plot design. Wheat grass was ensilaged with galega according to the good feed value 160 CP, 530 g kg^{-1} NDF (Malhi et al., 2003). Maize was harvested at the milky ripeness stage. The leaves of sugar beet were ensilaged at root-crop harvesting. At these stages the amount of dry material (DM) reaches the optimal content for ensiling. The fresh matter (FM) of crops was cut at a length of 12–13 mm, thoroughly mixed, accurately pressed and the ensilage was hermetically sealed to achieve better extraction of soluble carbohydrates and to increase preservation of silages (Davies et al. 1998, Yahaya et al., 2000). The silages were stored for 6.5 months in 3-litre hermetical jars in two replications at 3–5^{o}C temperature. Silage of galega-maize was preserved by 0.3% formaldehyde pitch of carbamide (FPC), produced in the ‘Achema’ chemical factory, Lithuania. Other silages were preserved by spontaneous fermentation. When jars were opened, silage was estimated by the sense method and samples were taken for quality analysis.

DM and silage analyses

Dry matter (DM), crude protein (CP), crude fibre (CF), crude fat (Cf), and neutral detergent fibre (NDF) of silages were determined according to the commonly used Wende method for forage analyses; pH – after pHmetry; saccharose, amino fermentation of acids, according to the chromatography method, in accordance with EG-Dokument 2354/VI/82, 84/4/EWG and 92/84/EWG in ‘Tempus’ laboratory of the Lithuanian University of Agriculture (Nauman & Baasler, 1993). Mineral element concentrations in DM were analysed using near-infrared reflectance (NIR) spectroscopy (PSCO/ISI IBM-PC 4250; Pacific Scientific, USA) according to the database of researched plants.

Losses of DM and ME were estimated after comparing the weight or chemical composition of fresh mass and silage respectively. The quality of silage was estimated by usability (very good, good, satisfactory and bad) according to pH and organic acid content (DLG–Information, 1999).

Metabolic energy (ME MJ kg^{-1}) of silages and examined forage grasses was expressed by a formula (Nauman & Bassler, 1993; Baranauskas et al., 1998):

ME = 14.07+0.0206 x Cf-0.0147 x CF-0.0114 x CP $\pm$ 4.5 %;

Neto energy of lactation (NEL MJ kg^{-1}) of DM feeds was calculated:

NEL = 9.10+0.0098 x Cf–0.0109 x CF–0.0073 x CP;

Means:

Cf- crude fat g kg $^{-1}$;

CF- crude fibre g kg $^{-1}$;

CP- crude protein g kg $^{-1}$.

Statistical methods

The level of statistical confidence of the data was calculated by the method of dispersion analysis using the statistical package *ANOVA*. The least significant difference (*LSD*) method was used to evaluate differences between the chemical composition, ME and NEL, of the crops studied.

RESULTS AND DISCUSSION

The concentration of crude protein is sufficient: high–average 231 g kg^{-1} of galega DM. Not only the total protein amount, but also the composition and quantity of particularly essential amino acids have great importance in forage. The galega content of some essential amino acids and their comparison with soybean cake is presented in Table 1.

Table 1. The concentration of amino acid in fodder galega DM.

Aminoacid	Content mg kg^{-1}	In compare with soy %	Galega mass equivalent to 1 kg soybean cake, kg	Sequence by amino acid concentration among 72 forages
Arginine	6.58	22.38	4.468	23
Asparagine	18.83	68.22	1.466	24
Phenylalanine	10.09	56.37	1.724	17
Glutamine	15.06	33.69	2.968	28
Histidine	6.66	65.29	1.532	21
Izoleucine	4.42	23.02	4.344	21
Leucine	6.36	38.31	2.610	16
Lysine	9.62	36.37	2.767	17
Methionine	3.56	62.46	1.601	9
Serine	7.69	35.93	2.783	19
Tyrosine	6.36	38.31	2.610	16
Threonine	6.67	40.18	2.489	19
Valine	6.58	37.18	2.690	21
LSD_{05}	1.02	0.74	0.61	

The largest amount determined of these amino acids: asparagine – 18.83, glutamine – 15.06 and phenylalanine – 10.09 mg kg^{-1}. The data of analogous amounts of asp and phenyl are appointed in literature (Nõmmsalu, 1994). Protein concentration in galega fresh mass is rather high and the above-mentioned above amino acids constitute 68.22–56.37% of their concentration in soybean cake.

Due to its high protein content, galega could substitute for the soybean cake in equivalent amounts according to the following amino acid concentration: histidine – 1.5 kg, phenylalanine – 1.8 kg, threonin – 2.5 kg, tyrosine and leucine – 2.6 kg, valine – 2.7 kg and lysine – 2.8 kg. The high quantity of amino acid in fresh mass of fodder galega indicate that this crop could be used to increase protein content of rations for livestock and could successfully replace soybean cake, which is imported and expensive.

Examination results in Lithuania indicate that the chemical composition of galega at flowering stage is better than traditional forage crops such as timothy and red clover (Table 2). The highest protein, fat and ash content (231, 29.5 and 105 g kg^{-1} respectively) were determined in galega dry matter, indicating the good feed value of this crop. According to data of Table 2, the supply of mineral elements, except chromium, is considerably higher in galega than in timothy or red clover. This considerable amount of micro- and macro-elements could accumulate due to abundant roots in a well-developed root system.

Table 2. Chemical composition of fodder galega and other grasses.

Indices	Unit of measurement	In DM of galega	In DM of timothy	In DM of red clover	LSD_{05}
CF	g kg^{-1}	245.8	351.6	255.3	14.01
CP	g kg^{-1}	231.0	119.8	113.0	9.81
Cf	g kg^{-1}	29.5	28.0	27.7	1.74
Crude ash	g kg^{-1}	105.0	73.2	83.3	19.11
P	%	0.48	0.28	0.45	0.09
K	%	3.17	2.71	5.38	1.02
Na	%	0.06	0.03	0.03	0.01
Ca	%	1.24	0.21	0.64	0.78
Mg	%	0.36	0.04	0.06	0.01
B	%	1.23	1.34	1.92	0.43
Cr	mg kg^{-1}	0.95	1.25	0.90	0.10
Cd	mg kg^{-1}	0.15	0.07	0.17	0.01
Pb	mg kg^{-1}	1.37	0.75	1.15	0.11
Ni	mg kg^{-1}	1.87	0.72	1.12	0.13
Cu	mg kg^{-1}	8.00	3.50	6.00	1.01
Zn	mg kg^{-1}	15.00	10.00	18.50	8.02
Mn	mg kg^{-1}	12.00	7.50	15.00	3.01
Fe	mg kg^{-1}	100.00	75.00	85.00	14.06

As Mikulionienė & Stankevičius (2002) report, pure legumes are not suited for ensiling due to the low amount of WSCs, which guarantee good fermentation of silage. Therefore the chemical composition and fermentation of legumes could be improved by their ensiling in mixtures with graminaceous plants. Fresh mass of fodder galega was ensiled at budding–early flowering stage, when the most efficient stage of nutritious materials and optimal amount of DM had been reached. Before ensiling, the fresh mass of galega accumulated sufficient content – 221 g kg^{-1} of dry matter which, as Jeroch et al. (1999) reported, isn't enough to produce the best quality of silage (Table 3).

The silage of flowering-stage galega suggested the high content of protein (219 g kg^{-1}), carotene (12 mg kg^{-1}), mineral materials and produced the high ME (10.78 MJ kg^{-1}) (Table 3). The losses of nutritious materials during the ensiling of galega, without additive, constituted 16% of protein (initial content 261 g kg^{-1} in DM of fresh mass), 82% of carotene (67.3 mg kg^{-1}) and 72% of saccharose (18 g kg^{-1}), but increased fat (21 g kg^{-1}) and mineral K (35.7 g kg^{-1}) content. Silage of pure galega without additives fermented weekly due to the low amount of saccharose (5 g kg^{-1}) and high pH value. After 6.5 months of fermentation, pure galega silage produced rather high pH (5.3) and low lactic acid content (35.9%). The content of butyric acid was found to be high–26.9%, therefore the silage quality deteriorated. The addition of 0.3% FPC improved the quality of pure galega silage by decreasing butyric acid up to 1.3% and significantly increasing acidity up to 4.9 pH. Pure galega silage with preservative 0.3% FPC was evaluated as good quality.

Table 3. Influence of chemical conservant on quality of galega and galega- maize (1:1) silages.

Indices of DM	Galega		Galega-maize		LSD_{05}
	without conservant	with conservant	without conservant	with conservant	
DM g kg^{-1}	271	272	214	225	14.0
CP g kg^{-1}	219	226	164	181	8.12
CF g kg^{-1}	251	262	263	275	0.81
Cf g kg^{-1}	37	31	27	23	4.65
C. ash g kg^{-1}	94	88	87	73	10.3
Carotene mg kg $^{-1}$	12.0	27.6	34.7	37.7	0.94
Saccharose g kg $^{-1}$	5	5.5	6.4	7.2	7.31
NDF g kg $^{-1}$	419.2	426.4	531.3	539.8	9.71
P g kg^{-1}	3.5	3.5	3.3	3.2	0.25
K g kg^{-1}	36.0	36.4	19.4	18.5	4.51
Ca g kg^{-1}	12.16	12.30	11.77	11.75	0.11
ME MJ kg^{-1}	10.78	10.58	10.99	10.70	0.19
NEL MJ kg^{-1} SM	6.42	6.48	6.71	6.56	0.10
Silage pH	5.3	4.9	4.4	4.7	0.3
Organic acid %:					
Lactic	35.9	69.7	65.2	64.1	7.6
Acetic	37.2	29.0	34.8	35.9	0.23
Butyric	26.9	1.3	-	-	0.54

As analysis indicated, ensiling galega with maize at ratio 1:1 produced better quality silage than pure galega alone, resulting in the best balance of protein and saccharose ratio (2:1). The neutral detergent fibre content (531.3 g kg^{-1}) was the highest in galega-maize silage as compared with other silages (Fig.1).

The best indices of quality were determined in the galega-maize mixture (1:1) silage with the preservative FPC. The addition of 0.3% FPC to galega-maize silage did not have significant influence on DM (225 and 214 g kg^{-1}), mineral element content and pH (4.7 and 4.4), as compared to galega-maize silage, without preservative. But CP (181 g kg^{-1}) in DM, and carotene (37.7 mg kg^{-1}) content significantly increased in galega-maize silage when the preservative FPC was added.

The positive indices of galega mixtures with timothy, orchardgrass, sugar beet leaves and coach grass (1:1) fresh mass and silages confirm that pure galega isn't profitable for silage (Figs 1, 2, 3; Table 4).

Table 4. Acid composition and pH value of silages.

Acidity	Galega	Galega+ maize	Galega+ timothy	Galega+ Orchard grass	Galega+ s.beet	Galega+ coach grass	LSD_{05}
pH	5,1	4,2	3,8	3,8	3,7	4,8	0,08
Lactic acid	35,9	75,2	73,4	69	48,7	63,9	14,84
Acetic acid	37,2	24,8	26,4	27,7	49,1	21,8	8,91
Butyric acid	26,9		0,2	3,3	2,2	14,3	6,52

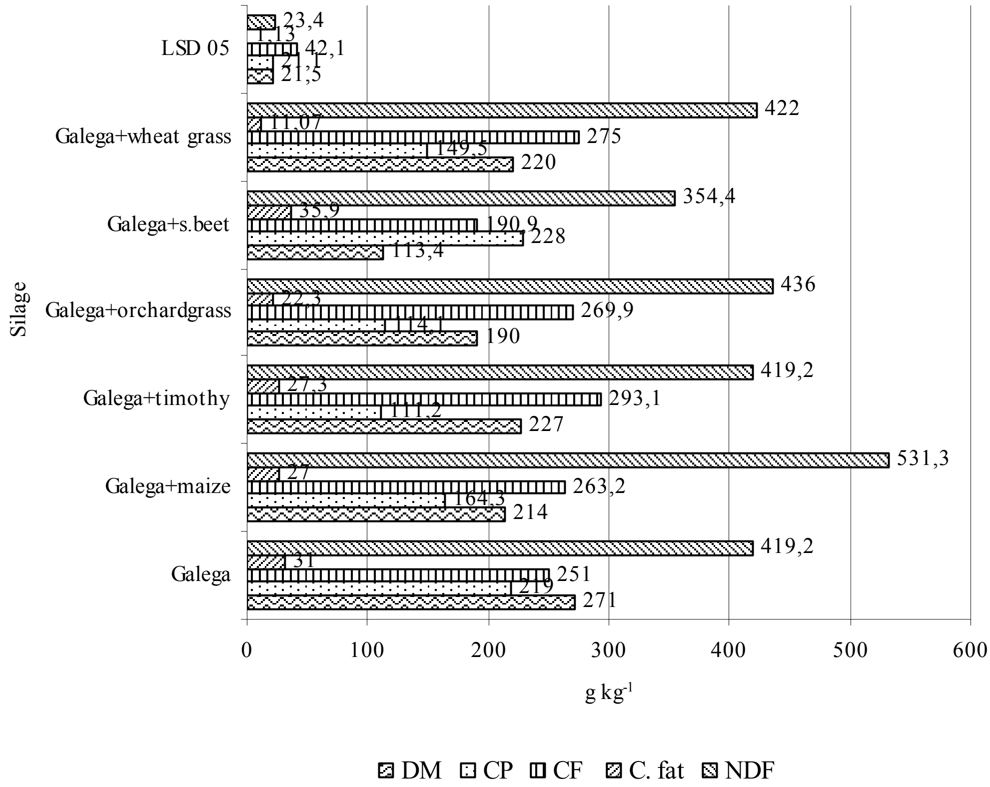

Fig. 1. Organic compound of silages.

Quality indices of fresh mass and silage of galega-timothy mixture (1:1) concluded that pure galega was better for ensiling in mixtures with graminaceous plants. The content of DM (293 g kg^{-1}) of timothy fresh mass is optimal for ensiling, but the protein content–129.9 g kg^{-1} is too small for the formation of balanced livestock diets (Jeroch et al., 1999). Therefore CP content (160 g kg^{-1}) was low in fresh galega-timothy mass as well as in silage (111.2 g kg^{-1}).

In the ensiled galega-timothy mixture (1:1) the losses of DM consisted of only 15.7 and protein–30.5%. Silage pH was 4.1 and indicated the right fermentation of silage, good chemical composition and quantity of organic acids. Galega-timothy silage contained the least amount of NDF in comparison with all galega-grass silages. Lactic acid predominated among acids and composed 73.4%. The butyric acid content was low - 0.2% - therefore galega–timothy silage was good quality, but did not reach the recommended level of protein content..

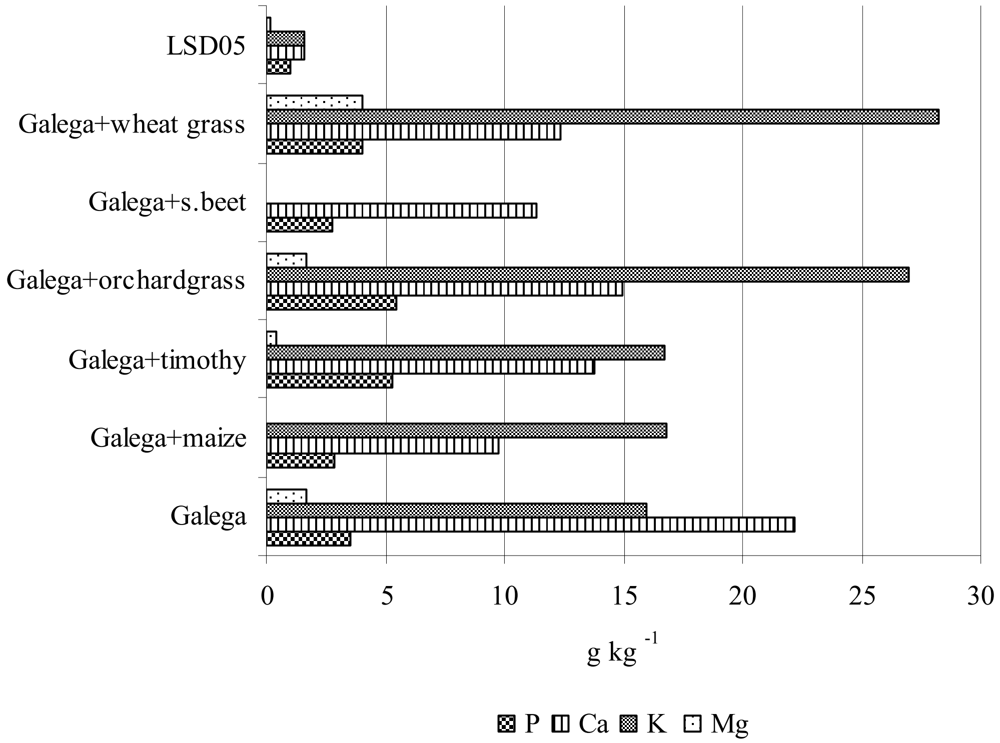

Fig. 2. Mineral content in DM of silages.

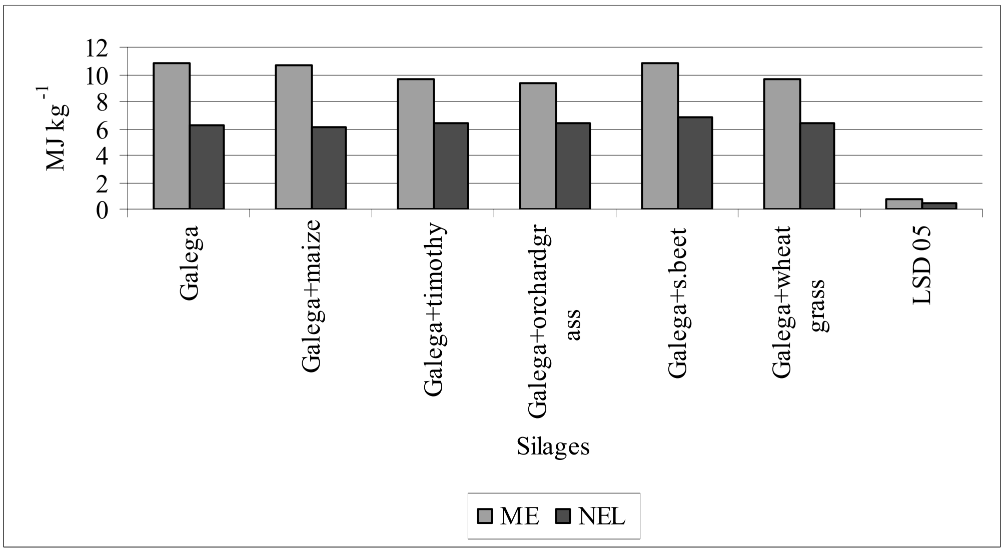

Fig. 3. Comparison of silages metabolic energy and netto energy of lactation.

The fermentation process of galega-orchardgrass silage was similar to that of galega–timothy. The losses of DM, protein and energetic value content of galega-orchardgrass silage rated 23.2, 28.6 and 7.2% respectively. This silage was distinguished for the high K content. Galega-orchardgrass silage was good quality due to the lower pH – 4.0, but decomposition of proteins occurred intensively, therefore it produced a higher butyric acid concentration–3.3% as compared with galega–timothy silage.

Galega-wheat grass silage was of lesser quality than galega-orchardgrass silage. This silage fermented weekly due to low saccharose content (3 g kg^{-1}) and acidity–4.8 pH. According to Feroch et al. (1999), the optimal content of carbohydrate is 8–10% for producing good quality silage. The poor carbohydrate-protein ratio for fermentation determined the accumulation of a high content of butyric acid–14.3%, resulting in poor quality silage.

In late October, galega was ensilaged with sugar beet leaves, which enriched galega mass with water-soluble carbohydrates and increased silage fermentation due to high saccharose content, as compared with silages of pure galega and mixtures. Galega-beet leaf silage has the highest value of ME (10.77 MJ kg^{-1}), but a low concentration of mineral elements. Acidity of this silage was the highest among those tested – 3.9, with pH – an NEL value of (6.81 MJ kg^{-1}); therefore, sugar beet leaves can be considered a proper component for ensiling in combination with galega.

CONCLUSIONS

The chemical composition of fodder galega was evaluated as better than traditionally used forage, i.e. graminaceous plants–timothy and legume–red clover, making galega more valuable as forage. Due to the high concentration of total protein (231 g kg^{-1}) and amino acid, fodder galega, used in equivalent amounts, could enrich the protein concentration of livestock ration and replace expensive soybean cake.

The 0.3% formaldehyde pitch of carbamide is recommended for applying as a preservative because it decreases losses of nutritious materials and guarantees good fermentation of both pure galega and galega-maize mixture. Pure galega and galega-wheat grass mixtures are not profitable for ensiling because of poor concentration of sugars, but galega is acceptable to ensilage with maize, timothy, orchardgrass or sugar beet leaves in ratio 1:1 and can supply livestock with succulent forage during the year.

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