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15th INTERNATIONAL CONFERENCE

FORAGE CONSERVATION

24th – 26th September, 2013
High Tatras, Slovak Republic

FORAGE CONSERVATION

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Ľubica Rajčáková

Nitra 2013

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FORAGE CONSERVATION

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PREFACE

Development of production efficient agriculture, which will provide purposeful and effective management of land resources in the country and availability of raw materials of good quality for processing industry, is of top priority in EU countries. The present agriculture in developed countries has not only production functions but also increasingly important position in elimination of negative agro-anthropogenic influences, preservation of biodiversity and creation of cultural landscape. Demands of the society as a whole on creation of food raw materials of good quality with simultaneous maintenance of ecological principles of utilization of renewable resources can be realized only by using scientific and research knowledge. It is obvious that effective transfer of this knowledge from research laboratories into agricultural practice will be limiting factor in further development of agro-food sector.

From the viewpoint of present needs in users and consumer spheres are most of the agricultural production capacities aimed at production of food raw materials of good quality. This production is influenced by basic inorganic and organic inputs into processes in primary production. With regard to losses that arise in the process of transformation making more effective the change of nutrients in feeds to high quality raw materials of animal origin has more and more important position. Important factors in decrease of losses in matter and nutrients during the production of feeds are the new methods of conservation. Within them it will be inevitable to develop new means to achieve marked decrease in losses of matter and nutrients in conserved feeds. By means of new ensilaging additives, microbiological flora, anti-mycotic preparations and new methods it will be possible to achieve minimum differences between native and conserved feeds.

Within this context is the 15th international conference on feed conservation a continuation of the tradition of previous meetings of experts from institutions, universities and users aimed at exchange of new knowledge in the sphere of technological viewpoints of forage crops production, optimum structure and choice of forage crops for particular localities and production objectives, technical and agro-technical problems of growing, treatment, harvesting and conservation, microbiological control of fermentation process as well as improvement of nutritive value in feeds and techniques of feeding.

Participation of outstanding native and foreign specialists is a guarantee that the conference will contribute not only to development of new knowledge but it will contribute also to more effective transfer of scientific and research information into the user’s sphere of service and primary production.

Nitra, 30th August 2013

Organizing Committee
of 15th ICFC

CONTENTS OF PROCEEDINGS

Plenary session – invited papers

PERMANENT GRASSLANDS IN CENTRAL EUROPE – A RESOURCE FOR AN EFFICIENT AGRICULTURAL PRODUCTION?

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Introduction

Grasslands are a main resource for agricultural production. In Europe they cover some 35% of the utilized agricultural area and some 8% of the total European land surface (Smit et al. 2008). Ruminant and equine livestock husbandry depend on grasslands; herbage is either grazed or cut for conservation and indoor feeding. Permanent grasslands provide important additional ecosystem services, e.g. environmental goods, such as high biodiversity, carbon sequestration, protection against soil erosion, and provision of drinking water.

Generally, herbage from grassland is a highly valuable forage, providing the animals with an efficient amount of feed energy and essential nutrients. Grass is considered a complete feed to ruminants and, in principal, they can maintain and perform without any additional feed. However, due to increased individual performance of the livestock during the last decades, in particular the dairy cows, the nutritive value of the feed had to be improved. For grass, this was achieved by intensifying the grassland management through herbicide application, reseeding, fertilizing, and increasing the defoliation frequency; thereby herbage production and feed quality increased (Peeters 2009). Yet, the share of grassland herbage in the diets of dairy cows went down and the cows were fed a higher percentage of high energy feed from arable crops like silage maize or cereals. As a result, milk production is increasingly relying on arable farming and grassland seems at risk of being, in part, abandoned from dairy farming. At the same time, the demand for biomass from arable land is steadily increasing: food for human nutrition for growing global markets and biomass for bioenergy. Production of feed for ruminants on arable land therefore exerts an extra pressure on the arable land and enforces land use conflicts. A better utilization and management of grassland for ruminant husbandry and a raise of the grass share in the diets of dairy cows is therefore a desired option (Humphreys et al. 2009). This could reduce the biomass demand from arable land and would help to contribute to the overall production of the farmed land.

The aim of this review is to analyse the production potential of permanent grasslands. The focus will be on EU countries of Central Europe as the physical conditions for forage production in these countries encompass a smaller gradient than the whole European Union (see Table 1). Production and production potential will be balanced against non-marketable ecosystem services and, as an example, grassland biodiversity will be looked at in more detail.

Management history of grasslands in Central Europe

The grasslands of temperate Europe are characterized by a permanent vegetation and the swards are dominated by perennial plants of a strong clonal growth. Times of limited growth are generally short and mainly restricted to low temperatures during the winter months. The canopy cover is more or less closed and the radiation is utilized for photosynthesis and growth as soon as the temperatures are above 5°C. The grass swards and the grassland species therein had developed over millennia. Grasslands are mainly man-made habitats that occur as a result of defoliation by domesticated grazing herbivores. Cutting herbage from grassland has a less long tradition in Central Europe and did first occur in the iron age (Hejcman et al. 2013). The multiple benefits of grassland are closely related to grassland management and utilisation. Over centuries, a multitude of grassland farming practices had developed, and these practices well reflected the differences of the site conditions and the climate of the different regions. The herbage production from European grasslands is highly variable (Smit et al. 2008) and until the second half of the last century used to depend mainly on soil fertility, plant available soil nutrient content and soil water regime. The broad range of site conditions and the traditionally extensive grassland management led to the development of a high plant and animal diversity (Isselstein et al. 2005). Grassland management and production was markedly increased since the 1960s leading to higher herbage production and livestock performance (Hopkins & Wilkins, 2006). This was accompanied by the development of more uniform grass swards and a loss of grassland biodiversity.

Grassland based livestock production and grassland area

The importance of grasslands in Europe for agriculture and livestock husbandry is demonstrated based on livestock production figures and land use data available from European databases (EUROSTAT 2013). Results are shown for all EU countries (EU27) and for Central European countries (EU7, Austria, Czech Republic, Hungary, Germany, Luxembourg, Poland, Slovakia). The average annual rainfall among the EU7 countries ranges from 589 mm (Hungary) to 1100 mm (Austria) (The World Bank 2013). Dairy farming is of huge importance for grassland management in the EU. Milk production figures are fairly stable over the last decade with little inter annual variation (Figure 1). There was a slight increase of the total milk production over the whole EU as well as in the Central European member states (EU7). During the same time the number of dairy cows decreased. Thus, the individual performance of the dairy cows increased; this change was stronger in the EU7 compared to EU27 (Figure 2). In contrast to milk production the milk price paid to farmers was much more variable during the last decade as is shown in Figure 2. Obviously, there was little adaptation of milk production to price fluctuations. This seems to be due to the milk quota system where farmers try to fulfill their alloted rate of production. There is a trend of increasing prices over the years which reflects a globally increasing demand for dairy products. The incline of this trend is however lower as compared to the development of the price for wheat which is obviously more dependent on global markets. Yet, the price stability is higher for milk which is an important incentive for production decisions.

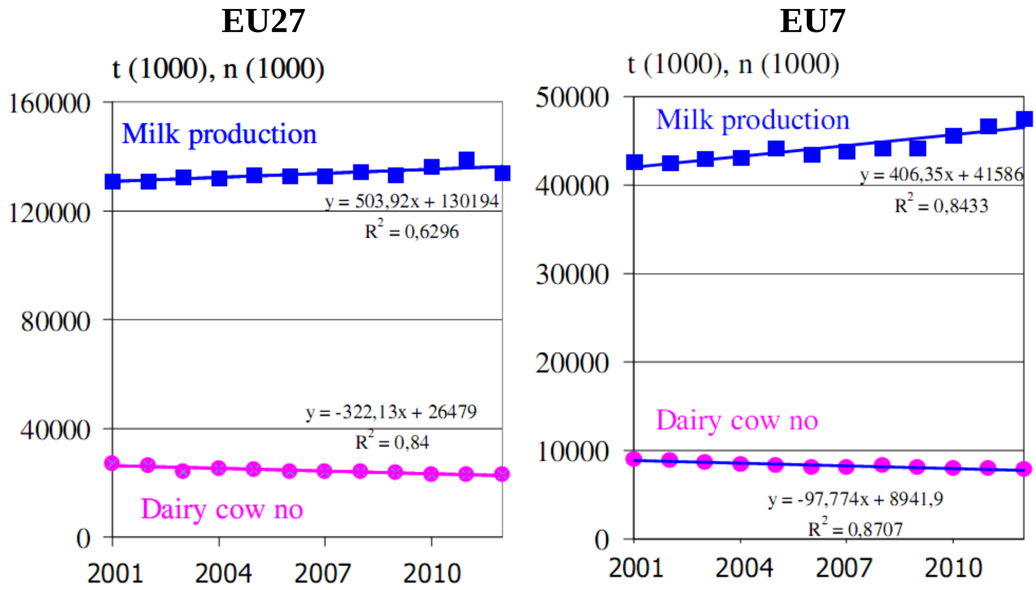

Figure 1 Trend of dairy milk production and dairy cow stock from 2001 to 2012 for the EU27 countries and for Central European countries within the EU (EU7), after EUROSTAT (2013), and own calculations. Quadrats: milk production, circles: dairy cow numbers

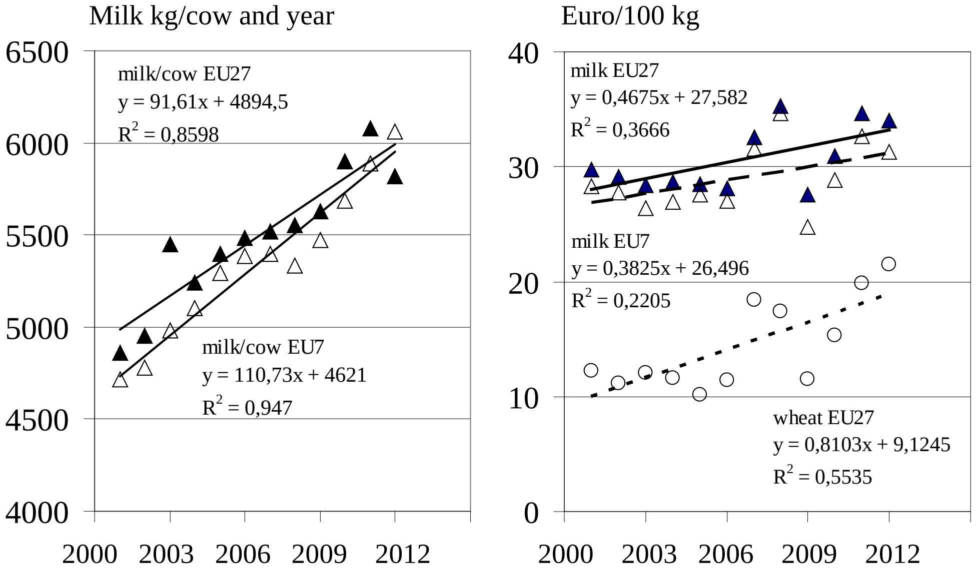

Figure 2 Trend of milk production per cow (left diagram) and trend of product prices (right diagram) from 2001 to 2012 for milk and wheat in the EU27 countries and for Central European countries within the EU (EU7), after EUROSTAT (2013), and own calculations. Closed triangles: milk EU27, open triangles: milk EU7, open circles: wheat EU27.

In contrast to milk production, the total beef meat production went down. This effect was stronger over the whole EU and less strong in the EU7 countries. Over the last decade production decreased by 9% for EU27 while it was only 3% for EU7 (Figure 3).

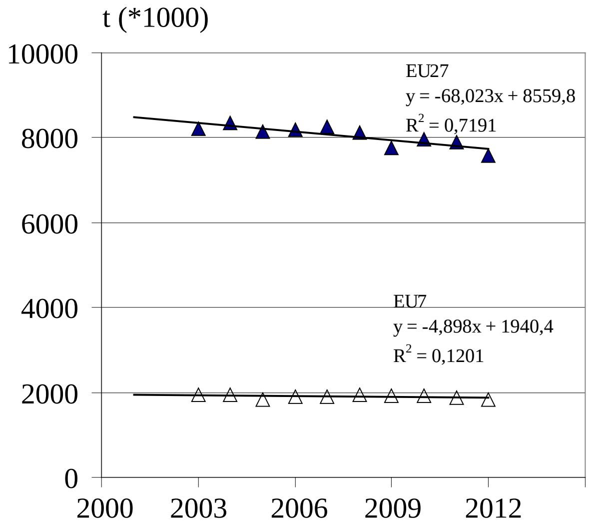

Figure 3 Trend of beef meat production from 2001 to 2012 for the EU27 countries (closed triangles) and for Central European countries within the EU (EU7) (open triangles), after EUROSTAT (2013), and own calculations.

The total forage area of the Central European countries (EU7), i.e. the sum arable grass leys, forage maize and permanent grassland in relation to the utilized agricultural area ranges between 15 and 55%. There is a clear distinction between the eastern part of Central Europe with relatively low values and the western part with considerably higher figures. Data on the different types of forage land are shown in more detail in Table 1.

Table 1 Land-use characteristics of the agriculturally utilized area in Central Europe, data from 2010 (EUROSTAT (2013), and own calculations)

	UAA	AGA	MA	PGA	PGA	MPA	MGL	UGA
Country		1000 ha			% UAA		% PGA	
Austria	2878	60	82	1439	0.50	0.62	0.38	0.002
Czech Republic	3484	36	181	929	0.27	0.98	0.01	0.010
Germany	16704	389	1829	4655	0.28	0.95	0.04	0.005
Hungary	4686	18	71	721	0.15	0.03	0.97	0.000
Luxembourg	131	11	13	68	0.52	1.00	0.00	0.003
Poland	14447	124	387	3229	0.22	0.91	0.02	0.067
Slovakia	1896	71	78	531	0.28	0.82	0.15	0.028
average	6318	101	377	1653	0.32	0.76	0.22	0.016

UAA: utilized agricultural area, AGA: arable (temporal) grassland area, MA: forage maize area, PGA: permanent grassland area, MPA: agriculturally utilized meadows and pastures, MGL: marginal grassland area, UGA: unutilized grassland area

The arable grassland area (grass leys) contribute little to the total forage area with insignificant differences among the EU7 countries. The area of forage maize exceeds the ley area but compared to the permanent grassland area its contribution is also fairly low. However, the significance of forage maize varies among the countries. In Germany, in contrast to the other countries, the forage maize area makes up more than 10% of the utilized agricultural area. Maize silage is a main constituent in dairy cow rations in Germany. In addition, there is a growing demand for maize biomass to be used for bioenergy as producing bioenergy from biogas plants is a dominating strategy of the energy transition efforts in Germany. Although, forage maize is not a major crop in the other Central European countries, the maize acreage has been increasing among EU7 by 29% during 2005 and 2010. For comparison, in EU27 the growing rate of the forage maize area went up by only 16 % during that time. It seems as if in Central Europe dairy rations are increasingly amended by silage maize as a source of digestible energy.

The permanent grassland area is highly variable among the different in countries in Central Europe. High figures are found in Austria and Luxembourg, low values in Hungary and Poland. In general, permanent grassland sites in

Europe can be found on agricultural land that is less suitable for arable farming. A main reason for this is often a surplus of water. This is confirmed by an obvious relationship between annual precipitation in a country and the percentage of permanent grassland of the utilized agricultural area (Figure 4).

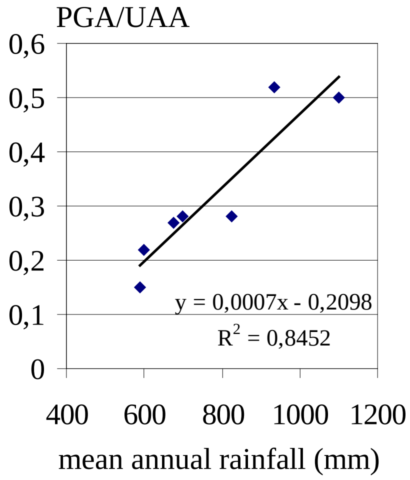

Figure 4 Share of the permanent grassland area (PGA) to the total utilized agricultural area (UAA) of Central European countries (EU7), own calculation, data from EUROSTAT (2013) and The World Bank (2013)

The permanent grassland area can be distinguished into different categories: the commonly managed (agriculturally utilized) meadows and pastures (MPA), the marginal grassland area (MGL), and the unutilized grassland area (UGA) (Table 1). The importance of these different categories vary widely among the countries. In particular the marginal grassland area is different with high values in Austria and Hungary which is obviously related to the alpine areas in Austria and the Puszta in Hungary.

Area related livestock performance

Data on area related livestock performance in Central Europe is compiled in Table 2. Livestock numbers had been transferred into livestock unit (LU). A livestock unit is defined as 500 kg body weight. The stocking rate of all grazing stock, i.e. ruminants and equines, per total grass area (arable and permanent) ranges between 0.79 and 2.45 and has an average value of 1.56. In Germany, the figure of 2.45 LU/ha does not completely reflect the real situation, as the forage maize area is not included in the reference area. However, as has been shown above, maize plays a considerable role in feeding the dairy. In all EU7 countries dairy farming contributes significantly to ruminant husbandry. Interestingly, the percentage of dairy cows of all grazing stock is fairly similar among the countries with values ranging from 31 to 49 %. However, the production of milk and meat per grass area differs widely. For Germany, again, it should be stated that the high amount of milk per grass area is probably related to the additional feeding of silage maize which is not accounted for in this calculation. Another general weakness of this calculation is that concentrate feeding was not included as no data of concentrate feeding in dairy farming was available. Differences in milk production among countries are thus not only affected by the stocking rate of the grass area which has to be considered when drawing conclusions from the findings.

As could be expected milk production per ha grass area was related to the stocking rate of the dairy cows. The more animals are kept per ha grass area the higher is the milk output. What was not expected is that the milk and meat production per ha grass area was positively related. That means that a lower milk production was not compensated by a higher meat production, rather, the opposite was true. Therefore, it seems justified to use the milk production data to characterize the performance of the grass area and recognising some unaccuracy due to the unknown amount of concentrate that is fed to the cows.

The considerable variation in milk production per ha grass area among the different countries could be a starting point to improve forage area production and production efficiency. The example of Ireland shows that the amount of milk being produced from grass may exceed 10000 kg per ha of grass area. It is an open question whether improved animal performance per ha could be achieved by improved primary, i.e. herbage production or by better utilization of the grown herbage. During the last decades emphasis had been placed on increasing the herbage production through intensification measures such as introducing new germplasm to the grasslands, or heavy fertilization. However, those measures increase the risk of environmental damage such as nutrient losses into the waters or the atmosphere or biodiversity losses. Thus, alternative measures for a sustainable intensification would be desirable. The study of Smit et al. (2008) on the herbage production potential of grassland revealed differences among the Central European countries under consideration in the present paper. However, these differences seem to be smaller than the differences in livestock performance. Thus, improving the utilisation of the herbage by the livestock rather than improving herbage production seems a promising option for the future. Interestingly, in Ireland, it could be shown that already by improving the grazing management while at the same time reducing the nitrogen fertilizer input a higher milk performance per grass area was obtained. The reason was that through advanced grazing management the grown herbage was more efficiently transferred into livestock performance and less herbage was lost through dying off leaves. Another important field for a better utilisation of the grown herbage is to improve the efficiency of the mechanical harvest of the forage and the forage conservation. Both processes are of overriding importance in livestock production systems where indoor feeding dominates. It is suggested that in Central European countries more emphasis should be placed on those options for improvement.

Table 2 Livestock characteristics, number and production figures, data from 2010 (EUROSTAT (2013), and own calculations)

Country	Livestock LU n/ha	Dairy cows LU n/ha	Dairy cows LU %	Cattle LU n/ha	Cattle LU %	Milk production kg/ha	Meat production kg/ha
Austria	1,23	0,43	35	0,79	64	1,848	155
Czech Republic	1,27	0,47	37	0,78	62	2,397	77
Germany	2,45	1,00	41	1,35	55	5,767	239
Hungary	1,07	0,39	36	0,48	45	1,789	37
Luxembourg	2,23	0,70	31	1,50	67	3,565	121
Poland	1,86	0,91	49	0,72	39	2,685	115
Slovakia	0,79	0,32	40	0,41	52	1,328	24
average	1,56	0,60	38	0,86	55	2011	110

Livestock LU (n/ha): number of all grazing stock including dairy cows, beef cattle, equines, small ruminants per permanent and arable grassland area
Dairy cows LU (n/ha): number n in % of all grazing stock (LU) that feed on roughages
Dairy cows LU (%): number n in % of all grazing stock (LU) that feed on roughages
Cattle LU (n/ha): number n of cattle excluding dairy cows in % of all grazing stock (LU) that feed on roughages
Dairy cows LU (%): number n of cattle excluding dairy cows in % of all grazing stock (LU) that feed on roughages
Milk production from dairy cows: kg milk per ha permanent and arable grassland
Meat production, cattle, small ruminants: kg meat per ha permanent and arable grassland

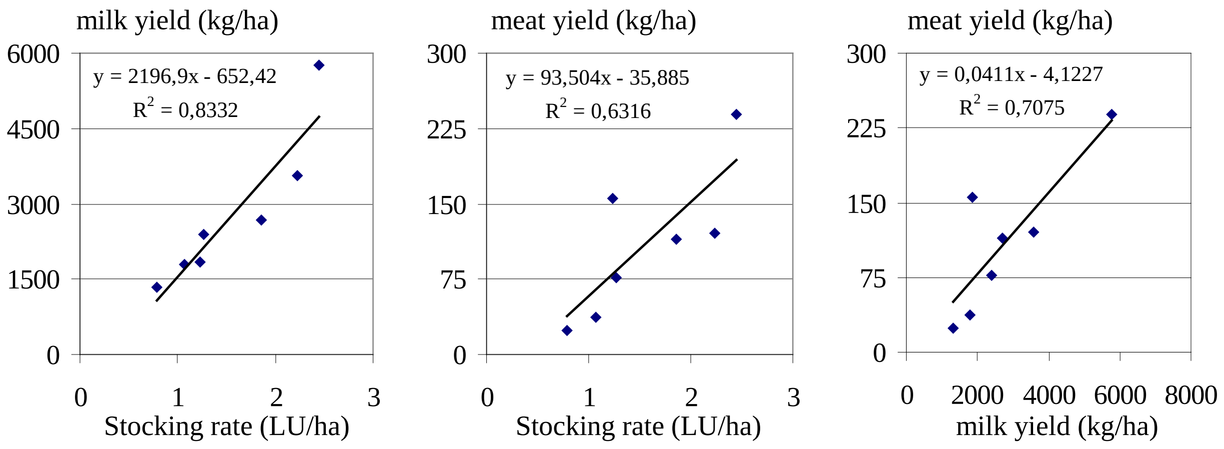

Figure 5 milk (left graph) and meat (central graph) production per ha arable and permanent grassland in relation to the stocking rate of this area and the relationship between milk and meat production per ha grass area (right graph) of Central European countries (EU7), own calculation, data from EUROSTAT (2013).

Options for a sustainable intensification of herbage production from grassland?

Although the major pathway for an improved livestock performance is seen in a better utilisation of the grown herbage, recent developments on an ecological or sustainable way to increase herbage production should not be disregarded. In depth biodiversity research during the last 15 years in sown grasslands had demonstrated the strong effect of plant species density in a grass sward on herbage productivity. A well known example for this is the so called BIODEPTH experiment that was performed in several European countries employing the same experimental design. Results of this experiment are shown in Figure 6. Across a range of European countries there was univocal result that herbage production could be markedly raised merely through the inclusion of more plant species in sown grass sward. This finding was confirmed in other biodiversity experiments so that a higher species number of grass swards as are common in the agricultural practice has been suggested as a mean to improve production at the farm level (Weigelt et al. 2009).

Further research on this topic that extended this type of research from sown grasslands to old permanent grassland could not confirm a phytodiversity effect on the herbage productivity. An example for this is given in Figure 7. The data shown are based on an observational study where grasslands sites from practical farming situations were included. Neither the above ground herbage nor the root mass showed any relationship to the plant species number. Thus, it remains to be further explored whether for permanent grassland the plant species number or the vegetation composition is affecting herbage yield and whether this could be exploited by grassland farming. Research from ley-farming with a selection of a few grasses and forage legumes showed that designing simple mixtures with grasses and legumes can help to sustain or even improve yield with a reduced input of fertilizer nitrogen (Lüscher et al. 2013).

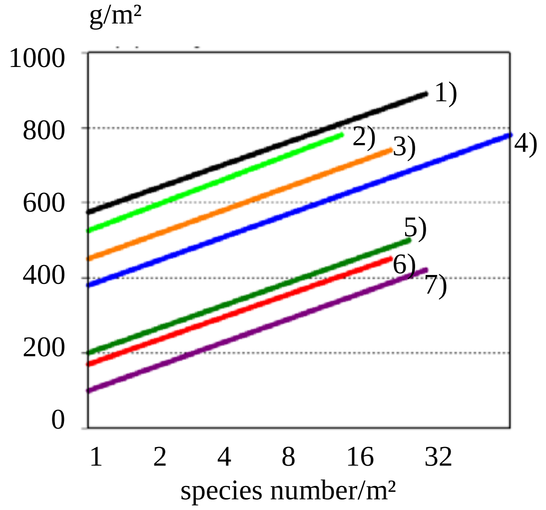

Figure 6 Effect of sown plant species number on the hay yield of grass leys according to experiments in seven different European countries, 1) Germany, 2) Ireland, 3) United Kingdom, 4) Switzerland, 5) Portugal, 6) Sweden, 7) Greece, from BIODEPTH experiment, after Hector et al. (1999).

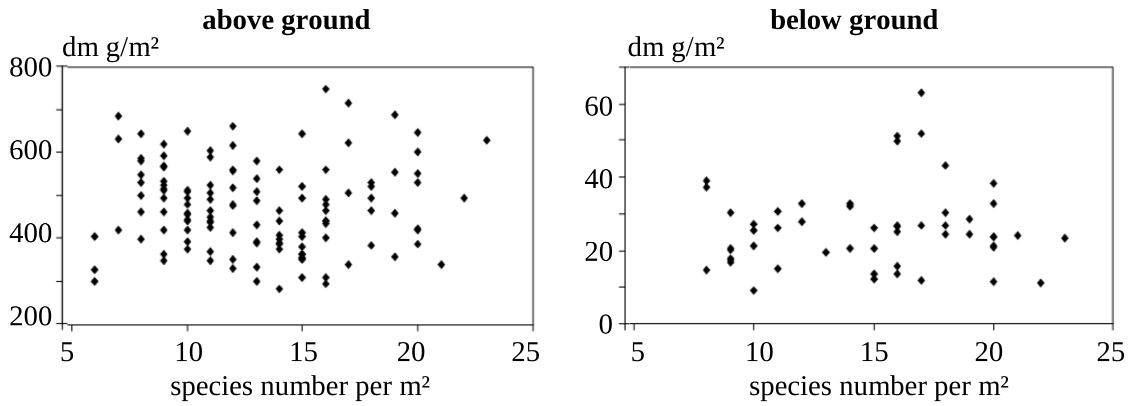

Figure 7 Relationship between plant species number and peak standing crop and root mass in an observational study including practically managed agricultural grasslands, Assaf et al. (2011).

Conclusions

The analysis of ruminant production figures in Central European countries in relation to the grassland area revealed strong differences among different countries which are only in part explained by the variation of the potential herbage production on the grasslands. Thus, improving herbage utilisation either by improved grazing management or by reducing harvesting and conservation losses seems to be a promising way for a sustainable increase of grass based livestock production. Increasing the phytodiversity of grass swards has been shown to have a potential for an increased herbage production without any further external input. However, this was only found in grass leys and could so far not be confirmed for permanent grassland. Research is needed to follow these options for sustaining livestock production from grassland, i.e. the more efficient utilisation of herbage and innovative measures to improve production while reducing fertiliser and chemical input.

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CONTROL OF THE FERMENTATION PROCESS AND THE QUALITY OF CONSERVED FORAGE

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Introduction

Good quality silage and hay are important for the nutrition of ruminants, as well as for the quality and safety of dairy products. Poor silage or hay results in high conservation losses, unpalatable forage and a reduced intake, which in turn causes lower animal performance. Microbial activity in silages or hay can decrease the nutritional value and can lead to health problems for both animals and humans (Lindgren, 1991).

The conservation process involves many steps that should be managed carefully to ensure good quality. This starts in the crop composition; continues with harvest, ensiling, and feed-out management; and is influenced by additives. In Switzerland, most grassland is permanent grassland, and leys are composed of different grasses and clover. Pure swards are very rarely found. Grass-clover mixtures with 30 to 50% of legumes seem to be an optimal system: They yield high amounts of N from symbiotic N fixation and generate high forage yields of high nutritive value, which in turn generates high voluntary intakes and livestock performances (Lüscher *et al.*, 2013).

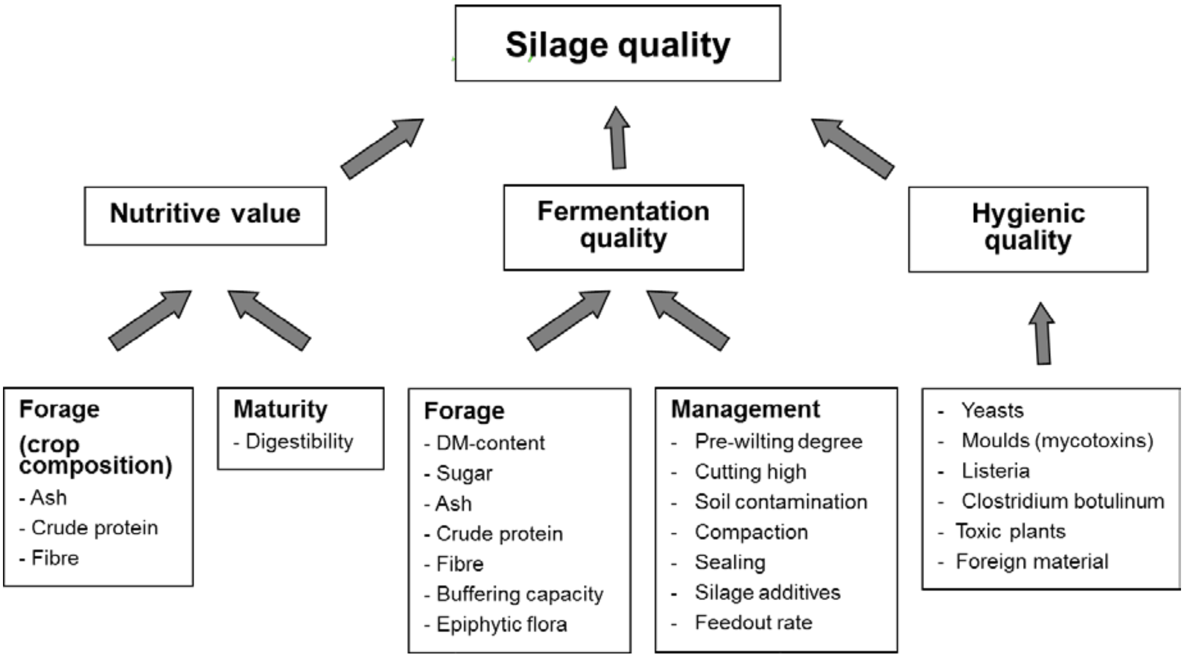
In the present paper, well-known factors that influence the fermentation process are discussed and the results from trials carried out at our research station during the last 20 years are reviewed. In addition, a special element in haymaking—where preservatives are introduced to moist hay—will be discussed.

Forage quality

Silage quality depends on many factors (Figure 1). In terms of the nutritive value of the forage, the botanical composition and the stage of maturity (and therefore the digestibility of the forage) are important. The fermentation quality is also influenced by many elements. The crop composition at harvest has a major impact on the ensiling process and quality of silage (Buxton and O'Kiely, 2003). Furthermore, harvest and ensiling management procedures such as wilting, chopping, compacting, and sealing influence the silage quality (Muck *et al*., 2003) The key factor in producing a well-preserved silage is anaerobic fermentation dominated by lactic acid bacteria (Piltz and Kaiser, 2004). In addition, undesirable bacteria, molds, and toxic plants influence the hygiene quality of the silage. The risk of health problems caused by molds and listeria can almost be eliminated through good silage-making practices (Piltz and Kaiser, 2004).

The factors of nutritive value, fermentation and hygienic quality all influence the silage quality and have an effect on the intake of silage and animal performance. Therefore, producing good quality silage or hay should be the farmer's main objectives.

Figure 1 Different factors influencing silage quality



Crop composition

The composition of the forage at ensiling has a major influence on silage fermentation. The most important components are dry-matter (DM) content, sugar content, and buffering capacity (Piltz and Kaiser, 2004). In relation to these parameters, white and red clovers, as well as lucerne, are known to be more difficult to ensile in comparison to grasses.

At our station, the ensilability and silage quality of four types of botanical composition were investigated (Vogel, 1994). The following four compositions were tested: a grass-rich type with more than 70% grasses (G), a balanced type with 50–70% grasses (E), a legume-rich type with more than 50% white and red clover (L), and a herb-rich type with more than 50% dandelion (H). Forage of the first and fifth cut was moderately pre-wilted (between 22 and 36% DM) and ensiled at two different maturity stages. The lowest sugar contents and the apparently least favorable sugar:crude protein ratios at ensiling did not produce a bad silage quality. The legume-rich and herb-rich forages did not behave more problematically than the others (Table 1). In both cuts, the quality of the silage was poorer with increasing maturity stage. The fermentation quality, expressed as a score according to the DLG evaluation scheme, was negatively correlated with the crude fiber content (-0.63) and with the proportion of grasses (-0.57).

Table 1 Influence of botanical composition and maturity stage on silage quality

			Botanical type			
Cut	Parameter		G	E	L	H
1/early	DM content	%	27.9	29.6	32.1	24.9
	pH		4.6	4.5	4.5	4.1
	DLG points		48	84	97	100
1/late	DM content		34.0	28.1	29.0	32.7
	pH		4.9	5.1	4.7	45
	DLG points		45	36	60	96
5/early	DM content		32.0	31.2	32.2	32.0
	pH		4.9	4.8	4.7	5.0
	DLG points		86	86	87	80
5/late	DM content		23.4	22.2	21.8	22.5
	pH		5.3	4.6	4.8	4.6
	DLG points		28	80	68	64

The negative effect of the stage of maturity on the ensilability and the silage quality was also documented in a trial carried out by Vogel (1996). The grass exhibited low butyric acid production, low pH, relatively low in-silo gaseous losses, and good fermentation quality from the early maturity stage (Table 2). With increasing maturity stage, the butyric acid production and pH increased and the fermentation quality decreased.

Table 2 Influence of the maturity stage of the grass on the silage quality

Maturity		Stage 2	Stage 3	Stage 4
Date of cutting		30th April	14th May	28th May
DM content	%	29.6	28.1	25.6
pH		4.5	5.1	5.9
Lactic acid	g/kg DM	56	57	16
Acetic acid	g/kg DM	12	22	7
Butyric acid	g/kg DM	2	11	34
Gaseous losses	%	5	8	11
DLG points		90	30	-5

The ensilability and silage quality of several grasses and legumes from the first, second, and fourth cuts were investigated (Wyss, 2006). The forage was pre-wilted to 30–35% DM, short chopped, and ensiled in laboratory silos.

Ash, protein, fiber, and sugar content, as well as buffering capacity, were different between the plant species. As a result, the fermentability coefficients varied between 36 and 72. The fermentabily coefficient is calculated with the DM content and the sugar/buffering capacity ratio (Weissbach, 1998).The forage of the first cut had the highest value, while the forage of the fourth cut had the lowest. Furthermore, the fermentability coefficients of the legumes were lower in comparison to the grasses. However, there were also differences within the grasses. The ray-grasses, which had the highest sugar contents, had on average higher values (56) than cocksfoot, which only had an average value of 39. Concerning the legumes, lucerne had a lower value (38) than the white and red clovers (47 and 45). All silages of the first cut had fermentation quality of good to very good. The silages of the fourth and mainly of the second cut were of an inferior quality. The relation between the fermentability coefficients and the fermentation quality (DLG-points) was not very high (Figure 2). A higher relation was found between the sugar content and the fiber content and the fermentation quality (Figure 3). The lowest fermentation quality was shown in the silages using lucerne and cocksfoot. By contrast, with white and red clover good quality silages can be produced

Figure 2 Relation between the fermentability coefficients and the fermentation quality (DLG points)

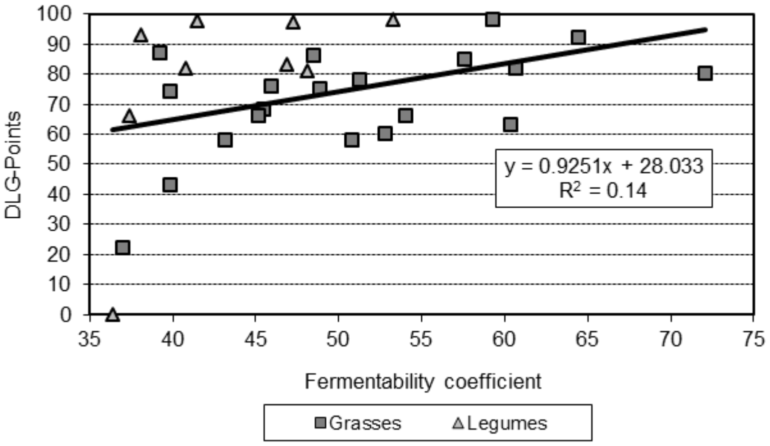


Figure 3 The relation between fermentation quality (DLG points) and the crude fiber and sugar contents

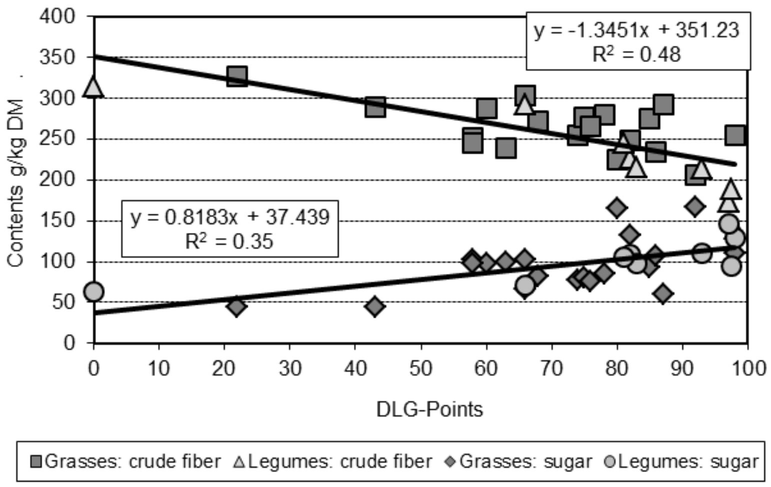
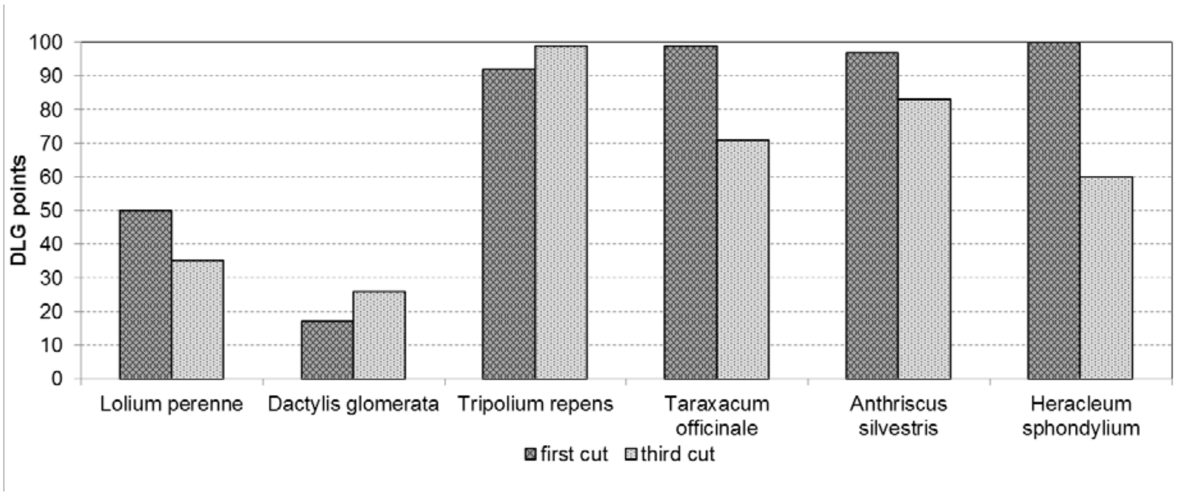


Figure 4 The silage qualities of different plant species



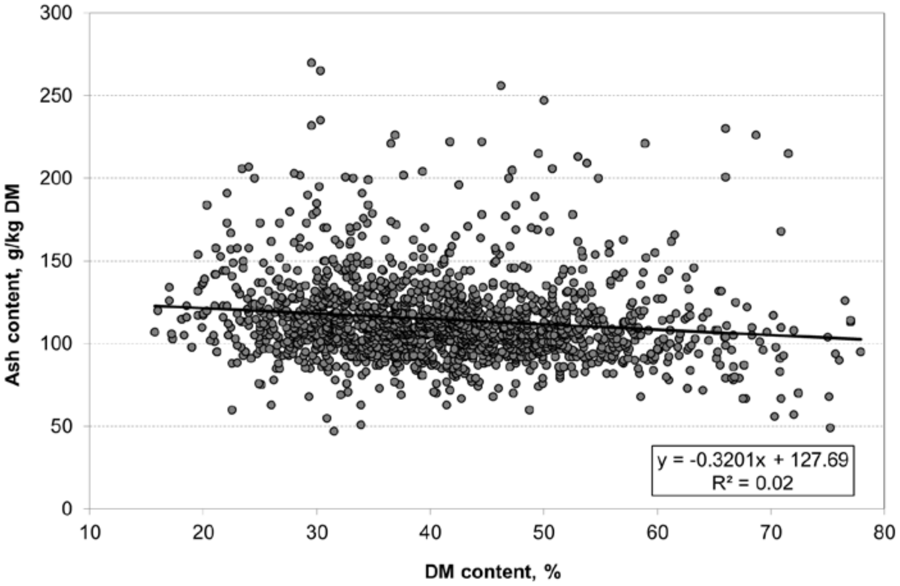
On the grassland, which is cultivated less intensely, the botanical diversity and the proportion of herbs are increased. Moreover, the sugar and buffering capacity of different herbs vary widely. In addition, some herbs contain secondary plant compounds, which can inhibit lactic acid fermentation. According to tests carried out with 52 different plant species, Weissbach (1998) found no indication of secondary plant compounds on the fermentation process.

Trials at our research station showed that almost all tested herbs had higher sugar, higher crude protein, and lower crude fiber content than the two grasses *Lolium perenn*e and *Dactylis glomerata* (Wyss and Vogel 1999). The silages of the herbs and white clover had a better fermentation quality in the first and third cut than the silages with the two grasses (Figure 4).

Harvest and ensiling management

Grass silages produced on farms have often high soil contamination (Figure 5). The average ash content of approximately 2’000 silage samples collected on Swiss farms between 2007 and 2011 was 114 g/kg DM. However, only 25% of the samples had an ash content below 100 g/kg DM. The same problem was also described by Pötsch *et al.* (2010) in Austria and Nussbaum (2007) in Germany. These contaminations result in butyric acid fermentation, higher losses, and lower energy content. According to Hünting and Pries (2008), the net energy content is reduced by 1 MJ for each additional 100 g of soil contamination.

Figure 5 Ash contents of silage samples from farms



In one trial, the influence of the cutting height was investigated on the silage quality (Wyss, 2009). In autumn, the forage of a ley was cut at 7–8 and 3–4 cm. Cutting high strongly influenced the ash content, as well as the energy content, in both the fresh forage and the silages (Table 3). As a result of the high nitrate contents in the green forage (about 10 g/kg DM), no butyric acid was produced. Nevertheless, due to the high pH values and high acetic acid content, the quality of both silages was poor.

Table 3 Influence of the cutting height on the nutritive values and the fermentation quality

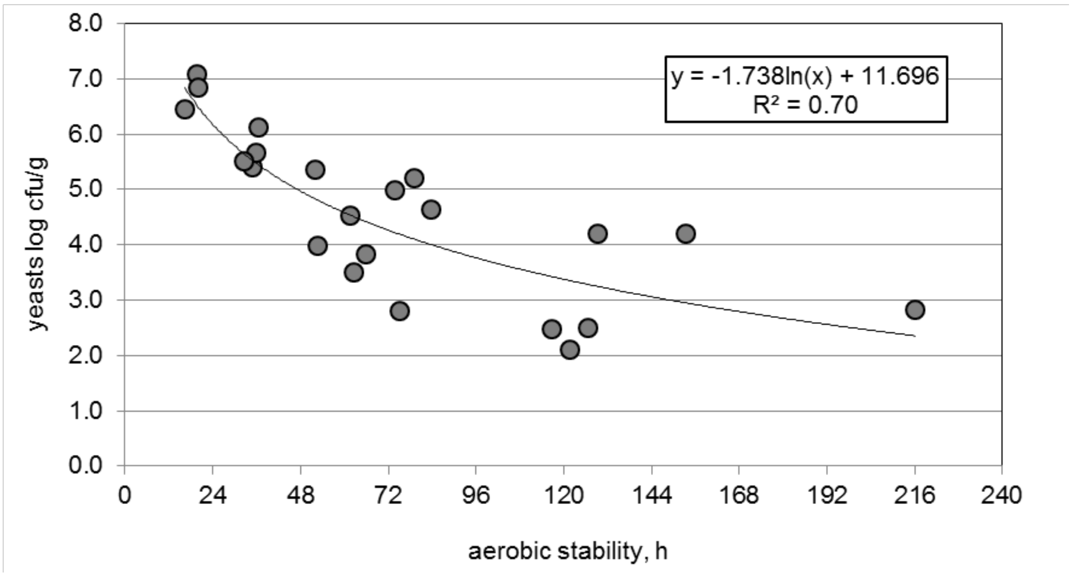
		Fresh material		Silage	
Cutting height		High	Low	High	Low
DM content	%	17.4	17.9	16.7	16.6
Ash	g/kg DM	145	237	177	267
Crude protein	g/kg DM	216	180	224	183
Crude fiber	g/kg DM	230	215	242	231
Sugar	g/kg DM	72	59	7	5
NEL	MJ/kg DM	6.0	5.2	5.6	4.7
pH				4.9	4.9
Lactic acid	g/kg DM			80	67
Acetic acid	g/kg DM			87	77
Butyric acid	g/kg DM			0	0
Gaseous losses	%			6.6	6.3
DLG points				20	28

The feed-out phase

The anaerobic storage phase ends when the sealed silage is opened and the feeding period begins. Silage is a perishable product and aerobic spoilage begins as soon as it is exposed to air. Silage density and porosity are key factors that affect the rate of ingress of oxygen into the silage mass during the feed-out period (Wilkinson and Davis, 2012). However, the feed-out rate is also very important. In farm-scale studies on maize silages in Italy, Borreani and Tabacco (2012) showed that a feed-out rate below 0.5 and 0.8 m per week, for winter and summer consumption, respectively, cannot prevent aerobic deterioration even if very good silo management practices are applied.

Yeasts initiate the aerobic deterioration process and the silage starts to heat up. Figure 6 shows that the higher the yeast content in silage, the less aerobically stable the silage will be (Wyss and Aeby, 2009).

Figure 6 Relation between the aerobic stability and the yeast concentration in maize silage



Use of silage additives

One way to control fermentation is to apply additives. There are countless numbers of inoculants and chemical additives on the market in Europe. With the new EU regulation (No 1831/2003), silage additives are included in the Community Register of Feed Additives in the category of technological additives. According to Wilkinson and Toivonen (2003), additives are used to a very small extent in several countries around the world. The reason for this is that farmers think that under good conditions, the silage will still have good quality without silage additives, or that they are skeptical about their cost effectiveness. On the other hand, Davis (2010) showed that silage additives will play a greater role in the future, as they can help to reduce the environmental impact of ruminant farming and can improve the safety and healthfulness of human food.

It is not always easy for farmers to choose the right silage additive. We revised Nussbaum's (2004) scheme to choose the right additive for grass silage (Figure 7). Here, the farmer has to decide whether he or she wants to improve the fermentation quality by inhibiting butyric acid production or whether he or she wants to improve the aerobic stability of the silage. The main criteria for this are DM content and crude fiber content in relation to the age of the forage.

Trials by Wyss and Vogel (1994) showed that in forage that is difficult to ensile—that with low DM and sugar contents—inoculants can only improve the silage quality if sugar is added (Table 4).

Table 4 Effects of additives in difficult-to-ensile forage on the fermentation quality

		Without Additives	Chemical product	Dextrose	Inoculant	Inoculant + dextrose
DM content	%	16.9	18.8	17.0	17.2	18.8
pH		5.9	4.6	5.6	5.8	4.5
Lactic acid	g/kg DM	12	93	8	7	93
Acetic acid	g/kg DM	56	27	36	24	26
Butyric acid	g/kg DM	68	0	82	85	0
Gaseous losses	%	15	4	14	13	4

Inoculants containing lactic acid bacteria (LAB) are the most common additives used in silage making. The homofermentative strains promote intensive lactic acid production and a rapid decrease in pH. Inoculants with heterofermentative LAB particularly improve the aerobic stability of silages. In heavily wilted forage, the water availability becomes a limiting factor for the development of LAB (Pahlow and Weissbach1996).

In one trial, the efficacy of three different silage inoculants on fermentation quality and the aerobic stability of ryegrass silage with three different pre-wilting degrees were investigated (Wyss and Rubenschuh, 2012). Inoculant 1 contained homo- and heterofermentative LAB. Inoculants 2 and 3 contained only homofermentative LAB. The DM losses decreased in the treatments without additives with increasing DM content (Table 5). The three inoculants reduced the DM losses in the treatments with 34 and 46% DM. In the treatment with 61% DM, only inoculant 1 with homo- and heterofermentative LAB strongly reduced the DM losses. Concerning the fermentation quality, most silages showed high DLG points and therefore a very good quality except for the treatment without additive and 34% DM. Here, butyric acid was produced. When the inoculants were applied, the pH had already decreased after 3 days in the forages with 34 and 46% DM, but not in the forage with 61% DM.

Figure 7 Scheme for the use of silage additives in grass silages

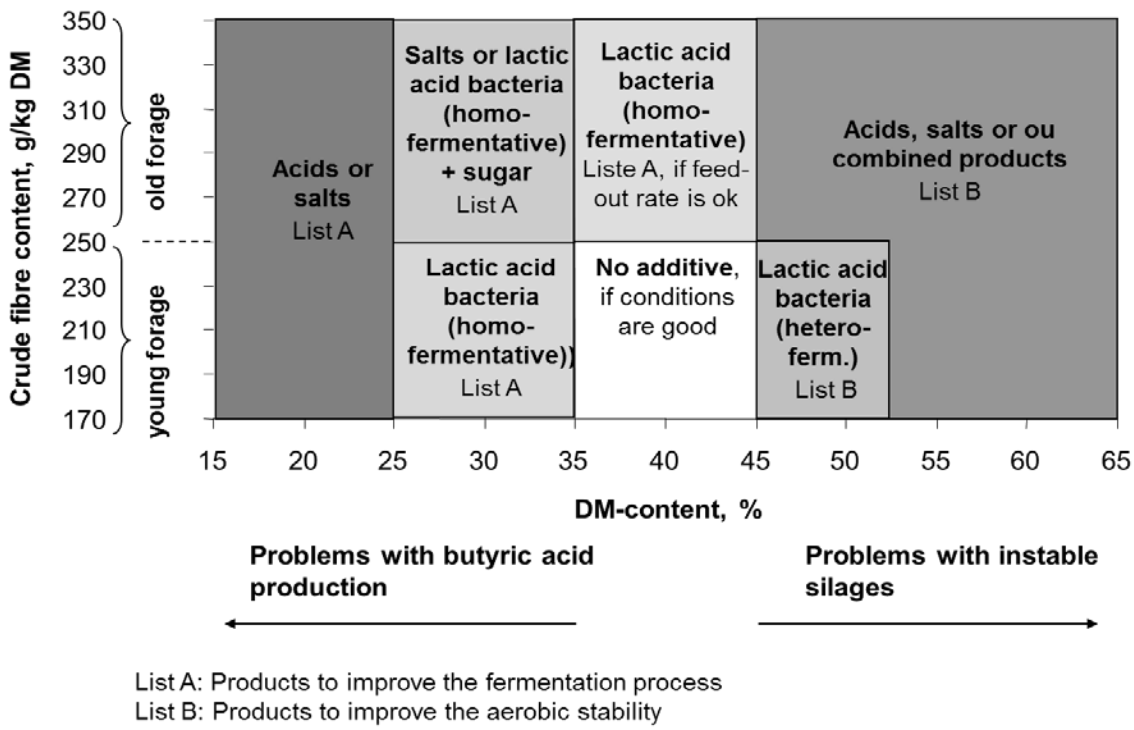


Table 5 Influence of different inoculants on the fermentation quality at different degrees of pre-wilting

Treatment	DM	pH	pH	Lactic	Acetic	Butyric	Ethanol	DLG	DM

		Day 3	Day 91	acid	acid	Acid		points	losses
	%			g/kg DM					%
Control	30.7	6.0	4.9	35	2	17	24	38	11.7
Inoculant 1	33.3	4.3	3.9	118	15	0	3	100	4.5
Inoculant 2	33.0	4.3	4.0	114	5	0	9	100	4.4
Inoculant 3	33.1	4.4	4.0	111	6	0	6	100	4.4
Control	43.1	6.1	5.8	21	3	1	55	90	10.5
Inoculant 1	45.2	4.9	4.1	100	16	0	2	100	4.6
Inoculant 2	44.2	5.0	4.2	92	4	0	3	100	3.8
Inoculant 3	45.2	5.3	4.2	92	4	0	2	100	3.9
Control	59.3	6.1	6.0	4	1	0	46	90	8.1
Inoculant 1	59.4	6.1	4.4	47	24	0	3	100	5.0
Inoculant 2	59.6	6.1	5.3	36	2	0	38	90	7.6
Inoculant 3	58.6	6.1	4.9	46	2	0	30	90	6.7

A good choice is to use silage additives that have been tested by the DLG. The DLG approval scheme for silage additives takes into account different aims of actions, especially the two main ones, which are to improve the fermentation process on the one hand and improve aerobic stability on the other (Staudacher *et al.* 1999). The tests were mainly carried out in small-scale laboratory silos. It is more difficult to distribute silage additives in round bales than in other systems, as round bales are often made of unchopped forage with high dry matter content.

Table 6 Silage quality and aerobic stability of the 2010 silages

Country	Parameter	Laboratory silos			Round bales		
		No add.	Inoculant	Chemical product	No add.	Inoculant	Chemical product
D	DM content, %	35.1	36.4	36.6	37.9	37.2	38.2
	pH	4.3	4.1	4.3	4.7	4.5	5.3
	DLG points	82	100	87	94	98	91
	DM losses, %	7.6	9.7	6.5	6.1	7.8	4.5
	Aerobic stability, days	6.5	16.8	14.4	6.0	13.6	5.7
S	DM content, %	45.3	45.0	45.1	43.9	47.0	46.3
	pH	5.0	4.1	5.1	5.7	4.4	5.9
	DLG points	90	100	90	90	100	90
	DM losses, %	4.4	5.0	3.8	5.7	5.7	4.1
	Aerobic stability, days	1.4	7.0	7.0	1.5	7.0	4.0
CH	DM content, %	37.8	37.9	37.9	35.6	36.6	39.6
	pH	4.6	4.4	4.6	5.0	4.6	5.3
	DLG points	96	98	95	91	97	90
	DM losses, %	5.4	5.5	5.2	4.8	5.2	4.2
	Aerobic stability, days	14.0	14.0	14.0	12.1	14.0	14.0

D: Germany, S: Sweden, CH: Switzerland

To study the efficacy of silage additives in round bales in comparison to laboratory silos, different trials have been carried out in Germany, Sweden and Switzerland in 2010 and 2011 (Wyss *et al.*, 2012). Some results are indicated in Tables 6 and 7. They show that silage additives can also be tested in round bales provided that the treated and untreated forages have the same DM content and that silage additives have been applied homogeneously and in the recommended dose. Furthermore, it is also possible to generate for the tests air stress on the round bales and thereby to make the conditions more difficult for the silage additives.

Table 7 Silage quality and aerobic stability of the 2011 silages

Country	Parameter	Laboratory silos		Round bales					
		No stress		No stress		Stress 1		Stress 2	
		No add.	Ino-culant	No add.	Ino-culant	No add.	Ino-culant	No. add.	Ino-culant
D	DM content, %	36.8	39.9	39.3	43.1	41.8	43.7	43.1	48.2
	pH	4.3	4.2	5.2	4.7	5.1	4.9	5.1	4.8
	DLG points	100	100	90	93	90	91	90	91
	DM losses, %	4.5	4.9	9.1	9.2	9.8	9.3	9.5	9.6
	Aerobic stability, days	7.1	13.5	10.5	7.0	9.5	9.3	7.9	11.0
CH	DM content, %	39.9	40.0	37.9	39.8	40.0	39.4	38.3	40.5
	pH	4.4	4.1	4.6	4.4	4.7	4.4	4.6	4.4
	DLG points	100	100	91	100	84	100	94	100
	DM losses	5.3	5.2	5.4	5.3	5.4	5.3	5.4	5.3
	Aerobic stability, days	8.6	14.0	8.5	14.0	8.1	14.0	6.4	12.8

D: Germany, S: Sweden, CH: Switzerland
Stress1: Four holes (diameter 2 cm) were made 7 days before opening the bales; the holes were closed after 24 hours.
Stress 2: Twenty holes were made with a nail (diameter 0.2 cm) 7 days before opening the bales. Here, the holes were not sealed until the samples were taken.

Haymaking: moist hay

Haymaking has decreased greatly in Europe in recent years. Nowadays, only 3% of milk in Europe is produced without silage. In Switzerland, on the other hand, this proportion is quite a bit higher, at 37%.

Weather conditions make it difficult to produce good hay with a DM content over 85% in the field. The alternatives to making good hay are barn drying systems; however, these systems are expensive and their capacity is limited.

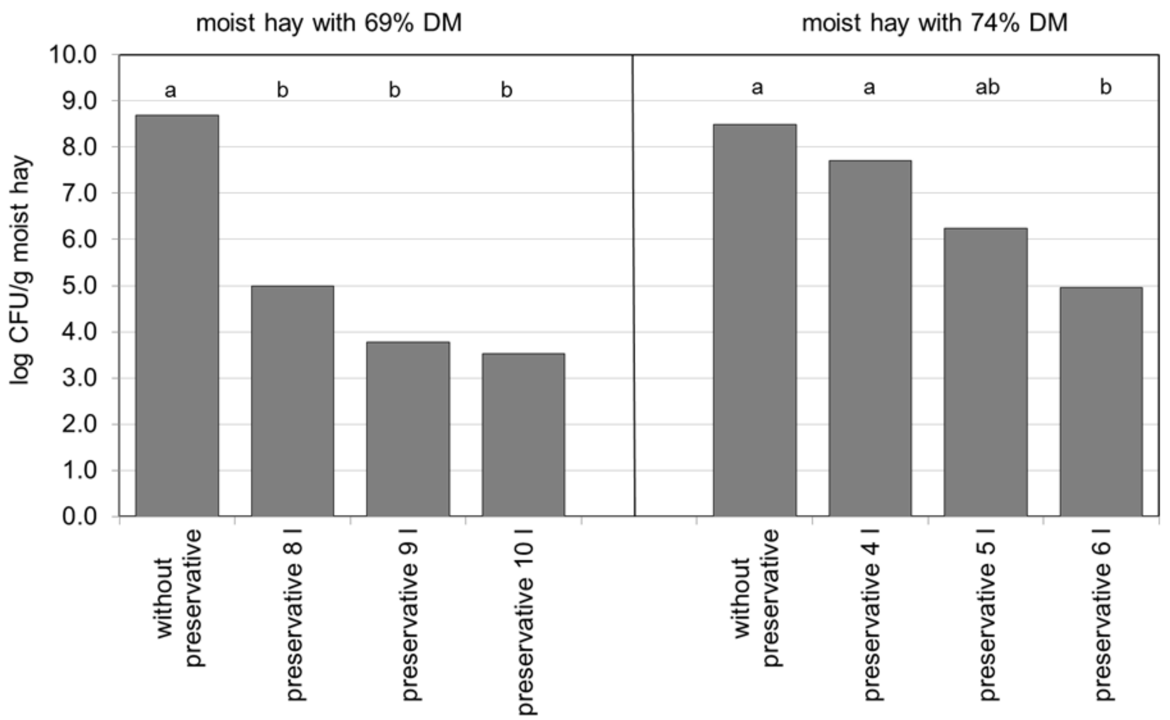
Another technology for preserving hay harvested above optimum moisture levels is to apply organic acids to the hay at harvest time. The use of organic acids has proven to be an effective strategy for preserving baled hay. Interest in using such products has increased with improvements in application equipment, product handling, and corrosiveness, and increased use of large bale packages However, when hay is baled and put into storage at moderate moisture levels (18–30%), a favorable environment exists for the growth of undesirable bacteria, fungi, and yeast. Both moisture and temperature drive the population growth of these microorganisms. Fungi such as Aspergillus and Fusarium can produce a wide range of toxic metabolites and greatly reduce hay palatability (Rankin, 2000).

Propionic acid was the first additive used for hay stabilization; this was examined on a practical scale in the 1970s. Due to its volatility, however, the effects were not always satisfactory (Küntzel, 1991). Less volatile additives with neutral compounds like ammonium-propionate were then developed. Meisser and Wyss (1999) used big square bales to test the effect of an additive based on ammonium-propionate under practical conditions in three trials. The hay was pressed with 70, 69, and 79% DM content. The untreated and treated forage heated up. The poor quality of treated hay was obviously attributable to technical problems (dosage and distribution of the additive).

A further trial was conducted with a two-factorial design comprising preservative dosage (0, 1.6, and 2.0 l per bale) and baler type (round baler with constant and variable press chamber); the design was investigated under field conditions (Meisser, 2003). The hay was pressed with DM-contents of 76%. Big balers with a constant press chamber proved to be better suited than those with a variable press chamber. The former produced bales with a relatively soft core, which facilitated the elimination of excess moisture. Although the preservative limited the rise in temperature, however, its fungi-static effect was unsatisfactory in certain cases. Some treated bales presented a high degree of mold infection. The only distinct difference in nutrient contents between treated and untreated bales concerned the sugar content. The significantly lower sugar contents of the untreated bales reflected microbial growth and activity.

Detailed knowledge of the DM content and the correct dosage is important for a successful conservation procedure. In a trial under laboratory conditions, the efficacy of a preservative containing buffered propionic acid was investigated in hay with two different dry matter contents (69 and 74% DM) and three different dosages per DM-content. Dosages 8, 9, and 10 l/t were applied to the hay with the lower DM-content and dosages of 4, 5, and 6 l/t were applied to that with the higher DM-content. As negative control, variants without additives were tested (Wyss, 2012). Temperature was continuously controlled over a period of 30 days. Before and after this period, the dry DM and other parameters were analyzed. At both DM levels, the untreated hay heated strongly, and at the end of the experiment, it was totally moldy. The mold contents are indicated in Figure 8. Independent of the dosage, it was possible to prevent the heating up and deterioration in quality completely with the addition of preservative to the hay with 69.2% DM. In contrast, in the hay with 74.2% DM, the dosage of 4 l could not prevent spoilage.

Figure 8 Mold contents in moist hay with two DM contents and untreated and treated variants (CFU: colony forming units)



Conclusions

Good quality of silage and the hay is important for the improved nutrition of ruminants and the resulting dairy products. Apart from unfavorable weather conditions, the main reasons for a bad forage quality are obvious management mistakes during harvest, ensiling, or the feed-out period. The factors that influence the forage quality are well known and many trial results have shown that with good management, quality can be improved. Silages of clover or of herbs do not automatically exhibit inferior silage quality in comparison with grass silages. Additives to silages or moist hay can be used to improve the forage quality; however, additives do not compensate for poor management.
On farms, problems remain in relation to bad forage quality—e.g., high soil contamination—or unstable silages, as well as moldy forage during the feeding period. Bringing the results and knowledge obtained from the research to the farmer continues to represent a big challenge.

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PRODUCTION RESPONSES TO CHANGES IN NUTRIENT SUPPLY IN DAIRY COWS FED SILAGE-BASED DIETS[1]

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Introduction

Milk production systems in different climatic zones have developed to utilize local feed resources. Due to the relatively short grazing periods in Central and Northern Europe the contribution of conserved forages of total feed energy intake for dairy cows is high. This emphasizes the importance of nutritive value of conserved forages. Nutritive value of forages is a function of intake potential, digestibility and profile of absorbed nutrients. Because of the central role of feed intake in determining production responses, accurate and precise determination of intake potential of forages is important in the formulation of economically optimal dairy cow diets.

Dairy cow ration formulation and economical optimization are facing several challenges within the current EU market. First, the prices of feed components (grain and protein feeds) and milk fluctuate according to market conditions. Traditionally, ration formulation systems have been based on static feed values and standard feeding recommendations, while the target in optimization is to formulate a least-cost ration to sustain a fixed production level. However, with variable feed costs and milk prices this approach may not maximize the margin over feed cost. For example, with increased grain prices optimal concentrate level will be decreased. It is also well established that in addition to metabolisable energy (ME) and protein (MP) intake other nutrients such as fat and carbohydrates can influence milk yield and composition (Hristov et al., 2005). Consequently, an ideal ration formulation system includes (1) an intake model that takes independently in account both dietary and animal characteristics (2) takes into account feeding level and associative effects on the true nutrient supply (3) and accurately predicts production responses to the changes in nutrient supply. For optimization of the margin over feed costs within a herd, accurate prediction of the marginal production responses to the changes in nutrient supply is more important than predicting actual production levels (Hulme et al., 1986).

Several attempts have been undertaken to model the responses of dairy cows to the changes in ME intake derived from the forage to concentrate ratio (Hulme et al., 1986; Woods et al., 2003 and 2004). Their exponential models clearly indicated that dairy cows exhibit diminishing returns in milk and milk energy output with increasing nutrient supply. However, although based on biologically sound concepts these models do not consider other nutrients such as MP or diet composition (fat, carbohydrates).

Two different approaches can be used to predict milk production responses to the changes in nutrient supply: mechanistic dynamic models that mechanistically describe absorption and metabolism of nutrients in detail (e.g. Baldwin, 1995; Danfær et al., 2006), and empirical models that are based on statistical relationships between different input (e.g. ME, MP) and output (e.g. milk, milk protein) variables. Several reviews of animal science research have relied on regression in an attempt to evaluate quantitative relationships between independent (X) and dependent (Y) variables. In such reviews, however, it has been usual to ignore the fact that observations within a given study have more in common than observations across studies (St-Pierre, 2001). Ignoring the study effect has as a consequence that the estimation of parameters (slopes and intercept) of regression models can be severely biased. Development of mixed model regression analysis using a random study effect allows investigating the relationships between input and output variables and enables the estimation of marginal responses to the changes in nutrient supply without bias (St-Pierre, 2001; Sauvant et al. 2008). Compared to simple fixed model regression analysis this approach allows reducing the variability resulting from differences between studies in animals (breed, stage of lactation etc.), analytical methods and other systematic factors. Basically, this approach corresponds to practical feeding situation within a single dairy farm. There are several criteria that must be encountered before ration formulation systems based on maximizing milk income over feed cost can be successfully used: accurate and precise forage analysis (i), feed evaluation systems that describe accurately and precisely relative productive values of feedstuffs (ii), an intake prediction model in which animal and dietary factors are not confounded (iii), models that predict accurately production responses to the changes in nutrient supply (iv) and accurate estimation of the current feed intake and production (v). The objectives of this paper are to review the development of ration formulation system that allows optimisation of milk income over feed cost. The paper is based on earlier publications (Huhtanen and Nousiainen, 2012, 2013).

[1]This paper is based on publications by Huhtanen and Nousiainen (2012; Livest. Sci 148: 146–158); Huhtanen and Nousiainen 2013; Recent Advances in Animal Nutrition, in press)

In addition, factors influencing the responses to increased level of concentrate supplementation and protein concentrate of concentrates will be discussed in more detail.

PREDICTION ON NURIENT SUPPLY

Feed analysis

Reliable feed analysis both in terms of precision and accuracy is the first requirement in development of models predicting intake and production responses. In the case of on-farm feed samples the analysis should also have low costs. Because of greater contribution to the total dry matter intake (DMI) and greater variability in composition and feeding values, it is more important to analyse forages than concentrates. The main emphasis in forage analysis should be in the variables that either directly [energy and crude protein (CP) concentration] or indirectly primarily via intake effects (digestibility, neutral detergent fibre (NDF), DM concentration, fermentation characteristics) influence nutrient supply to the animal.

Feed evaluation

Metabolisable energy (ME)

Developed intake and production response models are based on “old-fashioned” factorial feed evaluation systems [metabolisable energy (ME) and protein (MP)]. The reason is that dietary parameters of especially ME model are much more accurate and precise compared with digestion and passage kinetic parameters required in mechanistic or semi-mechanistic models. In a recent study with 30 forages (Jančík et al., 2011) digestion rate of potentially digestible neutral detergent fibre (pdNDF) determined by the in situ technique was approximately 0.60 of that determined by automated *in vitro* gas production technique. Consequently, calculated values for organic matter (OM) digestibility (OMD) were much lower than those derived by empirical equations from pepsin cellulase solubility or indigestible NDF concentration (iNDF). Similarly, in the study of Dønnem et al. (2011) ruminal NDF digestibility (NDFD) determined by in situ was proportionally only 0.71 of the total NDFD in vivo. Another weakness of the method is large between laboratory variation (Madsen and Hvelplund, 1994). It is possible that the *in situ* ranks the feeds reasonably well within the study and laboratory, but in feed evaluation and especially in predicting feed intake and production responses exact precise ranking of the feeds is not adequate – the values must also be accurate.

Feed ME values in model development (Huhtanen and Nousiainen, 2012) were estimated according to MAFF (1975) equations from digestible nutrients for concentrate feeds and as function of D-value (digestible organic matter concentration in DM) for forages. Within the practical range of digestibility or q-value (ME/GE) the variation in the efficiency of ME utilization above maintenance is marginal and there is no evidence that net energy predicts production responses in dairy cows better than ME.

Because the digestibility of forages is highly variable, accurate estimates of OMD / D-value (concentration of digestible OM in DM) of the on-farm forages are critical for accurate predictions of intake and production responses. In vivo digestibility in sheep fed at maintenance is the standard, but it is not practical in farm conditions. A lot of efforts have been placed to predict digestibility from chemical composition of feeds, but with limited success (Van Soest, 1994; Huhtanen, et al., 2006). Fortunately, *in vitro* methods based on rumen fluid (Tilley and Terry, 1992; Goering and Van Soest, 1970) or commercial enzymes (Jones et al., 2000; Nousiainen et al., 2003) can predict digestibility of forages accurately. In a meta-analysis predicting diet digestibility in dairy cows from OMD estimates at maintenance, DM intake and some dietary variables prediction error was not greater when forage OMD at maintenance was determined by *in vitro* methods compared to *in vivo* OMD in sheep fed at maintenance (Huhtanen et al., 2009). In practise forage D-values are estimated by near infrared reflectance spectroscopy (NIRS). In Finland NIRS is calibrated against pepsin – cellulase solubility that is calibrated against *in vivo* digestibility (Huhtanen et al., 2006). Another alternative is to calibrate NIRS using indigestible NDF (iNDF) determined by 12 d *in situ* incubation using nylon bags of small pore size as a reference method. This method resulted in more uniform empirical predictions of in vivo OMD than other methods (Huhtanen et al., 2006; Krizsan et al., 2012), and it can successfully be calibrated to NIRS (Nousiainen et al., 2004). The main focus in feed evaluation should be measuring NDF concentration and quality accurately and precisely, because cell solubles (i.e. OM-NDF) are almost completely digested by ruminants (Huhtanen et al., 2006)

In development of both intake and production response models we used tabulated digestibility coefficients for concentrate feeds to calculate ME and MP values. Currently, there is no reliable laboratory method that could improve the accuracy and prediction of concentrate energy values compared to using tabulated digestibility coefficients, which are based on large number of digestibility trials. The accuracy can be improved by using analysed chemical composition rather than tabulated composition, especially when deviations from tabulated values can be expected. One problem is that the calculation of ME is still based on the Weende analysis, although dividing carbohydrate fraction to crude fibre and N-free extracts lacks sound biological basis.

Metabolisable protein (MP)
The concentration of MP was calculated as a sum of microbial and feed MP. Microbial MP is calculated as:

Microbial MP (g/kg DM) = 152 × (DOM_m – RUP) × 0.75 × 0.85

where DOM_m and RUP are concentrations of digestible OM at maintenance intake and rumen undegraded protein (kg/kg), and 0.75 and 0.85 are proportion of amino N in microbial N and digestibility of microbial N. Although it is well known that silage fermentation products, fat and starch escaping ruminal fermentation do not provide energy for microbial growth in the rumen, predictions of milk protein yield were not improved by including these parameters in the model predicting microbial MP (e.g. Huhtanen, 2005; Rinne et al. 2009). Feed MP was calculated as:

Feed MP (g/kg DM) = (1 – EPD) × CP × 0.82

where EPD = effective ruminal degradability of CP and 0.82 is digestibility of RUP. Tabulated values for EPD (MTT, 2011) and constant digestibility of RUP (0.82) were used in model development even when EPD and intestinal digestibility of RUP were published. Using tabulated rather than determined values can be justified due to large between laboratory variation (Madsen and Hvelplund, 1994).

Feed intake prediction

Intake is the most important factor influencing animal performance, and variability in intake is greater than in digestibility (Mertens, 1994). Differences in converting digestible energy to ME and conversion of ME to net energy are relatively small, but not unimportant. The importance of DMI is clearly demonstrated in our treatment mean dataset (n = 1116 diets) from milk production trials in dairy cows (Huhtanen and Nousiainen, 2012). Of the variation in energy corrected milk (ECM) yield 81% was related to DMI. Even within a study with much small variability 62% of the variation in ECM yield was related to DMI. For individual cow dataset (n = 1451) the corresponding values were 65 and 63%, respectively. Slightly more variation was accounted for by ME intake, probably because the very close relationship (R^2 = 0.91) between DMI and ME intake and between digestibility and DMI. For maximising forage intake in dairy and beef rations it is important to determine the intake potential of forages. There is a dilemma of forage intake potential in forage evaluation and ration formulation. In forage evaluation intake potential is a response (output) of feed characteristics, but in ration formulation intake is used as an input to predict output (animal performance).

Due to its important role in influencing animal performance accurate prediction of DMI responses is a prerequisite for the formulation of economical dairy cow diets. Despite intensive research, no generally accepted intake model has been developed. Limited success is at least partly due to complicated interactions between the animal and feed factors, and difficulties in distinguishing and quantifying these factors. Many intake models include observed milk yield as a predictor of intake. However, these models are primarily useful in predicting intake required to sustain a given level of milk production, as stated by Keady et al. (2004a). It should also be noted that the yield can only be known retrospectively after the diet has been fed (Ingvartsen, 1994). Several attempts have been made to develop prediction equations for practical ration formulation using multiple regression equations for individual animal data. However, these models have usually large prediction errors due to large between animal variability and inappropriate statistical models. These models can result in biased estimates of parameters and erroneous conclusions e.g. of the effects of silage fermentation characteristic on silage DMI. Using mixed model regression analysis with random study effects for treatment mean data allows estimating quantitative relationship between dietary variables and DMI and the relative intake potential of diets.

The first relative silage DMI index (SDMI-index) model included D-value, quadratic negative effect of TA concentration and logarithmic of ammonia N (Huhtanen et al. 2002). Volatile fatty acids, especially propionic acid, had a stronger negative effect on intake than lactic acid. Digestibility was a much better predictor of SDMI than CP and NDF. The effects of D-value and fermentation quality were combined into a single index by defining standard silage (SDMI-index = 100) and that 0.10 kg DM is one index point. Root mean squared prediction error (RMSE) adjusted for the random study effect was 0.41 kg/d, i.e. the model predicted precisely the differences in the intake potential of silages within studies. The model was revised to include other variables that significantly influence SDMI (Huhtanen et al., 2007). In addition to D-value and fermentation characteristics, the revised model includes the concentrations of silage DM and NDF, harvest of grass silage (primary vs. regrowth) and forage type (grass, legume and whole-crop). Silage DM concentration influenced quadratically SDMI with maximum intake at DM concentration of 350-400 g/kg. Intake of regrowth silages was 0.4 kg DM/d smaller than that of primary growth silages when the differences in other variables were taken into account. Both legume and whole-crop silages displayed positive associative effects on SDMI, i.e. the intake of silage mixtures was greater than the mean of the two silages when fed alone. Maximum NDF intake was observed at a D-value of 640 g/kg DM suggesting that the cows do not use the full rumen capacity when fed high D silages. Indeed, rumen NDF pool has reduced with increased silage digestibility (Bosch et al., 1992, Rinne et al., 2002) despite increased SDMI. These observations do not support the bi-phasic intake regulation theory (e.g. Mertens, 1994); it rather suggests that DMI is regulated by interplay between physical and metabolic factors. In the revised model fermentation variables were simplified to the linear negative effect of TA concentration. However, with silages displaying secondary fermentation the intake predictions can be improved by including acetic acid or VFA in the model (Eisner et al., 2006). Adjusted RMSE of the revised model was 0.34 kg/d and it explained 0.85 of the variation in SDMI within a study. D-value, fermentation quality and DM concentration were the three most important variables. Ammonia N was excluded from the current model because some additives contain ammonia.

It is well-known that both the amount and composition of the concentrate supplements influence SDMI. Therefore the next step in developing the intake prediction model was to include concentrate factors in the model (Huhtanen et al. 2008a). Total DMI increases with increased concentrate DMI (CDMI) but the increases diminished at high levels of supplementation; i.e. substitution rate increased. Substitution rate also increased with increased intake potential (SDMI-index) of silages. Interestingly, SDMI explained the variation in substitution rate better than any single component of it. The interaction between forage intake potential and concentrate supplementation is also included in the Feed into Milk model presented by Keady et al. (2004b). In their model silage intake potential is determined by NIRS calibrated against standardized intake data by cattle. In addition to CDMI, the model of Huhtanen et al. (2008a) includes the quadratic effect of supplementary protein intake, negative linear effect of fat and positive linear effect of concentrate NDF. Adjusted RSME of the CDMI model in studies in which different concentrate treatments were used with the same silage was 0.27 kg. The two indexes were combined to a single total DMI index (TDMI-index) that describe quantitative differences in DMI within a study by assuming the effects are additive. In the model evaluation the observed DMI response at 0.095 kg/index point was close to default value of 0.100 and the adjusted RMSE of the TDMI-index model was 0.37 kg DM/d.

Evaluation of the TDMI-index model indicated that quantitative differences in the intake potential of the diets can be estimated accurately. The modelling was based on an assumption that within a study the animal factors [e.g. yield, live weight (LW)] are similar for all diets. However, in practical ration formulation in addition to relative intake potential related to diet characteristics, accurate predictions of actual intake including animal factors is required. Most intake prediction models use milk yield and live weight as animal variables. Because milk yield is a function of both cow's genetic potential and diet characteristics, it is important that animal and diet variables are modelled independently of each other to avoid double-counting. It is important to note that cow's genetic intake potential does not increase when she is fed a better diet; the intake response is entirely due to the diet effect. To avoid this double-counting and to have unbiased estimates of diet effects in the model, we used standardised energy corrected milk (sECM) rather than observed yield to describe production potential of the cow (Huhtanen et al., 2011a). Observed ECM was adjusted for days in milk, TDMI-index and dietary MP concentration, i.e. to predict how much the cow would produce at a given stage of lactation when fed a standard diet. An advantage of this approach is that all data is available at the time of prediction, in contrast to observed ECM yield. The final model comprised sECM, LW, days in milk as animal factors and TDMI-index to describe the dietary intake potential. The regression coefficient of TDMI-index (0.09) remained close to the default value suggesting that the true animal and diet effects were separated properly.

In optimisation of diet (maximum milk income – feed cost) it is important that the intake prediction is based on cow's intake potential that is independent of the current diet. Especially in situations, in which the optimal diet differs from the current one, using the recent milk yield in predicting future intake would be misleading. The study of Friggens et al. (1998) demonstrated elegantly that observed milk yield can be misleading in predicting intake potential. Ten kg difference in milk yield between the cows fed low and high concentrate diets during the first period would suggest a great difference in intake potential, but this was not realised when the diets were switched. In this case the differences in milk yield were related to the diet's intake and production potential – not to the potential of the cows.

MODELS PREDICTING MILK PRODUCTION RESPONSES

Models predicting milk, ECM and protein yield were developed from a dataset based of treatment means (n=1098) 235 studies (Huhtanen and Nousiainen, 2012) using mixed model regression analysis with random study effect (St-Pierre, 2001). With this approach responses to the changes in nutrient supply are predicted within a study, an approach that is similar to predicting yield responses in farm conditions when the animal and management factors are constant. The response of ECM yield to ME intake above maintenance was proportionally 0.45 greater when derived by a simple regression model compared with the corresponding mixed model regression with random study effect (0.144 vs. 0.099 kg ECM/MJ ME). This difference indicates that using fixed regression models can result in biased estimates of production responses, and consequently erroneous models for ration optimization.

Empirical models predicting milk, ECM and protein yield are presented in Table 1. The models for milk and ECM yield showed a highly significant curvilinear relationship between ME intake above maintenance and milk or ECM yield. Intake of ME estimated at maintenance was adjusted to take into account the effects of feeding level and diet composition (associate effects) on diet digestibility at production intake Huhtanen et al., 2009). It is well established that the response in milk output by dairy cattle to changes in nutrient intake is curvilinear (Agnew et al., 1998), reflecting an increased partitioning of nutrients from milk production to body tissue with increased energy intake. In agreement with respiration chamber studies (Agnew et al. (1998), at zero energy balance additional increment in ME intake is partitioned approximately equally between milk output and body tissues.

In addition to ME intake the supply of other nutrients has significant effects on milk production responses. To reduce the collinearity between energy and protein variables feed MP rather than total MP, and concentration rather than intake variables were used to describe protein supply. Increased supply of feed MP had positive effects on milk and ECM yields indicating a galactopoetic effect of protein with the responses being greater in milk than in ECM yield Clearly higher efficiency of the utilization of incremental ME intake in protein supplementation studies compared to the whole dataset (0.18 vs. 0.11 kg ECM/MJ ME) indicates that either the efficiency of ME utilization improved and/or a greater proportion of incremental energy was partitioned towards milk with increased protein supply. The data from the calorimetric studies do not indicate improvements in the efficiency of ME utilization with increased dietary CP concentration (Tyrrell and Moe, 1980; Vermorel et al., 1982). However, it is worth noting that even small improvements in the efficiency of ME utilization can result in noticeable improvements in the efficiency of the utilization of increment in ME intake. In the whole lactation study (Law et al., 2009) enhanced dietary CP concentration (114, 144 and 173 g/kg DM) decreased calculated cumulative energy balance, but this was not reflected in body condition score, LW or blood metabolites. Similarly, in established lactation substantial increases in production performance with protein supplements were not associated with any changes in blood metabolites reflecting changes in mobilization of body tissues (Shingfield et al., 2003).

Table 1 Production response equations for milk, ECM (kg/d) and protein (g/d) yields derived from milk production trials[b] with cows fed predominantly grass silage-based diets and using mixed model regression analysis to remove the study effect. Adapted from Huhtanen and Nousiainen (2012, 2013).

Item	Milk	ECM	Protein
Intercept	5.30	1.84	122
Production ME intake (MJ/d)	0.140	0.175	3.25
Production ME intake $(MJ/d)^2$	-0.00018	-0.00023	
Feed MP (g/kg DM)	0.109	0.071	
Feed MP intake (kg/d)			513
Feed MP intake (kg/d)			-242
Non-fibre carbohydrates (NFC, kg/kg)	19.3	28.3	521
NFC × NFC (kg/kg)	-32.5	-51.7	-702
Concentrate crude fat (CCF, g/kg DM)	0.0913	0.0473	1.21
CCF × CCF (g/kg DM)	-0.00105	-0.00067	-0.0176
DIM (d)	-0.0224	-0.0146	-0.434
Adjusted root mean square error [a]	0.424	0.497	15.2

[a] Adjusted for random study effect; [b] n=1098 from 245 studies.

Milk and ECM yield responses were also significantly related to dietary concentrations fat and non-fibre carbohydrates (NFC) in a quadratic manner (Table 1). Fat concentration was expressed as concentrate fat (analysed as ether extract) in total DM to avoid errors related to variable composition of forage ether extract, which in addition to fatty acids contains other components (chlorophyll, waxes, fermentation acids). True fatty acid concentration in forages is relatively low and constant. The effects of concentrate fat agree with Sutton and Morant (1989), who concluded that inclusion of lipids in dairy diets generally increases milk yield, but depresses milk protein concentration while the effects on fat concentration are variable. Dietary fatty acids can be directly incorporated in milk fat during mammary synthesis, and therefore increase the energy efficiency and milk component output (Kronfeld, 1976). The diminishing production response to fat at higher dietary concentrations may partly result from negative effect on diet (NDF) digestibility (Tamminga, 1993), and more specifically from the decline in marginal true fat digestibility (Weisbjerg et al., 1992).

Even though the effects of dietary NFC concentration on milk and ECM yield were significant, within the practical range of NFC concentration (200-400) the maximum ranges in milk and ECM yield were 0.7 and 0.8 kg/d. The effects can be related to better balances in substrate supply to rumen microbes and/or nutrient supply to metabolism. The decreases in milk and especially in ECM yields at high NFC concentrations may result from a decrease in NDF intake and changes rumen VFA proportions that reduce milk fat production and may partition more nutrients towards body tissues.

Milk protein yield is predicted from ME intake above maintenance, feed MP intake, and dietary concentrations of concentrate fat and NFC (Table 1). The supply of feed MP displayed curvilinear responses in milk protein yield that agrees with many earlier studies demonstrating diminishing returns to increased total MP supply (Doepel et al., 2004; Lapierre, et al., 2006; Huhtanen and Hristov, 2009). ME intake was an important determinant of milk protein yield reflecting the high contribution of microbial MP to the total MP supply. In previous meta-analysis (Huhtanen and Hristov, 2009) based on large datasets (>1 700 diets) energy intake was at least as good predictor of milk protein yield than MP intake, when the feeding values were calculated according to NRC (2001) system. Marginal response to incremental microbial MP was approximately five times greater than that of feed MP in bivariate models predicting milk protein yield (Huhtanen and Hristov, 2009). This emphasizes the importance of separating their effects in models predicting milk protein yield, and demonstrates the key role of energy intake in regulating milk protein production. It was estimated that at constant energy and CP intake marginal protein yield responses to incremental MP derived from reduced ruminal protein degradability were only 0.06-0.08 (Huhtanen and Hristov, 2009). Small responses to incremental Feed MP can also partly result from inherent methodological problems of the in situ technique that can overestimate the true range in protein degradability among feedstuffs (Broderick and Cochran, 2000; Huhtanen and Hristov, 2009). Analysis of data from omasal sampling studies (Broderick et al., 2010) supports this suggestion. Because microbial MP supply is very closely correlated to ME intake, ME intake rather than microbial MP is used in protein model to reduce the total number parameters required in the models. One advantage of using ME intake in the model is that it can be estimated more accurately and precisely than MP or feed MP. Excluding ME intake from the protein model would likely increase the error due overemphasizing the effect of ruminal protein degradability.

Model evaluation

To be useful in practise, the models predicting production responses must be based on predicted rather than observed feed intake estimates, since actual intake data is not available at the time of formulation and optimisation of the ration, as was the case in model development. Therefore accurate predictions of production responses demand that intake responses to the changes in diet composition can be accurately and precisely predicted. Because intake models also involve errors, it is likely that the total errors of the production response models are greater when based on predicted rather than determined feed intake. The model evaluation was made using the data from five production trials with dairy cows (54 diets) as described by Huhtanen and Nousiainen, 2013). Intake of each diet within a study that were estimated by the TDMI-index model (Huhtanen et al., 2008a):

$$\text{DMI} = \text{Mean DMI (kg)} + (\text{TDMI-index} - \text{Mean TDMI-index}) \times 0.09.$$

According to the equation one unit in TDMI-index above the mean index in the study corresponds to 0.09 kg/d increase in DMI above the mean DMI. The difference between observed and predicted DMI represents random variation of the intake model or factors not accounted in the model. Responses of ECM yield and milk protein yield were estimated using the equations of Huhtanen and Nousiainen (2012) and predicted DMI. All studies were conducted using cyclic change-over designs with factorial arrangement of treatments. The treatments included silage digestibility, silage harvest (primary vs. regrowth) and silage fermentation quality, level of concentrate supplementation and CP concentration in the concentrate.

The model explained proportionally 0.85 of the variation in ECM yield (Figure 1). Observed increase in ECM yield was slightly smaller than predicted as indicated by the slope below 1.0. The residuals (observed – predicted) were significantly related to the residuals of intake predictions (Figure 1) emphasising the importance of accurate estimates of feed intake. Most of variability in intake predictions is likely to be random, since excluding two outliers means squared prediction error was 0.35 kg that corresponds to standard error of a treatment mean for a treatment with 10 cows and residual standard deviation of 5%. The two outliers are interesting; observed intake was about 2 kg/d greater than predicted intake. Intake of grass silage was exceptionally high (17.4 and 15.0 kg DM/d with concentrate supplements of 6.9 and 10.2 kg DM/d). With these diets increases in ECM yield were clearly greater than predicted due to the greater than predicted feed intake. In bivariate model with predicted ECM and residual of DMI the regression coefficient of the intake residual was 1.34 kg ECM/kg DM, a value being consistent with marginal production responses to increased DMI in production studies with dairy cows. This also indicates that errors in DMI predictions, either random or systematic, influence predicted production responses. The model predicted milk protein yield responses better than ECM yield responses (Figure 1) by accounting for 90% of the variation in observed milk protein yield. When the residual of feed intake was included in the model R^2 increased to 0.93. The good performance of the model can be attributed to the accurate evaluation of feed protein value.

FACTRORS INFLUENCING CONCENTRATE RESPONSES

Production responses to increased concentrate or protein supplementation can vary according to different animal and feed factors. In concentrate level studies (99 studies, 247 diets) the same silage was fed ad libitum with different levels of the same concentrate and in protein supplementation studies (123 studies, 328 diets) the same silage was fed *ad libitum* with the same level of concentrates differing in CP concentration. Rapeseed meal, rapeseed expeller, soybean meal and fish meal were used as supplementary protein sources. Relationship between input (kg concentrate DM, ME, kg CP) and output variables (ECM and milk protein) were evaluated with mixed model regression analysis using the following model:

$Y = B_0 + B_1X_{1ij} + b_0 + b^1X_{1ij} + e_{ij}$, where B_0 and B_1X_{1ij} are the fixed effects (intercept and effects of independent variables) and b_0, b_1, and e_{ij} are the random experiment effects (intercept and slope), where i = 1 . . . n studies and j = 1 . . . ni values.

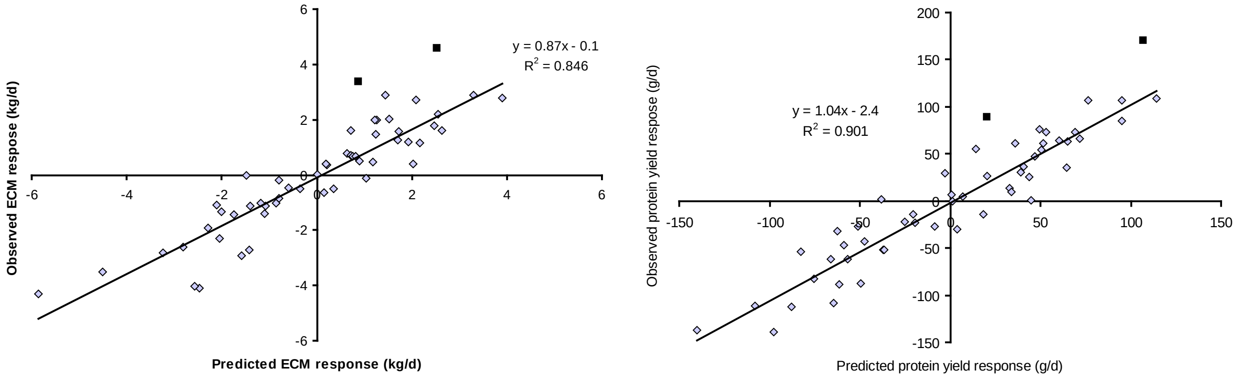

Figure 1. Predicted and observed ECM (left) milk protein (right) yield responses (adapted from Huhtanen and Nousiainen, 2013).

The effects of different animal and dietary variables on ECM and milk protein yield to increased nutrient supply were evaluated by plotting the random slope effect (B_1 + b_1) in each trail against observed animal and diet variables on the control diet in each trial (lowest concentrate or level dietary CP concentration).

Responses to concentrate level

The mean response to increased concentrate feeding was 0.69 (SE = 0.047) kg ECM/kg DM. The response was close associated to intake response (Figure 2) indicating that the greater the substitution rate (decrease in silage DMI per increase in concentrate DMI) the smaller the production response to increased concentrate feeding will be. This emphasise the importance of accurate intake predictions in diet formulation and optimisation models. When the intercept was forced to zero the slope was 1.30, i.e. if substitution rate were zero (no effect on forage DMI) ECM yield would increase 1.3 kg/kg incremental DMI. Assuming ME concentration of 12.5 MJ/kg DM for concentrates and ME requirement of 5.2 MJ/kg ECM production the response to increased concentrate feeding is about 55% of that based on feeding recommendations. This discrepancy can partly be attributed to decreased diet digestibility with increased feeding level and negative associative effects between feeding level and proportion of concentrate in the diet. In meta-analysis of digestibility data (Huhtanen et al., 2009) diet OM digestibility decreased 2.6 g/kg increase in DMI. The regression coefficient between predicted digestibility at maintenance level of feeding and that observed in dairy cows with production diets was only 0.685. This indicates that the increases in ME intake with increased concentrate feeding are smaller than predicted. However, decreases in digestibility with increased feeding level are partly compensated for by reduced methane and urinary energy losses per unit of digestible energy. With increased concentrate feeding more nutrients are partitioned towards body tissues at the expense of mammary gland, which in addition to overestimation of ME supply explains the deviation in ECM yield from that estimated from feeding recommendations. Data from respiration studies have also indicated that at zero energy balance about half of incremental ME intake is partitioned towards mammary gland and half to body tissues (Agnew et al. 1998).

Surprisingly, the ECM responses were negative related to the production level of the cows fed the lowest level of concentrate in each trial (Figure 2). This is mainly because of the smaller initial level of concentrate in studies conducted at lower production levels, since there was a strong negative relationship between initial level of concentrate and marginal response to incremental concentrate feeding. Reduced ECM response with increased initial concentrate intake is least partly due to diminishing total DMI responses with increased concentrate level. When the ECM responses were expressed per unit of incremental ME intake the effects of both initial milk yield and concentrate intake were much smaller, but they were still statistically significant ($P < 0.01$). Estimates of ME intake were discounted for the effects of feeding level and diet composition. Diminishing ECM responses to incremental ME intake with increased initial milk yield and concentrate intake can be due to repartitioning more nutrients to body tissues or reduced efficiency of ME utilisation. However, calculated ME balance was not related to initial milk yield or concentrate intake. Most feed evaluation and ration formulation systems assume linear relationships between ME intake available for production and net energy output (milk + body tissues). Reduced marginal responses to incremental ME intake gives support to the British Feed into Milk system (Thomas, 2004), in which Mitscherlich function is used to describe the relationship between ME intake above maintenance and milk energy output.

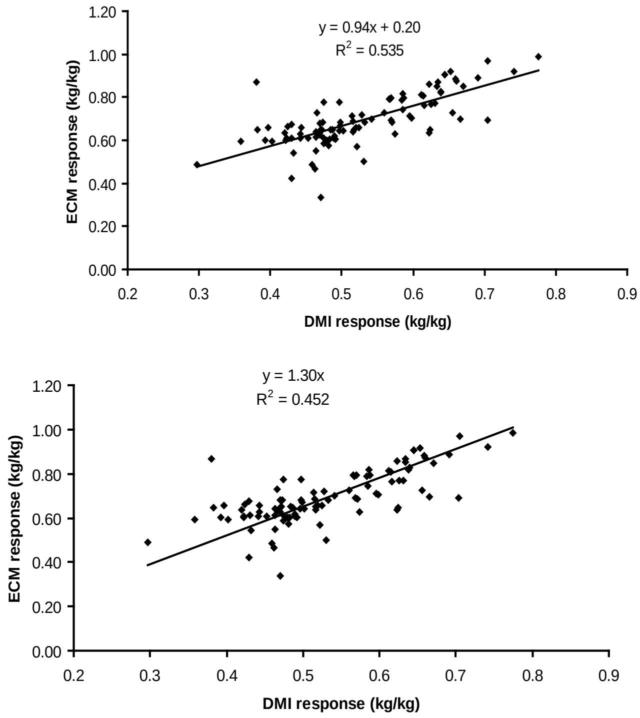

Figure 2 Relationship between total DMI and ECM responses to increased concentrate feeding. Left: allowing intercept; right: intercept forced to zero.

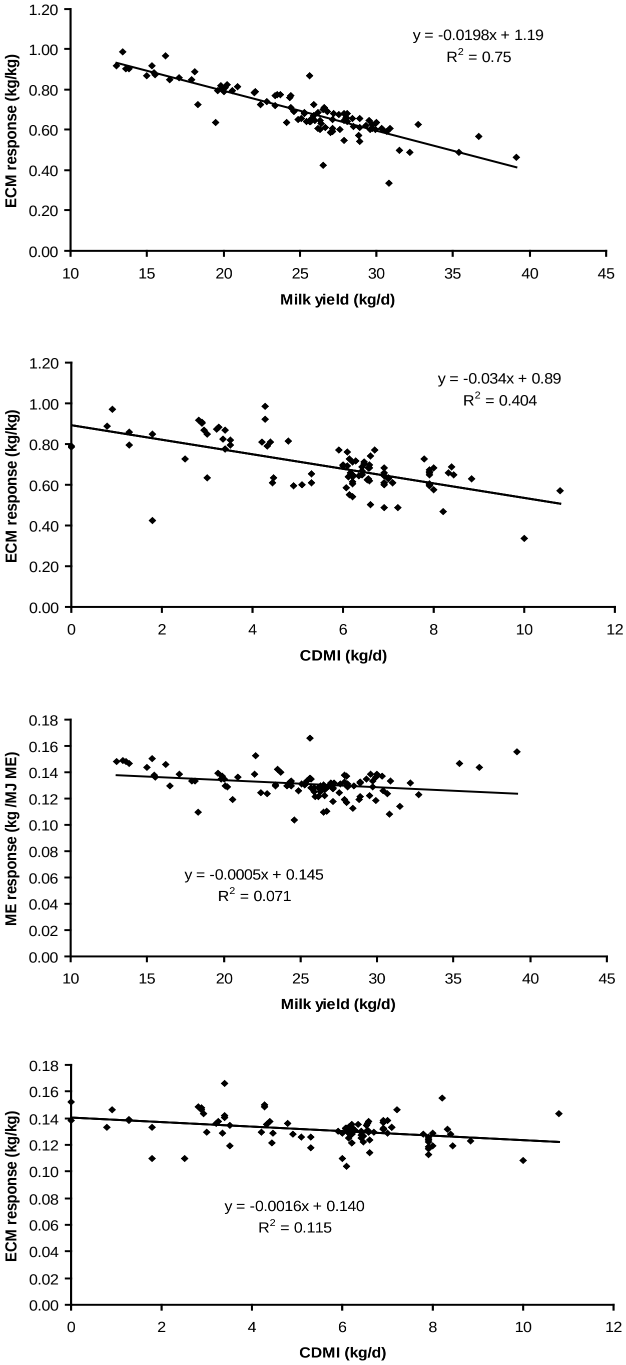

Figure 3 Relationships between ECM responses per kg concentrate DM (above) and incremental ME intake (below) to initial milk yield (left) and concentrate level (right) in the study.

The responses of ECM yield to incremental concentrate DMI was negatively (P < 0.01) related to D-value and intake potential of silage (Figure 4). Silage intake potential was described by relative silage DMI-index (Huhtanen et al., 2007). Consistently with DMI predictions, interactions between forage quality and concentrate intake was more closely related to intake potential than D-value (Huhtanen et al., 2007). However, when the ECM responses were expressed per incremental ME intake the relationships were not significant (Figure 4). This suggests that diminishing ECM responses to increased concentrate intake were mainly associated with reduced total DMI intake responses with improved silage intake potential. Substitution rate increased 5.8 g/kg concentrate DMI when silage DMI-index increased 1 unit.

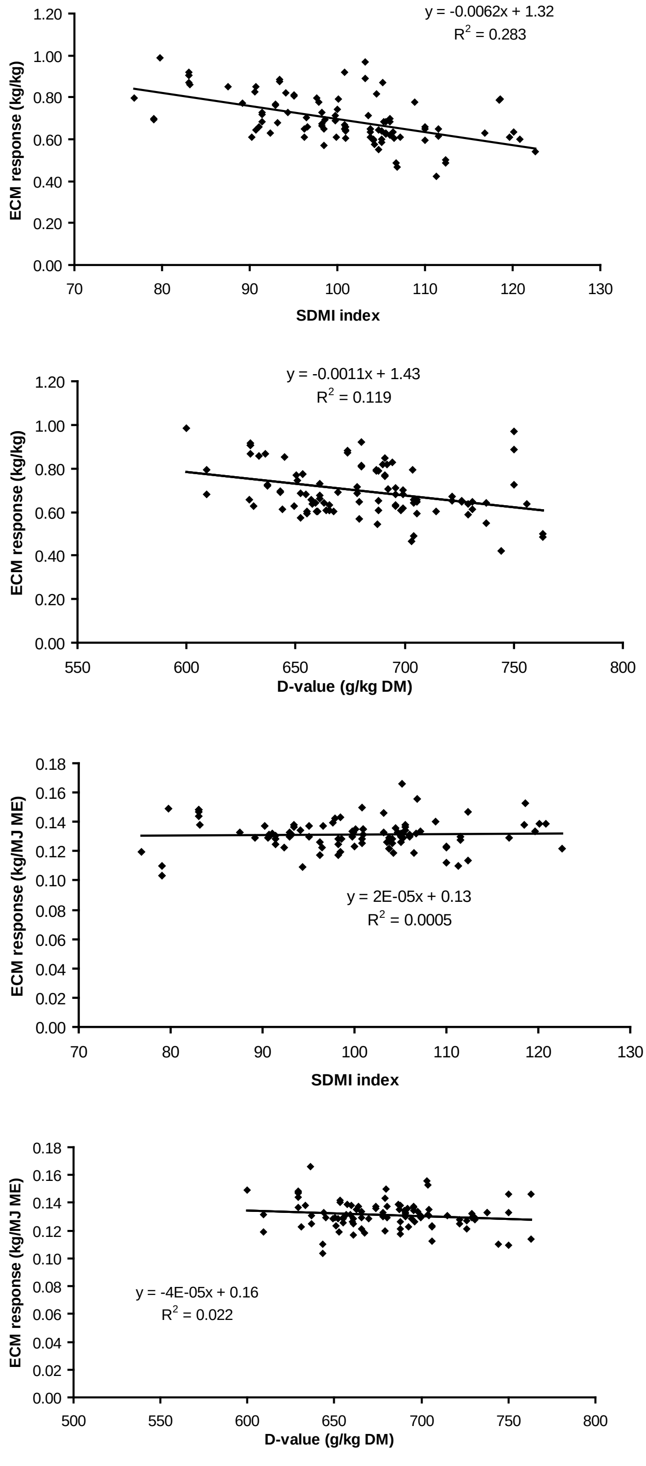

Figure 4 Relationships between ECM responses per kg concentrate DM (above) and incremental ME intake (below) to silage DMI-index (left) and D-value (right) in the study.

Responses to supplementary protein

Responses to supplementary protein were rather poorly related to animal and feed factors. It is interesting to note that initial milk yield was slightly, although significantly (P =0.03) negatively related on milk protein yield response to supplementary protein feeding (Figure 5). In studies carried out using rapeseed feeds marginal milk protein response was slightly (143 vs. 123 g/kg CP) in studies with mean milk yield <28 kg/d (mean 24.4) than in studies with mean milk yield >28 kg/d (mean 30.0) in the meta-analysis by Huhtanen et al. (2011b). It could be expected that high yielding cows benefit more from supplementary protein compared with low yielding cows because MP requirements increase proportionally more than ME requirements with increased production level. On the other hand, the efficiency of microbial N synthesis increases and ruminal protein degradability decreases with increased intake thereby increasing the ration between AA and ME in absorbed nutrients. Milk protein yield was negatively ($P < 0.01$) related to the amount of concentrates (Figure 5). This effect may be related to increased energy supply and consequently microbial protein synthesis with higher levels of concentrate supplementation. This may also explain the slightly negative relationship between initial milk yield and marginal protein yield response, since initial milk yield and concentrate DMI were positively correlated.

Protein yield responses were negatively related to forage CP concentration and positively to the proportion of water soluble N (Figure 6). Numerically the effect of silage CP concentration was negligible suggesting that increasing forage CP concentration has rather limited potential to replace supplementary protein. Consistent with this, increasing silage CP concentration from 120 to 150 g/kg DM by N fertilization had no influence on milk yield, whereas isonitrogenous supplementation with rapeseed expeller increased milk yield substantially (Shingfield et al., 2001). Positive relationship between silage soluble N and the response to supplementary protein indicates that protein value was negatively influenced by increased proteolysis in the silo, but quantitatively the effects were marginal. Similar trend was found for the concentration of total acids in silage. Previous analysis of data from silage studies indicated that silage protein value in terms of milk protein yield was mainly related to intake and digestibility, whereas CP concentration (Huhtanen et al., 2010) and N solubility (Huhtanen et al., 2008b) had only minor effects. Soluble N had a negative influence on milk protein yield when silage MP was estimated using constant protein degradability irrespective of N solubility, but the adverse effect was almost completely related to ammonia N (Huhtanen et al., 2008b). It appears that the effects of silage fermentation quality on milk production are mediated mainly by the influences of fermentation end-products on feed intake.

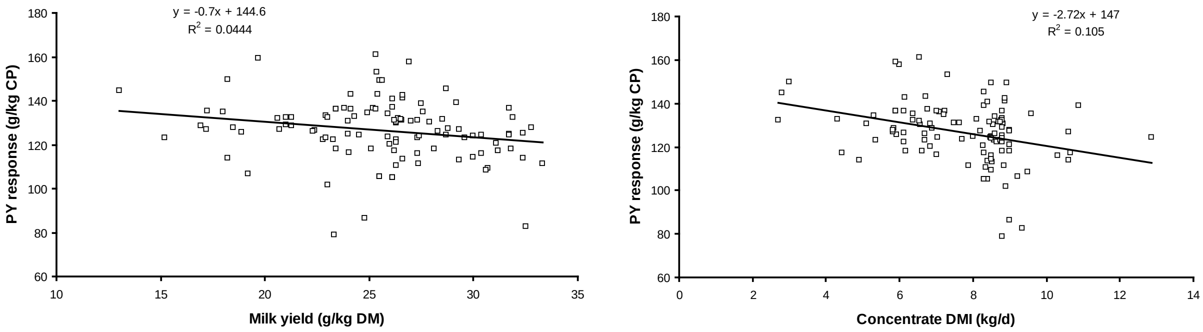

Figure 5 The effects of milk yield and concentrate DMI in cows fed the control diet on responses to supplementary protein feeding.

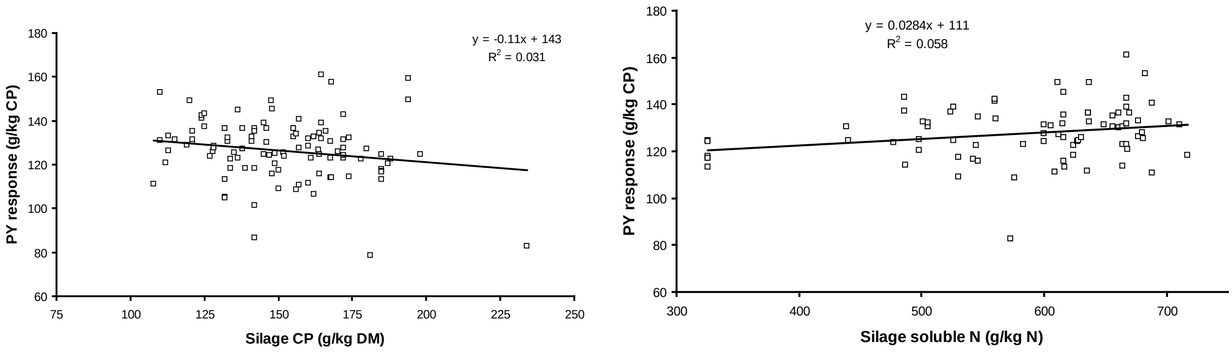

Figure 6 The effects of silage CP concentration and proportion of soluble N on responses to supplementary protein feeding.

Conclusions

Developed ration formulation model is a flexible tool for the optimization of the economy of milk production under conditions with rapidly changing feed and milk prices. It is currently the basis of ration formulation programs used by the Finnish advisory service for dairy farmers. It also allows comparing strategies in mitigation of N and P surplus or methane emissions from dairy farms. There are several prerequisites of the model: (1) accurate and precise forage analysis, (2) feed evaluation systems that describe accurately and precisely relative productive values of feedstuffs, (3) an intake prediction model where animal and dietary factors are not confounded, (4) models that predict accurately production responses to the changes in nutrient supply and (5) accurate estimation of the current feed intake and production to determine the current nutritive status of the cows. The accuracy of forage analysis, especially D-value is important because of strong influences on both ME concentration and intake potential. As an example of feed evaluation systems predict a lower protein value (MP/CP) for rapeseed meal than for soybean meal (relative value of rapeseed protein 0.80-0.90), but in a meta-analysis marginal milk protein yield response to incremental CP intake was significantly greater (130 vs. 100 g/kg CP) for rapeseed meal (Huhtanen et al., 2011b). With such failures in predicting the true productive values of feeds maximum profit with optimization according to margin over feed costs is not likely to be attained. Feed intakes should be based on models in which animal and diet effects are not confounded; increased milk yield in response to better diets does not increase cow's intake potential – intake increases only due to improve intake potential of diet. The model can also be used as a tool to evaluate different strategies for mitigating environmental emissions from dairy production.

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NEW CONCEPTS OF BIOGAS SYSTEM FOR SUSTAINABLE ANIMAL AGRICULTURE

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Biogas plant has attracted much attention recently from the view points of bio-waste recycling for environmental protection and a measure of global warming control as one of the renewable energies. However, biogas plant still has a major obstacle to be its wide use, except some European countries, such as Germany, due to relatively expensive power generation costs compared with large scale wind turbine systems and the problems in epidemiology and nitrogen contamination on spraying the digested biomass slurries.

The thermophilic fermentation system newly developed at higher temperature than the conventional one, such as 60℃ or 65℃, enables the reduction of construction by miniaturization of digesters due to their shorter retention times, the easy excess ammonia stripping from digested slurries and the pasteurization or inactivation of bacteria, viruses and seeds. Various agricultural wastes could be co-digested fluently by hyper-thermophilic or thermophilic fermentations after effective degradation of biomasses as the pretreatment. It is also possible for biogas systems to reduce their generation costs by scaling up of the systems from small individual to large centralized plants, which also enables to obtain the higher efficiency in power generation. Biogas plants are in an advantageous position in the generation cost, compared with photovoltaic and wind turbine generations, since it is not necessary for biogas generation to have batteries for energy storage. Further advantages by introducing generation quartet (electric power, hot water, carbon dioxide for greenhouse application, and digested slurry as nutrients for aquaculture application) and novel bio-fuel cell systems were also discussed.

***Keywords**: renewable energy, biogas, fuel cell, bio-wastes, hyper-thermophilic fermentation, generation quartet*

1. General

Biogas plant systems are characterized by two important functions of organic waste disposal for environmental protection and energy supply such as CHP (combined heat and power) plants (Takahashi et al., 2003; 2004; Takahashi, 2010). The further advantages could be obtained by introducing biogas systems for the preservation of agricultural eco-system from desertification and contamination of pesticide residue and excess nitrogen by over fertilizing. Organic wastes are reclaimed by anaerobic digestion in the form of slurry type fertilizer with high retaining properties of water and nutrition, which are expected to prevent the desertification by spraying the digested slurry to the farmlands. Aquaculture application of digested slurries is also available after adjusting their nutrients concentrations and redox conditions. Sanitary reuse of the digested organic wastes should be given the first priority in consideration, therefore, the types of fermentation should be thermophilic, 55℃, or hyper-thermophilic, such as 65℃.

Composting is still major method of disposal for cattle and swine manure, garbage and other organic wastes. However, a problem has been brought up that the compost generates GHGs, such as N_2O and CH_4, in relatively large quantities (Ondrey, 2004). Thus, the strict control is necessary in the redox and water content conditions on manufacturing and storing composts to restrict the metabolism of methanogens and some fungi without N_2O reducing enzymes. Biogas plants could solve the problem of GHGs emission from composts by introducing hyper-thermophilic and digested slurry treatment systems (Kebreab, et al., 2006).

In the IPCC scenario, biomass energies including biogas systems are characterized by key words; “renewable, abundant, carbon neutral, storable and substitutive”, and are expected to supply 1/3 of global energy consumption at the end of this century. However, biomass energies still have a major obstacle to be widely used, due to relatively expensive collecting cost of biomass resources from a wide area of fields to a power plant and to the problem of the digested bio-waste treatment. In farmland areas, some total systems are being established from the bio-waste collecting to its recycling as digested slurry. On the other hand, local governments with garbage collecting systems as a municipal service are possible to obtain another type of biomass resources for biogas plants without any additional expense, especially in the case of separate collection of garbage.

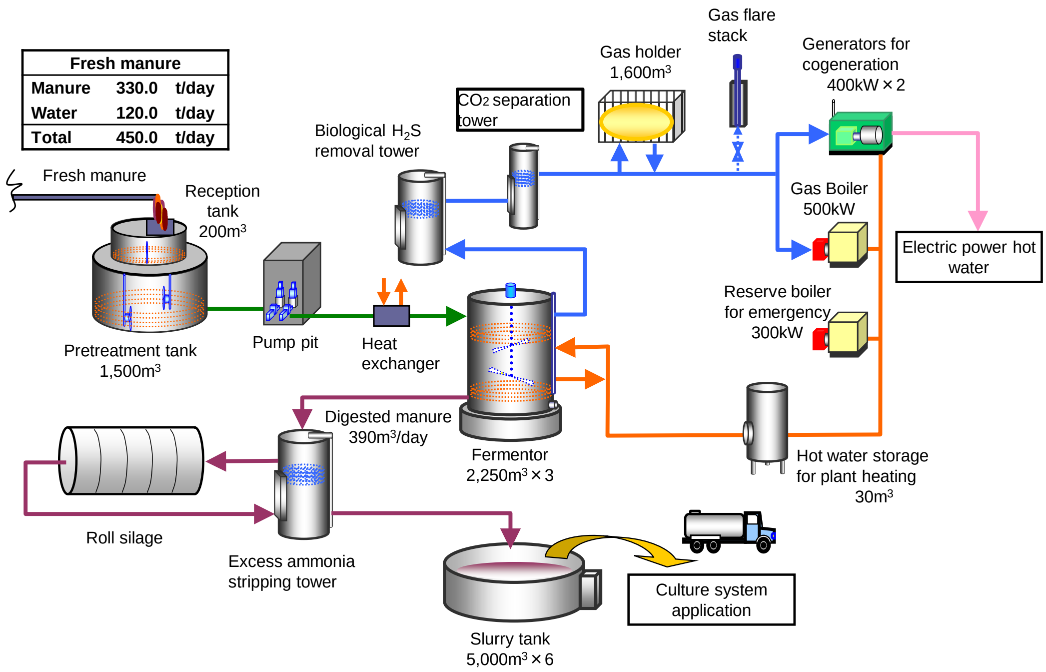
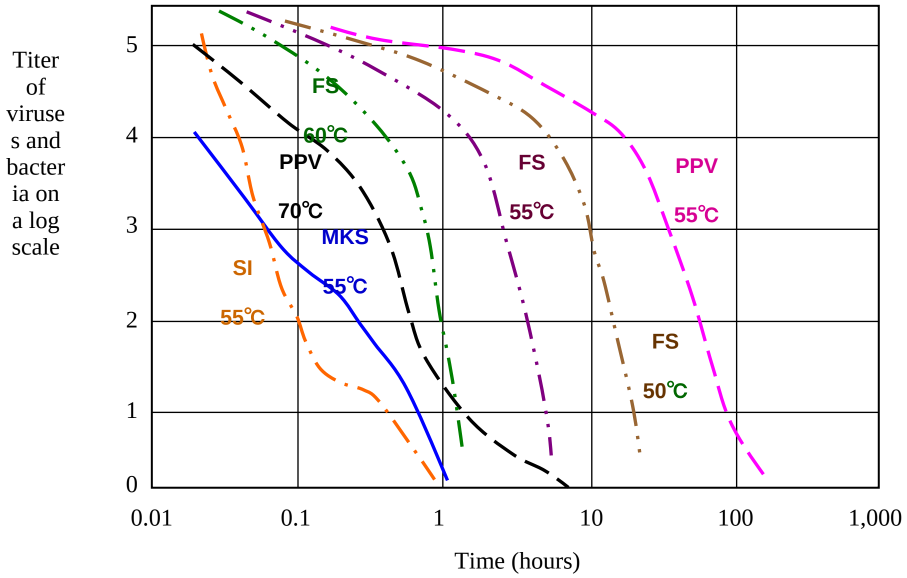


Fig. 1 A new biogas system with generation quartet functions

Fig. 1 shows an example of the advanced biogas system, which is characterized by following items; (1) Thermophilic and hyper-thermophilic digestion makes to improve the quality of digested slurries in sterilizing sanitation, nitrogen concentration reduction, and prevention of foul odor emission. (2) Stable supply and increased calorie of the biogas in this system enable gas engine co-generation to be superior in the point of total generation costs including energy storage compared with photo- voltaic or wind turbine application (Umetsu, et al., 2006). (3) The digested slurry spraying to fields is expected to be strong countermeasures against desertification, especially inland areas of continents, due to their nutritious and humectants characteristics (Umetsu, et al., 2005). On the other hand, aquaculture application of digested slurries, after nutrients concentration and redox conditions, enables organic agriculture reducing pesticides consumption as much as possible. The redox condition adjustment of digested slurries is important for aquaculture application, since low oxidation states of ammonia, such as hydroxylamine, contribute to prevent root diseases of plants caused by *Fusarium* for example.

Fig. 2 shows sterilizing conditions for animal viruses and a fecal bacterium (Bendixen, 2000), and Table 2 shows ammonia and foul odor removal performances at the results of the demonstration plant and 10 litters' digesters in Obihiro University of Agriculture and Veterinary Medicine (Joint Project Program of Obihiro University of Agriculture and Veterinary Medicine and The University of Queensland, 2008). Fig. 3 shows the biogas demonstration plant and its subsidiary digested slurry treatment process.

According to the performance of sterilization, 60 to 65°C digestions are important for spraying or aquaculture application of digested slurries in the system of sustainable animal agriculture. Thermophilic and hyper-thermophilic digestion is suitable for ammonia and other odorous gases concentration reductions in the digested slurries as shown in Table 1. In rural areas, the stripped excess ammonia could be use to improve agricultural byproducts such as wheat straws to more nutritional feeds. The ammonia will make softer fibrous feeds by partially acting on β1, 4-glycoside bond of cellulose. Additionally, crude protein content in these cellulose biomasses will increase binding ammonia into the broken sites of β1, 4-glycoside bond as amide by ammonolysis (Takahashi, 2007).



PPV : Porcine parvovirus,

MSK : Foot-and mouth disease virus,

SI : Swine influenza virus and

FS : Faeces entrococci.

Fig. 2 Inactivation of animal viruses and a fecal bacterium at various temperatures

Fig. 3 Thermophilic biogas plant (4 tons per a day) and bench scale ammonia stripping plant attached to the biogas plant in Obihiro University of Agriculture and Veterinary Medicine

2. The advanced biogas system performance

The new biogas system are characterized by new additional concepts of the utilization of CO_2 separated from biogas and digested slurry for aquaculture as shown in Fig. 4.

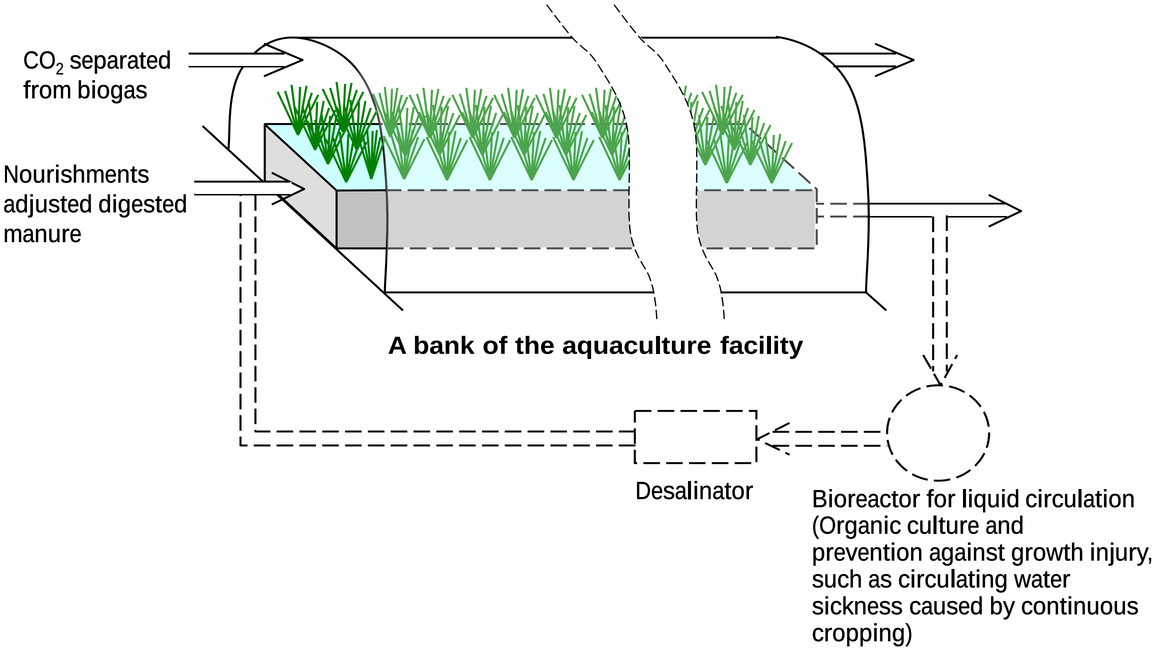


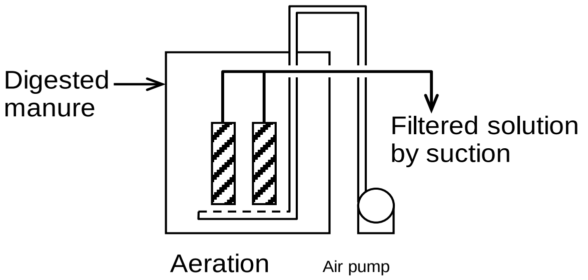
Fig. 4 A conceptual example flow of the nuticulture technology using the separated CO_2 from biogas and digested slurry

Improper management of livestock wastewater will causes eutrophication in hydrosphere due to nitrate and nitrous oxide emission in atmosphere attributed to excess amount of ammonia nitrogen (Puckett 1999). Even digested slurries of biogas plants involve thousands milligrams of nitrogen in the form of ammonia and organic amino compounds, which

Table 1 Ammonia stripping performance and odorous gas concentrations in the stripped gases

Digested manure	NH_3-N concs. in digested manure		Concs. in the stripped gases		
	Before NH_3 stripping (mg/ℓ)	After NH_3 stripping (mg/ℓ)	NH_3 (ppm)	H_2S (ppm)	MeS (ppm)
Mesophilic pH 7.8 (approx. 37°C)	2110	1950	155	250	26
Thermophilic pH7.5 (approx. 53°C)	1650	1140	470	30-87	0-5
Hyper thermophilic pH 7.5 (approx.62°C)	1870	380	970	12	0

causes contamination of underground water by nitrate ion and a GHG emission of N_2O on spraying them to rural fields (Takahashi, 2006). Table 2 shows some examples of nitrous oxide emission in case of digested cattle manure spraying to meadows. The emission rates greatly depend on redox conditions and moisture contents of the soil sprayed by digested slurries. Since it seems to be difficult to avoid constantly the condition of soil to emit the nitrous oxide, the best way to control the nitrous oxide emission is to reduce the nitrogen content reduction in digested slurries. As shown in Fig.3, ammonia stripping from digested slurry is one of the options to reduce excess nitrogen efficiently as a physical method, because most nitrogen compounds in organic wastes will be changed to inorganic forms by anaerobic fermentation Takahashi, 2007). Alternatively, some biotechnological methods are proposed using autotrophic or heterotrophic bacteria. So far, most biotechnological approaches on ammonia removal from livestock wastewater have been implemented by aerobic nitrification and anaerobic denitrification using autotophs. However, the autotorophic bacteria are presumably unsuitable for livestock wastewater treatment because of high strength of ammonium and organic matters. Furthermore, the long retention for autotrophic nitrification has been designated due to slow proliferation rate of the bacteria. In an attempt to seek ammonia removal ability of heterotrophic bacteria *Alcaligenes faecalis* strain No.4 was isolated from sewage sludge (Joo, et al. 2006). As an alternative way to mitigate N_2O and nitrate emission derived from animal agriculture, heterotrophic nitrification and aerobically denitrifying effect of *A. faecalis* strain No.4 on excess amount of ammonia nitrogen was evaluated in bench scale removal system. Possible removal of ammonia from digested slurry using *A. faecalis* strain No. 4 was confirmed under proper controlling pH and redox potential.



Performance of the bench scale removal system of nitrogen of digested manure

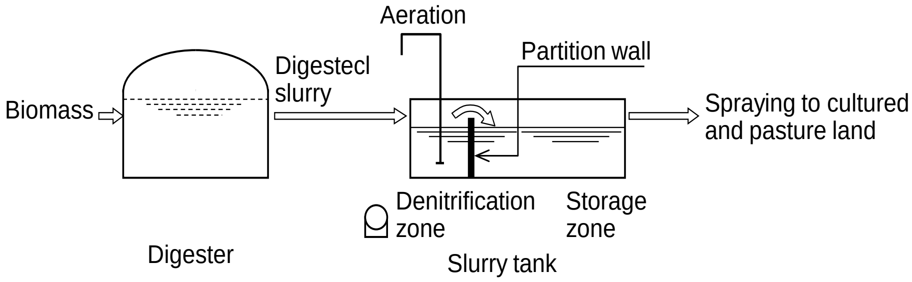
Temperature, pH	23℃, 7.7～7.9
Redox potential	-50～+10mVAg/AgCl
Removal of T-N	2,500→1,100mg/l
Removal of NH4+-N	2,100→200mg/l
Retention time	15hrs.

Culture of Alcaligenes feacalis Strain No.4

Reactor for aerobic denitrification

Inside of the reactor

Fig. 5 Nitrogen removal of digested manure using *Alcaligenes faecalis* strain No.4



Evolution of N_2O from Cattle Manure Treatment Systems

Samples (gases)	Estimated gas volumes evolved per a ton of fresh manure	Components of the evolved gases					Remarks
		C_2 (%)	N_2 (%)	CO_2 (%)	CH_4 (%)	N_2O (ppm)	
Biogas	Approx. 35m^3	1.4	4.0	32.2	62.5	0.5	After H_2S removal
Composting yard	Approx. 10m^3	20.5	77.4	1.1	0.95	8.5	pH7.8 +20mV 16℃
Soil of the pasture after spraying digested manure	Approx. 1m^3	21.3	78.5	0.0	0.1	0.6	pH7.1 +55mV 12℃

Fig. 6 Practical application of the aerobic denitrification using *Alcaligenes faecalis* strain No.4

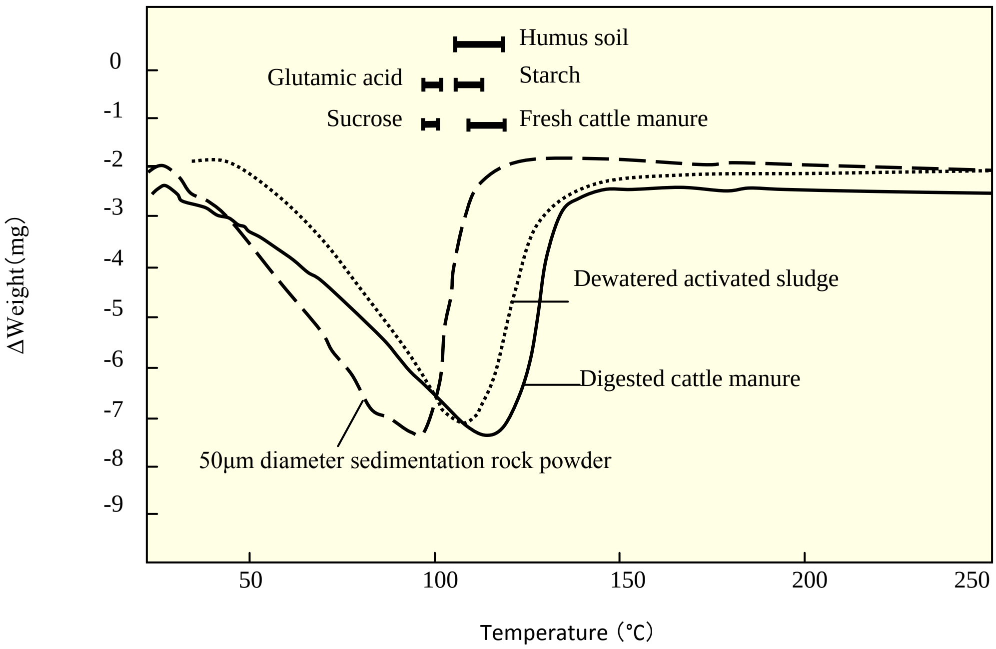


Fig. 7 Water retaining properties of some materials
(TG measurements of some sludgy materials) N_2 atmosphere, rate of heating: 10°Cmin^{-1}

Fig. 7 shows an example of the property for digested cattle manure in Obihiro. Relatively higher water retaining property in digested slurry was demonstrated. It might be suggested to be useful as a suitable material for water supply in arid or semiarid areas.

3. Energy storage functions in biogas systems

It is possible for biogas engines to obtain the high efficiency of electric power generation in natural gas and biogas generations, compared with gas turbine generations. The efficiencies of electric power generations are almost 50% for MW class gas engines and above 30% for 20~30kW class engines, in contrast to about 25% for MW class gas turbines.

On the other hand, from the view point of demand side conformity, it is possible for natural gas and biogas generation systems to store energies in the form of gaseous condition, which is the same function as the battery energy storage for load leveling, peak shaving and smart grid applications. The energy storage of biogas systems by gas holders is superior to battery storages in construction costs, whereas photovoltaic and wind turbine generations need batteries for their effective energy use. Comparing the total generation cost of biogas systems with those of other renewable energy systems, such as photovoltaic and wind turbine, especially in case of standalone types, biogas storage by gas holders gives them an advantage of inexpensive generation cost, since photovoltaic and wind turbine need relatively expensive batteries for their generated electricity storage. The energy storage method by gas holders makes supply and demand adjustments easy in case of grid connected power systems, and this feature is important for smart grid application, too.

Table 2 N_2O emissions of cattle manure treatments

Sample Numbers	Sampling Spots in the treatment processes	pH	Redox potentials measured in the lab.	Dry matter	600 ℃ ignition losses	Nitrogen contents			
						T-N	NH_3-N	NO_2 -N	NO_3 -N
			(mV vs.Ag/AgCl)	(wt%)	(wt%)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)
1	Covered pond	6.8	-98	6.35	2.42	471	111	0.20	30.0
2	Open pond	7.3	-71	8.93	5.43	283	21.0	0.01	17.5
3	Lagoon	7.1	-45	14.4	4.77	620	81.0	1.00	22.5
4	Cattle manure pond	6.5	-72	10.7	3.87	140	17.0	0.00	7.50
5	Obihiro cattle Digested manure	7.8	-172	3.98	3.10	1510	1480	0.70	20.0

Sample Numbers	Gas generated		N_2O evolution in case of beef cattle manure treatments	Remarks (Estimated gas evolution rates : approx. 300ml / g-VS, 20℃)	
	Methane concentration	Nitrous oxide concentration			
	ppm	ppb	kg of N_2O/(a beef cattle・Year)		
1	0	205,000	0.240	995ppm of CH_4 and 3,600ppb of N_2O were produced at -156mV of redox potential	Australia
2	0	395,000	0.460	920ppm of CH_4 and 4,100ppb of N_2O were produced at -190mV ofredox potential	Australia
3	0	6,000	0.007	—	Australia
4	0	32,000	0.037	—	Australia
5	440	8,000	0.009	—	Japan

4. Further technologies and applications

Another energy recovery method is under development in the advanced biogas system. It is possible for heat exchangers with electric current collecting function, as a bipolar cell stack structure, to discharge their redox substances in before and after digestion of biomass slurries and to collect the electric power as a microbial fuel cell as shown in Fig.8. Fig.9 and Table 4 show the performance of a laboratory test. This system is available to sewage treatment facilities as new energy recovery processes.

This bio-electrochemical technology will be promising measures for energy recovery and acceleration of microbial metabolisms.

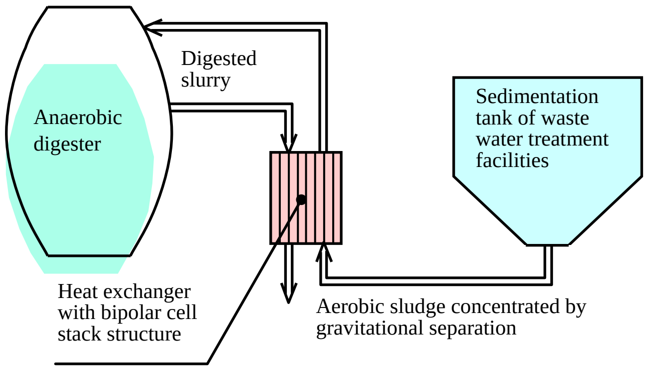
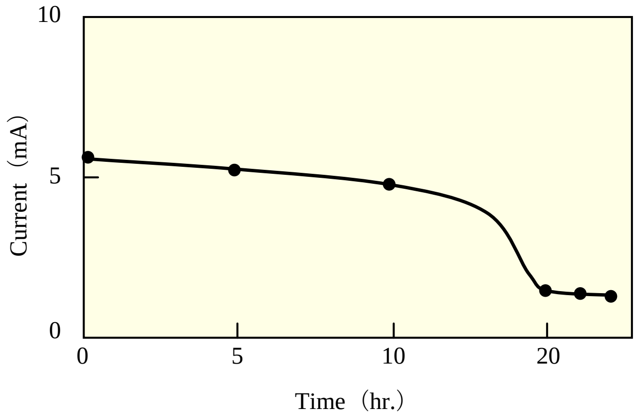


Fig. 8 A bio-fuel cell with a heat exchange structure



F ig.9 Single cell performance of the heat exchanger type bio-fuel cell

Table 4 Single cell performance of the heat exchanger type bio-fuel cell

	Activated sludge	Digested manure	Remarks
pH	6.1	7.9	
Total solid	4.6 wt%	2.0 wt%	110℃ drying
Ignition loss	3.5 wt%	1.2 wt%	600℃ burning
CODcr	15,400 mg/ℓ	6,900 mg/ℓ	
Redox equivalents	10 meq/ℓ	15 meq/ℓ	Coulometric determination
Temperature, inlet	15℃	55℃	
Temperature, outlet	27℃	35℃	

Reduction of energy consumption in some treatment facilities: Introduction of anaerobic digestion for sewage treatments instead of anaerobic activated sludge processed as an example. UASB pre-treatment and aerobic post – treatment process (Power consumption for biological treatments is reduced from 0.4to 0.2kWh per m^3 of sewage.) Effective N_2O and CH_4 emission reductions by spreading individual farm-type biogas plants for animal agriculture is approx. $30,000/ton-manure of the construction cost(Introducing private sectors into the environmental protection and energy supply)

5. Conclusion

The advanced biogas systems is expected to be one of the most effective renewable energies and to contribute sustainable agriculture, since the problems, such as desertification, nitrogen contamination and GHGs' emission, in the fields of energy and environment in rural and urban areas seems to be solved by introducing these technologies. And new approach is now working over to apply these technologies to the world. Especially, the feature of generation quartet is important in agriculture and energy fields.

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Session 1 – Production of forage crops

Oral presentations

Poster presentations

FORAGE QUALITY OF SELECTED GRASS SPECIES FROM CONSECUTIVE SAMPLING IN THE 1ST HARVEST IN 2011 - 2012

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Abstract

The contribution evaluates dry matter increase and changes in concentrations of nutrients and energy of 6 grass species and varieties in the 1st harvest from 7 sequential samplings in weekly intervals from the beginning of May at the site in Hladké Životice. Therefore in 2010 a stationary trial was established at the Hladké Životice site on fluvisoil (277 m above sea level, 7.9 ^{o}C, long-term rainfall average 642 mm) by a method of quick renovation with six grass species (*Dactylis glomerata* L. ´Vega´, *Festuca arundinacea* L. ´Kora´, Festulolium ´Hykor´ and ´Hostyn´, *Festuca pratensis* L. ´Kolumbus´and *Lolium perenne* L. ´Kentaur´ (4n). Vega, Kolumbus and Kentaur belong among serotinous varieties from the given assortment of varieties. The trial was fertilized in 2011, 2012 with N 120 kg/ha in the form of ammonium nitrate with lime applied in three doses per 60 kg/ha (in spring, after the first cut), 35 kg/ha P and 100 kg/ha K; seven-cut utilization during 1st cut growth, first cut on 27 th April 2011 and 2th May 2012, next sampling in weekly intervals until mid-June. In the second year of observation substantial drought resulted in lower yield as well as worse forage quality expressed by deterioration of parameters, except for nitrogen concentration which was higher (the same rate of fertilization and much lower forage yield).

Key words: *grass; clover; quality; time of harvest*

Introduction

The recent increase of individual milk production of dairy cattle in the Czech Republic (over 7000 kg FCM) makes higher demands on voluminous fodder quality. The quality of forage changes a lot during the first harvest regrowth. Individual species within forage mixture of grasses and legumes demonstrated significant differences in earliness (1 – 3 weeks) and even higher differences in forage quality (3 – 4 weeks) - Pozdíšek *et al.* (2002). In order to determine an optimum date for harvest for each individual species, sequential samplings were analysed during the first harvest regrowth.

Materials and Methods

A stationary trial was established in 2010 at the **DLF – TRIFOLIUM** Hladké Životice site on fluvisoil (277 m above sea level, 7.9 °C, long-term rainfall average 642 mm) by a method of quick renovation with six grass species (*Dactylis glomerata* L. ´Vega´ (hereafter DG), *Festuca arundinacea* L. ´Kora´ (FA), Festulolium ´Hykor´ (Fl-Hy) and ´Hostyn´ (Fl-Ho), *Festuca pratensis* L. ´Kolumbus´ (FP), *Lolium perenne* L. ´Kentaur´ (4n) (LP). , Kolumbus and Kentaur belong among serotinous varieties from the given assortment of varieties. The trial was fertilized in 2011 with 120 kg/ha and in 2012 with N 60 kg/ha in the form of ammonium nitrate with lime applied in three doses per 60 kg/ha (in spring, after the 1st cut in 2012 the trial was not further observed), 35 kg/ha P (superphosphate) and 100 kg/ha K (potassium salt); seven-cut utilization during 1st cut growth, first cut on 27th April 2011 and on 2nd May 2012, next sampling in weekly intervals until mid-June. The quality of forage dry matter in 2012 was evaluated by Weende analysis. The parameters measured were crude protein (CP), fibre (CF), OMD which is determined by the laboratory method ELOS (Míka *et al*., 2009) suitable for routine operations, NEL (net energy of lactation), with the aim to determine yield, and concentrations of nutrient and energy in the period 1st cut growth. This contribution due to its limited extent presents dry matter production only in the dry year 2012 evaluated by linear regression, correlation coefficients and critical values r_{α} (n=7) of correlation coefficient for $\alpha_{0.05}$ a $\alpha_{0.01}$ were calculated.

Results and Discussion

Year 2011 was characterized by dry frosts and drought in the early spring, quick start of spring with above-average temperatures in April (+3.0 °C), substantial rainfall late in April and early in May which accelerated vegetation growth by more than a week. The average dry matter production of evaluated species at the first sampling date (27th April 2011) was 2.72 t/ha, with the highest DM production for LP (3.23 t/ha DM) and the lowest for DG (2.44 t/ha). At the 4th sampling date (18th May 2011) Fl-Ho reached the highest DM production (9.42 t/ha DM), DG had again the lowest DM production (6.79 t/ha DM).

The average crude protein (CP) content in the forage at the first sampling was 180.9 g/kg DM, crude fibre (CF) content was 201.1 g/kg DM, NEL content was 7.09 MJ/kg DM and organic matter digestibility (OMD ELOS) was 85.0.

During the regrowth period the content of CP decreased by 24 g/kg DM (the fastest decrease in DG and the slowest decrease in Fl-Ho), CF content increased in average by 24 g/kg DM (the fastest increase in DG and the slowest increase in FA), NEL conncentration decreased by 0.4 MJ/kg DM (insignificant differences among species) per every week of regrowth. Pozdíšek *et al.* (2002) found that in grass forage NEL concentration decreased by 0.26 MJ/kg DM per week in the period of spring regrowth. OMD decreased by 4.30 per week, the fastest decrease in DG as expected, the slowest in Fl-Hy and LP.

Low NL concentration in *Lolium perenne* L. and Fl Hostyn was caused in 2011 by a drought in the beginning of vegetation, when the species with shallow root system have difficulties with nutrient uptake, as several authors say (Garwood, Sinclair, 1979; Thomas, 1986) and also primarily after heavy rainfall in the late April and early May which washed away a part of nitrate nitrogen and there was not sufficient amount of available nitrogen left from 60 kg of applied N for high forage production of both species. Perennial and deep-rooted species *Dactylis glomerata*, *Festuca arundinacea* and *Festuca pratensis,* as well as Festulolium Hykor were not affected by the early spring drought.

Year 2012 was arid not only in early spring, apart from one torrential rain in the early May, and the spring was very dry until 5th June and from the late April rather warm. The course of weather affected yields in general, not only of the observed trial. The yields of meadow grasslands were reduced by half, the yields of ryegrasses were even lower. Average dry matter production of evaluated species and varieties (Fig. 1) at the 1st sampling date on 2nd May 2012 was 1.5 t/ha, with the highest DM production for Fl-Hy (2.14 t/ha DM), the lowest for Fl Hostyn (0.91 t/ha). At the 4th sampling date (23rd May 2012) Fl-Hy reached the highest DM production (6.51 t/ha DM), followed by FA, LP had the lowest DM production (3.99 t/ha DM).

The quality of harvested forge was also affected by dry and warm spring – most significantly CP content, by the increase of nitrogen content in all species, with the biggest difference compared to 2011 in ryegrasses. At the 1st sampling date in LP by 99 g/kg DM, in Fl Hostyn by nearly 121 g/kg DM. At the other dates the differences were smaller, in fescue grasses at the 7th date the difference was minimal. CF at the 1st sampling date was higher in DG by 53 g/kg DM, in the other grasses by about 20 – 30 g, the differences quickly decreased and at the last 3 dates (from 30th May) the CF content was lower than in 2011. There were small differences in NEL concentrations in perennial species between the two years of the trial, in Fl Hostyn and LP the difference varied from 0.40 to 0.60 MJ/kg DM, the progress roughly copied the average of years. On the other hand, there were bigger differences in digestibility in perennial species at the first three sampling dates, when OMD was by 7 to 8 lower in 2012 at the 1st date; in ryegrasses the differences were minimal.

If we use digestibility as the main criterion for determination of the optimum harvest date, then it is the beginning of the second decade till mid-May (the 3rd date) for perennial species, for ryegrasses one week later. NEL concentration and fibre content is acceptable at these dates for the same species. However, crude protein content at the given fertilization (60 kg/ha N) is low in moisture favourable year at these dates and there is an apparent need for higher amount of nitrogen fertilization. If the harvest is demanded at the beginning of grass heading, grasslands should be fertilized with at least 80 kg/ha N in two doses, so that the forage had about 16% of crude protein in the dry matter at the time of harvest.

Acknowledgements

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Figure 1 Dry matter production from consecutive sampling of grass species, Hladké Životice

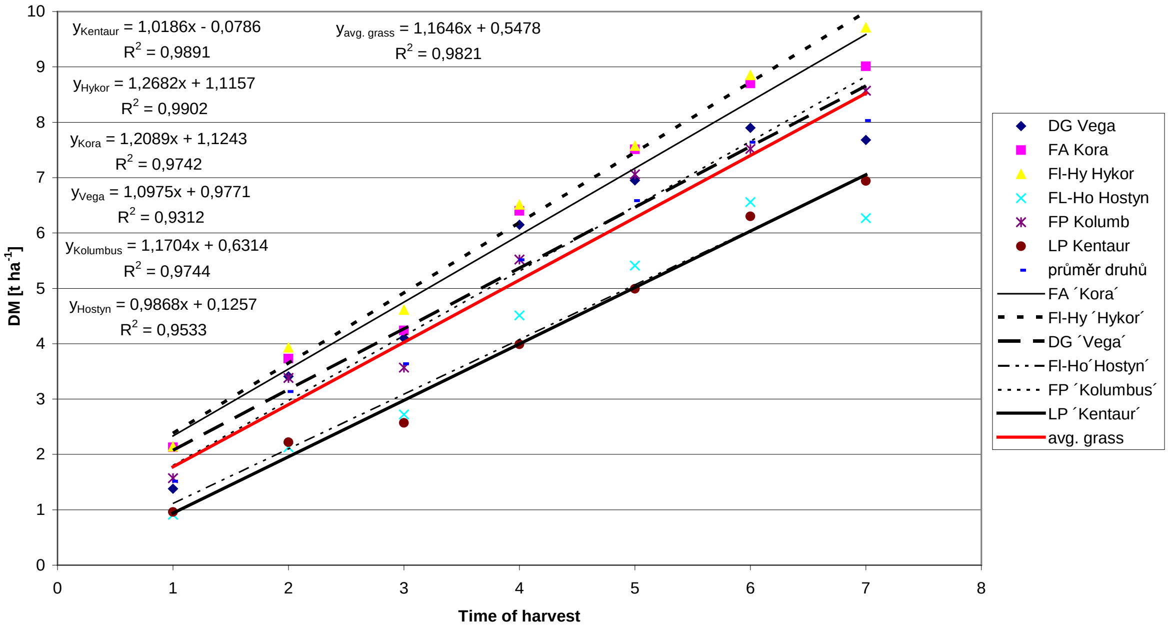


Figure 2 Crude protein (CP) of selected species at 7 sampling dates [g/kg DM]

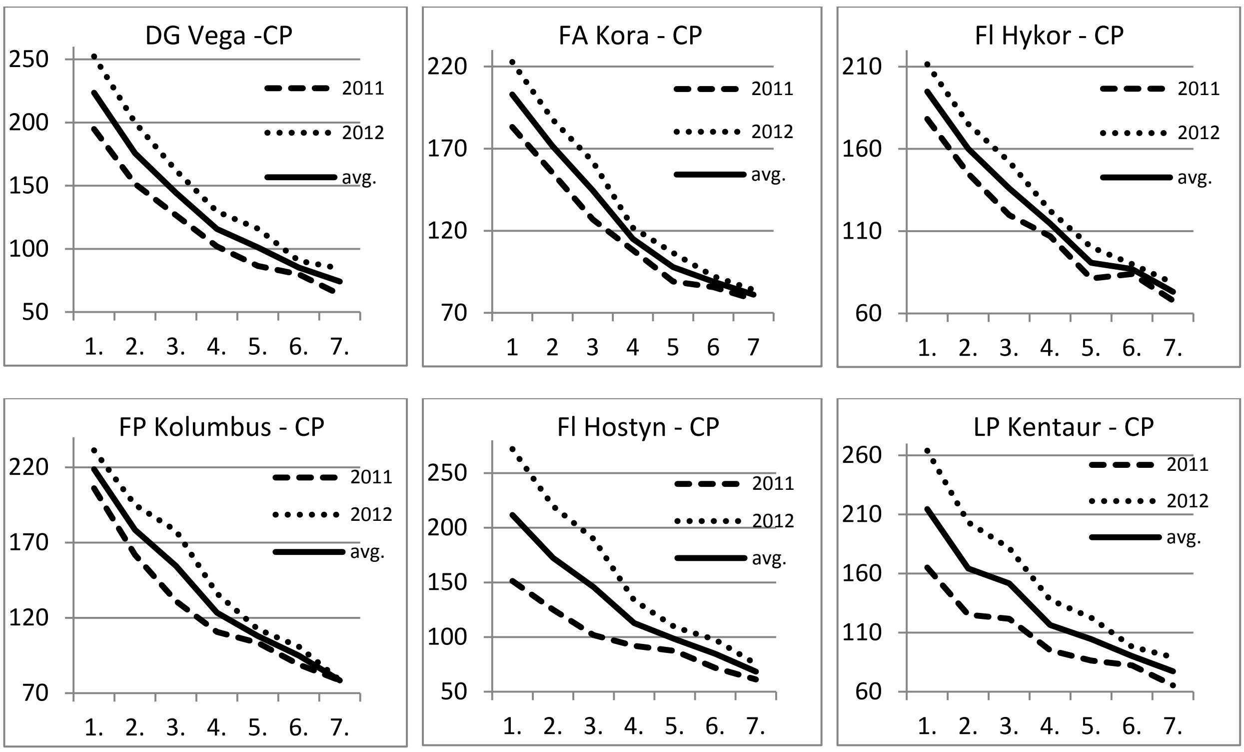


Figure 3 NEL concentrations of selected species at 7 sampling dates [MJ/kg DM]

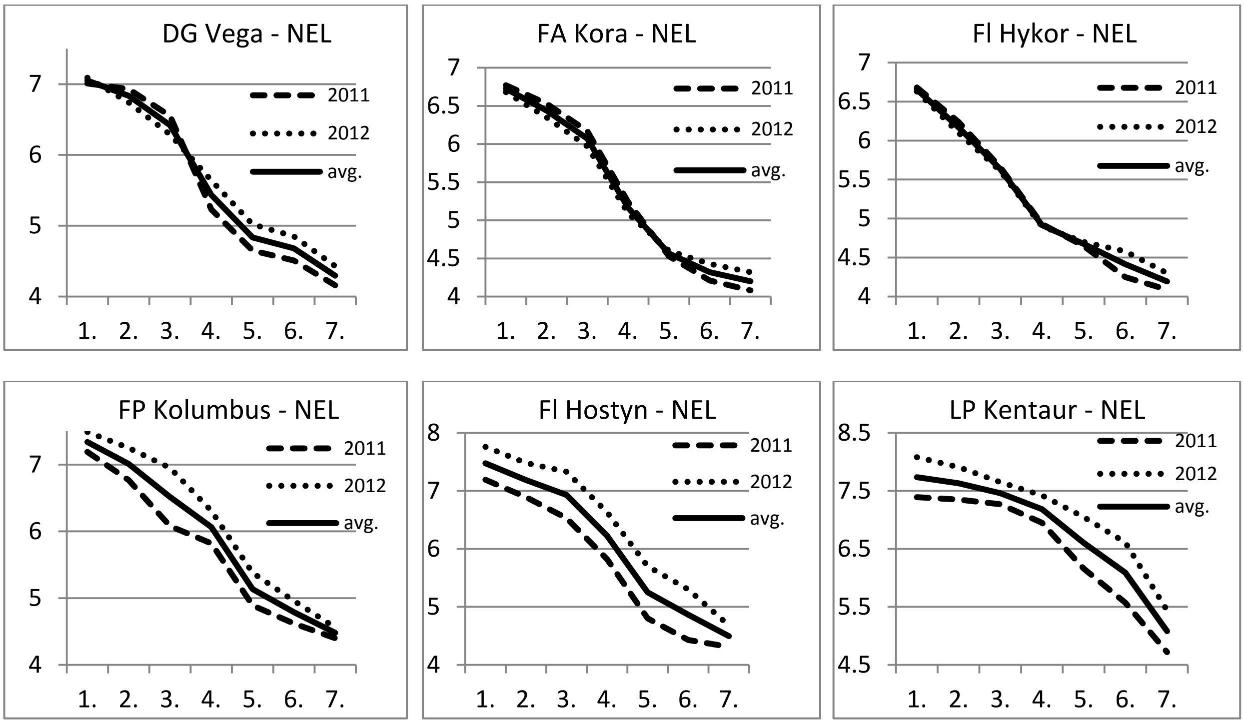
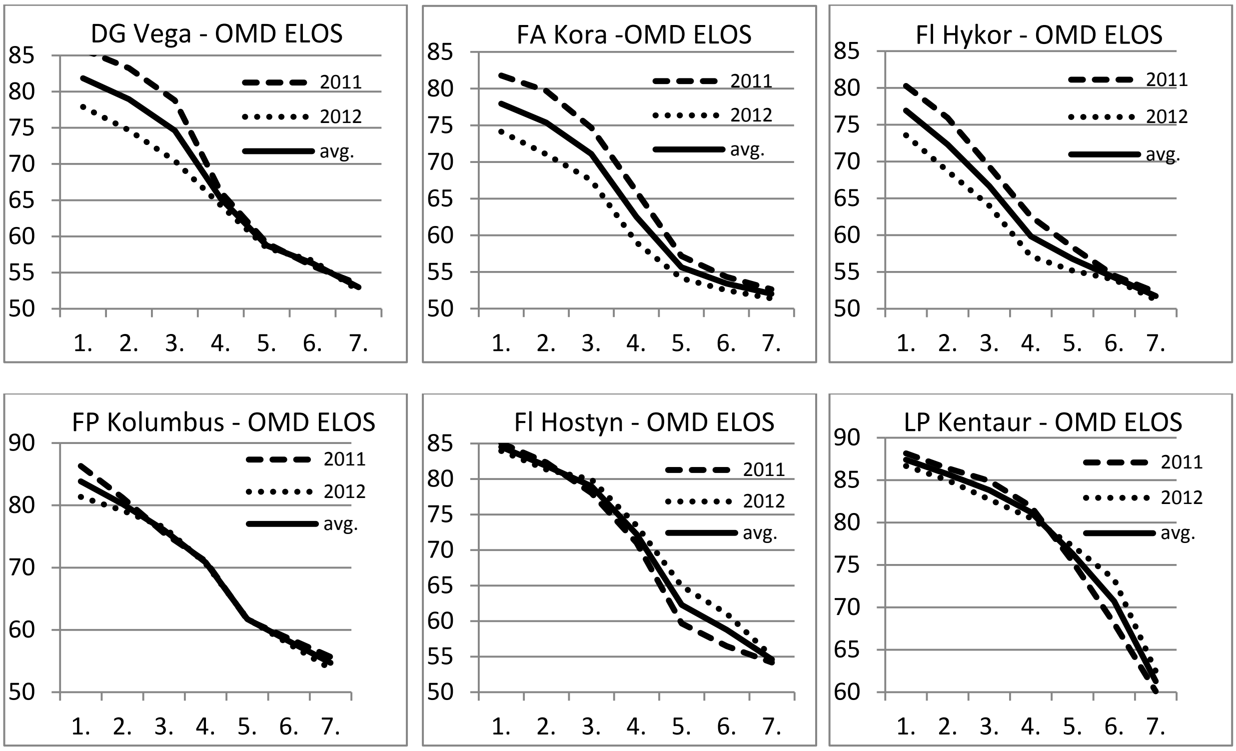


Figure 4 Forage digestibility (OMD) ELOS of selected species at 7 sampling dates



POSSIBILITIES OF CRUDE PROTEIN PREDICTION IN THE FORAGE OF LUCERNE

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Abstract

The aim of this study was to evaluate possibilities of crude protein prediction in the lucerne forage through "Predictive Equations Alfalfa Quality" (PEAQ) and allometric function. In 2012, the forage sampling was repeatedly realized at the late bud and at the late flower stage over three cuts with three replicates. Each sample was analyzed for the maximum stem length, dry matter weight of leaves and stems, and nitrogen content. The decline of CP in lucerne forage in each cut was given by changes in leaf-stem ratio and also by decrease of CP content in both lucerne plant parts which could be explained by dilution effect. Higher R^2 value was obtained for PEAQ model; however substantially lower standard error of estimate was recorded for allometric function. It is possible to conclude that both PEAQ and allometric function could be successfully used for prediction of CP (N) in the lucerne forage or in the each plant parts. It seems that fitting of function was slightly better for PEAQ whilst accuracy of estimate was higher for allometric function.

Key words: forage, alfalfa, quality, nitrogen

Introduction

The N concentration in plants has been widely investigated, mainly in relation to plant physiology or to crop N management (Lemaire *et al*., 2008). Understanding of the N distribution within a canopy of crops is relevant for the analysis of behavior of an individual plant in a dense stand where competition for light, minerals, and water may be occurring between plants (Lemaire *et al*., 2005). This decline in %N was described by a negative power function called dilution curve which has been developed for several crop species which was reviewed by Lemaire *et al*. (2008).

Except of plant physiological point of view, the N concentration in the forage plants also plays an important role in animal nutrition through a forage protein value. Feeding value is generally closely connected with timing of harvest, therefore range of authors reported predictive models for forage feeding value and optimal harvest date. However, these predictions were focused mainly on neutral and acid detergent fiber (NDF/ADF) as was reported by Sulc *et al*. (1997). For lucerne (*Medicago sativa* L.), the most widely used of these are the predictive equations for alfalfa quality (PEAQ). This method is based on the length of the tallest stem and the stage of the most mature stem in the sample (Hintz and Albrecht, 1991). For NDF and ADF, the equations also performed well across the spring and summer growth cycles (Sulc *et al*., 1997). These equations were also successfully tested in European conditions (Hakl *et al*., 2010; Anderzejewska *et al*., 2013). Prediction of crude protein (CP) was investigated rarely and with less success. Owens *et al.* (1995) reported that the crude protein (CP) was not accurately predicted using PEAQ. In the first cut, they obtained R^2 values of 0.83 for NDF, 0.78 for ADF and 0.37 for CP. According to Hakl *et al*. (2010), the CP was predicted more accurately (R^2=0.85), however, the best prediction of CP was based only on the code of developmental stage. It must be remembered that these properties are closely related to leaf-stem ratio therefore the aim of this study was investigated the possibilities of CP prediction in lucerne across the spring and summer growth cycles in relation to detailed stand structure.

Materials and Method

To test our hypothesis, we used a running experiment aimed at comparing 7 lucerne entries growing in the monoculture stand. In July 2004, the experiment was established by broadcast seeding with seeding rate 20 kg/ha at the experimental field station in Prague – Suchdol of the Czech University of Life Sciences Prague (286 m above sea level). The soil is a deep loamy degraded chernozem with permeable subsoil. The long-term annual temperature is 9.3°C and precipitation 510 mm. The plot experiment was arranged in completely randomized blocks with four replicates for each lucerne entry. The plot size in each block was 2 x 2 m. For CP assessment, the samples were taken only at Jarka variety in 2011 with three replicates. The samplings were realized in the late bud and late bloom stage from the first to third cut. The dates of sampling and developmental stage according to the most mature stem in the sample area are summarized in Table 1. In the described terms, biomass was clipped in 4 cm height above the ground in the area 30 x 30 cm. The stem length of the longest stem (maximal stem length, MSL), dry matter yield (DMY), weight of leaves and stems were assessed in each sample. These samples were oven-dried at 60 ºC, homogenised to a particle size of 1 mm, and analysed for N content by Dumas method with calculation of crude protein (N*6.25). Two-way (cut, stage) or three-way (cut, stage, plant part) ANOVA with interaction and regression analyses were performed using STATGRAPHICS Centurion XV.

Results and Discussion

The result of CP concentration, stand structure and forage yield over three cut are shown in Table 1. From late bud to late bloom stage, the decline of CP content in lucerne forage was not given only by changes in leaf-stem ratio but also by decrease of CP content in both main lucerne plant parts. For explaining of the dilution effect of N, Lemaire *et al*. (2005) described the allocation of N in leaves within a canopy is not uniform and more or less parallels the light distribution profile which could be connected with maximal stem length or forage yield in our experiment. The competition for light among individual plants within dense canopy induces developmental changes in plant morphology (leaf-stem ratio) that explain the difference s observed in forage N concentration (Lemaire *et al*., 2005). In our experiment, a higher dose of light in the second part of vegetation could be explanation for higher leaf weight ratio and CP content in lucerne forage in the second and third cut in comparison with first cut.

The comparison of predictive models in Table 2 shows that both models were significant, however, higher R^2 value was obtained for PEAQ model. This fact supporting our previous results, that CP could be predicted successfully by this method (Hakl *et al*., 2010). In spite of it, substantially lower standard error of estimate was recorded for allometric function which supports idea about its higher accuracy of estimate. The dilution effect in relation to DMY was slower for leaves in contrast to stems. For lucerne forage, the parameter *b* of this function was comparable with value 0.33 presented by Lemaire *et al*. (2008), however parameter *a* was lower than 4.8 given by Lemaire *et al*. (2008). This parameter represents the quantity of N required to produce the first unit of shoot mass (Lemaire *et al*., 2005).

Table 1 Means of crude protein (CP), maximal stem length (MSL), leaf weight ratio (LWR), and dry matter yield (DMY) of lucerne forage parts in the bud and flower stage over three cuts (n = 4; two-way or three-way ANOVA).

cut	date	stage	leaves	stems	forage			
			CP (g/kg)	CP (g/kg)	CP (g/kg)	MSL (cm)	LWR (%)	DMY(g/m^2)
1.	20. May	Late bud	291^{b}	141^{d}	202^{a}	86^{a}	40.5^{a}	606^{abc}
	1. June	Late bloom	252^{g}	111^{a}	162^{b}	117^{b}	36.4^{a}	828^{a}
2.	21. June	Late bud	357^{c}	213^{f}	292^{d}	43^{c}	55.0^{b}	206^{b}
	13. July	Late bloom	274^{b}	108^{a}	169^{a}	97^{ab}	36.5^{a}	925^{a}
3.	8. August	Late bud	357^{c}	187^{e}	273^{c}	55^{c}	50.3^{b}	266^{bc}
	29. August	Late bloom	288^{b}	120^{a}	179^{a}	108^{ab}	35.1^{a}	737^{ac}

Different letters document statistical differences in each column, for leaves and stems within their interaction (Tukey HSD, α = 0.05

Table 2 Comparison of allometric function (prediction of N, %) and PEAQ method (prediction of crude protein, %) in lucerne leafs, stems and in the total forage (n = 18, SEE = standard error of estimate, significant values at α=0.05 are in bold).

model	Allometric (N %)				PEAQ (CP %)			
	equation	R^2	SEE	P	equation	R^2	SEE	P
Leaves	$2.86*DMY^{-0.241}$	0.75	0.07	0.000	42.3 - 0.13*MSL - 0.18*S	0.86	1.65	0.000
Stems	$2.55*DMY^{-0.305}$	0.82	0.12	0.000	28.2 - 0.11*MSL - 0.88*S	0.87	1.57	0.000
Forage	$3.28*DMY^{-0.335}$	0.86	0.09	0.000	37.8 - 0.16*MSL - 0.63*S	0.92	1.56	0.000

Conclusion

With limited data from one year, it is possible to conclude that both PEAQ and allometric function could be used with similar success for prediction of CP (N respectively) in the lucerne forage or in the individual plant parts. It seems that fitting of function (expressed as R^2) was slightly better for PEAQ whilst accuracy of estimate was higher for allometric function.

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THE EVALUATION OF QUALITY OF SILAGE HYBRIDS BY NEW NATIONAL SYSTEM

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Introduction

At present, the maize hybrids are selected in an agricultural company particularly by the agronomists. Their goals are sometimes a little different from the goals of the livestock specialists. also the goals of the seed corn sellers can be different too. The offers of hybrids of seed corn companies can be sometimes difficultly compared between each other, as the companies use different methods of definition and evaluation of the monitored indicators. Great attention must be paid also to the unification of the sample taking methods. The very farmers expressed the need of introduction of a unified system of evaluation of maize hybrids with higher emphasis on the need of animal production. Since 2012, the work on the research Project QJ1210128, supported by the National Agency for Agricultural Research and called “Innovate systems of assessment of quality of feeds with emphasis on introduction of a new national evaluation system”. The main goal of the project consists in creation of an independent and unified system of assessment of maize hybrids intended for production of silage for animal nutrition for agricultural practice. At the same time, the demand of authorization of the hybrids tested and of their availability on the Czech market should be observed. The project is set so that during the research, as many companies offering seed maize on the Czech market can enter in the research and as broad range of hybrids as possible can be assessed.

Materials and Methods

In 2012, ten companies in total delivered seed corn of hybrid maize. The maize hybrids were grown in the localities of Troubsko and Prague – Uhříněves in form of exact small-plot field experiments. 42 hybrids intended for production of silage, intended for production of silage, were grown in a range of FAO 230-310. The hybrids in vegetation were assessed from the perspective of the physiological and health condition. The harvest was planned so that the individual hybrids were harvested approximately at the same level of maturity, with average dry matter of 32%, in a range of ± 2 %. Samples were taken from the chaff and dried at 55°C. The samples were homogenized in a laboratory mill (sieve size of 1 mm) and used for determination of dry matter, contents of ash, nitrogen matter, sugar, rough fibre, NDF, NDF digestibility (SNDF – incubation of samples in rumen liquid of dairy cow in 24 hours) and starch content. Standard methods according to AOAC (1995), Commission Regulation (EC) No. 152/2009 (2009), were used for chemical analysis of samples. The vegetation period in 2012 in the locality of Troubsko was characterized by precipitation strongly below normal level and temperatures above normal level. The statistic evaluation was performed with the method of variance analysis (ANOVA α - 0.05) in the Statistica 9.1 program (StatSoft, Tulsa, OK, USA).

Results and Discussion

The average values of the contents of organic nutrients, NDF digestibility and energy concentration (NEL) of maize hybrids grown in Uhříněves and Troubsko are shown in table 1. The harvest in Uhříněves was carried out according to the detected content of dry matter gradually between 21. to 24.8. and in Troubsko on 31.8. and 10.9., i.e. in two dates.

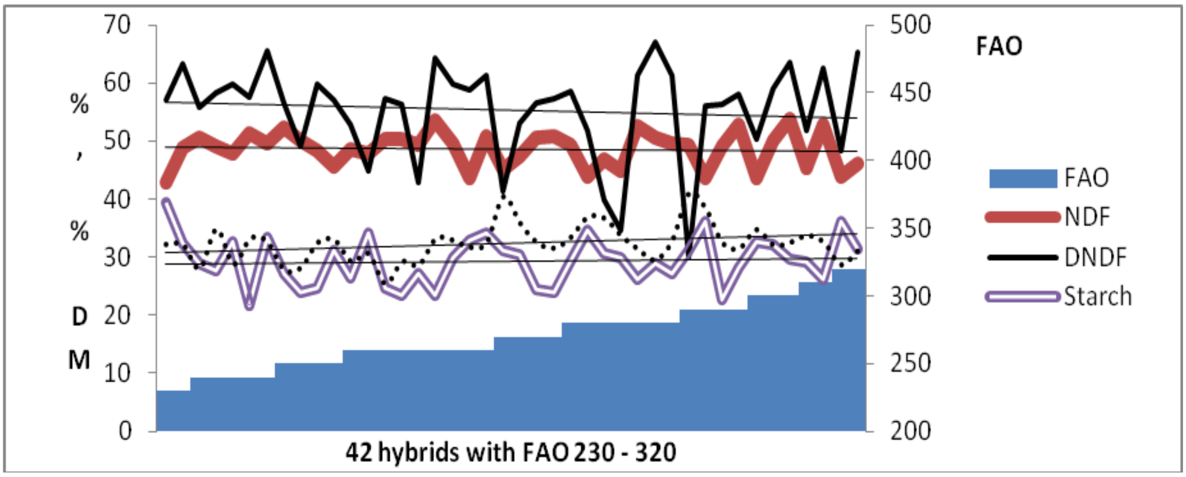
Table 1 Average values of contents of organic nutrients, NDF digestibility and energy concentration (NEL) of maize hybrids grown in Uhříněves and Troubsko (2012)

Locality	Dry matter	N-matters	Ash	Fibre	Sugars	NDF	SNDF 24 hours	Starch	NEL
	in %	% in DM	% in DM	% in DM	% in DM	% in DM	v %	% in DM	MJ.kg DM
Uhříněves	32.19	8.08	5.24	21.68	11.01	50.03 a	60.77 a	28.25 b	6.45 a
Troubsko	32.85	9.37	5.48	21.70	9.46	47.37 b	50.28 b	30.32 a	6.13 b

Different letters document statistical differences in each row (Tukey HSD, á = 0.05)

The yields of dry matter differed markedly in both localities, in 22 hybrids in Troubsko (13,21 t.ha^{-1}) and in 20 hybrids in Uhříněves (25,66 t.ha^{-1}). The development of weather constituted the main factor influencing the different yields. Although the conditions for growing of maize were markedly different, it can be stated that the differences of the average values of the content of dry matter in the harvest of Uhříněves 32,19%) and Troubsko (32,85%) were minimal. No significant differences were detected between the average contents of dry matter of the hybrids grown in the localities of Uhříněves and Troubsko. It can be stated that the hybrids were harvested in both localities in approximately the same stage of growth at optimal level of dry matter, i.e. exactly according to the original project assignment and in compliance with the results of foreign authors (Bal et al. 1997, Andrae et al., 2001 and Cone et al., 2008). The differences in the contents of dry matter and nutrients (including NDF digestibility) between the hybrids assessed in one set together from both localities are shown in Graph 1.

Graph 1 Effect of FAO on the DM, Starch, NDF and digestibility of NDF.



The regression equation of the connection line of the trend and the coefficients of regression were as follows: for DM y = 0,0117x + 31,657 (R^2 = 0,0009), starch y = 0,0266x + 28,764 (R^2 = 0,0063), NDF y = -0,0168x + 48,996 (R^2 = 0,0046) and DNDF y = -0,063x + 56,626 (R^2 = 0,0088). The above stated facts show that if the hybrids were harvested in the optimal stage, the DM, starch and NDF remained approximately at the same level with the growing FAO number. The digestibility of DNDF, which is very important for cattle nutrition, showed relatively high differences between hygrids with FAO numbers of 260 to 280; the values oscillated from 30 to 67%. If working on the assumption of Aba and Allen (1999) who determined that one-percent increase of NDF digestibility can increase milk production by up to 0.25 1 FCM of milk per dairy cow and day, such difference (37% DNDF) could theoretically amount up to 9 litres of milk.

The individual indicators showed only very low correlation coefficients; only the correlation between NDF and starch was of -0.65.

Due to lack of space for this article, the results of chemical analyses of individual hybrids are not stated here, but they are available at any of the authors of the article. The current average values of the monitored indicators of the individual sets of maize and localities can be used by the farmers for choice of their hybrids for production of silage as success criterion of the potentially selected hybrid.

Conclusion

Although the hybrids with different FAO numbers (230-320) were gradually harvested in both localities at approximately the same maturity level (32,19% in Uhříněves, 32,85% in Troubsko), the results of the analyses of the nutritional and fermentation values were significantly different between the localities ($P<0.05$) (NDF, DNDF, starch, NEL). The milk production can be significantly influenced particularly by the differences in NDF digestibility between the hybrids.

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NUTRITIVE VALUE OF DIFFERENT MAIZE SILAGE HYBRIDS

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Introduction

Maize silage is one of the most important forages in the world today, primarily because it is an excellent energy source in dairy rations. Increased nutritional requirements for optimal animal performance challenge, maize producers to select hybrids and management practices for high forage yields and favorable quality characteristics (Graybill et al., 1991). Commercial maize hybrids has been selected primarily for forage yield and disease resistance. Selection of hybrids for silage has ignored potential hybrid differences in the quality of maize silage (Kim et al., 2001). The aim of this study was evaluated the nutritive value of different maize silage hybrids (with FAO 450 and 550) harvested in the same phenological phase milk - waxy maturity stage.

Materials and Methods

In the location Dvory nad Žitavou were tested 2 silage maize hybrids with different numbers of FAO, which were grown on station in the same agroecological conditions. Harvest was carried in phenological phase milk - waxy maturity stage. The silage hybrid FAO 450 (medium late hybrid) is maize with fixed haulm, extremely green color and built upright leaves. Hybrid is characterized by good health and a great stay - green effect. Hybrid FAO 550 is a tall plant with long conical cob. Hybrid is characterized by drought tolerance and good record harvest in sufficient with a high proportion moisture grain in silage. For analyzing of nutrients we used standard analytical methods (Regulation of the Slovak Ministry of Agriculture no. 2145/2004-100). Significance between individual means was identified using the Tukey's multiple range test of the software package SAS 9.1 (SAS Institute Inc., 2004). Mean differences were considered significant at $P<0.05$.

Results and Discussion

The results concerning nutritive value of different maize silage hybrids are shown in Table1. Dry mater (DM) content in analyzed silage hybrids was 297.60 (FAO 550) and 321.2 $g.kg^{-1}$ (FAO 450). According to Kudrna et al. (2006), for successful fermentation process of maize silage is the best stage milk - wax ripeness, when the whole plant dry matter ranges between 280-340 $g.kg^{-1}$. The optimal dry mater (DM) content for maize silages is according to Doležal et al. (2012) 280-330 $g.kg^{-1}$, and Rajčáková and Mlynár (2009) 310-350 $g.kg^{-1}$. The crude protein content of the whole plant is generally low. In our experiment, the crude protein (CP) content was 78.5 (FAO 550) and 88.2 $g.kg^{-1}$of DM (FAO 450). Silage hybrid mass FAO 450 had a significantly higher content of CP ($P<0.05$) compared to hybrid FAO 550. The content of carbohydrates in the form of nitrogen-free extract (NFE) was 668.5 (FAO 450) and 681.6 $g.kg^{-1}$ of DM (FAO 550). The content of organic matter in analyzed maize silage hybrids was 950.8 (FAO 450) and 957.9 $g.kg^{-1}$ of DM (FAO 550). From the cereals is maize characterized by the highest starch content (Šimko et al., 2010). We found statistically higher value ($P<0.05$) of starch in hybrid FAO 550 compared to FAO 450 (295.2 $g.kg^{-1}$, resp. 280.5 $g.kg^{-1}$ of DM). Swift (2004) reported in maize hybrids with 32% of DM similar average starch content of 289 $g.kg^{-1}$ of DM. Water soluble carbohydrates (WSC) content was in hybrids: 119.7 (FAO 450) and 119.8 $g.kg^{-1}$ of DM (FAO 550). Cherney et al. (2004) determine the content of WSC from 80 to 150 $g.kg^{-1}$ of DM. In the silage hybrid FAO 550, we found higher content of acid detergent fiber (ADF) 195.0 $g.kg^{-1}$ of DM and lower content (189.2 $g.kg^{-1}$of DM) in hybrid FAO 450. The differences between hybrids in ADF were statistically significant ($P<0.05$). The content of lignin was 17.4 (FAO 450) and 19.4 $g.kg^{-1}$ DM (FAO 550), differences were insignificant ($P>0.05$). Kim et al. (2001) reported higher values of lignin. The concentration of energy expressed by net energy of lactation (NEL) in tested hybrids was 6.36 (FAO 450) and 6.41 $MJ.kg^{-1}$ DM (FAO 550), where we found a statistically significant differences ($P<0.05$). Sommer et al. (1994) referred in silage maize average value of NEL 6.45 $MJ.kg^{-1}$ DM. Evaluation of the content of nitrogenous substances in ruminant nutrition is realized by the PDI system (digestible crude protein in the intestine). This system takes into account the mainly separate intake of crude protein for the body of animal and flora in the digestive tract (Pajtáš et al. 2009). The lower value of PDIN was recorded in silage hybrid FAO 550 48.6 $g.kg^{-1}$ of DM, higher content in hybrid FAO 450 54.6 $g.kg^{-1}$ of DM, where we found a statistically significant difference between hybrids ($P<0.05$). Similar results reported Machačová and Loučka (2001), who recorded average value of PDIN 53.44 kg^{-1} DM. The values of PDIE was 77.1 (FAO 550) and 78.2 $g.kg^{-1}$ of DM (FAO 450). Sommer et al. (1994) reported in identical phenological phase of harvesting higher average PDIE (81 $g.kg^{-1}$ DM).

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Table 1 Nutritive value of different maize silage hybrids

		Hybrid			
		FAO 450		FAO 550	
		n=3		n=3	
Parameter	Unit	$\overline{x}$	S.D.	$\overline{x}$	S.D.
DM	a	321.2	0.42	297.9	0.42
CP	b	88.2[a]	0.64	78.5[a]	1.41
Fat	b	31.1[a]	0.28	27.6[a]	0.35
Ash	b	49.3[a]	0.07	42.1[a]	0.14
NFE	b	668.5[a]	0.07	681.6[a]	0.78
OM	b	950.8[a]	0.07	957.9[a]	0.14
Starch	b	280.5[a]	2.55	295.2[a]	1.13
WSC	b	119.7	1.77	119.8	1.34
ADF	b	189.2[a]	0.07	195,0[a]	0.01
NDF	b	395.4[a]	3.68	371.7[a]	4.74
Lignin	b	17.4	0.92	19.4	1.13
NEL	c	6.36[a]	0.01	6.41[a]	0.01
NEG	c	6.36[a]	0.01	6.41[a]	0.01
PDIN	b	54.6[a]	0.42	48.6[a]	0.85
PDIE	b	78.2	0.07	77.1	0.35

a: $g.kg^{-1}$, b: $g.kg^{-1}$ of DM, c: $MJ.kg^{-1}$ of DM , S.D.: standard deviation, DM: dry matter, CP: crude protein, NFE: nitrogen-free extract, OM: organic matter, WSC: water soluble carbohydrates, ADF: acid detergent fiber, NDF: neutral detergent fiber, NEL: net energy of lactation, NEG: net energy of gain, PDIN, PDIE: digestible crude protein in the intestine, [a]: the values with identical superscript in row are significantly different at $P<0.05$

Conclusions

Selection of an appropriate silage hybrid is one of determinants for the production of high quality corn silage. Silage hybrid affects the optimal maturity stage, digestibility of nutrients and thus the nutritive value, epiphytic microflora composition, nutrients and energy yield, silage production efficiency and the overall efficiency of milk and meat production. Our result confirmed differences in nutritive value of maize silage hybrids with different FAO number (450 and 550) harvested in the same phonological stage. Hybrid FAO 550 had significantly ($P<0.05$) higher content of starch, organic matter and energy value in comparison to hybrid FAO 450.

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DYNAMICS OF PRODUCTION ABILITY OF A MOUNTAIN HAY MEADOW

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Introduction

The production function of grassland is very important from the viewpoint of land management and economy. A number of authors (GÁBORČÍK *et al.*, 1997; ILAVSKÁ, 1998 and others) evaluated this function as the main one for grassland. FIALA (2002) considers the following factors to be the most decisive ones for the economic yield: natural soil fertility and nutrition level; botanical composition; cutting frequency and dates; weather during the spring and throughout the growing season. This paper aims at assessing the productivity dynamics of a mountain hay meadow at different cutting dates.

Materials and Methods

A research was carried out at Liptovská Teplička (altitude 1390 m), a village located within the *Nízke Tatry* National Park (NAPANT). The research site (*Zálom*) with the sward type of alliance *Polygono* - *Trisetion* Br.-BL. et R. Tx. ex Marshall 1947 was 1052 m above sea level wit the south-west exposure (180 – 190°) and 6° average slope gradient. The total research area was 17 ha; it was a part of a large landscape segment of approx. 100 ha. The herbage production was determined twice a year, in 2002 - 2004. The basic scheme consisted of herbage sampling from at least three plots (1 m^2 each) alongside the diagonal of the research site. The cutting was simulated by three samplings, with the exception of the respective 2nd cuts in 2003 and 2004. The third sampling date agreed with the actual 3rd cut. On the basis of the sward monitoring, the first two samplings were carried out at the earing of dominant grass species, however, the first sampling was performed about 10 – 15 days earlier. The dates of the respective 2nd cuts were defined in agreement with the state of sward. The results were evaluated by the two-factor analysis of variance verifying the authenticity of differences by Tukey test at the 95 % probability level (P = 0.05).

Results and Discussion

In 2002, the production of dry matter (DM) was rising in the subsequent samplings at the 1st cut (Table 2). The yield of DM was 2.629 t ha^{-1}, 5.440 t ha^{-1} and 6.222 t ha^{-1}at the 1st, the 2nd and the 3rd sampling, respectively. The re-growth period between the first and the last sampling was 15 days. The difference between the first sampling date and the third one was very significant statistically. The increase in the production between the first sampling and the third one was not significant (Table 3). At the 2nd cut, the DM production also showed a rising tendency, but the differences between the samplings were not significant, despite the differences in DM yields. In 2002, the rainfall effect on DM production was very positive (r = 0.8294) and the relationship was very significant (P = 0.00560). Similarly, the relationship between DM production and the rising mean temperature was positive (r = 0.8302) and very significant (P = 0.00560).

The lowest DM production was recorded in 2003. It probably resulted from the severe drought, as confirmed by deviations from the long-term average (Table 1). At that time, there was only one sampling carried out, due to the weather and the subsequent decrease in the sward re-growth. The yield was 1.589 t ha^{-1} on the first sampling date (26 May) at the 1st cut (Table 2). At the following sampling, DM production increased by 1.227 t ha^{-1}, that was the statistical difference at the level of $P < 0.01$. There was not any marked increase in the DM production found at the 3rd sampling (12 June), as confirmed by the non-significant difference in the yield (0.154 t ha^{-1}). In this year, the yields were rising with the increasing total rainfall and mean daily temperature (r = 0.6909; r = 0.8206). This relationship was significant at the rainfall (P = 0.03966) and it was statistically very significant at the temperature (P = 0.00672).

In 2004, the first sampling to the 1st cut was done on 24 May and the production was 1.420 t ha^{-1}. (Table 2). The production was rising at the following two samplings and a notable increase was recorded (6.112 t ha^{-1}) at the third sampling on 4 August, when a local commercial farm was cutting the sward. This is expressed also by the statistical comparison, because the difference in DM yield was very significant. The dynamics of sward re-growth slowed down after the late 1st cut. At the 2nd cut, the DM yield was 0.987 t ha^{-1}, what is approx. 16 % of the yieldfound at the third sampling. These results agree with FIALA (2002) reporting that under the two-cut regime and the late date of the 2nd cut the yield can be as much as 80 % of the total annual production. Similarly to the other years, in 2004 there was also a positive relationship between the DM production and the increasing rainfall (r = 0.8879) and temperature (r = 0.9753), respectively. This relationship was very significant both at the rainfall (P = 0.00139) and the temperature (P = 0.00001).

Conclusions

There was a positive relationship between the DM production and rainfall and temperature in all the research years. The significantly increased yields were recorded on the respective dates of the first and the second research samplings performed at the 1st cut. At the respective third samplings in 2002 and 2003, when the sward was cut by the farm, the increase in DM production was not statistically significant by comparison with the earlier samplings. Under the given abiotic conditions, the dynamics of sward re-growth markedly decreased towards the next cut at a late date of the 1st cut (here in 2004) or at non-favourable weather (here in 2003).

Table 1 Mean daily temperature (t_d °C), rainfall (R mm) in total and over the growing season (VO) in 2002 – 2004

Year	t_d / R	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	VO	Year
		Months													
2002	t_d	-3.8	1.9	3.1	6.21	14.03	16.2	17.7	16.7	10.2	5.59	3.6	-6.4	13.56	7.1
	R	14	26.5	16.6	10.8	74.1	76.6	130.7	115.4	55	103	12.4	24.2	462.3	659.3
2003	t_d	-4.6	-6.1	0.9	5.2	14.5	16.8	17.1	17.8	11.2	4.0	3.6	-1.9	13.8	6.6
	R	23.7	7.9	9.8	40.6	79.5	33.6	99.9	24.3	44.9	29.5	14.3	12.8	322.8	420.8
2004	t_d	-6.4	-2.1	1.1	7.1	9.9	14.4	15.9	16.0	10.9	8.0	2.0	-2.0	12.4	6.3
	R	20.9	46.3	31.9	45.8	86.9	113.4	157.2	84.5	23.1	50.2	45.5	10.3	510.9	716.0
Long-term average (1951 – 1995) and the differences from the long-term average over the growing seasons															
1951-1995	t_d	-4.7	-3.4	0.5	5.8	10.8	14.1	15.7	15.1	11.4	6.5	1.2	-2.8	12.2	5.9
	R	23	25	28	43	70	90	73	69	47	40	40	30	392	578
2002	t_d				0.41	3.23	2.1	2	1.6	-1.2				1.36	1.2
	R				-32.2	4.1	-13.4	57.7	46.4	8.0				70	81
2003	t_d				-0.6	3.7	2.7	1.4	2.7	-0.2				1.6	0.7
	R				-2.4	9.5	-56.5	26.9	-44.7	-2.1				-69.2	-157.2
2004	t_d				1.3	-0.9	0.3	0.2	0.9	-0.5				0.2	0.4
	R				2.8	16.9	23.4	84.2	15.5	-23.9				118.9	138.0

Table 2 Dry matter yields (t ha $^{-1}$) and the sampling dates

Years	Cuts	Samplings	Dates	DM t ha^{-1}
2002	1st	1st	3 June	2.629
		2nd	14 June	5.440
		3rd	18 June	6.222
	2nd	1st	30 July	1.658
		2nd	20 Aug.	1.723
		3rd	2 Sept.	1.880
2003	1st	1st	26 May	1.589
		2nd	5 June	2.816
		3rd	12 June	2.970
	2nd	1st	2 Sept.	0.703
2004	1st	1st	24 May	1.420
		2nd	8 June	2.145
		3rd	4 Aug.	6.112
	2nd	1st	17 Sept.	0.987

Table 3 Dry matter yields – the least significant differences (LSD)

Year	LSD	1st cut	2nd cut
2002	0.05	2.315	1.066
	0.01	3.507	1.615
2003	0.05	0.670	-
	0.01	1.015	-
2004	0.05	1.142	-
	0.01	1.730	-

LSD – the least significant difference at the significance level of α = 0.05 and α = 0.01

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DRY MATTER PRODUCTION AND NUTRITIVE VALUE IN THE SELECTED REPRESENTATIVES OF PERENNIAL FORAGE CROPS

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Introduction

Considering the ecological conditions of upland and mountain regions, these reduce a range of forage crops able to supply the desired economic yields with high content of nutrients and energy. One possibility would be to grow very productive varieties of grasses, legumes and their mixtures as perennial forage crops on arable land, because these are able to provide feeds of high production potential and nutritive value as well. Swards established by sowing are characterized by high yields of good-quality bulky feeds. Ilavská and Vorobeľ (2006) report that the established swards surpass the semi-natural grassland in the amount and in the quality of production, as the prosperity of intensive sown grassland is given by choosing appropriate cultivars of very productive grasses and legumes. According to some authors (Frame, 2005; Hopkins and Wilkins, 2006) *Trifolium pratense* L. plays the key role in temporary grassland. The grass components in the mixtures support wilting, accelerate preservation at ensiling, improve the dry matter (DM) content and also have higher content of water-soluble carbohydrates (WSC) than legumes (Pozdíšek and Kohoutek, 2003). The *Festulolium* inter-generic hybrids rank among important components of grass/clover mixtures. Among the reasons for creating the inter-generic hybrids of ryegrass (*Lolium*) and fescue (*Festuca*) are an easy hybridisation, but also a connection of nutritive value of ryegrasses with the perseverance and the resistance of tall fescue (*Festuca arundinacea*) to drought, cold and frost (Kopecký et al., 2006; Kościelniak et al., 2006).

Materials and Methods

A research was performed in a mountain region of Slovakia at a site with the following characteristics: longitude 20° 06′; latitude 48° 55′; altitude 960 m; mean annual rainfall 950 mm; mean rainfall over the growing season 525 mm; mean daily temperature 3.5°C; mean daily temperature over the growing season 9.5°C; geological substratum: carbonates; soil type: rendzina; soil texture: loamy. The research aim was to investigate the efficiency in sward, dry matter yield and nutritive value of above-ground biomass in a range of varieties and their mixtures, namely: 1. x *Festulolium* cv. Achilles; 2. *Trifolium pratense* L. cv. Fresko; 3. *Medicago sativa* L. cv. Tereza; 4. *Trifolium pratense* L. cv. Fresko + x *Festulolium* Achilles; 5. *Medicago sativa* L. cv. Tereza + x *Festulolium* Achilles. The swards were utilised under three-cut regime every year.

Results and Discussion

Not only at producing forage crops on arable land should it be taken into consideration that satisfactory quantity and quality of yields is dependent on the state of sward and that relates to the site conditions as well as to appropriate agronomic techniques. Therefore, the ground cover of the sown species was determined in sward after every cutting. In the harvesting years, differences in the proportions of the investigated varieties were found in sward before the first cut, as influenced by biological properties of soil and by conditions at the site. In the first harvesting year, a high sward proportion was recorded at the markedly intensive cv. Achilles, but it was reduced almost by half in the following year. The sward proportion of *T. pratense* cv. Fresko was well-balanced during both the harvest years, though *M. sativa* cv. Tereza was not catching up with *T. pratense* cv. Fresko in the second harvest year either, despite its increased proportion in sward than in the first year. In the simple (binary) mixtures, the proportions of legumes copied those in their monocultures. The mixture with red clover (*T. pratense)* produced a balanced sward, while the sward with lucerne (*M.sativa)* mixture contained more weed species and bare patches. Such a state of swards influenced the yields of DM (Table 1). In the first harvest year, the swards with *T. pratense* cv. Fresko were the most productive ones when compared with *M. sativa* cv. Tereza, with the grass/lucerne mixture and with x*Festulolium* Achilles. The production was high also at the grass/clover mixture; it was significantly higher in comparison with *M. sativa* cv. Tereza or the grass/lucerne mixture. The DM yield of x*Festulolium* Achilles was significantly higher than that found at *M. sativa* cv. Tereza or at the grass/lucerne mixture. In the second year, the DM production of x*Festulolium* Achilles lightly decreased, but increased at the other treatments, even markedly so at the lucerne swards. The statistical differences were confirmed between x*Festulolium* Achilles and both the grass/clover and the grass/lucerne mixture. An earlier research was done on the application of inter-generic hybrid Achilles in mountainous areas (Ilavská, 2005; 2012 a; b). It was confirmed that the vitality and the ground cover of this type were better in the first harvest year, as shown by the higher DM yield. Houdek (2010) reported similar results. Considering the biological properties of *T. pratense*, its decline in the sward proportion and a decrease in DM yield might be expected in the second harvest year. However, this was not confirmed and its high proportion in sward influenced also the increase in DM production. In this harvest year however, the most markedly increased yields were recorded at *M. sativa* and the grass/lucerne mixture. As noticed by Bolton et al. (1972), the yield of forage varies a lot at lucerne due to various environmental and agronomic effects. Considering the conditions at the research site, this was utterly true for the yields achieved within the research presented here. The increased yield was recorded also at the grass/clover mixture in the second harvest year, though not so marked as that at the grass/lucerne mixture, because the yield was already high in the first harvest year. It was confirmed again that the grass/clover mixtures are more productive than the monocultures of *T. pratense*.

A comparison between the monoculture of x*Festulolium* Achilles and the legume monocultures showed that the values of protein digested in the small intestine when nitrogen is limiting (PDIN) and of protein digested in the small intestine when energy is limiting (PDIE) were higher and the parameters of net energy for lactation (NEL), net energy for fattening (NEV) and metabolisable energy (ME) were lower in the first harvest year (Table 2).

Here, the content of nutrients should be taken into account, because a higher content of crude protein (CP) was found at legumes and it influenced the nutritional parameters. At the grass/clover mixtures, the high values of nitrogenous parameters were recorded only at the first cut. The values were fluctuating and ambiguous at the following cuts, as shown by the significant differences in PDIN between x*Festulolium* Achilles and all the other treatments; in PDIE between x*Festulolium* Achilles and *T. pratense* L. cv. Fresko, *M. sativa* cv. Tereza and the grass/clover mixture, respectively. The differences in NEL, NEV and ME were found between x*Festulolium* Achilles and all the other treatments; between the grass/clover and grass/lucerne mixture and *M. sativa* cv. Tereza, and also between *T. pratense* L. cv. Fresko and *M. sativa* cv. Tereza and the grass/clover and the grass/lucerne mixture. In the second harvest year, the nutritive value parameters of x*Festulolium* Achilles fluctuated at the cuts and at the treatments as well (Table 2). Consequently, it is impossible to specify a trend of increase or decrease in the parameters. The statistically significant differences in PDIN were found between the grass/clover mixture and all the other treatments and also in NEL, NEV and ME between x*Festulolium* Achilles and all the other treatments.

Table 1 Dry matter production (t/ha)

Treatments	Harvest years		Mean
	1st	2nd	
1. *Festulolium* cv. Achilles	8.192	7.995	8.094
2. *Trifolium pratense* cv.Fresko	9.108	10.216	9.662
3. *Medicago sativa* cv. Tereza	6.241	9.365	7.803
4. Achilles + Fresko	9.014	11.103	10.059
5. Achilles + Tereza	7.021	10.836	8.929
$LSD_{0.05}$	0.872	2.667	

Table 2 Mean nutritive value of preserved grass, legumes and grass/legume mixtures

Years	Treatments	(1) PDIN (g/kg)			(2) PDIE (g/kg)			(3) NEL (MJ/kg)			(4) NEV (MJ/kg)			(5) ME (MJ/kg)		
		1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
	1	55.75	74.29	53.92	71.76	74.18	70.34	5.98	5.86	5.90	5.91	5.78	5.84	10.03	9.85	9.91
	2	95.30	120.59	89.48	91.05	98.21	88.63	5.55	5.48	5.57	5.38	5.30	5.40	9.44	9.33	9.45
	3	98.11	121.96	81.37	83.82	89.78	77.43	5.32	5.25	5.30	5.07	4.99	5.06	9.13	9.03	9.08
	4	92.12	104.00	90.61	89.52	92.09	88.74	5.59	5.49	5.57	5.42	5.32	5.40	9.50	9.34	9.46
2011	5	111.74	104.29	75.06	79.38	84.33	75.30	5.43	5.25	5.24	5.20	5.00	5.01	9.29	9.02	8.98
$LSD_{0.05}$				28.721			7.729			0.117			0.128			0.184
	1	55.13	69.13	76.55	72.86	72.66	73.77	6.04	5.70	5.78	5.97	5.62	5.70	10.14	9.59	9.73
	2	79.73	70.04	98.44	75.47	71.87	75.34	5.57	5.47	5.34	5.38	5.29	5.14	9.49	9.30	9.10
	3	71.81	89.33	102.09	68.32	69.69	72.61	5.38	5.14	5.30	5.15	4.91	5.06	9.21	8.81	9.10
	4	75.04	104.00	90.61	82.05	92.09	88.74	5.41	5.49	5.57	5.18	5.32	5.40	9.27	9.34	9.46
2012	5	66.20	104.29	75.06	70.02	84.33	75.30	5.53	5.25	5.24	5.33	5.00	5.01	9.43	9.02	8.98
$LSD_{0.05}$				27.770			7.662			0.249			0.271			0.393

(1)PDIN – protein digested in the small intestine when nitrogen is limiting; (2PDIE – protein digested in the small intestine when energy is limiting;
(3)NEL – net energy for lactation; (4)NEV – net energy for fattening; (5)ME – metabolisable energy

Conclusions

When x *Festulolium* cv. Achilles and the varieties of *T. pratense* and *M. sativa* were grown either as monocultures or as simple mixtures with *Festulolium* in a system of perennial forage crops at a mountain region, the simple grass/clover mixtures showed better results. The binary grass/clover mixtures were more efficient and produced more compact swards than the legume monocultures. In the second harvest year however, *M. sativa* and also its simple mixtures performed better when grown under the mountainous conditions.

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The list of references is available from the authors (or from the Conference Secretary).

FROM ABANDONED TO WEEDY GRASSLAND: A CONTINUUM IN DRY MATTER PRODUCTION AND ITS QUALITY UNDER TWICE A YEAR CUTTING MANAGEMENT

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Introduction

Covering such a large area of the earth´s land surface, it is no surprise that grasslands have been heavily used throughout human history. And, grasslands are associated with the co-evolution of major plant and animal groups – the grasses and grazing mammals, respectively (GIBSON, 2009). Grasslands and their biodiversity are the most endangered biome of the world by land use change, climatic changes and nitrogen deposition (SALA et al. 2000). The greatest alteration to grasslands worldwide has been through transformation to agricultural land (GIBSON, 2009). In Europe, the formation and expansion of semi-natural grasslands created to produce forage for domestic herbivores has accompanied the whole development of European agriculture, so that these ecosystems have acquired an essential role in the European landscape and for biological diversity. In the last few decades, this role has been endangered by agricultural intensification, which has led to the abandonment and afforestation of difficult to cultivate sites and intensive management of favourable areas (SCOTTON *et al*., 2012). In the Slovakia, JANČOVIČ and VOZÁR (2004) have estimated that 31% of grassland (*ca*. 270,000ha) is not used and 4.5% (*ca*. 40,000 ha) is weed-infested due to excessive use of fertilizers. While weed-infested grassland is represented an early stage of a succession process, abandoned one do an older stage of this continuum (BRITAŇÁK *et al*., 2012). This paper aims at assessing the forage productivity and its quality of different types of grassland and they were differed by stages of succession as well.

Materials and Methods

A research was carried out at the cadastre of the Liptovská Teplička village located within the *Nízke Tatry* National Park (NAPANT). In early 2006, we identified weed-infested grassland (as a result a temporal midden – altitude 1000 m) and abandoned one (not used approximately 15 years and first seedlings of tree species *Picea abies* and *Alnus glutinosa* were appeared on this type of grassland – altitude 1005 m). We reinstated a twice a year management on these grassland for four years of investigation. Results obtained were compared with permanently mowed semi-natural grassland (altitude 960 m). In these grasslands, we were interested in the dry matter production and its quality.

Results and Discussion

In the investigation period, it was recorded that all temperatures over the growing period were higher than long-term period (Table 1). Rainfall deficit was detected in 2006 only. Dry matter production was correlated negatively with temperatures (r = -0.39; P = 0.01). Temperature did not affect the fibre and crude protein concentrations. On the contrary, there was no relationship between rainfall and dry matter production. Rainfall have positively correlated with fibre concentrations only (r = 0.43; P = 0.005).

Table 1 Mean daily temperature (°C), rainfall (mm) over the growing period of 2006 to 2009, and their long-term averages (deviations from long-term averages are given in the parenthesis)

	1950-1995	2006	2007	2008	2009
Temperature	12.2	13.5 (+1.3)	13.9 (+1.7)	13.5 (+1.3)	14.0 (+4.8)
Rainfall	392.0	320.6 (-71.4)	523.2 (+131.2)	450.2 (+58.2)	396.7 (+4.7)

Dry matter production is given in Table 2. Dry matter production among types of grassland was differed marginally (P = 0.07). As we expected, the highest amount of dry matter was produced on the weed-infested grassland (3.457 $t.ha^{-1}$). Dry matter production of abandoned grassland was as high as the semi-natural grassland, on average. A (succession) continuum in the dry matter production can be drawn as follows: weed-infested grassland > abandoned = semi-natural ones.

Table 3 provides information about an average (weighted) concentration of fiber and crude protein in dry matter from different types of grassland. Fiber concentration is differed statistically (F = 23.44; P = 0.0000). Fiber concentration in the dry matter of abandoned grassland was the lowest of these three grasslands. In this parameter of quality, there are not differences between weed-infested and semi-natural grasslands (Table 3). A continuum in the fiber concentration is: weed-infested > semi-natural >> abandoned grassland.

Crude protein concentrations in the dry matter were quite the opposite. A continuum in crude protein concentration is as follows: abandoned grassland > semi-natural grassland > weed-infested one. There was statistically significant difference (F = 7.57; P = 0.002) between weed-infested and abandoned grasslands.

Table 2 Dry matter production (t.ha-1)

	WIG	SNG	AG	Average
2006	4.110	3.372	2.572	3.353
2007	2.609	2.356	3.446	2.759
2008	3.502	3.505	2.906	3.324
2009	3.609	2.300	2.627	2.791
Average	3.457	2.883	2.888	

Notes: WIG – weed-infested grassland; SNG – semi-natural grassland; AG – abandoned grassland

Differences in the quantity and quality of dry matter produced from different grassland can be attributed to the plant strategies (GRIME, 2001). For example, weed-infested grassland has consisted *inter alia* annual and biennial plants, which are typical for arable land as its weed. This type plants are competitors and its strategy is to produce bigger amounts of structural carbohydrates to promote to set flowers and seeds. Moreover, these plants are typical for their early development. Therefore, they have produced a lot of dry matter with the lowest concentration of crude protein and the highest one of fiber. On the contrary, abandoned and semi-natural grasslands have consisted of plants with strategy to tolerate the stresses. They are biennial or perennial and they have invested in the long-lived organs. Moreover, plant community of abandoned grassland was consisted of late flowering plant species. This lagged time of the set of flower and subsequent blooming and set of seeds is mirrored in better quality (low fibre concentrations and high crude protein ones) than weed-infested. Quality of semi-natural grassland is in the middle between weed-infested and abandoned ones.

If our aim was to support succession (weed-infested grassland) or to stop it (abandoned grassland), then in the last year of our investigation we did achieve a convergence in the qualitative properties of three types of grassland (Table 3; row of 2009 year).

Table 3 Concentrations of fiber and crude protein (g.kg-1)

	Fiber			Crude Protein		
	WIG	SNG	AG	WIG	SNG	AG
2006	220.1	226.6	172.7	103.0	150.5	131.9
2007	250.5	238.9	213.6	119.5	145.7	145.1
2008	242.8	219.2	178.5	98.4	97.3	153.3
2009	211.6	195.7	181.5	131.7	120.4	130.1
Average	231.3[a]	220.8[a]	186.6[b]	113.2[b]	128.5[ab]	140.2[a]

Notes: abbreviations are the same as under Table 2. Different letters in the superscripts denote differences between type of compared grasslands.

Conclusions

In the mountainous area of Slovakia, we investigated the effect of mowing twice a year on the production capacity of three types of grasslands and its dry matter quality. Over the years, the highest production of dry matter was produced on weed-infested grassland. Dry matter production of semi-natural and abandoned grasslands was the same. The highest concentration of fiber was produced by weed-infested grassland and the lowest by abandoned one. Situation in the crude protein concentration was in reverse. Semi-natural grassland was in the middle of the two. In the last year of investigation the nutrient concentrations were balanced.

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EFFECT OF DRYING METHOD ON ESTIMATED PARAMETERS OF CHEMICAL COMPOSITION OF ALFALFA

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Introduction

The treatment of forage samples after sampling and before analyzing is one of the most important operations affecting accuracy of chemical analysis. The accurate estimation of forage nutritive value attributes require sampling procedures that quickly reduce plant metabolic activity after cutting and preserve macromolecular structures (Pelletier et al., 2010). Purcell et al. (2011) claimed that drying methods involving heat can change the chemical composition of feeds. Freeze-drying provide chemical composition of samples closest to fresh herbage and is often considered to be an optimal system for drying forage samples (Pelletier et al., 2010; Purcell et al., 2011). However, freeze-drying method is expensive and difficult to apply to large samples under field conditions (Pelletier et al., 2010).

The objective of this study was to assess effects of different drying methods on estimated parameters of chemical composition of alfalfa.

Material and Methods

Hand-cut samples of alfalfa (*Medicago sativa* L.) were collected from spring growth and first regrowth at the Institute of Animal Science in Prague-Uhříněves (50°2´ N, 14°36´ E). Alfalfa was harvested in two identical stages of development (heading and flowering) in both growths. We compared nine drying procedures on fresh samples of alfalfa. Freeze-drying (FD), using freeze dryer mashine ALPHA 1-4 LSC (Martin Christ Gefriertrocknungsanlagen GmbH, Germany), was used as the control treatment to which other drying methods were compared. The others methods included oven-drying at 100 °C for 24 h (100), oven-drying at 50 and 60 °C for 48 h (50 and 60 respectively), oven-drying at 40 °C for 72 h (40), oven-drying at 30 °C for 96 h (30), high-temperature pretreatment at 100 °C for 1 h followed by oven-drying at 50 °C for 48 h (100+50), microwave pretreatment for 70 sec at high intensity to reach approximately 70 °C (microwave oven Fagor Mo25DGB) followed by oven-drying at 50 °C for 48 h (MO) and freezing pretreatment at -20 °C for 1 mo followed by oven-drying at 50 °C for 48 h (FREE). All tested samples were analyzed for dry matter, ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), crude protein (CP) and ether extract (EE) contents (AOAC, 2005). The results were analyzed using the MIXED procedure of SAS (SAS, 2002-2003) and differences in mean values were evaluated by Tukey's test.

Results and Discussion

The differences in chemical composition of alfalfa in growths and stages of development are indicated in Table 1. As expected, better quality of forage was detected in spring growth and in heading stage. Higher values of CP and lower values of NDF, ADF and ADL for spring growth in comparison with regrowth were in line with those presented by Niwińska et al. (2005).

Table 1 The effect of growth period and stage of development on chemical composition of alfalfa

	Growth			Stage of development		
	Spring	**Regrowth**	**P value**	**Heading**	**Flowering**	**P value**
DM (g/kg)	198.2	220.6	<0.001	183.1	235.6	<0.001
Ash (g/kg DM)	101.7	85.7	<0.001	101.5	85.9	<0.001
NDF (g/kg DM)	394.1	450.9	<0.001	380.2	464.9	<0.001
ADF (g/kg DM)	320.4	371.9	<0.001	309.1	383.2	<0.001
ADL (g/kg DM)	56.2	74.9	<0.001	55.4	75.8	<0.001
CP (g/kg DM)	189.7	184.1	0.001	207.8	166.0	<0.001
EE (g/kg DM)	11.2	12.1	0.008	12.2	11.2	0.002

The interactions among growth periods and stages of development showed the best quality of alfalfa forage for heading stage of spring growth and the worst for flowering stage of regrowth ($P<0.05$). The interactions are presented in Table 2. Lower CP content and higher NDF content for alfalfa in heading stage in comparison with flowering stage was verified also by four years study of Hakl et al. (2010).

The effect of drying pretreatments on parameters of chemical composition is given in Table 3. Crude protein content was different between freeze drying and oven-drying at 100 °C. The contents of fibre fractions (NDF, ADF and ADL) were comparable among freeze-drying, high-temperature pretreatment and microwave pretreatment methods. Purcell et al. (2011) showed that heat drying can lead to increasing of NDF and lignin and decreasing of total non-structural carbohydrates. High temperature drying can also result in formation of indigestible Maillard products, which increase cell-wall contents and reduce digestibility (Alomar et al., 1999). Pelletier et al. (2010) found that oven drying increased the N concentration compared with freeze-drying for alfalfa forage.

Table 2 Results of analyses of interactions among growth periods and stages of development

Parameters of chemical composition	Spring growth Stage of development		Regrowth Stage of development		P value
	Heading	Flowering	Heading	Flowering	
DM (g/kg)	165.3^{a}	231.0^{c}	200.9^{b}	240.2^{d}	<0.001
Ash (g/kg DM)	109.9	93.4	93.1	78.3	0.219
NDF (g/kg DM)	341.0^{a}	447.3^{c}	419.4^{b}	482.5^{d}	<0.001
ADF (g/kg DM)	272.6^{a}	368.1^{c}	345.6^{b}	398.2^{d}	<0.001
ADL (g/kg DM)	43.9^{a}	68.5^{b}	66.8^{b}	83.0^{c}	<0.001
CP (g/kg DM)	214.2^{c}	165.2^{a}	201.4^{b}	166.8^{a}	<0.001
EE (g/kg DM)	12.1	10.4	12.4	11.9	0.069

^{a,b,c}Within a row, means without a common superscript differ (P < 0.05).

Table 3 The effect of drying pretreatments on parameters of chemical composition (g/kg dry matter)

Drying method	DM	Ash	NDF	ADF	ADL	CP	EE
FD	212.9^{b}	95.1^{bc}	397.0^{a}	326.7^{a}	60.4^{a}	188.9^{b}	10.7^{ab}
100	212.2^{b}	89.5^{a}	449.4^{d}	358.8^{d}	70.2^{d}	177.4^{a}	12.7^{bc}
60	205.9^{ab}	94.1^{abc}	429.8^{bc}	356.2^{cd}	66.2^{bcd}	183.5^{ab}	11.8^{bc}
50	210.1^{ab}	93.0^{ab}	422.4^{bc}	337.8^{ab}	65.7^{bc}	190.1^{b}	13.0^{cd}
40	203.2^{a}	98.5^{c}	424.4^{bc}	353.4^{bcd}	68.7^{cd}	191.9^{b}	10.8^{abc}
30	207.2^{ab}	93.4^{ab}	436.5^{cd}	356.9^{d}	68.5^{cd}	189.5^{b}	9.4^{a}
100+50	211.8^{b}	93.7^{ab}	412.8^{ab}	336.8^{ab}	63.1^{ab}	184.5^{ab}	15.1^{d}
MO	210.0^{ab}	94.1^{abc}	414.8^{ab}	338.3^{abc}	63.1^{ab}	187.8^{ab}	13.0^{cd}
FREE	211.0^{b}	91.8^{ab}	415.9^{b}	350.6^{bcd}	64.2^{ab}	188.3^{b}	8.8^{a}
P value	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001

^{a,b,c,d}Within a column, means without a common superscript differ (P < 0.05).

Conclusions

It was concluded that drying methods using microwave and high-temperature pretreatments followed by oven-drying at 50 °C for 48 h didn’t differ from freeze-drying on main parameters of chemical composition (fibre fractions and CP). These methods represents alternatives to freeze-drying when that method is not feasible and therewithal they are easy and fast methods that can be applied to wide range of different samples. However, more research is needed on the effects of different drying methods especially on determination of nutrient digestibility.

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DEGRADATION OF NUTRIENTS IN DENT AND DENT X FLINT MAIZE HYBRIDS IN DIFFERENT STAGES OF MATURITY

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Abstract : The in situ experiment was conducted to determined degradation of starch and crude protein in maize hybrids with dent and dent x flint type of grain. The samples of grain were harvested in four stages of maturity. The first harvesting was organised in milk-waxy stage and than fornightly intervals until full grain ripeness. Used dent x flint hybrids were Mesnil, Chambord, Queen, and Aude, Meridien, KX 13 93, Omero were dent.

The effective degradability of crude protein and starch of maize grain has decreasing tendency with increasing of maturity stage. The maize hybrids of dent type had higher effective starch degradability (60.2%) than hybrids dent x flint (59.6%). The degree of maturity had a significant (P <0.01) effect on effective degradability of starch and crude protein. The maize hybrids KX 1393 and Meridien had the highest rate of starch degradability (parameter c: 0.075%. h^{-1} and 0.074.h^{-1}, respectively). Protein and starch in the hybrids dent x flint were less rapidly degraded than dent hybrids.

Introduction

Maize silage is one of the most important fodder crops in nutrition of ruminants. Maize gives good crop of dry matter with significant proportion of grain. This grain is a primary energy supplement in dairy diets and can contribute up to 30, 60, and 98% of the diet's protein, net energy, and starch, respectively. The default form for breeding based on kernel characteristics, maize are divided into five types: flint, popcorn, floury, dent and sweet corn (Corona *et al.*, 2006). The endosperm of flint corn consists of hard-textured vitreous starch and has a greater proportion of vitreous endosperm than dent maize (Philippeau *et al.,* 1999). Starch in vitreous dry corn is more extensively encapsulated by prolamins and is less degradable in the rumen as compared to floury or opaque maize grains (Hoffman and Shaver, 2010).

In Slovakia is currently grown maize hybrids imported from other geographical areas and it is important to determined their nutritional quality. The rate and extent of degradability of crude protein and starch are important characteristics for their effective utilization by ruminants. Therefore, the aim of our study was to determine using the method of in situ an effect of grain type and maturity stage on ruminal crude protein and starch degradability from selected corn hybrids of type dent and flint x dent.

Material and Methods

The grain of maize hybrids of the type dent (Aude, Meridien, KX 1393, Omero) and dent x flint (Mesnil, Chambord, Queen) were used in our experiment.

The maize grain was sampled in fornightly intervals, at the time of milk-waxy maturity (13.8., at harvest maize for silage), until its full ripeness, i.e. 26.8, 10.9 and 23.9

Starch and crude protein degradability in the maize grain were determined by the method *in sacco* (Harazim and Pavelek, 1999). In sacco experiments were carried out in three nonlactating cows with large rumen cannulae (an average 10 cm).

Ground samples were weighed (approx. 2.50 g dry matter) into bags made of Uhelon 130T with pore size 47 μm. Minimum three separate bags for hybrid, incubation time and animal were used. The bags with sample were incubated for 2, 3, 4, 6, 9, 16, 24, and 48 hours. The 0 h time bags were only washed in water to determine washing loses.

The content of starch was determined acoording to modified enzymatic method (Salomonsson *et al*., 1984) and crude protein according to Decree MP 2145/2004- 100. The parameters of degradability (a, b, c, and ED) were calculated using the equations by Ørskov and McDonald (1979) with outflow rate of 0.06.h^{-1}.

The statistical characteristics were calculated using mathematical- statistics models in statistical package Statistix 8.0.

Results and Discussion

Due to lack of information on the quality of grain maize hybrids grown in Slovakia in experiment was watched chemical composition and in situ ruminal crude protein and starch degradability in hybrids dent and dent x flin. Dent x flint maize (*Zea mays L.*) hybrids are commonly planted in the early maize growing regions of Europe (Moreno-Gonzales *et al.,* 2000). Starch and protein content, these two nutrients could most affect grain degradability in the rumen. The differences among maize hybrids as well as between the stages of maturity in concentration of nutrients and extent of degradability were observed in many experiments (Lebzien *et al.* 1997; Čerešňáková *et al.* 2003).

Results from the tested hybrids showed that the content of starch depends on hybrid respectively on the type of grain. The mean starch content was higher in dent hybrids, and was changed with ripening of grain. The maximum starch concentration was determined in hybrid KX 1393 (716.6 g/kg DM) and the lowest in hybrid Queen (669.3 g/kg DM). The differences between individual hybrids were significant (P<0.05), and between KX1393 and Queen were high significant (P<0.01). The results also confirm the changes in the starch content in corn grain during the ripening process. High significant differences were between 1st and 2nd, 3th, and 4th samplings (P<0.01) and between 3th and 4th samplings (P<0.05), resp. content of crude protein (CP) was also different among hybrids and changed with the date of sampling. Average (average of all hybrids and harvestings by type of grain) concentration was lower (102.8 g/kg DM) in the dent x flint hybrids than in dent hybrids (108.4 g/kg DM). Among the hybrids the differences were statistically significant, although dent hybrids had a higher content of about 2% units. Also according Michalet - Doreau *et al.,* (1995) differences in the degradation of starch hybrids between maize grain are primarily linked to the structure of the endosperm.

Dent type hybrids (Aude, KX 1393, Meridien and Omero) show higher effective degradability of starch than type dent x flint in all harvestins. Averages of degradability parameters for individual hybrids from all four harvesting times confirm lower starch degradation rate in dent x flint maize grain than dent maize grain. Effective degradation of starch (EDS) was lower for crossbread dent x flint varieties with properties closer to dent than for flint hybrids. The difference between them was not high even though among hybrids were differences significant. The hybrids Mesnil (62.7 %) and Aude (57.7%) were beyond the average. The rate of starch degradability was the highest in dent hybrids KX 1393 (0.075 $\%.h^{-1}$) and Meridien (0.074 $\%.h^{-1}$).

Average effective degradability of starch declined from 64.5 % (1st sampling) to 55.9 % (3th sampling) but in the last sampling increased (60.1%). The parameters of degradation (a, b, c) varied with grain ripening. There was found that the effective degradability of starch as well as the rate of degradation of fraction "b" (parameter "c") had decreasing trend with the stage of maturity. The rate of degradation in the hybrid Mesnil dropted from 0.082 $\%.h^{-1}$ in 1. sampling to 0.038 $\%.h^{-1}$ in 4th sampling. The decline the parameter “c” was more marked in hybrids dent x flint than in hybrids dent. The parameter „a“ was highest in hybrids dent (Meridien and Omero 33.0 %) from the 1st harvesting.

In individual stage of maturity were small differences in CP degradability among hybrids. The degradability was higher in the type dent than dent x flint but differences were not signifficant. Effective degradability of CP was statisticaly different ($P < 0.05$) only between hybrids Meridien and Aude that are both type dent. The effective degradability is affected by the rate of degradation „c“ of the insoluble fraction „b“. This parameter had decreasing tendency with ripening of grain (for Aude form 0.040 $\%.h^{-1}$ in the 1st sampling to 0.018 $\%.h^{-1}$ in the 4th sampling, Mesnil from 0.064$\%.h^{-1}$ to 0.014 $\%.h^{-1}$). Not every hybrid had such a sharp decline rate with maturation.

It is important that effective crude protein degradability declined with ripening grain in both type of maize grain. The most significant changes were in hybrids Mesnil and Chambord, where the differences between the first and fourth sampling in EDCP were until 18% units. For hybrid Omero (dent) degradation rate was declined only slightly with ripening (from 50.0 % to 47.9 %). Comparing the degradation of crude protein in all four samplings, was found that the parameters degradability and ECPD were highly statistically significant ($P < 0.01$). By reducing the degradation of the protein was also reduced degradability of starch.

Conclusion

The effective degradability of crude protein and starch in hybrids dent was higher than in dent x flint hybrids. In practical terms this means that the use of protein and starch as a source of energy and from maize dent x flint is in ruminants more effective. Hard texture hybrids may accentuated reduction in ruminal degradability under ensiling situation. The texture effect on ruminal starch degradability may be importatnt in farm using high moisture corn as a concentrate feedstuff, since these are normally harvested at dry matter content value above those capable of inducing a marked texture effect on ruminal degradability.

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Session 2 – Control of fermentation process, microbiology and hygienic quality of conserved feeds

Oral presentations

Poster presentations

INVESTIGATION OF AEROBIC STABILITY OF ENSILED WET CORN GLUTEN FEED (CGF) TREATED WITH DIFFERENT ADDITIVES

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Summary

Aim of the authors was to investigate the aerobic stability of ensiled wet CGF during 10 days aerobic storage (after 30 days fermentation) in model silos (3 different experiments). Treatments were the follows (1st exp) wet CGF ensiled with 20% maize silage, (2nd exp) wet CGF ensiled with 10% dried ground corn, (3rd exp) wet CGF treated with mix of formic- and propionic acid in different doses (59% formic acid, 20% propionic acid, applied dose: 4 litre/ton, 5 litre/ton, 6 litre/ton, respectively), wet CGF treated with a silage inoculant containing homofermentative bacteria (*Enterococcus faecium, Pediococcus acidilactici, Lactobacillus salivarius, Lactobacillus plantarum,* applied dose: 2 x10^5 CFU/g AF), and finally wet CGF treated with a product containing homofermentative bacteria and preservative salts (*Enterococcus faecium, Pediococcus acidilactici, Lactobacillus salivarius, Lactobacillus plantarum,* K-sorbate, Na-benzoate, applied dose: 250g/ton AF). The pH, acetic acid- and ethanol concentration, ammonia-N, aerobic mesophylic bacteria and moulds were measured after 240 hours (n=5). Temperature changes were detected by hours during the 240 aerobic hours.

Introduction

The wet corn gluten feed as by-product of the corn-based bio-ethanol industry is a potential protein- and carbohydrate source in the diary and beef cattle nutrition (crude protein content: 190-240 g/kg DM, starch content: 240-280 g/kg DM). The wet CGF is rather perishable by-product due to its 60% moisture content, therefore short-term storage (7-10 days) as fresh wet CGF may cause animal health risk in farm circumstances. Fermentation of wet CGF is a solution for long term storage, but there is limited information about aerobic stability of the ensiled wet CGF after the silo open. Aim of the authors was to investigate the aerobic stability of ensiled wet CGF during 10 days aerobic storage (after 30 days fermentation) in model silos (3 different experiments). Wet CGF was ensiled with maize silage (20%) and dry ground maize (10%), or different silage additives were applied (formic- and propionic acids mix in 3 different doses, a silage inoculant containing homofermentative lactic acid bacteria and a silage additive containing homofermentative lactic acid bacteria in combination with K-sorbate and Na-benzoate), respectively.

Materials and Methods

Ensiling was carried out in a model silo system (volume: 0,041 m^3/model silo, n=5). The model silos were open on the 30th day of fermentation and 1 kg aerated silage was placed back into the model silos for 10 aerobic days storage. The model silos were stored in thermoneutral room (20ºC). After 240 hours the pH, the acetic acid- and ethanol content, the ammonia-N, aerobic mesophylic bacteria (AEMB) and moulds were measured according to the Hungarian National Standards (n=5). Temperature changes were detected by hours during the 240 aerobic hours with temperature sensors built in the model silos (110 mm depth). Applied treatments were the followings:

Experiment 1 (density of 1108 kg / m^3 =443 kg DM/ m^3):

1. Control: ensiled wet CGF
2. MS: wet CGF ensiled with 20% maize silage.

Experiment 2 (density of 1192 kg / m^3=477 kg DM/ m^3):

3. Control: ensiled wet CGF
4. MG: wet CGF ensiled with 10% dry ground maize grain.

Experiment 3 (density of 980 kg / m^3=394kg DM/ m^3):

1. Control: ensiled wet CGF
2. KS4: wet CGF treated with formic- and propionic acid additive, applied dose was 4 litre/ton AF (59% formic acid, 20% propionic acid, 4,3% NH_4-formiate, 2,5% K-sorbate)
3. KS5: wet CGF treated with formic- and propionic acid additive, applied dose was 5 litre/ton AF (59% formic acid, 20% propionic acid, 4,3% NH_4-formiate, 2,5% K-sorbate)
4. KS6: wCGF treated with formic- and propionic acid additive, applied dose was 6 litre/ton AF (59% formic acid, 20% propionic acid, 4,3% NH_4-formiate, 2,5% K-sorbate)
5. SA*:* wet CGF treated with a silage inoculant *(Enterococcus faecium, Pediococcus acidilactici, Lactobacillus salivarius, Lactobacillus plantarum,* enzymes: pentosanase, hemicellulase, cellulase, amylase, applied dose: 2 x10^5 CFU/g, 10g/ton AF, 3 litre water/ton)
6. FG*:* wet CGF treated with a silage additive (*Enterococcus faecium, Pediococcus acidilactici, Lactobacillus salivarius, Lactobacillus plantarum,* K-sorbate, Na-benzoate, applied dose: 250g/ton AF, 3 litre water/ton).

Results and Discussion

Aerobic parameters of the ensiled wet CGF mixed with 20% maize silage or 10% dried ground maize, respetively, are given in Table 1. The aerobic profile and stability of the ensiled wet CGF treated with different silage additives are given in Table 2.

Table 1 Aerobic parameters and stability of the ensiled wet CGF and different mixtures (20% maize silage MS and 10% dried ground maize MG, respectively, 10 aerobic days storage, n=5).

		Exp 1				Exp 2			
10 aerobic days		wCGF		MS		wCGF		MG	
		mean	SD	mean	SD	mean	SD	mean	SD
DM	g/kg	407a	2.2	389b	3.1	445a	3.1	486b	4.6
pH		5.6a	0.5	5.9a	0.3	5.8a	0.4	5.8a	0.3
Acetic acid	g/kg DM	1.9a	0.7	2.8a	1.3	1.4a	0.3	0.9b	0.2
Ethanol	g/kg DM	8.0a	6.3	2.4b	3.2	3.3a	3.7	4.5a	4.7
Ammonia-N	g/kg total N	6.6a	1.3	5.8a	1.2	7.0a	1.6	5.8b	1.9
AEMB*	log10 CFU/g	6.1a	0.2	6.2a	0.2	5.8a	0.6	6.0a	0.1
Moulds	log10 CFU/g	1.1a	1.5	3.9b	2.3	0.0a	0.0	0.0a	0.0
Aerobic stability	hours/diff of 1°C	49a	4.1	28b	1.1	39a	2.5	84b	4.4

* AEMB = aerobic mesophylic bacteria; *ab* Means in the same row with different letters differ ($p \leq 0.05$)

Table 2 Aerobic parameters and stability of ensiled wet CGF treated with different silage additives (10 aerobic days storage, n=5)

10 aerobic days	Exp 3	wCGF		KS4		KS5		KS6		SA		FG	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
DM	g/kg	403a	3.9	411a	5.6	408a	4.6	406a	5.1	396a	5.6	397a	4.5
pH		5.2a	0.3	5.0a	0.6	4.6b	0.2	4.7b	0.2	5.1a	0.1	5.3a	0.7
Acetic acid	g/kg DM	14.6a	1.9	22.8a	14.0	34.3b	13.4	16.1a	4.8	14.3a	2.7	19.3a	12.6
Ethanol	g/kg DM	55.8a	46.3	8.2a	9.4	10.5a	17.0	9.5a	6.2	152.7b	26.8	29.2a	38.8
Ammonia-N	g/kg total N	3.9a	0.5	4.2a	0.5	4.4a	0.7	4.4a	0.5	4.0a	0.1	5.0a	1.7
AEMB*	log10 CFU/g	6.5a	0.8	7.1a	0.3	6.6a	0.9	7.3a	0.2	6.8a	0.4	6.9a	0.7
Moulds	log10 CFU/g	7.5a	0.0	7.1a	0.6	6.9a	0.8	7.3a	0.2	7.1a	0.1	6.7a	0.7
Aerobic stability	hours/diff of 1°C	33a	2.5	90b	3.9	157c	8.1	136c	6.9	36a	2.8	76b	4.8

* AEMB = aerob mesophylic bacteria; *abc* Means in the same row with different letters differ ($p \leq 0.05$)

Authors have found high variation and standard deviation in ethanol concentration during aerobic phase of each experiments. The high variability shows considerable sensitivity of the ensiled wet CGF for yeast proliferation (based on available starch content) and high standard deviation is an indication for microbiological heterogeneity of the ensiled wet CGF under aerobic conditions. Additionally, considerable differences were found in mould count among the control wet CGF comparing the different experiments to each other, showing instability and variable hygienic status of the wet CGF even applying fermentation technique. It may increase the animal health hazard during aerobic days on dairy and beef farms.

It was found that maize silage (20%) did not improve most of the aerobic parameters (except ethanol content) of the ensiled wet CGF during the 10 aerobic days, moreover increased the mould proliferation and reduced the aerobic stability compared to the control ensiled wCGF ($p \leq 0.05$). Maize silage had undesirable harmful effect on stability (49 hours/1°C. *vs* 28 hours/1°C). The dried ground maize (10%) addition was effective to increase aerobic stability of the ensiled wet CGF during the 240 aerobic hours. Dried maize decreased the proteolyses (ammonia-N %: 7.0 *vs*. 5.8) and acetic acid concentration (acetic acid: 1.4 *vs*. 0.9). Dried ground maize (10%) significantly improved the aerobic stability of wCGF (39 hours/1°C. *vs* 84 hours/1°C).

The mixes of formic- and propionic acids were effective to maintain the low pH and low ethanol concentration during aerobic spoilage compared to the control. Significant differences were not found in AEMB and mould counts among the acid treatments. Otherwise, acid mixes improved aerobic stability of ensiled wet CGF during 240 aerobic hours ($p \leq 0.05$). The dose of 5 litre/ton and 6 litre/ton acid mix applications were more effective than the 4 litre/ton dose, but there was no significant difference between KS5 and KS6 treatment.

Homofermentative bacteria inoculation at ensiling of wet CGF had no positive effect on aerobic parameters, moreover it increased the ethanol concentration compared to the control during 10 aerobic days (accelerated yeast proliferation). Combination of homofermentative bacteria and preservative salts (Na-bensoate and K-sorbate) did not have any significant effect on aerobic parameters, but improved the aerobic stability during the 240 aerobic hours ($p \leq 0.05$).

Conclusions : The silage additive containing mix of formic- and propionic acids (59% formic acid, 20% propionic acid, 4,3% NH_4-formiate, 2,5% K-sorbate), in dose of 5 litre/ton is recommended to apply for fermentation of wet CGF in order to improve aerobic stability during aerobic days after silo-opening. Formic- and propionic acid treatment in dose of 6 litre/ton did not have any additional effect on aerobic stability compared to 5 litre/ton. Preservative salts (Na-bensoate and K-sorbate) have moderate beneficial effect on aerobic stability of ensiled wet CGF compared to formic- and propionic acid treatments in dose of 5 litre/ton.

FITTING NON-LINEAR REGRESSION TO MAIZE SILAGE DEGRADABILITY ACROSS THE STORAGE PERIOD

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Introduction

Although there is a general consensus that silage fermentation stabilize in about three to six weeks, there is compelling evidence that shows changes in the chemical and microbial composition of silages well beyond this time (Der Bedrosian et al., 2012). Several studies have reported that ruminal dry matter (DM) digestion of maize silages is relatively low at harvest, but increase steeply with time of ensiling because of natural proteolytic mechanisms that occur in the silo, increasing starch availability (Kung, 2013). Thus, the objective of this study was to evaluate the influence of length of storage on maize silage degradability and compare mathematical models to predict DM degradability across a prolonged fermentation period.

Material and Methods

Whole corn plants were harvested at 400 g DM/kg fresh matter, chopped (without kernel processing), and packed in lab-scale silos (20 L buckets). Silos were stored for 3, 7, 15, 30, 60, 210, 390, 480, and 570 days. Microbial inoculants were also applied as treatments, however due to the lack of responses to additives, only storage length will be issued on this report. In each scheduled date, 9 silos were opened. A silage sample was oven dried and analyzed for chemical entities and another one was frozen at −20°C for the *in situ* assay. At the end of the storage period, frozen samples (70 g fresh matter) were thawed, allocated in macro-bags (20 cm × 40 cm) and positioned into the rumen ventral sac of two cannulated non-lactating cows for 24 h (DEG24h) or 48 h (DEG48h). Cows were fed with a diet containing maize silage (600 g/kg DM) and concentrates (400 g/kg DM). After incubation, bags were placed into cold water to stop the fermentation and washed in a machine by five cycles. Then, bags were dried in an oven at 60°C for 72 h and DM degradability was calculated as: DEG (%) = 100 × [Initial DM (g) − Residual DM (g)]/ Initial DM (g).

Five non-linear regression models were considered to predict maize silage degradability across the storage period: a) exponential, b) logistic, c) broken-line with linear regression for the first segment followed by plateau (linear, plateau), d) broken-line with linear regression for the first segment and other linear regression for the second segment (linear, linear), and d) broken-line with quadratic regression for the first segment followed by linear regression (quadratic, linear). The NLMIXED procedure of SAS version 9.3 was performed to establish the DM degradation curve. Model adjustments were compared by R^2-adjusted (largest is better), root mean square error (smaller is better), and Akaike's information criterion (smaller is better).

Results and Discussion

Exponential and logistic models were tested hence they describe reasonable well sigmoid phenomena (e.g., growth). On the other hand, broken-line regressions has been commonly employed in animal nutrition research fields, for instance to predict amino acid requirements. The latter approach has practical claims because a field recommendation could be obtained for storage length (break-point).

Anyhow, contents of neutral detergent fiber (455 g/kg), acid detergent fiber (230 g/kg), lignin (21g/kg), and ash (38 g/kg) were not significantly altered across the storage period (P>0.05). As expected, soluble carbohydrates were metabolized during the fermentation and decreased from 18 g/kg at d-3 to 9 g/kg at d-570 (P<0.01). Crude protein content changed slightly among opening dates (62 to 71 g/kg; P<0.01), but without biological significance.

The DM degradability, however, increased continually across the fermentation period (Figure 1). Indeed, the proportion of nitrogen as ammonia ($N\text{-}NH_3/N$) increased with the storage length (P<0.01), from 13 g/kg N at d-3 to 44 g/kg N at d-570, and might indicates increased proteolysis, which in turn, led to enhanced starch availability (Kung, 2013).

All models fitted to the DM degradability had reasonable adjustments (Table 1), although broken-line regression with first segment quadratic and second segment linear (quadratic, linear) presented the best fitness for both incubation times (DEG24h and DEG48h). Based on this approach, silage degradability enhanced wildly (~0.56 percentage unit per day for DEG24h; ~0.86 percentage unit per day for DEG48h) during the first 28 days of storage (see Parameter 'D' in Table 1) and still increasing slowly (~0.03 percentage unit per day for DEG24h; ~0.01 percentage unit per day for DEG48h) up to the end of the period (approximately two years).

Conclusions

The ruminal degradability of maize silage increases continually along the storage period, whereas the most important benefit occurs during the first month. Thus, it is recommended that maize silage should be fermented at least a month before feeding to the animals.

Table 1 Parameters of non-linear models fitted to maize silage degradability across the storage period.

Parameters[1]	Model: Exponential	Logistic	Broken-line (linear, plateau)	Broken-line (linear, linear)	Broken-line (quadratic, linear)
			DEG24h		
A	31.6	50.4	50.2	29.5	40.5
B	19.2	0.522	-0.195	0.562	-0.014
C	0.0148	0.0221		0.0260	0.0261
D			93.0	19.2	28.9
R^2-adj	0.671	0.661	0.647	0.742	0.744
RMSE	4.30	4.30	4.38	3.96	3.95
AIC	410	412	415	395	395
			DEG48h		
A	49.1	69.6	69.6	49.4	66.1
B	20.7	0.881	-0.583	0.858	-0.021
C	0.0594	0.0751		0.0105	0.0108
D			32.4	19.5	28.3
R^2-adj	0.802	0.797	0.765	0.811	0.819
RMSE	3.37	3.39	3.60	3.29	3.23
AIC	329	330	339	327	325

[1] A, B, C and D: model parameters; RMSE: root mean square error; AIC: Akaike's Information Criterion.
Exponential: DEG = A + B × [1 − exp(−C × t)]
Logistic: DEG = A / [1 + exp(−B − C × t)]
Broken-line (linear, plateau): If (t < D), then DEG = A + B × (D − t), else DEG = A
Broken-line (linear, linear): If (t < D), then DEG = A + B × t, else DEG = (A + B × D) + C × (t − D)
Broken-line (quadratic, linear): If (t < D), then DEG = A + B × (D − t) × (D − t), else DEG = A + C × (t − D)
where DEG = *in situ* degradability of maize silage incubated for 24 h (DEG24) or 48 h (DEG48) and t = storage period in days.

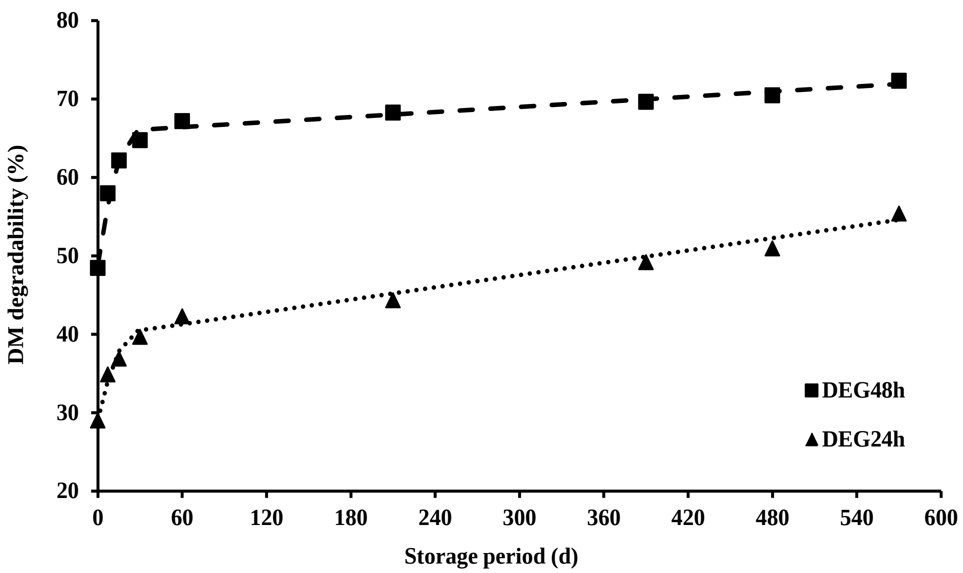

Figure 1 Influence of length of storage on *in situ* dry matter (DM) degradability of maize silage. Fresh samples were incubated in macro-bags for 24 h (DEG24h) or 48 h (DEG48h). Dash and dotted lines denote predicted values by broken-line (quadratic, linear) model.

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BIOGENIC AMINE CONTENT IN ALFALFA SILAGE INOCULATED WITH *L. PLANTARUM, L. AMYLOVORUS* OR *E. FAECIUM.*

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Introduction

The use of lactic acid bacteria (LAB) as an inoculant has been favored in ensiling feedstuffs due to the advantage of bacterial cultures over acids regarding the safety and handling (Weinberg, Muck et al. 2004). Efforts are still being made to select species of homo-fermentative LAB, which can promote pH decline and inhibit proteolysis and dry matter loss during ensiling (Weinberg, Muck et al. 2004; Nishino, Hattori et al. 2007). Variations in fermentation quality of silages affect the voluntary feed intake of ruminants (Phuntsok, Froetschel et al. 1998; Huhtanen, Vanhatalo et al. 2002; Krizsan and Randby 2007) but also of growing finishing pigs (Brooks, Beal et al. 2001) and piglets (Brooks, Beal et al. 2001; Moran, Scholten et al. 2006; Canibe, Hojberg et al. 2007).

An increase in the biogenic amine content of any product indicates a decrease in protein quality by loss of amino acids and increase in the concentration of potentially toxic compounds. Both of these outcomes are undesirable in animal nutrition. High levels of biogenic amines are commonly observed in silages prepared from forages with high protein content (e.g. alfalfa, clovers, some grasses) (Steidlova and Kalac 2004). However, amines are produced by decarboxylation of amino acids not only by enzymes of putrefactive bacteria, but also of many species and strains of lactic acid bacteria. Thus, high levels were reported even in maize silages (Krizek 1993). The objective of this work was to compare different homofermentative lactic acid bacteria (LAB) in their effects on overall silage quality and biogenic amine production in alfalfa silage.

Material and Methods

Wilted alfalfa (approx. 43 % dry matter [DM]), 2nd cut, start of blossoming, was inoculated in triplicate with and without single strains of the test organisms (5 x 104 cfu g-1 fresh matter) *L. plantarum* BIO96, *L. amylovorus* 592 or *E. faecium* BIO34 in laboratory scale model silos. Dry matter losses, pH, sugars and microbiological parameters were assessed on the day of ensiling and on day 3, 7, 44 and 90 of the experiment. Aerobic stability was determined after 44 and 90 days. Cadaverine, tyramine, putrescine and histamine as well as nutrients were quantified at baseline, after 90 days of fermentation and after 8 days of air exposure.

Results and Discussion

L. plantarum rapidly degraded glucose and fructose and significantly acidified the silage already after three days. *L. plantarum* inoculation significantly decreased the formation of tyramine (contents among trial groups varied between 400-1200 mg kg^{-1} DM), putrescine (35-72 mg kg^{-1} DM among trial groups) and cadaverine (140-340 mg kg^{-1} DM among trial groups). *L. amylovorus* showed a positive effect on fiber content, energy content and organic matter digestibility and was able to reduce tyramine compared to control. *E. faecium* had no significant influence on silage quality or biogenic amine content. Histamine levels reached 2000 mg kg^{-1} DM and above during anaerobic fermentation and decreased in most samples during an 8-day aerobic (feed out) phase. Cadaverine, tyramine and putrescine levels remained constant during 8 days air exposure.

Conclusions

L. plantarum BIO 96 showed very efficient acidification and lactic acid production together with rapid sugar degradation. *L. amylovorus* 592 increased the energy content of the silage by decreasing raw fiber contents and increasing organic matter digestibility. *L. plantarum* was able to reduce tyramine and to achieve a relative reduction in putrescine and cadaverine in alfalfa silage. *L. plantarum* and *L. amylovorus* both reduced histamine formation. Among the three tested strains, *L. plantarum* BIO 96 had the strongest beneficial effects on silage acidification and protein preservation in this lab scale trial.

Table 1 Fermentation products in alfalfa silage after 90 days ensiling (averages, n = 3)

		L. plantarum	***L. amylovorus***	***E. faecium***	**Control**
Day 90 g kg^{-1} DM	**lactic acid**	85.05^{a}	66.92^{b}	74.46^{a,b}	64.31^{b}
	acetic acid	13.44^{b}	13.72^{a,b}	19.47^{a}	15.56^{a,b}
	butyric acid	n.d.	n.d.	n.d.	n.d.
	ethanol	2.47	2.70	3.14	2.66

Values with different superscript letters differ significantly ($p \leq 0.05$); n.d. = not detected.

Table 2 Mean levels of biogenic amines in alfalfa silage after 90 days anaerobic fermentation and subsequent 8 days aerobic (feed-out) phase (n = 3).

		L. plantarum	***L. amylovorus***	***E. faecium***	**Control**
Day 90 [mg kg^{-1} DM]	**Putrescine**	36.7^{b}	62.2^{a}	52.1^{a,b}	54.6^{a,b}
	Cadaverine	140.6^{a}	190.6^{b}	217.9^{a,b}	319.3^{b}
	Histamine	2025.0^{c}	2318.7^{a,b,A}	2118.6^{b,c}	2440.5^{a,A}
	Tyramine	436.5^{c}	905.4^{b}	1122.6^{a}	1174.1^{a,A}
8 days aerobic [mg kg^{-1} DM]	**Putrescine**	38.4^{c}	58.7^{b}	48.3^{b,c}	61.9^{a}
	Cadaverine	147.6	185.6	224.6	296.6
	Histamine	1854.1	1546.4^{B}	1643.1	1463.2^{B}
	Tyramine	410.0^{c}	888.4^{b}	1138.1^{a}	1100.9^{a,B}

Values with different lower case superscript letters differ significantly among treatment groups ($p \leq 0.05$). Different upper case superscript letters within a column indicate a significant change of a specific amine during the aerobic phase ($p \leq 0.05$).

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OXYGEN BARRIER FILM COMPARED TO STANDARD POLYETHYLENE FILM AS COVERING SYSTEMS FOR SILOS: LOSSES DURING STORAGE AND AEROBIC STABILITY OF SILAGE.

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Introduction

Oxygen barrier (OB) film ("Silostop", B Rimini Ltd, London, UK) has reduced oxygen permeability compared to standard polyethylene film (Degano, 1999; Borreani et al., 2007; Borreani and Tabacco, 2008a). At similar thickness (e.g. 110 to 125 μm) the permeability of OB film to oxygen is about 0.005 that of standard polyethylene film.

Material and Methods

Results of research were drawn together in a meta-analysis in which standard polyethylene and OB films film were compared in systems of covering silos and bales. The studies covered a range of crops, and involved different types and sizes of silo, including wrapped bales. The paired data for each comparison were combined in a one-tailed paired t-test to test the hypothesis that within each data set the mean of the difference between OB and standard film was greater than zero.

A total of 51 comparisons were identified; details are in Wilkinson and Fenlon (2013). 41 sets of data were from bunker, unwalled clamps and laboratory silos, and 10 sets of data were for baled silage. Losses were assessed from the top 10 to 60 cm of bunker and clamp silos, or from the total mass for baled silage and laboratory silos. Silage judged subjectively by visual inspection to be unfit for use as animal feed (inedible) was assessed in 5 comparisons. The aerobic stability of maize silage in the upper layers of silos was assessed in 11 comparisons.

Results and Discussion

Mean losses of DM or OM during storage from the top 10 to 60 cm of bunker and clamp silos were 195 g kg-1 for standard film and 114 g kg-1 for OB film (n=41, P<0.001). These results are in reasonable agreement with estimates made by Bolsen et al. (2012) that the average loss of silage in the original top 75 cm of bunker and clamp silos was 250 g kg-1 for standard polyethylene film and 125 g kg-1 for OB film.

Mean total losses of DM from baled silage were 76.8 g kg-1 for standard film and 45.6 g kg-1 for OB film (n=10, P<0.001). Borreani and Tabacco (2008a and 2012) found that losses were related to both type of film and also to the number of layers of film applied to the bale. They also found that the number of layers of OB film potentially could be reduced compared with standard film without adversely affecting silage quality.

Although OB film has a greater unit cost than standard film, the value of the silage saved by sealing with OB film may produce a net economic benefit, as demonstrated by Borreani and Tabacco (2010) and Bolsen et al. (2012).

Top surface silage judged subjectively to be inedible was 107 g kg-1 for standard film and 29.6 g kg-1 for OB film (n=5, P=0.02). Borreani and Tabacco (2008b and 2012) and Orosz et al. (2012) recorded lower counts of moulds in the top layer of whole-crop maize stored in bunker silos sealed with OB compared to standard film. The implications of these findings are that by using OB film, i) less labour is likely to be needed in removing waste material from the top surface of silos, ii) the development of aerobic spoilage organisms at the exposed silo feed-out face may be reduced, and iii) there is lower risk of accidental inclusion of spoiled silage in the diet of the animal.

Mean aerobic stability was 75 h for maize silage stored under standard film and 135 h for silage stored under OB film (n=11, P=0.001). The aerobic stability of silage in the uppermost layer stored under OB film was 60 hours (2.5 days) greater than comparable material stored under the standard film covering system. This finding is of practical value, especially when the speed of removal of silage from the exposed silo face is relatively slow, in warmer seasons, and in tropical climates when ambient temperature and relative humidity are elevated. Improved aerobic stability is probably a reflection of slower development of yeasts and moulds (Orosz et al., 2012) and Acetobacter pasteurianus

(Dolci et al., 2011) due to restricted oxygen ingress into the outer layer of the silo under OB film compared to standard film prior to full exposure of the silage to air at feed-out.

Conclusion

The OB film covering system reduces losses, reduces spoiled silage and increases the aerobic stability of silage in the outer layers of silos.

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DRY MATTER LOSSES IN SILAGE MAKING – COMPARISON OF THREE DIFFERENT METHODS OF DETECTION

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Abstract : In a comparative study three different detection methods for dry matter (DM) losses throughout silage making in bunker silos were contrasted. DM losses were determined in two types of bench-scale silos (preserving jars and balance bags) and by analysis of 23 complete farm-scale silos (total in - total out study) at research stations of the Bavarian State Research Center for Agriculture. While mean DM losses of preserving jars and bags were 3.4 and 5.0 %, the total in - total out procedure exhibited mean DM losses of 10.3 %. Despite great variations of the total in - total out data the results strongly suggest, that even presuming good practical conditions, rubbish and DM losses due to aerobic processes at the face of silos lead to comparable amounts of DM losses as the fermentation process itself. These additional DM losses during removal of silage are not assessable using bench-scale silos.

Introduction

The amount of dry matter (DM) losses in the process of silage making is a well discussed field of agricultural scientific research (Gordon, 1967; McGechan et al., 1989 and 1990 and references cited; Bolsen et al., 1993). Nevertheless, the dimension of true DM losses in farm scale bunker silos remained unclear because most investigations are based on bench-scale or other sorts of silos. A recent study by Koehler et al. (2013) revealed mean DM losses in farm-scale bunker silos of good practical conditions of more than 8 % within a great range. Against expectation, there were no differences between the DM losses in maize and grass silages, indicating that the fermentation process is not the exclusive important source of DM losses in bunker silos. Aerobic deterioration at the face of the silo, reheating, molding and accumulation of rubbish were discussed as the most important factors leading to these results. Because those factors depend on the conditions of agricultural production and feed management and thus cannot be simulated easily, the significance of bench-scale investigations for practical use remains unclear.

Therefore, a comparative study was conducted to compare the results of bench-scale and farm-scale methods for determination of DM losses throughout silage making. The aim of the investigation was to show and number the differences between the methods. Furthermore it should provide clarity if results of bench-scale silos are transferable to farm-scale silos.

Material and Methods

Two bench-scale and one farm-scale systems for determination of DM losses were used in this investigation. One type of the bench-scale silo analysis uses preservation jars as recommended by the DLG (German Agricultural Society)-guidelines for testing silage additives. The other one, so called balance bags, is based on common sand bags for flood control as already used in former investigations (Groß, 1990). The third system was a total in - total out procedure for complete farm-scale silos.

Base material

Both types of bench-scale silos were filled on day of harvest with base material, derived from a mixed sample of harvest material. The mixed sample was stored at a cool place in a sealable box until usage. Preservation jars were brought immediately to a temperature chamber and stored at 25 °C until recovery of balance bags from the silos. Balance bags were filled with approximately 4 kg of base material and inserted into the practical silos, level and close to their centers.

Determination of DM losses

Determination of DM losses was performed as shown in Table 1. Weighing of preservation jars was conducted simultaneously to the recovery of balance bags from silos. Fresh matter losses in preservation jars were assumed to be DM losses. According to Weißbach (1998) further 2.5 % points of DM losses were added. Balance bags had to be frozen due to the need of transportation. Consequently the DM content had to be corrected for changes, caused by freezing and defrosting. A systematic loss of 0.7 % of water from weighing of balance bags (frozen) to DM determination was ascertained and included into calculation. Practical silos were sampled weekly over the period of removal. For this purpose, three single samples were combined to one mixed sample. The results were averaged and adapted to the fresh matter weights.

Table 1 Method of DM losses determination for three different systems

	number of DM-determinations		determination of fresh matter (kg)		determination of DM losses
method	basic material (bm)	silage* (s)	ensiling (e)	removal (r)	
preservation jars	3	1 per jar	laboratory scale	laboratory scale	(r-e)/e + 0.025
balance bags	3	3 per bag	laboratory scale	laboratory scale	(r*s - e*bm) /(e*bm)
total in – total out	1 per meadow/field	1 weekly	weighbridge	fodder mixing wagon	

* Correction of DM content according to Weißbach and Kuhla (1995)

Results and Discussion

Dry matter losses in bench-scale silos

For preservation jars, mean DM losses of 5.0 % could be observed, with a range from 4.5 to 5.6 %. Standard deviations did not exceed 0.15 %. Accuracy of balance bags was considerably lower, with a mean standard deviation of 1.9 %. Interestingly, mean DM losses were lowest for balance bags (3.4 %). However, the impact of DM losses correction according to Weißbach (1998) on these differences is unclear. For both systems the observed DM losses are low. This indicates, that results from balance bags do not include detrimental effects resulting from the impact of oxygen. Early recoveries of balance bags could be a reason for only low DM losses due to aerobic processes.

Dry matter losses in farm-scale silos

Mean DM losses of the 23 investigated farm-scale silos were 10.3 % and thus remarkably higher than found for bench-scale silos. Single values ranged from -1.3 to 18.5 % of DM losses (Table 2), indicating a weak accuracy of the total in - total out procedure. A higher frequency of sampling could solve that problem, particularly if sampling could be automatized. Agricultural machinery makers are working on that field already. Nevertheless, the mean of 23 investigated silos should provide reliable data to assess the true dimension of DM losses in bunker silos, even presuming good practical conditions. A surplus of more than 5 % of DM losses compared to bench-scale silos indicate a small transferability of results from the latter to farm-scale silos. The fact that no correlation was found between the DM losses in farm-scale and bench-scale silos may underline this statement.

Table 2 DM losses throughout making and storing of 23 silages as determined by three different detection systems

	DM losses (%)		
	total in – total out (n = 23)	balance bags (n = 23, triplicates)	preservation jars (n = 5, triplicates)
mean	10,3	3,4	5,0
median	10,5	3,7	5,0
min.	-1,3	-0,6	4,5
max.	18,5	5,3	5,6
mean SD		1,9	0,1
Pearson’s r against total in – total out procedure		0,4	-0,7

Conclusions

The comparison of two bench-scale silos and the total in - total out procedure for farm-scale silos for the determination of DM losses throughout silage making and storage revealed great differences between these methods. Bench-scale silos like preservation jars are convincing regarding the repeatability and accuracy of the results. To carry out statistical differences between varieties e.g. for testing the effect of silage additives, the use of bench-scale silos will be the method of choice. In assessing DM losses under practical conditions, bench-scale silos will underestimate DM losses. As no correlations between bench-scale silos and total in - total out procedure were found in respect to DM losses, a correction of this underestimation appears impossible. To get information about the true DM losses of bunker silos on practical farms, a fully automatized acquisition of ensiled and fed DM is required. Additional benefit for the farmers could emerge from the knowledge about the nutritional value of feed.

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LIGNIN CONTENT AND DEGRADABILITY OF CELL WALLS IN SILAGES.

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Abstract

Significant observation from this study are significant variations in chemical composition across silages and significant variation within silage class. More variable is content of cell wall with the highest average value of concentration in grass silage 577 g.kg^{-1} DM. Lignin content in individual silages ranged from 25.0 g.kg^{-1} DM in maize silage to 188.7 g.kg^{-1} DM in lucerne silage. The effective degradability of all classes of silages is relatively balanced (from 29.7 to 37.4 %) The large differences are in degradable NDF fraction „b“ between legume silages (50.9 %, 56.4 %, resp.) and maize and grass silages, that are much higher (73.2 %, 75.0 %, resp.). The differences were also in degradation rate (from 0.0261 to 0.0414%.h^{-1}) between silage classes. Correlation between content of lignin and effective NDF degradability and between lignin and degradability rate were modest across all tested silages (r = -0.355 and r = -0.377). For the silages quality is important the time of harvesting (stage of maturity) and an ensiling process.

Introduction

Forages play a pivotal role in ruminant nutrition and they comprise 35% to 70% of the dry matter (DM) in diets for lactating dairy cows. Variation in forage quality can impact DM intake. Forage quality is highly variable among and within forage types (NRC, 2001). Forage species, variety or hybrid, stage of maturity at harvest are the factors that contribute to this variation. From a nutritional standpoint, silages are considered very heterogeneous material consisting of crude protein, fibre, starch and other nutrients. The nutritional availability of all nutrients is depending on fibre composition, structure, degradability and digestibility (Graham and Åman, 1991; Buxton and Redfearn, 1997; Klopfenstein et al., 2001; Coblentz et al. 2008). The main source of fiber in feeds are plant cell wall consisting from cellulose, hemicellulose and nonsaccharidic component lignin. It is accepted that lignin is the most important plant component in determining the extent of fibre degradation (Graham and Åman, 1991). This paper will evaluate silages for their variation in content of lignin and ruminal degradability of neutral detergent fibre (NDF).

Key words: *silage; neutral detergent fibre; lignin; effective NDF degradability*

Material and Methods

Effective degradability of neutral detergent fibre (NDF) in maize silages (n=6), lucerne silages (n=9) and five other silages (grass, red clover and rey) was evaluated using in situ method. Silage samples were incubated in a ruminally fistulated nonlactating cows. All incubation began before morning feeding. Bags with silages were incubated for 6, 9, 16, 24, 48, 72 and 96 h. The 0-h disappearance of NDF was determined only by washing in domestic washing machine without spinning. Content of NDF in undegraded residues and in silage samples were determined according van Soest method. In silage samples was determined crude protein, acid lignin and N-ADF. The correlation (Pearson) between content of lignin and *in situ* characteristics was measured.

Results and Discusion

Significant observation from these data are that there are significant variations in chemical composition across silages and significant variation within silage class (Table 1). More variable is content of cell wall with the highest concentration in grass silage. The content of NDF varied from 349 to 690 g.kg^{-1} DM at a concentration of lignin from 58 to188 g.kg^{-1} DM in alfalfa silages. The NDF content of maize silages can be comparable to legume silages (lucerne and red clover silages) due to dilution with grain that comprise a high proportion of whole plant maize silage (Mertens, 2003). Corn silage had the lowest lignin content and proportionally lower content of ADF in comparison with other silages. Grasses and maize generally have more lignin and lignification increases with maturation and it is affected with growth conditions (Mertens, 2003). In legumes proportion of more lignified stems increase with plant age. Ensiled crops in late stage of maturity have more lignified tissues. A typical example was lucerne silage, that a concentration of CP was 132.5 g.kg^{-1} DM only, there was very high content of NDV, ADF, lignin and N-ADF (690.2, 592.9, 188.7 and 41.0 g.kg^{-1} DM, resp.).

Table 1 Chemical composition of silages.

Silage	n	CP	NDF	ADF	Lignin	N-ADF
		g.kg^{-1} DM				% of total N
Maize silage	7	72.0±9.5	438.4±67.9	242.9±35.8	29.5±5.5	16.2±7.2
Lucerne silage	9	171.0±37.0	433.8±103.2	370.3±89.0	87.6±40.3	11.6±4.7
Grass silage	2	164.7±24.9	577.0±51.1	349.6±51.3	45.1±12.7	10.0±4.9
Red clover silage	2	236.3±8.3	362.0±35.6	264.0±15.5	72.1±0.58	7.0±2.4
Rey crop silage	1	112.4	516.1	310.7	29.6	12.8

Also the parameter N-ADF (protein bound to ADF) is important indicator of the quality of produced silage, indicating harvesting in late stage of maturity and/or excessive heating of silage (Pichard and van Soest, 1977; Coblentz et al., 2008). Excesive heating of ensiled material leads to Maillard products between protein and carbohydrates. Protein bound to ADF or tannin cannot be degraded in the rumen and does not provide amino acids postruminally. Maize silage with content of N-ADF 31.1 g.kg^{-1} DM (i.e. 42.6 % ot total N) was product typical poor management of ensiling.

According to Akin (1979) ruminal NDF degradability is affected mainly by morphology and anatomy of crop plants. Our results show a negative correlation and very low regression (R^2 = 0.08) between lignin content and NDF degradability. The correlation between them across all tested silages were negative and weak (r = -0.355). When silages were divided according to classes the correlation was negative and has been improved: for legume silages r = -0.505, for grass silages r = -0. 796 and positive correlation was for maize silages r = 0.55.

In the Table 2 are parameters of NDF degradability. The large differences are in degradable NDF fraction „b“ between legume silages (50.9 %, 56.4 %, resp.) and maize and grass silages, that are much higher (73.2 %, 75.0 %, resp.). The effective degradability of all classes of silages is relatively balanced.

Table 2 Parameters of ruminal NDF degradability.

Silage	n	a (%)	b (%)	c %/h	ED - NDF %
Maize silage	7	8.4±7.2	73.2±6.9	0.0261±0.009	35.6±7.7
Lucerne silage	9	6.7±5.8	50.9±5.7	0.0406±0.010	31.6±3.8
Grass silage	2	9.9±4.6	75.0±3.3	0.0347±0.005	37.4±5.3
Red clover silage	2	8.9±3.7	56.4±25.0	0.0356±0.015	29.7±11.9
Rey crop silage	1	4.8	85.6	0.0414	37.0

Rate of degradation of NDF „c“ in the rumen is one of the important factor that affected extent of degradability. Correlation between rate of degradation and content of lignin was very weak when all silages were taken together (R^2 = 0.142, r = 0.377). Much better correlation was for individual classe of silages. Correlation coefficient was the highes and significant (P<0.01) for grass silages (r=0.963). The degradability rate with lignin content correlated negatively (r = -0.583) in legume silages, it was similar in maize silages but correlation was very poor.

Conclusion

Silage quality is highly variable among and within in forage types for nutrient composition as well as degradability of NDF, that affected digestibility and utilization of all nutrients from feed rations by ruminants. Silages with high content of lignified cell walls are the result harvesting of crop at a later stage of maturity. For good silages is very important time of crop harvesting, and proper ensiling.

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EFFECT OF SILAGE FERMENTATION, PLANT SPECIES AND HARVEST DATE ON THE CONTENT OF CAROTENOIDS IN GRASS SILAGES

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Abstract

The green fodders from new varieties and strain of Italian ryegrass contained more β-carotene than in green fodders from the other analyzed grasses (tabs 1 and 2). Postponing the harvest of grasses in the spring rsulted in a higher content of carotenoids (by about 13%), but later harvests (in the summer and autumn) caued a slight decrease in carotenoids against the green fodders from the first cut. Ensiling of green fodders resulted in a decrease in the concentrations of β-carotene and xanthophyll. The dry matter of ensiled grasses was determined to contain just 49% β-carotene and 64% xanthophyll against their concentrations in the dry matter of green fodders. Silages made from grasses harvested in subsequent spring cuts were determined to contain more β-carotene.

Materials and Methods

The purpose of this study was to determine the effect of ensiling green fodders made from grasses - meadow timothy cv. Karta, meadow fescue cv. Pasja, perennial ryegrass cv. Argona and varieties (Lotos, Jeanne, Gaza) and two strains (SzD 216, SzD 604) of Italian ryegrass, on the content of carotenoids. The tests completed in 2006 (from 4 to 29 May) and 2007 (from 25 April to 7 September). The research hypothesis was that the widespread practice of ensiling fodders with a low content of dry matter, results lower concentrations of important, biologically active compounds in silages, but such undesirable consequences can be controlled by an adequate selection of grown crops and dates of harvest, adjusted to local conditions. Chemical analyses of carotenoids: petroleum ether extract samples, chromatography column: aluminum oxide - activated, neutral, Brockmann I, eluents: petroleum ether, ethanol anhydrous, detection UV-VIS 450 nm, spectrophotometr EPOLL-20, standards β-Carotene Type I, synthetic, Xantophyll Lutein; α-Carotene -3,3’-diol SIGMA-ALDRICH).

Results and Discussion

The content of β-carotene in the green fodder from timothy grass was higher than in the green fodders from meadow fescue and perennial ryegrass harvested in the spring (tab. 1). Among the tested Italian ryegrass varieties and strains, the green fodder made from cv. Jeanne distinguished itself by the highest content of carotenoids (most β-carotene, a large amount of xanthophyll). Green fodders from varieties and strains of Italian ryegrass harvested in May and June were characterized by a higher content of β-carotene than cut in August and September (tab. 2). Green fodders from varieties and strains of Italian ryegrass harvested in May and June were characterized by a higher content of β-carotene than cut in August and September (tab. 2). The analyzed green fodders from timothy, fescue and perennial ryegrass had slightly more xanthophyll than β-carotene (by about 8%). In the green fodders from Italian ryegrass, the content of xanthophyll was lower than the amount of β-carotene. Our studies on green fodders from timothy, fescue and perennial ryegrass covered the early growth and development phase of the plants and did not include seasonal variations. The green fodders from grasses harvested on consecutive cuts in the spring (end of April – May) were found to contain increasing quantities of β-carotene (more by about 13% in the last cut) and an increase followed by the lowest content of xanthophyll (tab. 1). The content of β-carotene in silages from meadow timothy grass and perennial ryegrass was similar and higher than in silages from meadow fescue and Italian ryegrass (tabs 1 and 2). The content of β-carotene in ensiled timothy, fescue and perennial ryegrass was lower than in the green fodders from these grasses by 46, 49 and 37%, respectively. The silages from Italian ryegrass varieties and strains had from 37 (SzD216) to 45% (Gaza and SzD604) of the content of β-carotene determined in the dry matter of the green fodders. Low pH reduces the losses of carotene a claim that has not been verified by our experiment on silages from Italian ryegrass varieties and strains. Silages made from green fodders with the lowest quantity of β-carotene were characterized by the smallest losses of this compound (about 55% - Gaza and SzD 604) (tabs 1 and 2). The content of xantophyll in silages from timothy and perennial ryegrass was higher than in silages from fescue (tab. 1). Our results showed that – compared to the concentration of xanthophyll in green fodders – the least of this compound remained in silages from fescue (58%), more in silages from timothy and perennial ryegrass (63 and 69%). Our comparison of the content of xanthophyll in green fodders and in silages shows that the xanthophyll in silages equaled from 56% (Gaza) to 74% (Jeanne and SzD604) of the content of this compound in green fodders before ensiling. Losses of xanthophyll were smaller than those of β-carotene. (tabs 1 and 2). The ensiled feeds from later, spring harvests of green fodders from timothy, fescue and perennial ryegrass were determined to contain more β-carotene. These silages were also characterized by a lower value of pH. More xanthophyll than carotene was found in all silages, and the direction of changes in its concentrations win subsequent cuts of green fodder was the same. In ensiled later cuts of perennial ryegrass, a decrease in the content of β-carotene (by 14%) and an increase in the level of xanthophyll (by 22%) against silages from the first cut (may) were detected (tab. 2).

Conclusion

1. Out of the analyzed grass - species Italian ryegrass and meadow timothy contained the highest concentrations of β-carotene. Postponing the harvest of grasses in the spring rsulted in a higher content of carotenoids but later harvests (in the summer and autumn) caused a slight decrease in carotenoids. A decrease in the content of xanthophyll occurred slightly sooner than a decreased in β-carorene.

2. Ensiling of green fodders resulted in a decrease in the concentrations of carotenoids. Higher losses were noted in the content of β-carotene than xanthophyll. The silages made on a laboratory scal from meadow timothy and perennial ryegrass were characterized by a higher content of β-carotene. Silages made from grasses harvested in subsequent spring cuts were determined to contain more β-carotene, whose concentration declined in ensiled Italian ryegrass with the progressing vegetative season than silages from the other grasses.

Table 1. Content of β-carotene and xanthophyll (mg kg^{-1} DM) in green fodders and silages from meadow timothy grass, meadow fescue and perennial ryegrass, including species and harvest

Specification	Species			Date of harvest of green fodders				SEM	Interaction
	Meadow timothy grass, n=32	Meadow fescue, n=32	Perennial ryegrass, n=32	1. n=24	2. n=24	3. n=24	4. n=24		
Green fodders									
β-Carotene	564 Aa	489 B	528 Bb	487 Bb	526 a	546 A	549 A	6,58	**
Xanthophyll	587	539	577	561	586	592	531	10,16	
Silages									
pH	5.5	5.4 b	5.7 a	-	5.8 Aa	5.5 Ab	5.1 B	0.05	**
β-Carotene	304 A	248 B	331 A	-	265 Bb	303 a	325 A	6.54	*
Xanthophyll	371 A	311 B	397 A	-	327 B	393 A	366	8.68	

Table 2. Content of β-carotene and xanthophyll (mg/kg DM) in green fodders and silages from varieties and strains of Italian ryegrass, including the date of harvest

Specification	Varieties and strains of Italian ryegrass					Date of harvest of green fodders				SEM	Interaction
	Lotos n=8	Jeanne n=8	Gaza n=8	SzD 216 n=8	SzD 604 n=8	5. 25.05. n=10	6. 25.06. n=10	7. 02.08. n=10	8. 07.09. n=10		
Green fodders											
β-Carotene	581 C	624 A	551 E	598 B	561 D	594 Ab	601 Aa	584 B	554 B	8,65	**
Xantophyll	475 D	546 B	555 A	538 C	452 E	530 A	504 C	506 C	513 B	10,85	**
Silages											
pH	5.5	5.3	5.2	4.6	5.4	5.1 b	4.9 B	-	5.6 Aa	0.23	
β-Carotene	242 B	243 B	248 A	224 C	250 A	264 A	235 B	-	226 C	4.08	**
Xantophyll	314 C	405 A	310 C	336 B	328 B	309 C	329 B	-	378 A	11.29	**

*, ** - Level of significance of differences and interactions at p≤0.05 and p≤0.01, respectively; a, b – p ≤0,05, A, B - p≤0,01, SEM – standard error mean

EFFECTS OF PERMANENT GRASSLAND MANAGEMENT INTENSITY ON SILAGE QUALITY AND NUTRITIVE VALUE

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Summary

A research trial was performed at permanent grassland ("Suchý vrch" site) over 2011 – 2012. The research aim was to study effects of different sward management intensity (one cut, two cuts, zero utilization) on the quality and nutritive value of silage. The effects of reduced sward management intensity resulted in decreased lactic acid content, but increased acetic and butyric acids content in silage. The proteolysis was also rising. Consequently, the final quality of silage was notably decreasing when the sward utilization was restricted.
Keywords: *sward management intensity, permanent grassland, nutrient content, silage quality, nutritive value*

Introduction

A frequency of permanent grassland utilisation now, when the livestock numbers are still low in Slovakia, needs to maintain the ecological stability and also the balance between the re-growth and the decomposition of grass phytomass. The sward management and utilisation intensity is reflected in the total DM production and the quality of forage (Kohoutek et al., 2003) and also in changes in the botanical composition and character of sward. The ongoing changes in the species composition are then reflected in the production and quality of grassland (Kašparová and Šrámek, 2007).

Materials and Methods

Over 2011 – 2012, the research trial was carried out at *Suchý vrch* site (altitude 480 m; cambisol; geological substratum: disintegrated andesite). At the site, the permanent grassland ranked to association of *Arrhenatherum elatioris trisetetosum pratensis* Horvatic 1930, *Arrhenatherion* alliance. The research trial was established by the standard method of long plots and comprised five treatments (T) of sward utilization: T1/ two cuts: herbage removed from the plot after the 1^{st} and 2^{nd} cuts; T2/ two cuts: herbage removed after the 1^{st} cut but left at the site after the 2^{nd} cut; T3/ one cut: herbage removed; T4/ one cut: herbage one cut: herbage; T5/ control: the original sward without any management. The cutting dates complied with the phenological phase of sward (the earing of dominant grass species). The herbage harvested from every treatment was wilted to increase the DM content and then ensiled into laboratory plastic containers of 1000 ml volume (n = 2). The silage samples were analysed to determine the content of DM (gravimetry), crude protein (Kjeldal; N x 6.25) and fibre (Hanneberg-Stollman´s method). The water leach of silage was analysed to determine pH (potentiometry) and the content of carboxylic acids (lactic, acetic and butyric) by isotachophoresis. The silage quality was determined and classified in compliance with the Appendix No. 7 of the Decree of the Ministry of Agriculture of the Slovak Republic No. 39/1/2002-100. The nutritive value of silage was specified as the net energy for lactation (NEL) and the protein digested in the small intestine (PDI) and calculated by the equations defined in the Appendix No. 8 of the Decree of the Ministry of Agriculture of the Slovak Republic No. 39/1/2002-100. The results were processed by the calculations of arithmetic means and submitted to the multifactor statistical analysis of variance (ANOVA) and the Tukey test of contrasts.

Results and Discussion

The DM content was significantly lower ($P < 0.01$) in all the treatments at the 1^{st} cuts (353.53 g/kg) of both research years (Table 1). The lowest crude protein content (81.12 g/kg DM) was found in the silages made from the control treatment. The higher fibre content ($P < 0.01$) was found at the respective two-cut T4 (279.21 g/kg DM) and T5 (285.15 g/kg DM) than at the one-cut T1 and T2 treatments (Table 2). The significant differences in the protein component of nutritive value between the treatments were confirmed. The higher ($P < 0.01$) values of PDI ($P < 0.05$) were found at the silages made from the treatments T1, T2 and T3, while the lowest PDI content (49.26 g/kg DM) was recorded at the T5 control treatment. The values of NEL were significantly higher at the 1^{st} cut, though the differences in NEL between the treatments were not significant statistically. The lactic acid content (74.82 g/kg DM) was higher in the silages made at the 2^{nd} cuts and the two-cut treatments ($P < 0.01$). The lowest lactic acid content (57.70 g/kg DM) and high acetic acid content (14.28 g/kg DM) were found in the silages made from the control treatment. The butyric acid content (1.26 g/kg DM) was higher ($P < 0.01$) in the silages made at the 1^{st} cut and in the preserved herbage from the treatments T4 (1.10 g/kg DM) and T5 (1. 24 g/kg DM). High pH values (4.68) were found at the 2^{nd} cut, presumably due to the high DM content in the silage from this cut (r = 0.6283++). The values of pH were lower in the silages made from the treatments T1, T2 and T3 than those at the control (4.74). The recorded increase in pH resulted from the reduced intensity of sward management ($r = 0.5967^{++}$). The proteolysis was significantly higher in the silage made from the control (8.18 %) while the lowest level of proteolysis was found in the silage made from the T1 treatment (6.49 %). The silage quality parameters, i. e. the content of lactic and butyric acids, were very good at all the silages. The silages classified as the 2^{nd} Quality Class (QC) showed higher pH, proteolysis and fibre content than those defined for the 1^{st} QC silage. The silage classified as the 3^{rd} QC had a higher fibre content than that defined for the 2^{nd} QC. The final quality of silage was significantly influenced by the increased values of fibre content ($r = 0.7232^{++}$), pH (r =

0.6576^{++}) and proteolysis (r = 0.2939^{+}). The silage quality was significantly higher at the two-cut treatments than at the control. There were also significant differences in the silage quality between the treatments T3:T5, T1:T4, T2:T4 and T3:T4 (Table 2).

Table 1. Mean nutrient content, nutritive value and parameters of the fermentation process and the quality of silage

Mean values		Fresh herbage DM content ($g.kg^{-1}$)	Crude protein	Fibre content	PDI	NEL ($MJ.kg^{-1}$ DM)	Acid content ($g.kg^{-1}$ DM)			pH	Degree of proteolysis (%)	Quality class
			$g.kg^{-1}$ DM				Lactic	Acetic	Butyric			
Year	1	356.18	97.99	261.47	59.50	5.67	71.57	10.68	1.25	4.60	7.50	1.80
	2	405.75	88.92	267.38	53.99	5.70	63.58	15.05	0.63	4.62	6.75	1.75
Cut	1	353.53	96.48	256.22	58.58	5.74	60.34	13.00	1.26	4.54	8.11	1.80
	2	408.40	90.43	272.64	54.91	5.63	74.82	12.73	0.63	4.68	6.15	1.75
Treatment	1	367.10	99.34	241.66	60.32	5.70	76.39	10.56	0.84	4.51	6.49	1.13
	2	365.00	99.51	255.08	60.42	5.68	71.85	13.81	0.67	4.55	6.63	1.50
	3	376.88	95.67	261.03	58.09	5.68	67.29	12.68	0.87	4.57	6.95	1.38
	4	399.16	91.63	279.21	55.63	5.67	64.68	12.99	1.10	4.67	7.37	2.25
	5	396.69	81.12	285.15	49.26	5.71	57.70	14.28	1.24	4.74	8.18	2.63
Hd (year, cut) 0.05		17.583	3.934	10.805	2.388	0.023	3.713	1.626	0.286	0.057	0.450	0.319
Hd (year, cut) 0.01		23.639	5.289	14.526	3.211	0.031	4.991	2.186	0.385	0.077	0.605	0.429
Hd (treatment) 0.05		39.441	8.824	24.237	5.358	0.052	8.328	3.648	0.643	0.129	1.009	0.716
Hd (treatment) 0.01		48.319	10.810	29.693	6.564	0.063	10.203	4.469	0.787	0.158	1.236	0.877

Table 2. Nutrient content, nutritive value and parameters of the fermentation process and the quality of silage between treatments

Index	Treatment									
	1 : 2	1 : 3	1 : 4	1 : 5	2 : 3	2 : 4	2 : 5	3 : 4	3 : 5	4 : 5
Crude protein	-	-	-	++	-	-	++	-	++	+
Fibre content	-	-	++	++	-	-	++	-	-	-
PDI	-	-	-	++	-	-	++	-	++	+
Lactic acid	-	+	++	++	-	-	++	-	+	-
Acetic acid	-	-	-	+	-	-	-	-	-	-
pH	-	-	+	++	-	-	++	-	++	-
Degree of proteolysis	-	-	-	++	-	-	++	-	+	-
Quality class	-	-	++	++	-	+	++	+	++	-

Tukey HSD test: non-significant - ; significant $P < 0.05$ +; significant $P < 0.01$ ++

Conclusions

The quality of silage made from herbage of treatments T1, T2 and T3 was significantly higher than that of T4 and T5. The reduced sward management intensity resulted in the decreased lactic acid content (r = - 0.5408^{++}), increased content of acetic acid (r = 0.2744^{+}) and butyric acid (r = 0.2739^{+}) and also rising proteolysis. Consequently, these factors were markedly affecting the final quality of silage (r = 0.7324^{++}).

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POSSIBILITIES OF PEA WASTE CONSERVATION

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Abstract

It is possible to feed farm animals with pea waste that arises during the production of frozen pea in canning factory. Content of fibre is low; content of crude protein, starch and energy is high (tab. 1). Because of low content of dry matter (about 20 %) in this feed there occur fermentation processes very quickly. Conservation by ensilaging is therefore inevitable for storage. It is necessary to use chemical additives for ensilaging.

In our experiment we created one control silage (K) without treatment with silage additive, and two experimental silages (P1, P2) that were treated with chemical additives. We found out that the fermentation process in silages was very intensive (tab. 2). Undesirable acetic fermentation took place in the control silage; content of acetic acid on the level 66 g in kilogram dry matter of silage gives evidence of it. Very high level was also with pH (4.76) and content of ammonium nitrogen (13.8 %). Fermentation quality of silages was improved by treatment with chemical conservatives P1 and P2. Content of fermentation products varied from 91 to 132 $g.kg^{-1}$ dry matter. Level of pH decreased to 3.95 and 3.53. Content of acetic acid decreased and content of lactic acid increased. The observed losses of dry matter corresponded with the course of fermentation process (tab. 3). Losses in non-treated silage represented 12.8 %, in treated silages 3.6 and 3.8 % only.

The best quality was obtained in the silage treated with P2 preparation, which consisted of organic acids.

Key words: *pea waste, conservation, fermentation, chemical additives*

Introduction

During the processing of pea in canning factories arises waste that can be potentially considered to be a feed suitable for farm animals.

Pea is a source of good quality proteins and amino acids. It has favourable content of lysine and arginine but insufficient content of methionine and tryptophan. It is a suitable source of energy with lower production level because of high starch content. Balance digestibility of pea is high but pea contains also some antinutritive matters. They are mainly trypsin inhibitors, lectins (phytohemaglutines), flatulent oligosaccharides, gallic acid and other from the group of phenolic matters. However, in the new varieties of pea is the content of these matters markedly lower than in the past.

Objective of this study was to assess the nutritive value of pea waste and to test possibilities of its conservation.

Material and Method

The pea waste contained fragments of pea of different size, shells, rests of plants but also impurities (mud) and non-physiological water from the processing line in the canning factory. Proportion of individual components in waste is not stable because it changes in dependence on quality of the raw material.

Pea waste in this experiment was ensilaged in laboratory conditions. There was one control variant without the silage additive and two experimental variants that were treated with chemical ensilaging additives because of low dry matter content:

A1 – 24.4 % sodium nitride, 16.3 % hexamethylentetramine, application rate 3 l/t feed

A2 – 49.0 % formic acid, 24.0 % ammonium formate, 10.0 % propionic acid, 2.2 % benzoic acid, application rate 6 l/t feed

The silages were stored in a dark room at the temperature 20-22^{0}C for 180 days. The course of weight losses was observed at regular 21 day intervals during the fermentation process. Parameters of the fermentation process were analysed in silages after the termination of the experiment.

Results and Discussion

Pea waste can be considered as feed of proteinic character according to the content of nutrients (tab. 1). Content of crude protein on the level 26 % dry matter and starch on the level 20 % dry matter manifested itself in high nutritional value of feed. Problematic is high content of ash as a consequence of increased portion of impurities as well as very low dry matter content in the feed.

Table 1 Parameters of nutrition and energy values in pea waste

Parameters		Parameters	
Dry matter in g/kg FM	228.50	Total sugar in g/kg DM	84.91
Organic matter in g/kg DM	893.62	Reduced sugar in g/kg DM	51.97
Crude protein in g/kg DM	260.15	Fat in g/kg DM	19.75
Crude fibre in g/kg DM	140.54	Ash in g/kg DM	106.38
ADF in g/kg DM	173.87	ME in MJ/ kg DM	11.03
NDF in g/kg DM	298.86	NEL in MJ/ kg DM	6.67
Hemicelluloses in g/kg DM	124.99	NEV in MJ/ kg DM	6.75
NFE in g/kg DM	473.18	PDIN in g/kg DM	169.25
Starch in g/kg DM	195.63	PDIE in g/kg DM	125.77

Low dry matter content caused a very intensive course of fermentation in all variants of produced silages (tab. 2). Fermentation degraded into acetic fermentation in the untreated control silage. The sum of acetic and propionic acids represented as much as 66 g in kilogram of dry matter in silage. According to valid rules the silage with such high content of acetic acid must not be fed without special test on health and hygienic traits. Level of pH and content of ammonia N were also high.

Fermentation quality of silages improved by treatment of feed using chemical preservatives compared with non-treated control. In these silages also was observed intensive fermentation process in spite of effectiveness of additives used; content of fermentation products varied from 91 to 132 $g.kg^{-1}$ dry matter. The silage treated with preparation P2 was of the best quality; the preparation consisted of organic acids. In silages treated with preparation P1 was high content of acetic and butyric acids. Dry matter losses corresponded to the course of fermentation process.

Table 2 Parameters of fermentation process in pea waste silage

Parameters	Control		A1		A2		Statistical of differences
n = 6	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	P < 0,01
pH	4.76	0.06	3.95	0.19	3.53	0.02	C: A1,A2 A1: A2
Acids in g/kg DM							
- lactic	49.30	1.64	100.59	12.71	79.69	5.81	C: A1,A2 A1: A2
- acetic	62.19	6.23	28.25	8.49	7.97	3.57	C: A1,A2 A1: A2
- propionic	3.54	0.80	0.38	0.33	2.39	0.40	A1: C,A2
- butyric + i.b.	0.50	0.31	2.87	1.17	0.61	0.39	A1: C,A2
- valeric + i.v.	0.08	0.03	0.08	0.02	0.42	0.21	
- capronic + i.c.	0.06	0.02	0.05	0.01	0.14	0.20	
Total VFA	66.37	6.35	31.63	9.50	11.53	5.07	C: A1,A2 A1: A2
Alcohol in g/kg DM	12.99	0.31	5.33	0.64	3.61	0.44	C: A1,A2 A1: A2
NH_3-N of total N in %	13.80	0.22	6.15	0.97	2.44	0.76	C: A1,A2 A1: A2

It was not possible to compare the obtained results with results of other authors because the problem of pea waste ensilaging occurs in specialist literature only sporadically.

Conclusion

Pea waste that arises during the processing of pea in canning factories can be a suitable feed for farm animals. It has low content of fibre, high content of crude protein, starch and enough energy. The fermentative processes occur very quickly at storage; conservation by ensilaging is therefore necessary. Results in this study show that undesirable acetic fermentation occurred at ensilaging of pea waste without application of ensilaging preparation. Chemical ensilaging additives are necessary for pea waste ensilaging because of very low dry matter. Silage produced with preparation on the basis of organic acids was of better quality than silage produced by use of preparation on the basis of salts. Variable content of field impurities are a risk because they are a source of undesirable clostridia, yeasts and moulds. Therefore the hygienic quality of this potential feed must be observed very strictly.

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EFFECT OF SILAGE TO CHANGE FRACTIONS N-SUBSTANCES IN ALFALFA SILAGE

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Introduction

The degree of proteolysis (protein decomposition) is considered one of the most important indicators of the quality of the fermentation process during ensilaging of proteinous and semi-proteinous silages. The degree of proteolysis of those crops depends on how quickly and in what way the chopped mass wilts, and also on how quickly and in what quality it is conserved. The proteins are broken apart by vegetable and bacterial enzymes (proteases) into peptides and the latter further into free amino acids. The Cornell Net Carbohydrate Protein Model has developed the need for uniform procedures to partition of feed nitrogen into A, B, and C fractions. Fraction A is non-protein nitrogen (NPN), B is true protein, and C is highly resistant to breakdown by microbial and mammalian enzymes, and it is assumed to be unavailable for the animal. During wilting of the fodder as well as in the course of its fermentation in ensilaging, there are changes of fractions of nitrogenous substances (A, B, C) that take place, under certain conditions, to disadvantage of high-quality protein fractions (B). If the silage is heated up during inadequate storage, the proportion of fraction C rises. The self-heating of the silages is caused by chemical reactions in presence of excessive oxygen (Carpinter and Suarez, 1992).

The goal of the work consisted in testing the influence of the chemical and biological silage additive on changes of protein fractions in the course of fermentation of alfalfa silage.

Materials and Methods

Samples (1 kg) of alfalfa, wilted from 17.7 % of dry matter content to 31.5 %, chopped to the theoretical length of cut of 40 mm, were treated with two different additives (chemical and biological) and put into plastic bags from which the air was sucked out by VacSy Professional Bag Sealing Unit with VacSy pump VOM-010. Formic acid (F) in a dose of 5 l/t was used as chemical additive; inoculant (L) with *Lactobacillus plantarum, Pediococcus pentosaceus* and *Pediococcus acidilactici* 1 x 10^{11} CFU/g in dose of 1 g/t was used as biological additive. The third variant, control, was untreated (U). The samples were stored at a stable temperature ranging from 20 to 24°C for the period of 2, 14 and 60 days; 6 replications were taken for each variants. Samples were analysed using Weende methods (AOAC, 1995) and fractions of crude protein according to Licitra et al. (1991). The results were analysed statistically using the ANOVA Scheffe test by QC-Expert 3.0 program (TriloByte Statistical Software, 2010).

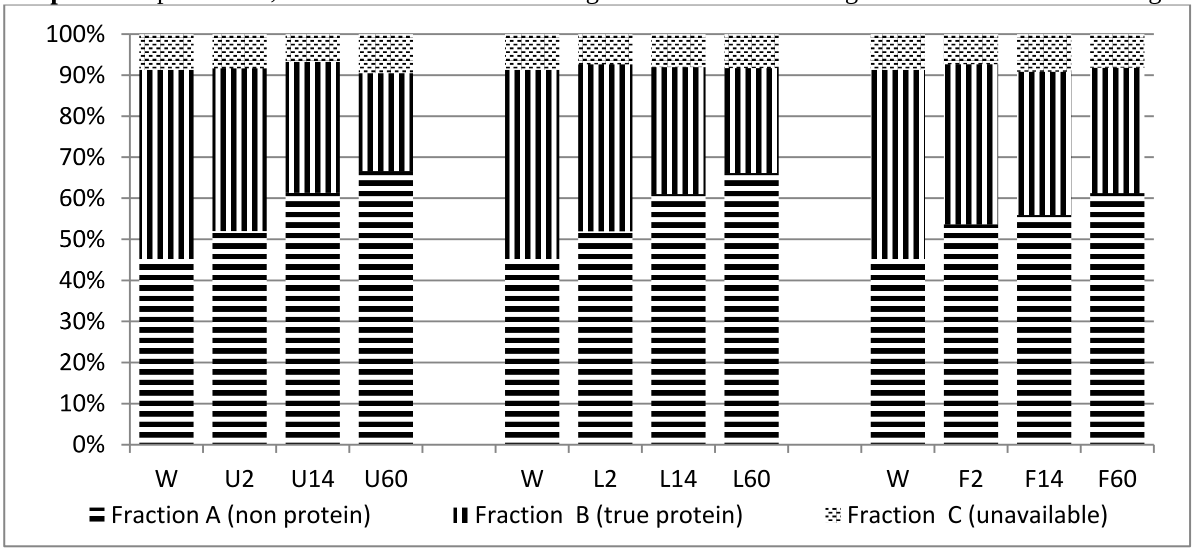
Results and Discussion

During 24 hours of wilting, the dry matter (DM) content of alfalfa increased nearly twice (i.e. from initial 17.7 % to 31.5 %). At this DM, content it was a little risky to preserve the chopped material without a preservative, and for that reason additives, the first based on formic acid and the second based on *L. plantarum,* were used. The concentration of crude protein (CP) increased in our experiments through ensilaging insignificantly ($P>0.05$), but significant moves were found between individual fractions. Fraction A was significantly higher in wilted fodder than in fresh fodder (40.2 vs. 45.2). The proportion of fraction A increased during fermentation at the expense of fraction B in all variants (Graph 1). The proportion of fraction A was lower by 5.0 % in silage F than in L and by 5.5 % as compared to U, but the result was not statistically conclusive. The proportions of fraction A in silages F and L were comparable both on the second and on the fourteenth and sixtieth day of fermentation. Fraction C did not change significantly ($P>0,05$), which confirms that the silages were well conserved and Maillard reaction did not take place in them.

The conclusions of Richardt and Steinhöfel (2000) that the proportion of non-proteinous fraction A was increased more than twice through ensilaging of clover grass, were not confirmed. In our experiments with alfalfa, the 45% proportion of fraction A in wilted chaff increased in silage U by 21,5% to 66,7%, in silage L by 21% to 66,2% and in silage F by 16% to 61,2% after 60 days of fermentation. But such result also shows that the silages may include a relatively high percentage of non-protein nitrogen (fraction A). The conclusions of Richard and Steinhöfel (2000) that the proportion of fraction A in inoculated silages was demonstrably ($P<0,01$) lower by 5,1% than in silages without preservative were not confirmed either. In our experiments, the difference in proportion of fraction A was not demonstrably higher ($P>0.05$) in silages L (5.5%) or F (5%) than in silages without preservative. U. Richard and Steinhöfel (2000) worked with a significantly larger (n=246), but non-homogenous set of farm silages than we did.

The experiment follows the results, which were presented at 14th ISFC conference at Brno (Loučka, 2010): During the process of alfalfa wilting on the field and during the subsequent fermentation under anaerobic conditions there are changes not only in the DM content but also in percentages of individual nutrients, above all of total crude protein and fibre (as well as in their fractions). Although the differences between contents of NDF in wilted and ensiled alfalfa were statistically insignificant, the content of hemicelluloses was significantly higher in wilted material than in silage. This indicates the fermentation activity of lactic acid bacteria, which use hemicelluloses for their growth and propagation.

Graph 1 Proportions A, B and C of fractions of nitrogenous substances during fermentation of alfalfa silage



W = wilted alfalfa, U = untreated silage, L = treated with biological additive, F = treated with formic acid, 2 = 2 days of fermentation, 14 = 14 days of fermentation, 60 = 60 days of fermentation

Conclusions

- During wilting of alfalfa and fermentation of alfalfa silage, the proportion of multi-soluble non-proteinous fraction (A) of nitrogenous substances increases demonstrably ($P<0.05$) at the expense of soluble proteinous fractions (B), both in silage without preservative and in silages with bacterial inoculant and with formic acid.
- Fraction C did not change significantly ($P>0.05$), which confirms that the silages were well conserved and Maillard reaction did not take place in them.
- The proportion of fraction A in silage with formic acid (F) was lower by 5.0% than in control silage without preservative (U) and by 5.5% than in silage with inoculant (L) after 60 days of fermentation, but the result was not statistically conclusive ($P>0.05$).

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CHEMICAL COMPOSITION AND QUALITY OF VARIOUS TYPES OF SORGHUM SILAGES

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Introduction

A corn maize silage is one of the most important feedstuff in cattle feeding. Unfortunately, due to climate changing in the Poland area it occurs an agricultural drought, that is causing considerable loss of maize crop. Additionally, growing maize as a monoculture causes that on its plantation could occurs not earlier found pest species, i.e. the European corn borer. Those problems has forced farmers to cultivate sorghum as an alternative for maize. Both quality and nutritive value of sorghum silage depends on its variety in large extent measure. The aim of conducted study was to evaluate possibility of silages from various varieties of sorghum production with or without of microbial additive application. The sorghum varieties were growing in the Lower Silesia region. The estimation was done on the base of chemical composition as well as quality of made silages comparison.

Materials and Methods

In the experiment following cultivars of sorghum were examined: two varieties of sugar sorghum - Rona and Sucrosorgo 506, Sudan grass - Akklimat and sorghum – Sudan grass hybrid - Nutri Honey. Silages were made in 1,5 L microsiloses with or without bacterial additive (Blattisil lacto-bac: *Enterococcus feacium* (one strain), *Pediococcus acidilactici* (two strains), *Lactobacillus plantarum* (two strains) in 4 replications each. In silages, according to conventional methods, basic nutrients content was assayed. Structural carbohydrates – ADF and NDF were determined according to Georing and Van Soest methods, pH – with using pH meter N-512 ELPO, ammonia nitrogen was determined according to Conway method, and content of lactic, acetic and butyric acids according to Lepper method.

Results and Discussion

Table 1 Chemical composition of sorghum silages (g/kg of dry matter)

The kind of silage*	Nutrient							
	Dry matter	Crude protein	Crude fat	Crude ash	N-free extract	Crude fibre	NDF	ADF
1	295,0 ABa	90,7 Aab	23,8 ABab	52,3 ABa	591,3 ABab	251,8 ABab	539,3 Aab	315,0 ABa
2	320,4 CDbc	85,4 Aab	20,4 ABabc	46,9 Ad	632,6 Bc	225,0 Aa	563,2 ABab	323,1 ABab
3	334,4 CDcd	93,2 Ab	28,1 b	59,4 Cc	550,7 ACDad	288,3 Bc	609,9 ABCbcd	360,0 Cc
4	344,2 Dd	90,6 Aab	24,3 ABab	55,2 BCabc	579,3 ABCab	266,1 ABbc	591,0 ABCabc	342,4 BCbc
5	326,2 CDbc	78,1 ABa	23,8 ABab	55,6 BCabc	612,3 Bbc	242,1 Aab	536,8 Aa	281,3 Dd
6	313,1 BCb	79,9 ABab	24,8 ABb	57,3 BCbc	585,7 ABab	270,0 ABbc	553,3 ABab	300,1 ADad
7	272,4 Ae	61,6 Bc	9,4 Ac	54,6 BCab	527,1 CDce	349,1 Cd	648,1 BCcd	393,3 Ee
8	271,7 Ae	61,3 Bc	11,6 ABac	56,1 BCabc	500,8 Ce	370,8 Cd	670,4 Cd	422,1 Ef
Factor	Two factors anova; p value							
The kind of material	<0,0001	<0,0001	0,0046	0,0001	<0,0001	<0,0001	0,0002	<0,0001
Additive	0,2053	0,6192	0,7242	0,1119	0,6470	0,9805	0,4896	0,0880
Interaction	0,0243	0,8563	0,8256	0,0302	0,0272	0,0284	0,7315	0,0370

Means in columns designated with the different letters differ significantly at the level a,b - P≤0,05; A,B,C - P≤0,01
*) 1. RONA + inoculum, 2. RONA, 3. AKLIMAT + inoculum, 4. AKLIMAT, 5. NUTRI HONEY + inoculum, 6. NUTRI HONEY, 7. SUCROSORGO 506 + inoculum, 8. SUCROSORGO 506

Obtained data of two-way analysis of variance indicate that application of the silage additives had no effect on means nutrients content in examined silages (table 1). However, chemical composition of silages were significantly affected by the kind of plant material. The highest content of dry matter were stated in silage made from Akklimat grass and the lowest in Sucrosorgo 506 sorghum. Statistical analysis indicated high significant (P≤0,01) differences in crude protein and crude fat content between Sucrosorgo 506 sorghum and remain sorghum cultivars. Akklimat grass silage were characterized with the highest crude protein, crude fat and crude ash content in a kilogram of dry matter. Content of crude ash in Rona sorghum was statistically lower (P≤0,01) than in the others silages. Sucrosorgo 506 sorghum silage was contained statistically (P≤0,05) less N-free extractives then others. The lower share of crude fibre were stared in Rona sorghum. In Sucrosorgo 506 sorghum the highest level of crude fibre as well as NDF and ADF fractions were determined whereas Nutri Honey cultivar were characterized by the lowest NDF and ADF fractions content. The similar influence of sorghum cultivar on the content of NDF was stated by Lema at al. (2001). Podkówka and Podkówka (2011) noted in their experiment similar amount of NDF but higher ADF fraction. Fermentation parameters of silages are presented in table 2. As two-way analysis of variance indicted protein decomposition to ammonia was affected by both kind of material (P=0,014) as well as inoculum application (P=0,0256). The lowest N-NH_3 content was stated in Nutri Honey cultivar. Protein decomposition were significantly (p≤0,05) decreased by application of the additives. In silages made with the additives decrease of ammonium nitrogen from level 12,03%N_{total}, to 9,69% N_{total} were stated. Slottner and Bertilsoon (2006) noted that low pH favours decrease of dezamination processes what was also confirmed in our experiment. The influence of treatments on acetic acid content in silages wasn't observed. Data concerning the lactic acid concentration which were dominated in all kinds of silages, indicated that ensilaging sorghum with bacterial preparation caused significant (P≤0,01) increase its concentration (84,35 vs 105,94 g/kg). Silage that were made from Sucrosorgo 506 variety was contained the highest amount of lactic acid, what caused the lowest pH value in this silage. Concentration of acetic and lactic acid in analyzed silages was considerably higher than given by Tabacco et al. (2011). The most undesirable butyric acid wasn't been detected in any samples. Inoculum addition decreased the pH of examined samples from 4,06 to 3,93. Similarly, an advantageous effect of bacterial additive were stated by Fily et. al (2003)

Table 2 The quality of sorghum silages

The kind of silage*	Parameter				
	N-NH_3% N total	Acetic acid	Lactic acid	Butyric acid	pH
		g/kg of dry matter			
1	6,74 Aa	47,5	145,9 Aa	0	3,83 Aa
2	14,30 Cc	31,3	78,1 BCb	0	4,11 C b
3	12,30 ABCbc	25,1	70,5 Cb	0	4,01 ABCb
4	13,63 BCc	25,4	73,4 Cb	0	4,09 Cb
5	8,62 ABCab	37,2	70,6 Cb	0	4,06 BCb
6	7,58 ABa	22,6	67,0 Cb	0	4,03 ABCb
7	11,09 ABCabc	27,9	136,8 Aa	0	3,84 ABa
8	12,6 ABCbc	40,5	118,8 ABa	0	3,99 ABCb
Factor	Two factors anova; p value				
The kind of material	0,0140	0,4504	<0,0001	-	0,0410
Additive	0,0256	0,4963	0,0074	-	0,0027
Interaction	0,0334	0,3469	0,0110	-	0,0384

Means in columns designated with the different letters differ significantly at the level a,b - P≤0,05; A,B,C - P≤0,01
*) designation as in table 1

Conclusions

The varieties of ensilaged sorghum influenced on nutrients content in silages: silage made from the Akklimat Suddan grass contained the highest level of dry matter, crude protein, crude fat as well as crude ash, the highest concentration of crude fibre, NDF and ADF were stated in silage made from Sucrosorgo 506, on the other hand the highest content of N-free extractives were stated in silage made from Rona variety. The ensilage additives that were used had no influence on chemical composition of silages but improved its quality.

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EFFECT OF BIOLOGICAL INOCULANTS ON FERMENTATION QUALITY OF SILAGES FROM *SORGHUM X SUDAN GRASS* HYBRID

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Introduction

The raise of the temperature at the simultaneous decrease in precipitations during the vegetation causes a decrease in plant production. Losses arising from climatic changes influence significantly the economy in the whole agriculture. One of the possibilities how to eliminate these losses, at least partially, is a diversification of plant production and a gradual introduction of drought withstanding crops into the crop rotation. Sorghums seem to be very suitable in the feedstuff production for ruminants.

Sorghums are plants of physiological type C_4, with more intensive photosynthesis and lower water evaporation because of waxy leaves with lower number of stomas (*Avasi et al., 2001*). They are noted for a quick growth, tolerance of high temperatures and long lasting draughts. They give enough feed also in dry years. Importance of sorghums growing increases in regions, where the yield of maize is uncertain because of soil and climatic conditions. These are mainly maize production regions with lighter soils, lower level of underground water and low atmospheric precipitations. Cold and wet soils limit their growth, therefore it is recommended not to grow them in higher situated regions (*Lang, 2001*).

Hybrids of *Sorghum sudanense* can be mown several times and they can give three cuts during the vegetation period with total yield of fresh green matter up to 80 tons per hectare. It is possible to use the obtained feed in many ways; for grazing, green feeding, ensilaging in horizontal silos, and packed into bales. It is a problem to use them for hay because of thick stalks. Classic technology used at harvest of other bulky feeds is used also at sorghum harvest.

Aim of this work was to test the effectiveness of biological ensilaging preparations on fermentation process at ensilaging of hybrid *Sorghum sudanense x Sorghum bicolor*, variety GK Czaba (HU).

Materials and Methods

Sorghum sudanense hybrid (variety GK-Csaba) was sown in south Slovakia, at the altitude of 118 m above sea level. It was sown in the first decade of May at seeding rate 50 kg seed per hectare. Average annual temperature varied from 9 to 10.5^{o} C and annual precipitation depth from 530 to 650 mm in the course of this task. Hybrid was taken immediately before heading of plants to assess nutritive value of feed.

The stand wilted to 33 % content of dry matter for ensilaging. At ensilaging we used one control variant (C) not treated with silage additive and four experimental variants in which was the ensilaged matter treated with following preparations:

1 – biological inoculant (*Lactobacillus plantarum* DSM 3676 and 3677, *Propionic bacterium* DSM 9576 and 9577), application rate 2 ml of preparations' activated solution per 1 kg ensilaged feed
2 – biological inoculant (*Enterococcus faecium* M 74, *Lactobacillus plantarum*, *Lactobacillus casei*, *Pediococcus species*), application rate 1.1 ml solution of preparation per 1 kg ensilaged feed
3 – granulated biological inoculant (*Lactobacillus rhamnosus* NCIMB 30121, *Enterococcus faecium* NCIMB 30122), application rate 0.5 g per 1 kg feed
4 – granulated biological inoculant (*Lactobacillus plantarum* DSM 4784-7, *Enterococcus faecium* DSM 4788-9), application rate 0.5 g granulated preparation per 1 kg ensilaged feed

In the course of fermentation were assessed weight losses in silages by weighing in regular 21 days intervals; dry matter losses in silages were calculated. Chemical analysis was done in samples of fresh feeds and silages; results were statistically processed and evaluated.

Results and Discussion

On the basis of nutrients concentration assessed in hybrid of sorghum (tab. 1) it is possible to state that in our fodder crop was medium content of crude protein, fibre and ash compared with other fodder crops grown normally in our country. NDF content was very high as far as nutrients requirement of high yielding dairy cows are concerned. On the contrary, fat concentration in the hybrid was low.

Table 2 gives results of fermentation in sorghum sudanense hybrid ensilaged at optimum content of dry matter 33 %. Parameters of fermentation process in individual silages show positive influence of applied biological inoculants. Measurement of pH on day 3 of silages fermentation shows that the fastest onset of fermentation was in silages treated with biological preparations in liquid form, followed by silages treated with granulated preparations and the slowest onset of fermentation process was in the untreated silage. Further course of fermentation was also in line with its onset. Inoculated silages had lower pH, higher content of lactic acid, lower content of volatile fatty acids, alcohol and ammonia nitrogen compared with untreated silage.

Table 1 Content of nutrients in ensilaged hybrid *Sorghum bicolor x Sorghum sudanense*

Parameter	Value (g.kg^{-1} DM)	Parameter	Value (g.kg^{-1} DM)
Dry matter	332.52	Crude fibre	271.10
Organic matter	931.58	ADF	292.11
Crude protein	133.96	NDF	542.09
Fat	22.15	Total sugars	137.63
Ash	68.42	Reducing sugars	120.43

Table 2 Parameters of fermentation process and selected nutrients in silage of hybrid *Sorghum bicolor x Sorghum sudanense* (in g.kg^{-1} dry matter)

Parameter		Silage variants					Statistical of differences	
		C	1	2	3	4	p ‹ 0,05	p ‹ 0,01
pH	average	3.85	3.69	3.75	3.81	3.79		1:C,3,4
	SD	0.06	0.01	0.09	0.03	0.01		3:4
pH on day 3 of fermentation		4.49	4.09	4.16	4.35	4.29		
Acids - lactic	average	50.91	68.28	67.65	72.37	69.71		C:1,2,3,4
	SD	3.66	5.59	5.87	6.16	4.99		
- acetic	average	4.54	2.96	3.02	4.13	4.72	C:1	2:C,3,4 1:4
	SD	1.00	0.51	0.14	0.64	0.57		
- propionic	average	0.68	0.41	0.31	0.43	0.35	C:1	C:2,3,4
	SD	0.19	0.12	0.08	0.07	0.06		
- butyric + i.b	average	0.12	0.50	0.37	0.32	0.25	1:4 C:2,3	C:1
	SD	0.08	0.12	0.15	0.18	0.16		
VFA total	average	5.89	4.22	4.05	5.22	5.69		4:1,2
	SD	1.08	0.71	0.24	1.12	0.55		
Alcohol	average	3.93	3.39	3.46	2.93	3.88	C:3	
	SD	0.92	0.47	0.89	0.18	1.19		
NH_3-N of total N in %	average	4.02	3.36	3.40	3.96	3.62	1:C,3 2:4	2: C,3
	SD	0.36	0.21	0.08	0.32	0.16		
Dry matter in g	average	310.5	311.8	311.4	309.3	308.8		
	SD	6.37	5.81	7.94	2.92	6.29		
Losses of DM in %	average	8.2	6.8	7.5	7.3	8.1		
	SD	1.16	1.76	1.22	0.87	1.40		
Crude protein	average	129.2	131.0	132.4	130.2	130.5		
	SD	6.53	2.43	2.69	5.73	1.04		
Crude fibre	average	287.0	292.0	293.8	291.8	287.8		
	SD	3.93	3.62	5.83	3.49	3.83		
Total sugars	average	64.7	69.2	65.0	48.5	52.0	C:2	1: C,2,3,4
	SD	3.53	1.86	2.99	2.38	2.79		2: 3,4
Reducing sugars	average	51.1	58.0	51.3	35.1	43.2	C:2	1:C,2,3,4
	SD	9.07	1.51	3.74	3.63	7.68		2: 3,4
Fat	average	29.6	28.3	29.6	28.0	26.2		
	SD	2.00	1.82	1.27	3.07	2.48		
Ash	average	63.4	62.3	63. 8	66.0	65.3		
	SD	0.72	1.67	0.45	0.94	1.4		

Conclusion

We consider ensilaging during suitable vegetation stage to be the most convenient utilization of sorghums in nutrition of cattle. For common sorghum it is the stage of wax ripeness, for the hybrid of sorghum sudanense it is the period closely before heading of plants. This fodder plant is ensilaged by two-stage harvest. Optimum content of dry matter is on the level 30-35 % after wilting of the chopped matter.

The results obtained in our experiments show good ensilability of sorghum sudanense hybrids. Biological inoculants based on homo-fermentative as well as on combination of homo- and hetero-fermentative bacteria of lactic fermentation, accelerate the onset and improve the course of fermentation process.

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ENSILING OF SORGHUM LEAVES AND SEEDS AS BY-PRODUCT OF BIO-ETHANOL PRODUCTION

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Abstract

The aim of recent study was to investigate the fermentation quality of different by-products derived from the sorghum plant applied in the bio-ethanol industry for sugar extraction. Authors ensiled the whole crop, the sorghum leaves (by-product) and the sorghum seedhead-leaf mix (1:1 fresh weight) and investigated the nutrient content, fermentation profile, microbial composition of the whole sorghum plant silage (DM: 292g/kg), the sorghum leaf silage (DM: 401 g/kg) and the sorghum seedhead-leaf mixed silage (1:1 fresh weight, DM: 453 g/kg) on the 7th and 40th day of anaerobic day (density: 190kg DM/m^3). It was found that the sorghum leaf and the seedhead-leaf mix could be ensiled efficiently. Sorghum leaf- and seedhead-leaf mixed silages can be potential feedstuffs for dairy cattle (especially heifers, dry cows) and beef cattle according to the measured nutrient content.

Introduction

The sorghum is a drought-tolerant plant highly adapted to the dry climatic conditions (Orosz et al, 2033, 2005). The sugar-type sorghum plant has a potential green yield of 50-90 ton/ha with render of 4-9 ton/ha total sugar. The aim of the study was to investigate the fermentation quality of different by-products derived from the sugar-type sorghum whole plant applied in the bio-ethanol industry for sugar extraction. Authors ensiled the whole sorghum plant, the leaves (as by-product) and seedhead-leaf mix (1:1 fresh weight) determining the fermentation process during the anaerobic phase, the fermentation quality and hygienic status of the different silages.

Materials and Methods

The sorghum whole plant, the stems, the seedheads and the leaves were harvested and chopped individually by hand (2009). Composition of the seedhead and leaf mix (1:1 fresh weight) suited to the natural fresh weight ration of the whole plant parts in 2009. The different fresh raw materials were packed into 30 model silos (n=5, volume: 0,041 m^3, applied density: 180-200 kg dry matter/m^3). Applied treatments were the followings: chopped whole crop sorghum plant (WCS), chopped mix of sorghum seedhead and leaf, in ratio of 1:1 fresh weight (SSL), soghum leaf (SL). Similar dry matter density was applied in the model silos (WCS 190 kg dry matter/m^3; SSL 192 kg dry matter/m^3; SL 195 kg dry matter/m^3). Two samplings were carried out, on the 7th and 40th day of fermentation (n=5). Crude nutrients, fiber fractions (NDF, ADF, ADL), total sugar content (fresh material and silages), pH, lactic- and volatile fatty acid, ethanol, ammonia content and microbial status (moulds and aerobic bacteria) were measured (silages, 3 treatments, n=5) according to the Hungarian National Standards. All microbial counts were log10 transformed to obtain log-normal distributed data. The chemical compositional data of the fresh material and the silage samples (n=5), fermentation profile and microbial counts of the silage samples (n=5) were analyzed for their statistical significance with SPSS (version PASW Statistics 18). Chemical composition, fermentation profile and microbial status were analyzed for their statistical significance by ANOVA (Student t-test, Welch's t test, Wilcoxon test post-hoc test were applied).

Results and Discussion

Crude nutrient composition of the whole crop sorghum silage (WCS), the sorghum seedhead-leaf mixed silage (SSL) and the sorghum leaf silage (SL) on the 40th day of fermentation are given in Table 1.

Table 1 Nutrient content of the whole crop sorghum silage (WCS), the sorghum seedhead-leaf mixed silage (SSL) and the sorghum leaf silage (SL) on the 40th day of fermentation (2009, n=5)

40th day of anaerobic phase		**WCS**		**SSL**		**SL**	
		Mean	SD	Mean	SD	Mean	SD
Dry matter	g/kg	292a	7.1	401b	5.8	453b	15.2
Crude protein	g/ kg DM	52a	4.7	54a	3.2	45b	2.8
Crude fat	g/ kg DM	15a	0.9	18a	0.5	25b	3.1
Crude fiber	g/ kg DM	304a	11.5	330b	3.3	340c	2.9
Crude ash	g/ kg DM	52a	4.9	57a	3.1	57a	4.5
NDF	g/ kg DM	610a	21.5	745b	9.3	740b	3.4
ADF	g/ kg DM	342a	10.1	416b	7.6	409b	8.7
ADL	g/ kg DM	53a	2.5	57a	1.9	41b	2.1
Hemicellulose	g/ kg DM	238a	4.3	316b	5.8	321b	7.9
Cellulose	g/ kg DM	289a	9.1	355b	6.8	367b	5.9

Different letters show significant differences $p \leq 0.05$

Fermentation profile and microbial status of the whole crop sorghum silage, the sorghum seedhead-leaf mixed silage and the sorghum leaf silage on the 7th and 40th day of anaerobic phase (fermentation) are showed in Table 2.

Table 2 Fermentation profile and microbial status of the whole crop sorghum silage (WCS), the sorghum seedhead-leaf mixed silage (SSL) and the sorghum leaf silage (SL) on the 7th and 40th day of anaerobic phase (2009, n=5)

		7th day, n=5						40th day, n=5					
Parameter	**Dimensions**	**WCS**		**SSL**		**SL**		**WCS**		**SSL**		**SL**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
pH		4,3a	0,1	5,7b	0,1	6,3c	0,5	3,7a	0,3	5,0b	0,4	5,6b	0,5
Lactic acid	g/kg DM	20,6a	1,3	7,6b	2,0	3,9b	3,5	106,7a	1,8	14,3b	4,2	9,42b	3,17
	% total acid	58,4		67,3		59,9		74,9		72,5		73,35	
Acetic acid	g/kg DM	14,7a	1,3	3,6b	0,2	2,3b	1,3	14,5a	0,9	5,3b	0,4	3,02b	1,36
	% total acid	41,6		32,7		40,1		29,2		27,4		23,55	
Propionic acid	g/kg DM	0,0a	0,0	0,0a	0,0	0,0	0,0	0,0a	0,0	0,0a	0,0	0,13b	0,0
	% total acid	0,0		0,0		0,0		0,0		0,0		1,08	
Butyric acid	g/kg DM	0,0a	0,0	0,0a	0,0	0,0a	0,0	0,0a	0,0	0,0a	0,0	0,25b	0,07
	% total acid	0,0		0,0		0,0		0,0		0,0		2,02	
Ethanol	g/kg DM	14,1a	2,6	6,7b	0,9	5,4b	3,3	22,2a	1,8	7,7b	0,3	11,4b	3,7
Volatile acids	g/kg DM	14,7a	1,3	3,6b	0,2	2,3b	1,3	14,5a	0,9	5,3b	0,4	3,4b	1,4
Organic acids	g/kg DM	35,2a	1,8	11,2b	2,0	6,1c	4,6	121,2a	2,6	19,6b	4,1	12,8b	4,1
Ferm.products	g/kg DM	49,3a	3,2	17,8b	2,4	11,5b	5,6	143,4a	0,8	27,3b	4,4	24,2b	4,9
LA/AA	g/g	1,4a	0,2	2,1a	0,6	1,6a	0,7	7,4a	0,1	2,7b	0,8	3,2b	1,0
NH_3-N/total N	%	13,0a	1,1	14,6a	0,3	11,0a	1,0	21,0a	3,4	25,0a	2,6	20,0	2,8
Aerobic bact.	log10 CFU/g	5,4a	0,1	8,1b	0,1	8,5b	0,4	6,0a	0,6	8,7b	0,5	9,0b	0,9
Moulds, yeast	log10 CFU/g	2,3a	0,3	3,4b	1,1	4,3b	1,8	3,0a	0,2	4,4b	0,9	5,1b	1,9

Different letters show significant difference p≤0,05. DM - dry matter, LA/AA – lactic acid to acetic acid ration

The authors have found that the WCS silage had the most intensive fermentation (7th and 40th day) based on the lowest pH and highest fermentation product concentration compared to SSL and SL (p≤0,05). Fermentation profile of WSC significantly differed (pH, lactic acid, acetic acid, ethanol, volatile acids, organic acids, total fermentation products) from SSL and SL, while character of SSL and SL was very similar to each other on the 40th day of fermentation. Significantly higher lactic acid content was found in WCS compared to SSL and SL on the 40th day. However, WCS contained significantly higher ethanol and acetic acid content, than SSL or SL. The presumable reason of lower fermentation intensity (higher pH, lower lactic-, acetic-, organic acid and ethanol content), but very similar organic acid ration in SSL and SL compared to WCS, can be the significantly higher dry matter content in SSL and SL (401 g/kg and 453 g/kg, respectively). Fermentation profile of the sorghum leaf silage treatment was especially poor and consolidation was extremely difficult, therefore additional water application (minimum 100 kg water/ton fresh material) during packing is recommended to increase moisture content and fermentation intensity in the silage. High pH, low lactic- and organic acid content were found in the seedhead-leaf mixed silage (1:1 fresh weight) and sorghum leaf silage, therefore additional homofermentative lactic acid bacterial inoculation is recommended. Microbial composition of WSC significantly differed from SSL and SL, while character of SSL and SL was very similar to each other on the 40th day of fermentation. WSC contained significantly less aerobic bacteria, mould and yeast than SSL and SL. These results showed higher porosity in SSL and SL, compared to WCS.

Conclusions

The authors summarized that the sorghum seedhead-leaf mix (1:1 frresh weight) and the sorghum leaf can be ensiled efficiently. It was found that SSL and SL silages can be potential feedstuffs for dairy cattle (heifers, dry cows) and beef cattle according to the measured nutrient content.

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INVESTIGATION OF ELDER *(SAMBUCUS NIGRA)* AND BLACK LOCUST *(ROBINIA PSEUDO-ACACIA)* AS POTENTIAL RAW MATERIALS OF ENSILING

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Abstract

The aim of the study was to investigate the ensiling, nutritional value, fermentation, aerobic stability and microbial parameters of elder (*Sambucus nigra*) and black locust (*Robinia pseudo-acacia*) shoots. The shoots were chopped, mixed with 20% dried corn (*Zea mais*) and ensiled in barrels (60 litres) (n=4). The silos were opened after 370 days of ensiling. The sugar and crude-fibre content of the silages were significantly lower than the values of raw material ($p \leq 0.05$). During the fermentation process the number of yeasts, moulds and aerobic mesophylic bacteria decreased significantly ($p \leq 0.05$). The pH values of the silages were about 4-4.5 considered to be optimal at this dry matter level. The amount of fermentation products were relatively low, but their composition was about optimal. The ratio of lactic acid/acetic acid in the silages was good at about 3:1. In aerobic conditions the silages proved to be very stable. After 14 days aerobic phase no significant changes were found in the pH values ($p > 0.05$). Moderate increases were determined in the number of yeast, moulds and aerobic mesophylic bacteria (AEMB). According to the results it can be summarized, that the early summer shoots of elder and black locust can be preserved effectively by ensiling. The secondary plant compounds of the two investigated species could have a significant effect on the fermentation process and the aerobic stability. In further investigations examination of the secondary metabolites, the microbial composition of the shoots, and the rumen degradability of the silages are recommended.

Introduction

Supplementary winter feeding of game animals, and particularly deer, is a relatively widespread practice throughout northern Europe and parts of North America, however the efficiency is doubtful in several cases. Inadequate forage quality and improper feeding practice of captive and free ranging deer seem to be the main causes (Putman and Staines, 2004). This recent study is an attempt to invent an adequate foraging technology for wild game species. The aim of the research was to investigate the ensiling, nutritional value, fermentation, aerobic stability and microbial parameters of elder (*Sambucus nigra*) and black locust (*Robinia pseudo-acacia*) shoots as potential forages for wild ruminants. Several studies indicated, that arboreal species dominate the diet of wild ruminants (Gebert and Verheyden-Tixier, 2001; Mátrai, 1994; Mátrai and Szemethy, 2000; Szemethy et al., 2000) and in certain studies elder and black locust were preferred feed components (Mátrai and Szemethy, 2000). Preference for these species could be due to their favourable nutrient content. The two investigated species are generalists, widespread, have high biomass production, and are also cultivated plants (DeGomez and Wagner, 2001), thus making them suitable for forage production. Former studies proved that cultivated black locust could properly be preserved by ensiling (Chen et al., 2011; Zang et al., 2010).

Material and Methods

The early summer green shoots were collected and chopped. The leafs were mixed with 20% dried corn (*Zea mais*) in order to reduce the risk of effluent production and an undesirable fermentation, moreover to increase the energy content of the silages. The mixed feedstock was ensiled in barrels (60 litres) (n=4) with a density of 850 kg/m^3 (250 kg/m^3 DM). The silos were opened and sampled after 370 days of fermentation. Aerobic stability of the silages was determined in opened model silo systems over a 14 day term.

Results and Discussion

Although the DM content of the silages was adequate, the amount of the fermentation products were relatively low in both cases. Poor fermentation intensity could be due to the low fermentable organic matter content of the green shoots. Another main reason can be the secondary metabolite content of these species, which has a known inhibitory effect on the growth of microbial populations (Wallace, 2004) and may modify the ruminal degradability. However even with the relatively low organic acid production, the pH decreased to an optimal level and the composition of fermentation products were favourable as well. Results of the fermentation are shown in *Table 1*.

The extent of nutrient losses during the fermentation was low even over long periods of time which could be due to the low intensity of fermentation. The fibre contents of the silages were about the same value of an average lucerne haylage, however the protein contents were slightly lower. Relatively high carotene content was found in the case of elder. High carotene content of forages have positive effects on ruminants (Noziére et al., 2006). Results of nutrient content of the different phases of ensiling are shown in *Table 2*.

The pH of the silages did not rise significantly in the 14 days of aerobic exposure . Changes of the nutrient content and the fermentation products were reasonably low after 14 days, which suggest that the silages are stable in aerobic conditions. Low sugar and lactic acid content, as the main substrates for microbes related to aerobic deterioration of silages, could be the main causes of the relatively good aerobic stability. Probable high concentration of secondary plant metabolites could also have an inhibitory effect on aerobic decomposers as well.

Table 1 Composition of fermentation products in Black locust and Elder mixed silages

Fermentation and aerobic stab. (N=4)		Anaerobic						Aerobic			
		Elder			Black locust			Elder		Black locust	
		mean	SD	%	mean	SD	%	mean	SD	mean	SD
pH		4.22*	0.0		4.52*	0.1		4.14*	0.1	4.51*	0.1
Lactic acid (LA)	g/kg DM	44.56*	2.6	75.4	38.47*	1.0	72.0				
Acetic acid (AA)	g/kg DM	13.21a	1.0	22.4	14.03	1.0	26.2	15.21b	0.80	14.74	1.52
Prop. acid	g/kg DM	0.06*	0.0	0.1	0.54*	0.2	1.0				
Butyric acid	g/kg DM	0.94	1.1	1.6	0.22	0.3	0.4				
Ethanol	g/kg DM	2.43a	1.0		2.24a	0.3		5.32b	0.28	5.15b	0.53
Volatile fatty acids	g/kg DM	14.53	1.5		15.00	1.4					
Organic acids	g/kg DM	59.09*	2.2		53.47*	1.5					
LA/AA ratio	g/g	3.40*	0.4		2.75*	0.2					

abc:significant differences among the phases of the same spec.(P≤0.05),*: differences between the 2 spec. in the same phase (P≤0.05)

Table 2 Nutrient content of the raw materials and different silages during the anaerobic and aerobic phases

Nutrient content (N=4)		Raw material+ 20% corn				Silages				Aerobic phase			
		Elder		Black locust		Elder		Black locust		Elder		Black locust	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
DM	g/kg	285.6a*	10.09	308.3a*	15.13	305.7b*	8.49	334.7b*	7.56				
C. protein	g/kg DM	141.5*	9.06	167.9a*	3.21	135.8*	5.17	157.0b*	6.49				
C. fibre	g/kg DM	164.5	10.41	172.3a	17.18	149.0	29.91	146.6b	9.27				
Crude fat	g/kg DM	34.4a*	1.56	26.2a*	0.74	39.5b*	3.02	32.5b*	2.54				
NDF	g/kg DM	282.5a*	24.66	403.5a*	24.82	231.6b*	27.67	313.0b*	14.63				
ADF	g/kg DM	180.4*	13.56	223.7a*	25.16	169.6	30.26	179.5b	10.57				
ADL	g/kg DM	51.2*	3.24	59.9a*	5.07	42.5	10.66	48.0b	3.88				
Sugar	g/kg DM	53.9a*	5.04	31.0a*	2.57	4.4b	3.57	1.6b	1.39	13.5	9.93	8.0	4.35
Carotenes	mg/kg DM	104.5*	19.62	33.3*	7.90	93.4*	27.44	21.6*	14.09				
AEMB	log10CFU/g	5.1a*	0.25	6.7a*	0.79	3.6b*	0.40	4.7b*	0.16	5.2c	0.73	6.3c	0.52
Mould	log10CFU/g	3.6a	0.44	5.4a	1.71	0.3b	0.65	0.0b	0.00	0.9*	0.62	4.4c*	1.86

abc: significant differences among the phases of the same species (P≤0.05), *: significant differences between the two species in the same phase (P≤0.05)

Conclusions : According to the results, it can be summarized that elder and black locust shoots can be effectively preserved by fermentation. These foliage silages could provide high quality and nutritious feedstuffs for wild ruminants. However, further investigations are required (investigation of ruminal degradability, feeding experiments).

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EFFECT OF NOVEL SILAGE INOCULANT ON CONSERVATION OF DIFFERENT FORAGES

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Introduction

It is difficult to control desired fermentation in free fermentation occurring in forages. Therefore, there may be wide variations in the quality of silage. Silage crops and fluctuations in weather conditions are the main factors that cause such differences. Increasing the content of dry matter and water soluble carbohydrates (WSC) by wilting and using silage additives improve favourable fermentation conditions. Lactic acid bacterial inoculants have been used to promote the silage process, to increase the extent and rate of lactic acid production and thereby to guard silage against spoilage. The objective of this study was to determine the effect of inoculant on conservation of forages with different content level of WSC.

Material and Methods

Efficacy tests were designed (according to OJEU, 2008) for the following silage crop categories: easy to ensile forage (forage WSC content >3% in fresh material), moderately difficult to ensile forage (1,5–3,0% WSC in fresh material) and difficult to ensile forage (<1,5% WSC in fresh material). Experiment was carried out in 2010. Easy to ensile forage was 48h wilted regrowth red clover–timothy mixture, ratio 25:75. Moderately difficult to ensile forage was primary growth ryegrass. Difficult to ensile forage was primary growth red clover–timothy mixture, ratio 25:75. Plant material was chopped into approximately 2 to 3 cm lengths and mixed. Control silages were made without additives. Test silages were inoculated with lactic acid bacteria *Lactobacillus plantarum* E-98 NCIMB 30236, which is registered as a silage additive in the European Union register of Feed Additives (OJEU, 2011). The concentration of inoculated *L. plantarum* E-98 was $2,4\times10^5$ cfu/g fresh material. Silages were packed in 3-litre glass jars in triplicates for each treatment-control comparison and stored for 100 days in dark room under constant temperature conditions (20 °C) until opening. Silages were analysed for chemical composition and fermentation parameters according to generally accepted methods (AOAC, 2005).

Statistical differences within silage crop between control and lactic acid bacteria inoculated silages were analysed with the t-test.

Results and Discussion

Easy to ensile forage dry matter content was 387,0 g/kg and WSC content was 30,1 g/kg in fresh material. Regardless of fermentation under favourable conditions the quality characteristics of silage ensiled by natural epiphytic microflora of freshly harvested crop were not as good as those of *L. plantarum* E-98 inoculated silages. *L. plantarum* E-98 improved silage fermentation compared with the control silage (table 1). Inoculation of lactic acid bacteria strain *L. plantarum* E-98 increased lactic acid concentration in silage and thereby reduced silage pH value to 4,1. In addition to these parameters, the ethanol and NH_3-N in total N contents in inoculated silage were also statistically significant in difference ($p<0,05$) compared with the control silage.

The content of dry matter and WSC of moderately difficult to ensile forage were 192,4 g/kg and 21,2 g/kg, respectively. Ensiling such forage the effect of *L. plantarum* E-98 was more expressive. *L. plantarum* E-98 increased lactic acid concentration over 40 g/kg than it in control silage. Silage pH value was much lower (pH 4,0) compared with the control silage (pH 4,7). Detrimental microorganisms' activity was inhibited. Concentrations of ethanol, produced by yeasts, was more than twice lower, and concentrations of NH_3-N in total N, produced by proteolytic microorganisms, was 2,6 times lower in inoculated silage compared with the control silage. There was also lower butyric acid content in *L. plantarum* E-98 treated silage. The ethanol, propionic acid, butyric acid, lactic acid and ammonia content and pH of control and inoculated silages were statistically significantly different ($p<0,05$).

Difficult to ensile forage dry matter content was 151,3 g/kg and WSC content 9,1 g/kg in fresh material. Control silage made from difficult to ensile forage had very poor fermentation characteristics. High concentrations of butyric acid and NH_3-N/total N in silage indicate extensive proteolysis during fermentation. The magnitude of the content of lactic acid and butyric acid was the same in control silage and pH value of that silage was insufficient. However, *L. plantarum* E-98 increased the extent and rate of lactic acid production. Inoculated silage contained 2,5 times more lactic acid than untreated silage. Due to faster pH drop and low final pH value in inoculated silage the activity of unfavourable microorganisms was inhibited. It resulted in much smaller concentrations of ethanol, propionic acid, butyric acid and NH_3-N in total N. Despite the obvious in results, the statistical analysis did not show significant differences in fermentation parameters (except that of ethanol) between *L. plantarum* E-98 inoculated and untreated silages. It is explained by large variation in results between repetitions of untreated silage. Here the question about difficulties to control desired fermentation by epiphytic microflora rises again. At the same time the fermentation parameters between repetitions of inoculated silage were homogeneous.

Inoculated silages had a low pH level and higher lactic acid concentration compared to the untreated silages in all investigated forage categories. The rate and extent of pH drop inhibited the effect of microorganisms that cause spoilage in silage. Therefore, *L. plantarum* E-98 NCIMB 30236 favoured lactic acid fermentation and improved, thereby, silage quality.

Table 1 Effect of inoculant on conservation of different forages[1]

Item	Easy (S.E.)		Moderately difficult (S.E.)		Difficult (S.E.)	
	Control	LAB	Control	LAB	Control	LAB
Chemical composition						
Dry matter, g/kg	381,9±0,0	382,8±0,1	174,0±0,0	181,2±0,1*	132,7±0,3	144,0±0,1*
In dry matter, g/kg						
Crude protein	157,9±0,1	161,5±0,0	189,0±0,1	198,2±0,2*	153,1±0,5	154,2±0,5
Crude Ash	96,6±0,0	92,6±0,2	101,4±0,1	95,0±0,0*	97,4±0,2	93,7±0,2
NDF	490,3±0,3	491,0±0,4	450,6±0,1	433,1±0,1*	544,4±1,4	522,9±0,7
ADF	356,6±0,2	356,0±0,6	292,3±0,3	291,4±0,8	383,3±1,0	356,0±0,3
Fermentation parameters						
Ethanol	8,3±0,1	6,3±0,3*	14,7±1,7	6,7±0,3*	16,2±1,0	7,8±0,1*
Acetic acid	17,3±0,2	15,8±0,6	15,8±0,6	15,6±0,1	21,6±3,9	28,8±0,7
Propionic acid	0,1±0,0	0,1±0,0	0,1±0,0	0,2±0,0*	4,2±2,0	0,1±0,0
Butyric acid	0,1±0,0	0,1±0,0	0,1±0,0	0,0±0,0*	30,5±15,2	0,1±0,0
Lactic acid	65,0±1,5	76,0±2,1*	109,0±6,2	149,3±2,2*	34,2±18,4	86,3±2,3
pH	4,3±0,0	4,1±0,0*	4,7±0,0	4,0±0,0*	5,1±0,2	4,2±0,0
NH_3-N/total N	30,3±0,3	26,7±0,9*	118,7±5,0	45,0±0,0*	109,7±11,1	63,7±0,9

[1] Statistical differences within silage crop between control and lactic acid bacteria (LAB) inoculated silages
* - $p<0,05$

Conclusions

The silage inoculant *L. plantarum* E-98 NCIMB 30236 favoured lactic acid fermentation in all investigated forage categories. The inoculant improved fermentation quality, compared with the untreated silage. It is indicated by pH value, volatile fatty acid and ammonia nitrogen content in silages.

Acknowledgement

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THE ESTIMATION OF POSSIBILITIES OF SILAGE PRODUCTION FROM SOYBEAN-MAIZE INTERCROPPING[1]

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Introduction

More environment friendly systems of cropping has been searched recently and intercropping has been one of the possibility to achieve that goal. An example of such crop is maize with soybean intercropping. Silages that are made from the crops received by this cultivation method are a good quality material, which contains the proper amount of protein and energy. The silages positively affect the animal organism and productivity and could lead to limitation of concentrate feeding as well as reduction frequency of metabolic disorders occurrence in dairy cows.

The aim of conducted study was to determine an effectiveness of silages production from soybean-maize intercropping in dependence of sow standard for two species as well as ensilage additive application on the base of chemical composition and quality of the silages.

Materials and Methods

Experimental material was green matter of Kosmo 240 maize and soybean Tara. Crops differed in share of plants while sowing as well as nitrogen fertilization. The maize was cultivated in monoculture (130 kg N/ha) and soybean was cultivated alone (0 kg N/ha). Green matters of maize-soybean were cultivated in row intercrop in proportion: 60:40 (6 maize seeds and 20 soybean seeds per m², 78 kg N/ha), and 40:60 (4 maize seeds and 30 soybean seeds per m², 52 kg n/ha). Each of green matters form the experimental plants were chopped and ensiled in 1,5 L microsiloses in 4 replication for each treatment: without ensilage additives and with addition of chemical or biological preservative (Blattisil Combi and Blattisil lacto-bac Flüssig 2, respectively). In the silages, according to conventional methods, basic nutrients content was assayed. Structural carbohydrates – ADF and NDF were determined according to Georing and Van Soest methods, pH – with using pH meter N-512 ELPO, ammonia nitrogen was determined according to Conway method, and content of lactic, acetic and butyric acids according to Lepper method. The silage samples were exposed to air in constant temperature 21°C. Aerobic stability was determined as the time (number of hours) after which silages temperature increased by the 2°C when compared with the environment.

Results and Discussion

Table 1 Chemical composition of maize-soybean silages (g/kg of dry matter)

Nutrient	Content of soybean				Method of conservation		
	100%	60%	40%	0%	Inoculant	Chemical preservative	Without additives
Dry matter g/kg	229,7 A	276,9 B	273,7 B	257,2 B	267,7	254,9	255,5
Crude protein	120,6 A	78,0 B	71,0 B	78,1 B	89,6	88,0	90,8
Crude fat	17,4	16,0	20,3	18,3	20,3	18,4	17,3
Crude ash	135,4 A	64,5 B	65,0 B	76,5 B	82,7	90,0	83,3
Crude fibre	355,3 Aa	231,4 Bb	224,9 Bb	193,9 Bc	245,3	252,5	256,6
ADF	414,1 A	260,0 B	236,0 B	243,5 B	274,0	291,9	291,8
NDF	564,3 Aa	501,7 ABb	479,0 Bb	455,2 Bb	483,6	514,7	501,9
N-free extract	371,0 A	610,1 B	618,8 B	633,1 B	562,1	551,1	551,0

Means in rows (individually for share of soybean and method of conservation) designated with the different letters differ significantly at the level a,b - $P \leq 0,05$; A,B,C - $P \leq 0,01$

The lowest content of dry matter were stated in silage produced from sole soybean crop (tab. 1) and differed statistically ($P \leq 0,01$) in comparison with remaining variants. In accordance with expectation, the highest content of crude protein in the soybean silage was noted. Nevertheless, obtained result was visibly lower than is given in INRA standards for soybean green matter which amounts 140 g/kg of DM. Different soybean share in intercrop (60 vs. 40%) were not caused unambiguous increase of crude protein content and was similar as crude protein content in silages made from sole maize fertilized with nitrogen heavily. Crude fat content was similar in all ensilage treatments and had no tendency to changeability. Statistical analysis showed significant ($P \leq 0,01$) differences in crude ash content between silage from soybean cropped as monoculture and remaining variants. The content of crude ash in that variant was the higher and resulted of high content of minerals in soybean, especially calcium, phosphorus and potassium (Jasińska and Kotecki 1993). Silage made from soybean cropped as monoculture also had the highest content of crude fibre. Increasing of maize share in cropping caused decrease of crude fibre content in silages made from that material. The differences for ADF fraction were statistically significant ($P \leq 0,01$).

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The silage made from soybean contained the highest amount of ADF fraction - 414,1g/kg DM, and in remaining variants the content of ADF was lower and ranged on similar level, about 236,0. Similar dependence was noted for NDF fraction – the silage made from soybean contained the highest level of 564,3g/kg DM, but decreasing of soybean share caused linearly NDF content decreasing. Contents of fibre fractions in the silage made from soybean were much higher than recommended by Podkówka and Podkówka (2006). In accordance with expectation, silage made from maize cropped individually contained the highest amount of N free extractives – 623,1 g/kg DM. It could be explain by high content of starch accumulated in maize grain. With increasing of soybean level in silage the content of N-free extract decreased. The lowest and statistically different ($P\leq0,01$) level of this component in soybean silage were stated. Application of ensilage additives had no influence on the silages chemical composition.

Content of silage acids (tab. 2) in the silages were similar in all treatments. The concentration of acetic acid were high and in silage with 60% of soybean share the higher concentration of this acid noted, in remaining treatments content of acetic acid ranged from 50 to 60 g/kg DM. Raised level of acetic acid could lead to deterioration of silage taste (Jamroz, 2006). Butyric acid in trace amounts – 1 g/kg DM in soybean silage was only assayed. The content of lactic acid in all silages were high and varied between silages (statistically insignificantly) – the tendency was observed: lower share of soybean in silage = the lactic acid higher. Application of ensilage additives did not cause differences in concentration of silage acids in silages. The highest pH – near 5,0 in soybean silage - was stated. High pH level could be caused by high crude protein content and low content of carbohydrates (N-free extract) in soybean. pH of soybean silage differed statistically in comparison with remaining silages with pH not higher than 4,35 (tab. 2). Even though dry matter content was low none of silages achieve pH lower than 4,2. In experiments that were made by Podkówka (2004) on maize

Silages, its pH was on the level 4,0-4,2 and stated as the optimal. Application of a chemical additive and an inoculant caused differences in acidity ($P\leq0,05$; $P\leq0,01$). The inoculant decreased pH to 4,38 and chemical specimen didn't serve its role and after its application pH of silage increased in comparison with control one by the 0,18 pH units. N-NH_3 content expressed as percentage of total nitrogen in the soybean silage stated 10,6%. This indice is evidence of feed protein breakdowns during conservation and should be not higher than 10% in good quality silages (Jamroz, 2001). Remaining treatments fulfilled that quality criterion. Application of ensilage additives did not caused statistically confirmed changes in protein breakdowns extent. Aerobic stability of silages depends both on composition and applied ensilage agent: silages with high share of maize (60 and 100%) were less aerobically stabile and chemical additive significantly reduced secondary spoiling of organic matter in air access.

Table 2 The quality of maize-soybean silages

Parameter of quality	Content of soybean				Method of conservation		
	100%	60%	40%	0%	Inoculant	Chemical preservative	Without additives
Acetic acid	60,1	65,7	51,2	54,0	65,0	56,9	50,5
Butyric acid	0,9	0,0	0,0	0,0	0,0	0,8	0,0
Lactic acid	114,8	115,1	124,8	142,4	121,0	133,4	116,2
pH	4,92 A	4,35 B	4,24 B	4,32 B	4,38 Aa	4,59 Bb	4,41 ABa
N-NH_3%N total	10,6 A	6,4 B	6,8 B	7,1 B	6,9	9,2	7,0
Aerobic stability*	120 a	122 a	103 b	90 c	106 a	117 b	104 a

Means in rows (individually for share of soybean and method of conservation) designated with the different letters differ significantly at the level a,b - $P\leq0,05$; A,B,C - $P\leq0,01$

*) the time (number of hours) after which silages temperature increased by the 2°C when compared with the environment

Conclusions

Increase of soybean share in intercropping with maize could be an procedure that could allow nitrogen fertilization decrease – in presented study content of crude protein was similar for both sole maize and intercropping with limited nitrogen fertilization. In silages with high share of soybean the fibre fractions content could to increase above of recommendation for dairy cows. Both biological and chemical ensilaging additives had no significant influence on chemical composition of the silages. Maize incorporation to soybean growing improved quality of obtained silages but worsened its aerobic stability. Examined chemical ensilage additive significantly decreased spoiling processes of silages in air access.

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THE EFFECT OF DRY MATTER CONTENT ON THE QUALITY OF CORN SILAGE

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Introduction

Maize (Zea mays L.) represents the main feed in rations for ruminants due to the high yield potential and excellent feeding value. The correlations between the content of dry matter (DM) and nutrients, or even between dry matter content and fermentation quality indicators can be used for inclusion in feed rations for a given specific group of animals.

Generally, the effects of dry matter on the indicators of nutritional values and silage fermentation are known (Balet al., 1997, Andrae et al., 2001, Cone et al., 2008). We have been dealing with this issue for many years; our results are presented for example at the 14th ICFC conference in Brno (Loučka, 2010), at the 15th ISFC conference in Finland (Rajčáková et al., 2012) and this year in Brno (Loučka et al., 2013, Rajčáková et al., 2013). However, there are still some unknown matters; the results should be refined, updated and reviewed in relation to other aspects.

The objective of our research was to determine the effect of DM on the main indicators of nutritive value and silage fermentation in the Czech Republic as compared to those obtained in the Slovak Republic.

Materials and Methods

To assess the effect of DM on the main indicators of nutritive value and silage fermentation in the Czech Republic (CR), we used the results of chemical analyses of 596 corn silages from the years 2006-2012, which were recorded in the database of feed by AgroKonzulta, Ltd. of Žamberk. For the conditions of the Slovak Republic (SR), we used the results of analyses of 285 corn silages in the years 2010-2012, which were recorded in the database of feed by Animal Production Research Centre of Nitra. The results of the samples of silage from CR were, regardless of year setting, divided into four categories: the silage with DM 30% and lower, 30.1 to 35%, 35.1 to 40% and over 40% of dry matter. In the category <30%, 89 analyses were evaluated in CR and 56 in SR; in the category of 30.1 to 35%, 285 analyses in CR and 123 in CR; in the category of 35.1 to 40%, 197 analyses in CR and 64 in SR; and in the category over 40%, 25 analyses in CR 25 and 42 in SR. Chemical analyses were carried out in laboratories in CR and SR according to the same methodology by the Regulation of the Commission (EC) No. 152/2009 (2009), in accordance with AOAC (1995). The neutral detergent fibre with α-amylase (ANDF) was determined according to Van Soest et al. (1991). The influence of DM level on nutritional and fermentation quality was evaluated by ANOVA with Tukey HSD test for unequal numbers of cases in groups. The statistical procedures were performed using Statistica 9.1 (StatSoft, Tulsa, OK, USA).

Results and Discussion

The results are shown in table 1 for CR and in table 2 for SR. The silage in CR had an average DM content of 337.7 ± 36.50 g/kg (minimum 230.7 and max. 450.7 g/kg). As compared to that, the dry matter content in the silages in SR was 349.4 g/kg (164.6 min. and max. 512.0). In Austria, the average DM content in corn silage was 356 g/kg in the year 2009. The minimum content of DM was 285 g/kg and the highest 471 g/kg. In Switzerland, the average was 366 g/kg, with minimal content 320 and maximum 423 g/kg in the year 2009. In Niedersachsen, the average DM content ranged from 338, 351 to 349 g/kg for the years 2010, 2011 and 2012 (Rajčáková et al., 2013).

The silage in CR had the following average of other nutritional characteristics: OM 958.4 ± 6.8, NDF 455.2 ± 56.5, ADF 232.2 ± 34,3, starch 317,9 ± 56.0, CP 84.5 ± 10.9 g/kg DM, respectively. The fermentation characteristics were as follows: lactic acid 17.9 ± 5.8, acetic acid 5.5 ± 3.1, butyric acid 0.3 ± 0.3 g/kg DM, respectively, pH 3.75 ± 0.14, and the ratio of lactic acid with volatile fatty acids (LA/VFA) 3.61 ± 1.35. The results in CR and in SR were similar and there were also comparable with those stated in literature (Bal et al. 1997, Andrae et al., 2001 and Cone et al., 2008).

Bal et al. (1997) evaluated the chemical composition of corn silages designated by stage of maturity of whole-plant corn at harvest: early dent, quarter milkline, two-thirds milkline, and black layer. DM was 291, 324, 351 and 420 g/kg, NDF 520, 444, 405 and 413, starch 182, 287, 372 and 374 g/kg DM, pH 3.73, 3.98, 4.11 and 4.10, lactic acid 5.55, 4.67, 4.15 and 3.95, acetic acid 1.24, 0.92, 0.85 and 1.12, propionic acid 0.22, 0.40, 0.44 and 0.47 % of DM, respectively. The optimum stage for corn that was ensiled was two-thirds milkline with some flexibility between quarter and two thirds milkline, it means with DM between 324 and 351 g/kg. Andrae et al. (2001) harvested maize hybrid in DM 265, 300, 406 and 436 g/kg, respectively. That DM content corresponds with the values of starch of 294, 274, 413 and 374, NDF 443, 431, 371 and 396 g/kg DM, respectively. Di Marco et al. (2002) silage maize in 3 stages of maturity of DM content 200, 260 and 320 g/kg. Higher DM content increased ($P < 0.05$) the silage starch content (20-280 g/kg DM), but decreased ($P < 0.05$) the NDF content (600-410 g/kg DM. Cone et al. (2008) concluded that the increase in whole plant DM content from 250 to 320 g/kg caused the increase of starch content of the whole plants.

Table 1 The effect of level of dry matter content on the nutritional and fermentation quality of corn silage in the Czech Republic

Index	Units	Dry matter			
		< 30 %	30.1 - 35 %	35.1 - 40 %	> 40 %
		n = 89	n = 285	n = 197	n = 25
Neutral detergent fiber	g/kg DM	486.1 ± 54.6 a	458.4 ± 50.6 b	437.9 ± c	441.8 ± bc
Starch	g/kg DM	270.0 ± 56.0 c	310.4 ± 49.6 b	345.7 ± a	359.9 ± a
pH		3.73 ± 0.14 bc	3.74 ± 0.15 c	3.78 ± 0.14 ab	3.85 ± 0.10 a
Lactic acid	g/kg DM	87.9 ± 24.8 a	57.9 ± 15.8 b	39.5 ± 9.9 c	26.5 ± 6.5 d
Acetic acid	g/kg DM	32.1 ± 16.6 a	17.1 ± 7.6 b	11.1 ± 4.4 c	7.4 ± 2.9 c
Butyric acid	g/kg DM	1.7 ± 1.8 a	0.5 ± 0.5 b	0.5 ± 0.5 c	0.4 ± 0.3 bc
Lactic acid / voluntary fatty acids		3.15 ± 1.3 c	3.65 ± 1.4 b	3.74 ± 1.3 a	3.73 ± 1.2 ab

Different letters document statistical differences in each row (Tukey HSD, á = 0.05)

Table 2 The effect of DM on the nutritional and fermentation quality of corn silage in Slovak Republic

Index	Units	Dry matter			
		< 30 %	30.1 - 35 %	35.1 - 40 %	> 40 %
		n = 56	n = 123	n = 64	n = 42
Neutral detergent fiber	g/kg DM	511 ± 41	410 ± 57	418 ± 60	403 ± 33
Starch	g/kg DM	196 ± 67	333 ± 43	348 ± 44	336 ± 42
pH		3.79 ± 0.59	3.75 ± 0.53	3.86 ± 0.23	3.99 ± 0.27
Lactic acid	g/kg DM	68 ± 30	58 ± 21	43 ± 15	44 ± 22
Butyric acid	g/kg DM	1.2 ± 0.7	1.6 ± 1.2	1.5 ± 0.8	1.2 ± 0.6
Lactic acid / voluntary fatty acids		3.2 ± 1.2	3.1 ± 1.9	2.8 ± 1.5	3.2 ± 1.9

Conclusions

- The increase of DM content of corn silage increased significantly ($P<0.05$) starch and LA/VFA, while decreasing ($P<0.05$) NDF, ADF and all acids.
- The optimum of DM content of corn silage can be in the category of 30.1 to 35% DM.

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COMPARATIVE DESCRIPTION OF FERMENTATION QUALITY OF MAIZE SILAGES DERIVED FROM 16 DIFFERENT MAIZE HYBRIDS

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Summary

The authors determined fermentation quality of maize silages derived from 16 different maize hybrids (FAO 420-560). The pH, the lactic- and volatile fatty acid concentrations were analysed on the 70th day of fermentation of the 16 different maize silage ensiled into plastic barrels (n=3, net weight: 140 kg/barrel, density range: 168-220 kg DM/m^3). Dry matter range of the different hybrids was found 292-386 g/kg. The pH varied between 3.70-3.80. Lactic acid concentration range was 39.6-57.4 g/kg DM, while acetic acid 10.5-14.6 g/kg DM, with ration of LA:AA 3.3-5.4. Lactic acid ration compared to the total acid content was extremely high, with range of 74-84% in combination of low acetic acid ratio (15,7-23,2%). The amount of propionic acid (0.01-0.05%) and i-butyric acid (0.01%) were insignificant.

Introduction

In the dry continental Central-European area, the key forage crop is silage maize. Generally, the ratio of maize silage in the dairy cow diet is approx. 30% (on dry matter base) in Hungary. Therefore key issue is to use modern maize hybrids adapted to the dry ecological conditions, hybrids should be heat- and drought-tolerant, providing high yield and adequate nutrient composition with proper nutrient digestibility for cost effective milk production. According to Orosz *(2009)* and Allen et al. *(2003)* harvest- and preservation technology (initial dry matter content, phenological phase of the maize plant, theoretical chop length, kernel processing, packing density) have considerable effect on fermentation quality of the maize silage (target density: min. 600 kg/m^3 or 200 kg DM/m^3). Moreover, fermentaion profile of the maize silage fed in approx. 20 kg/day/cow may have hugh effect on ruminant digestive physiology, metabolic processes and reproductive biology, as well.

The aim of the study was to determine fermentation quality of maize silages derived from 16 different maize hybrids (FAO 420-560), grown, cutivated, harvested and ensiled with the same technology.

Matherials and Methods

The field experiment was performed on Experimental Farm of Szent István University in Hungary (Józsefmajor) between October 2009 and September 2010. Hybrids were grown, cultivated, harvested and ensiled with the same technology (experimental plot: 1 ha/hybrid). Harvest was carried out with a precision chopper harvester on the 1st of September in 2010. The 16 different types of hybrids were ensiled into plastic barrels (theoretical chop length: 15 mm, net weight: 140 kg/barrel, density: 200 kg DM/m^3, n=5).

The pH, the lactic- and volatile fatty acid concentrations were analyzed on the 70th day of fermentation of the 16 different maize silage according to the Hungarian National Standard.

Results

Fermentation parameters of the 16 different maize silage are shown in Table 1. Density of the model silos (barrels) varied between 510 - 659 kg/m^3 (168-220 kg DM/m^3).

Dry matter range of the different hybrids was found 292-386 g/kg. The pH varied between 3.70-3.80. Lactic acid ration compared to the total acid content was extremely high, with range of 74-84% in combination of low acetic acid ratio (15,7-23,2%). Lactic acid concentration range was 39.6-57.4 g/kg DM, while acetic acid 10.5-14.6 g/kg DM, with ration of LA:AA 3.3-5.4. The amount of propionic acid (0.01-0.05%) and i-butyric acid (0.01%) were insignificant.

The authors have found strong negative correlation between

- dry matter content and organic acid concentration,
- dry matter content and lactic acid concentration,
- lactic acid concentration and acetic acid concentration,
- lactic acid concentration and volatile fatty acid concentration.

Strong positive correlation was found between

- lactic acid concentration and organic acid concentration,
- lactic acid concentration and lactic acid %,
- lactic acid concentration and LA:AA ratio,
- lactic acid % and LA:AA ratio,

- acetic acid concentration and acetic acid %,
- acetic acid concentration and volatile fatty acid concentration.

Table Fermentation profile of 16 different maize silage grown, harvested and ensiled with the same technology (2010. Józsefmajor, Hungary)

Hybrid	**DM**	**pH**	**Lactic acid**		**Acetic acid**		**Propionic acid**	**Butyric acid**	**VFA**	**Organic acids**	**LA/ AA**
	g/kg		g/kg DM	%	g/kg DM	%	g/kg DM	g/kg DM	g/kg DM	g/kg DM	
1.	333	3,74	51,7	82,3	11,1	17,7	0,0	0,0	11,1	62,8	4,65
2.	325	3,74	56,3	84,3	10,5	15,7	0,0	0,0	10,5	66,8	5,38
3.	330	3,78	53,3	80,4	13,0	19,6	0,0	0,0	13,0	66,4	4,09
4.	358	3,80	51,4	80,3	11,5	17,9	0,8	0,3	12,6	64,0	4,49
5.	374	3,80	46,5	79,5	10,7	18,3	1,1	0,3	12,0	58,6	4,35
6.	354	3,75	48,3	78,8	12,4	20,3	0,6	0,0	13,0	61,3	3,89
7.	342	3,76	48,8	78,0	13,2	21,0	0,6	0,0	13,7	62,6	3,71
8.	310	3,73	51,9	79,7	13,2	20,3	0,0	0,0	13,2	65,2	3,93
9.	386	3,76	39,6	78,1	11,1	21,9	0,0	0,0	11,1	50,8	3,56
10.	314	3,73	52,5	77,8	14,6	21,7	0,3	0,0	15,0	67,5	3,59
11.	344	3,73	45,3	75,4	14,0	23,2	0,6	0,3	14,8	60,2	3,25
13.	338	3,80	48,5	78,5	12,7	20,6	0,6	0,0	13,3	61,8	3,81
14.	360	3,77	44,4	78,8	11,9	21,2	0,0	0,0	11,9	56,4	3,72
15.	318	3,75	44,3	74,2	13,5	22,6	1,6	0,3	15,4	59,7	3,28
16.	328	3,7	50,6	82,6	10,7	17,4	0,0	0,0	10,7	61,3	4,74
17.	292	3,71	57,2	82,3	12,0	17,2	0,0	0,3	12,3	69,5	4,77
Min.	292	3,7	39,6	74,2	10,5	15,7	0,0	0,0	10,5	50,8	3,3
Max.	386	3,8	57,2	84,3	14,6	23,2	1,6	0,3	15,4	69,5	5,4
Mean	338	3,8	49,4	79,4	12,3	19,8	0,4	0,1	12,7	62,2	4,1
SD	24,5	0,0	4,6	2,6	1,3	2,2	0,5	0,1	1,5	4,6	0,6
Correlation (R) between the different parameters (data according to the crossing rows and colums)											
DM		0,61	**-0,72**	-0,22	-0,37	0,20	0,18	-0,09	-0,27	**-0,81**	-0,23
pH			-0,31	-0,21	-0,10	0,09	0,42	0,05	0,05	-0,30	-0,16
Lactic a.				**0,70**	-0,06	**-0,70**	-0,37	-0,04	-0,17	**0,95**	**0,71**
Lactic a. %					**-0,70**	**-0,94**	**-0,64**	-0,28	**-0,82**	0,44	**0,95**
Acetic a.						**0,75**	0,25	0,06	**0,93**	0,25	**-0,74**
Acetic a. %							0,34	0,02	0,74	-0,46	**-0,99**
Prop.acid								0,59	0,58	-0,18	-0,40
Butyric acid									0,33	0,07	-0,05
VFA										0,16	**-0,76**
Organic a.											0,46

Conclusion

The authors summarized that there can be considerable differences between fermentation parameters comparing the different maize silages to each others derived from different maize hybrids with FAO number of 420-560 (DM: 292-386 g/kg) grown, cultivated, harvested and ensiled with the same technologies.

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THE CONTENT OF STARCH AND ENERGY IN MAIZE SILAGES IN SLOVAKIA AND THE CZECH REPUBLIC IN YEARS 2010-2012

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Abstract

The objective of our study was statistical evaluation of starch and energy content in maize silages in Slovakia and the Czech Republic during the years 2010 - 2012. We found out that average values do not differ much from each other. The average content of dry matter in SK was 349.4 g and in CZ it was 329.7 g, of starch in SK 314.3 and in CZ 325.8 $g.kg^{-1}$ dry matter. The average NEL concentration was equal in both countries, namely 6.3 $MJ.kg^{-1}$ dry matter. However, when we divided silages into groups according to starch content we found out that there still occur shortcomings in practical conditions at farms, the maize for silage is not harvested in optimum vegetation phase. Greater reserves in harvest time of maize hybrids were noticed in SK.

Key words: *silage, maize, starch, net energy, PDI*

Intensive cultivation of maize hybrids broadens the spectrum of grown maize by new hybrids that are of higher yielding capacity, better state of health and bring nutritionally more valuable feeds than the older ones. However, their quality and yielding capacity are still highly dependent on the development of weather, site character, agronomical practices, pest invasion on stands and many other factors.

Long lasting observation of the situation in practical conditions of farms and subsequent statistical evaluation of data are necessary to be able to appraise the real state in the country. The objective of this work was statistical analysis of the starch and energy content in maize silages in Slovakia and the Czech Republic during the years 2010 to 2012.

Material and Methods

Results of silage analyses made in practical conditions on farms were used to evaluate the starch and energy content in maize silages in Slovakia and the Czech Republic. The analyses were performed by standard valid methods, which are in line with the provision of the European Commission No. 152/2009, which specifies the sampling methods and laboratory tests for official feed control (2009). Methods valid in Slovakia are published in the bulletin of the MA SK.

Maize silages from the years 2010, 2011 and 2012 were incorporated into the statistical set. These silages were analysed in the laboratory of the Institute of Nutrition at the APRC Nitra and in commercial laboratories EKO-LAB Zamberk, Ltd. and AGRO-LA, Ltd. Jindrichuv Hradec. They analysed 128 maize silages from SK and 245 silages from CZ. The silages were divided into four groups according to starch content. Silages with starch content to 50 $g.kg^{-1}$ dry matter were in the first group, from 50.1 to 150$g.kg^{-1}$ d.m. in the second group, from 150.1 to 270 $g.kg^{-1}$ d.m. in the third one and over 270 $g.kg^{-1}$ d.m. in the fourth group. Content of dry matter, starch, crude protein and concentration of NEL, NEF and PDI were studied.

Results and Discussion

The results show that up to 7.8 % silages contained starch concentration, which did not reach the level 150 $g.kg^{-1}$ dry matter in SK, which indicates premature harvest of this forage crop and wrong selection of hybrid for the given locality. There occurred even silages, which contained minimum starch and it is assumed that the plants were harvested after they lost blossoms. Nearly 15 % plants were harvested at the level of starch from 150.1 to 270 $g.kg^{-1}$ dry matter, and 77.4 % at the starch content over 270 $g.kg^{-1}$ dry matter. The starch concentration in silages is closely connected to the vegetation stage of plants at harvest and the determined content of net energy and PDI were in line with it. Average level of NEL varied from 5.6 to 6.6. $MJ.kg^{-1}$ dry matter and PD from 65.8 to 46.8 $g.kg^{-1}$ dry matter. The group of silages with the lowest starch content showed the lowest NEL content and the highest PDI content and vice versa, the group of silages with the highest starch content showed also the highest NEL content but the lowest PDI content.
According to the starch concentration was proportion of maize silages more favourable in CZ than in SK. Content of starch up to 150 $g.kg^{-1}$ dry matter was in 2 % of silages only. Almost 15 % silages contained starch on the level from 150.1 to 270 $g.kg^{-1}$ dry matter, which was identical to SK, and 83 % silages contained more starch than 270 $g.kg^{-1}$ dry matter. With rising starch content was noticed rising NEL and NEF concentration and decrease of PDI in these silages also.

Although the relative division of maize silages in both republics as far as the starch level was concerned, there were minimum differences in absolute average values of all silages produced in SK and CZ.

These results were compared with statistical evaluations of other authors in different countries. Resch (2012) reported that in Austria was the average content of dry matter 356 $g.kg^{-1}$ and concentration of crude protein 71 $g.kg^{-1}$ dry matter in maize silages in 2009. The lowest dry matter content was observed on the level 285 $g.kg^{-1}$ and the highest 471 $g.kg^{-1}$. Average dry matter content 349.4 $g.kg^{-1}$ (min. 164.6 g, max. 512.0g) was detected in silages in SK during the period 2010 – 2012; in CZ was the average 329.7 $g.kg^{-1}$ (min. 230.7, max. 450.7). The dry matter content within the span 300 – 350 g.kg^{-1} is considered to be the optimum in maize silage. Therefore it is possible to evaluate the average level of dry matter content as optimum in silages produced in SK and CZ; however, it is not valid for the whole area because mainly in SK is great proportion of silages below but also above this limit.

The average dry matter content in maize silages in Switzerland was 366 g.kg^{-1} in 2009, the minimum content being 320 and maximum content 423 g.kg^{-1} (Hengartner, 2010). In Lower Saxony was the average dry matter content on the level 338, 351 and 349 g.kg^{-1} (Engling, 2013) in the years 2010, 2011 and 2012. Minimum starch content was on the level 40 g and the maximum one 490 g.kg^{-1} dry matter. In SK was the average starch content 314.3 g.kg^{-1} dry matter (min. 4.2, max. 453.4) and in CZ it was 325.8 g.kg^{-1} dry matter (min. 118.5, max. 489.4).

Table 1 Statistical evaluation of selected parameters of nutritional and energy quality of maize silages in SK and CZ in the period 2010 – 2012

Division of silages		Dry matter		Crude protein		Starch		NEL		NEV		PDI	
		g/kg FM		g/kg DM				MJ / kg DM				g/kg DM	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Content of starch	**Slovakia**, n = 128												
up to 50 g	n = 5	180.4	22.4	113.6	8.9	5.8	2.2	5.6	0.1	5.5	0.1	65.8	13.2
from 50.1 to 150 g	n = 5	252.0	38.2	98.3	8.4	114.8	24.7	6.0	0.2	6.0	0.1	56.7	9.8
from 150.1 to 270 g	n = 19	305.6	44.4	85.6	6.1	229.8	26.2	6.4	0.2	6.4	0.2	52.1	11.4
over 270 g	n = 99	364.4	44.3	74.6	8.1	343.4	36.7	6.6	0.3	6.6	0.2	46.8	12.7
Average		***349.4***	***56.2***	***77.2***	***10.2***	***314.3***	***57.2***	***6.3***	***0.2***	***6.3***	***0.1***	***54.2***	***9.3***
Content of starch	**Czech Republic** , n = 245												
to the 50 g	n = 0	-	-	-	-	-	-	-	-	-	-	-	-
from 50.1 to 150 g	n = 5	245.2	2.0	106.4	21.0	127.3	1.3	6.1	0.1	6.0	0.2	64.9	12.8
from 150.1 to 270 g	n = 37	293.5	2.4	84.2	8.0	239.4	0.2	6.3	0.2	6.3	0.2	51.5	4.9
over 270 g	n = 203	337.1	3.4	84.8	13.1	343.2	4.0	6.4	0.2	6.3	0.2	51.8	8.0
Average		***329.7***	***36.7***	***84.9***	***12.7***	***325.8***	***56.3***	***6.3***	***0.2***	***6.3***	***0.2***	***51.9***	***7.7***

The average concentration of crude protein was 77.2 g.kg^{-1} dry matter in SK, which is in line with the averages observed in Austria (71 g.kg^{-1} dry matter) and Lower Saxony (77 g.kg^{-1} dry matter). In CZ was the average level of crude protein slightly higher, namely 84.9 g.kg^{-1} dry matter.

Generally, 6.5 MJ.kg^{-1} dry matter are considered to be the target value of NEL concentration in maize silages. Silages produced in SK and CZ achieved on average only 6.3 MJ.kg^{-1} dry matter. In SK achieved 29.7 % silages the target value, in CZ it was 22.8 % only. In Switzerland was the average NEL concentration on the level 6.56 MJ.kg^{-1} dry matter in 2009, with minimum 6.2 and maximum 6.8 MJ.kg^{-1} dry matter. From the above mentioned follows that the NEL level is slightly underestimated and it has reserves, which are most probably connected with correct determination of harvest in maize for silage.

Conclusion

Comparison of starch and energy concentration in maize silages produced in SK and CZ during the years 2010 – 2012 showed that the average values do not differ from each other very much and they are in line with the target values, which represent the optimum.

However, when the silages were divided into groups according to the starch level, it turned out that there still occur shortcomings in practical conditions on farms, namely that maize is not harvested in the optimum vegetation phase and therefore it does not achieve the level for which it has the potential. Greater reserves in harvest dates of maize hybrids were detected in SK, where occurred also silages with very low starch concentration, which indicated that the hybrids were harvested closely after termination of blooming.

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AEROBIC STABILITY OF CORN SILAGE PRESERVED WITH AND WITHOUT CHEMICAL ADDITIVES FOR SILAGE BAG

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Introduction

When silage is exposed to air at opening the silo, or after its removal from the silo, fermentation acids and other substrates are oxidized by aerobic bacteria, yeasts and moulds. The aerobic stability of silage is a key factor in ensuring that silage provides well preserved nutrients to the animal with minimal amounts of mould spores and toxins. The concentration of fermentation products in silage is determined both by the initial chemical composition of the crop itself and by the type(s) of microorganisms that develop during the storage period. When the silage deteriorates because of exposure to air, its nutritional value is reduced due to loss of fermentation products that are potentially digestible substrates (Wilkinson and Davies, 2012). The silage density and porosity are key physical factors that affect the rate of ingress of oxygen into the silage mass during the feed-out period. A target for potential silage aerobic stability is 7 d including the time in the feed trough. The use of additives to increase the aerobic stability is advisable when there is risk of not meeting these objectives. The silage is also deemed to be stable if change in pH does not exceed 0·5 units over 5 days (Weinberg et al., 2008).

Aerobic deterioration is normally determined under laboratory conditions at constant ambient temperature, placing the composite sample loosely in a polystyrene box and leaving the silage exposed to air for several days. During this period, the temperature of the silage is monitored along with the ambient temperature. Aerobic stability is defined as the time that elapses before the silage shows clear evidence of heating, that is, when the temperature of the silage exceeds the ambient temperature by 2°C (Honig et al., 1999).

The goal of the experiment consisted in assessing the influence of application of an ensilage agent (sodium nitrite, sodium benzoate and potassium sorbate), intended to reduce the aerobic degradation of silages, on the reduction of their aerobic degradation. A secondary goal consisted in determining the adequate dose of the additive.

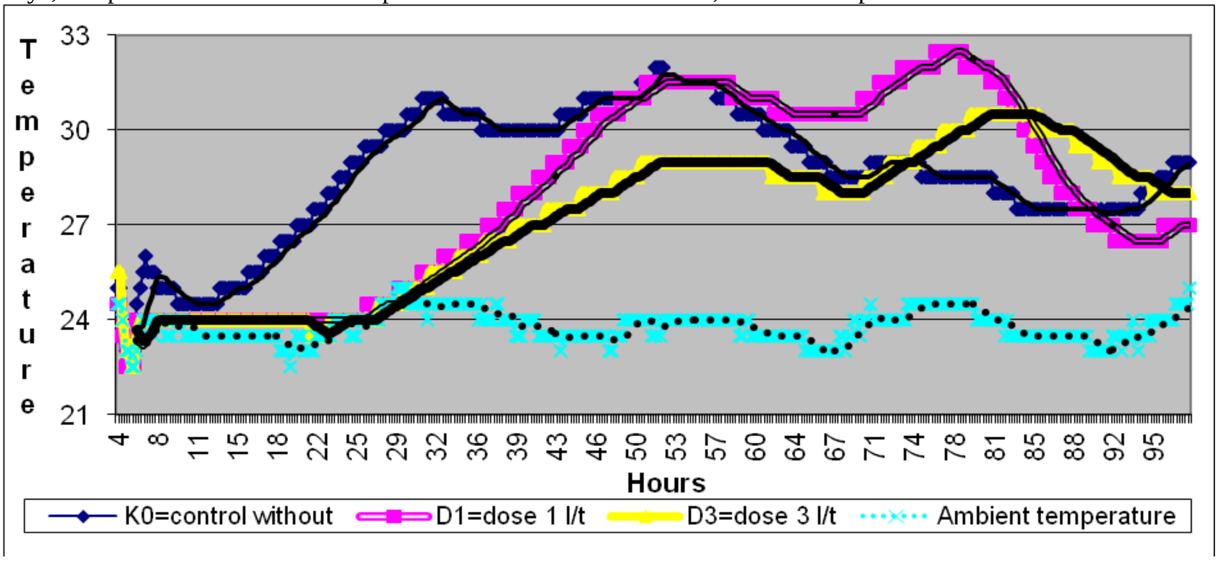
Materials and Methods

The experiment took place in VÚŽV Uhříněves and in the Netluky farm. The Ronaldinio (KWS) hybrid maize chaff was stored in a bag with a diameter of 2,7 m with the help of the AG-bag 2700 filling press on 23.9.2010. The 3 variants of application of the chemical preservative were stored in the bag with the chemical preservative (based on sodium nitrite, sodium benzoate and potassium sorbate) in a dose of 1 litre per ton (D1), 3 litres per ton (D3), and without preservative (K0). The ensilaging agent was applied with the help of an applicator situated on the Class Jaguar cutter. The places where the application was changed were marked on the bag with permanent marker. On 8.8.2011 and on 16.8., i.e. after about 10 months from storage, always 5 samples of each variant were taken from the bag with a probe (at a height of 120 cm from the floor, approximately to a depth of 0 to 15 cm from the foil towards the bag centre). The samples were transported to the laboratory for chemical analyses. The chemical analyses were carried out according to the Regulation of the Commission (EC) No. 152/2009 (2009). Simultaneously with the chemical analysis, the samples were tested on aerobic stability according to Völkenrode methodology (Honig, 1990). The method is based on monitoring temperature increases caused by microbial activity of the samples exposed to air. The silage was deemed to be stable until the internal temperature got more than 2°C above the ambient temperature.

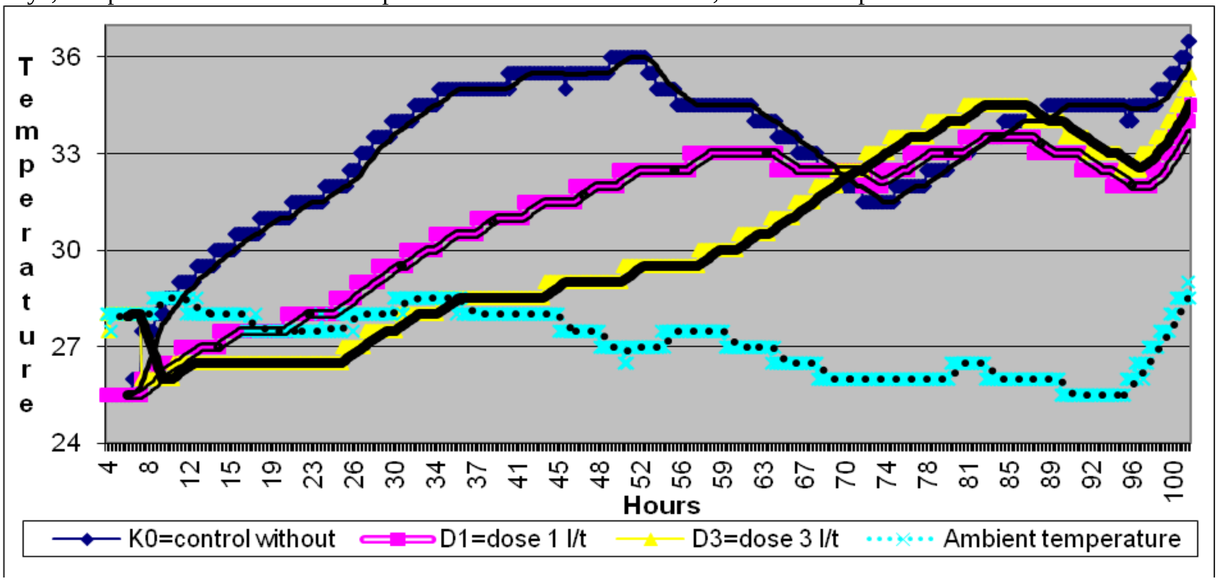
Results and Discussion

The aerobic stability of maize silage measured from the August 8, for 5 days, is shown in graph 1. Although the silage was stored in the bag for a very long time, its aerobic stability can be deemed good. The control silages without the additive always had significantly lower aerobic stability than the silages with additive dose of 1 litre per ton, which had lower aerobic stability than the silages with additive dose of 3 litres per ton. At higher ambient temperature (graph 2) at the second measurement (by 3°C on average), the time of aerobic stability was comparable to the temperature at the first measurement (only in samples with additive dose of 3 l/t by 10 hours longer). In the measurement on August 8, the silage untreated by the additive was stable (at that time the temperature did not increase by more than 2°C) for 16 hours, that with the dose of 1 litre per tone for 35 hours, and that with the dose of 3 litres for 39 hours. Result: the additive extended the time of the aerobic degradation twice (from 19 to 39 hours, both 1 and 3 litre). In the measurement on August 16, the silage untreated by the additive was stable for 14 hours, that with the dose of 1 litre per ton for 34 hours, and that with 3 litres for 49 hours. Result: the additive extended the time of the aerobic degradation (if the temperature increased by 2°C) more than twice (from 14 to 34 hours) with the dose of 1 litre, and more than 3 times with the dose of 3 litres (from 14 to 49 hours).

Graph 1 Aerobic stability of maize silage stored in the silage bag with 2.7 m diameter, measured from August 8 for 5 days; samples were taken from a depth of 0-15 cm below the sheet, ambient temperature 24°C.



Graph 2 Aerobic stability of maize silage stored in the silage bag with 2.7 m diameter, measured from August 16 for 5 days; samples were taken from a depth of 0-15 cm below the sheet, ambient temperature 27°C.



Conclusions

- The application of the chemical additive (based on sodium nitrite, sodium benzoate and potassium sorbate) extended the time of the aerobic degradation of maize silage twice and more times as compared to control silage that had not been treated with the additive.
- The additive must be chosen under consideration of the expected time of silage feeding; for summer period, when outer temperatures are higher, the preservative dose should be higher too.

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OCCURRENCE OF DEOXYNIVALENOL AND ZEARALENONE IN MAIZE SILAGES IN THE CZECH REPUBLIC – A YEAR SURVEY

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Abstract

Between January and December 2012 a total of 40 samples of maize silages were analyzed for the occurrence of deoxynivalenol (DON) and zearalenone (ZEA). Samples were collected in 40 dairy farms in different regions in the Czech Republic. DON was the most prevalent mycotoxin in 2012, with 100 % positive samples at a mean concentration of 894 µg/kg with significant differences ($P<0.05$) within the year. A total of 35 % of samples were positive also for ZEA, with a mean value of 131 µg/kg suggesting a possibility of synergistic effects of both mycotoxins on animals.

Introduction

Maize silage is an important animal feed and may constitute 50–75 % of the diet (Driehuis et al., 2008b) for a high-yielding dairy cows consuming up to 26 kg dry matter/day (Eastridge, 2006). However, maize silage can be infected by a broad range of toxigenic fungi either „storage“(genus *Aspergillus*) or „field“(genus *Fusarium*) that represent a hazard to feed safety. Due to a fact that maize is often colonized by a substantially greater number of *Fusarium* species (e.g. Eckard et al., 2011, Mansfield and Kuldau, 2007) in many situations multi-toxin contamination may occur (Glenn, 2007). In recent surveys on mycotoxins occurrence in feedstuffs Binder et al. (2007), Rodrigues and Griessler (2010) or Rodrigues and Naehrer (2011) found low level contamination throughout the world with significant regional differences, suggesting that deoxynivalenol (DON), T-2 toxin and zearalenone (ZEA) are major contaminants of temperate (European) area. As mentioned in many studies (e.g. Driehuis et al., 2008a, b, Fink-Gremmels 2008, Garon et al., 2006) silage is ascertained as an important source of DON and ZEA in dairy diets that can affect cows health (Korosteleva et al., 2009, Döll and Dänicke, 2011) and productivity (Fink-Gremmels, 2008).

The aim of the study was to determine the occurrence of *Fusarium* mycotoxins deoxynivalenol (DON) and zearalenone (ZEA) in maize silages sampled throughout the year 2012 in dairy farms in different regions of the Czech Republic.

Material and Methods

Between January 2012 and December 2012, a total of 40 samples of maize silages (10 samples per quarter) were analyzed for the occurrence of deoxynivalenol (DON) and zearalenone (ZEA). Samples were collected in the 40 dairy farms in different parts of the Czech Republic. Samples were taken and handled according to the valid recommendations (Commission Regulation (EC) No 152/2009) in order to obtain an average samples from the sampling wall and sent immediately after sampling for analyses to SVÚ Olomouc.

Data obtained in the experiment were analysed using the GLM procedure of the Statgraphics 7.0 package (Manugistics Inc. and Statistical Graphics Corporation, Rockville, Maryland, USA). Results were expressed as mean concentrations (µg/kg) ± SEM (standard error of the mean), minimum and maximum levels.

Results and Discussion

Feed quality is a very important factor determining both animal health and productivity. Table 1 summarises contamination of all maize silage samples regardless of the sampling time. In our study, DON was the most prevalent mycotoxin in 2012, with 100 % positive samples at a mean concentration of 894 µg/kg. Furthermore, a total of 35 % of samples were positive for ZEA, with a mean value of 131 µg/kg. Based on the results of our survey, maize silage can be considered as an important source of DON. This is in accordance with Driehuis et al. (2008a, b) who reported similar mean concentrations of DON in maize silages (854 µg/kg). However, in their study mean concentrations of ZEA were considerably higher, being 550 µg/kg, than determined in our survey. As mentioned above, 35 % of samples were positive for both studied mycotoxins. This is in agreement with many other studies, e.g. Schollenberger et al. (1999) or Döll and Dänicke (2011) suggesting a possibility of a synergistic effects of DON and ZEA on animals.

Table 1 Occurrence of deoxynivalenol (DON) and zearalenone (ZEA) in maize silages – a year survey in dairy farms in the Czech Republic (µg/kg)

	Deoxynivalenol	**Zearalenone**
No of samples	40	40
% of positive samples	100	35
Mean (± SEM)	894 ± 52.8	131 ± 20.1
Minimum	234	61
Maximum	1745	300

When data were separated by quarters of year (Table 2), significant differences were noted in the DON concentrations. The highest level of DON was found in III. quarter of 2012, being 1051 μg/kg and the lowest in IV. quarter (652 μg/kg). However, only concentration of DON in IV. quarter was significantly lower in comparison to I. or II. quarter ($P<0.05$). On the other hand, no significant differences within the year were noted in ZEA. The lowest concentration of ZEA was determined in II. quarter of 2012 when its occurrence was the lowest, only 20 % samples were positive. For the rest of the year percentage of positive samples per quarter was the same and concentrations of ZEA ranged from 99 to 189 μg/kg.

Table 2 Occurrence of deoxynivalenol (DON) and zearalenone (ZEA) in maize silages in single quarters of the year 2012

	I. quarter	**II. quarter**	**III. quarter**	**IV. quarter**
No. of samples	10	10	10	10
Deoxynivalenol				
% of positive samples	100	100	100	100
Mean ($\pm$ SEM)	947 ± 72.5^{a}	1051 ± 79.9^{a}	927 ± 150.0^{ab}	652 ± 66.4^{b}
Zearalenone				
% of positive samples	40	20	40	40
Mean ($\pm$ SEM)	99 ± 9.3	94 ± 3.5	189 ± 57.1	125 ± 32.9

^{a,b} means in the same row followed by the different superscripts differ significantly ($P<0.05$)

Conclusion

The *Fusarium* mycotoxins deoxynivalenol (DON) and zearalenone (ZEA) are of special importance due to their effect on the animal health and performance. Furthermore, these toxins are formed at the field prior to harvest, thus their occurrence cannot be completely avoided due to the major impact of weather conditions. Maize silage surveyed in this study was contaminated mainly with DON (100 % of samples) with mean concentration of 894 μg/kg with significant differences ($P<0.05$) within the year. Occurrence of ZEA was lower, 35 % of positive samples, in average 131 μg/kg. It means that about one third of samples was positive for both studied mycotoxins suggesting a possibility of synergistic effects on animals. The results of this survey reiterate the importance of mycotoxin testing prior to the feeding.

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THE EFFECT OF ENSILING TEMPERATURE ON SILAGE QUALITY OF BREWER'S GRAINS AND AEROBIC STABILITY

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Introduction

Brewer´s grains are a by-product of the beer production with an important emergence in countries like Germany or Russia with 1.9 and 2.1 million t per year in 2011 (calculation based on the production of beer of barley, FAOSTAT, 2013). Its high crude protein (250 g/kg dry matter DM) and fiber content (150 g/kg crude fiber) makes it a suitable supplement for ruminants. However, low content of water soluble carbohydrates (12 g/kg) and its humid presentation require a special handling for successful ensiling. Although it is assumed that high ensiling temperatures are obligatory for successful ensiling recently breweries started recovering heat from brewer's grains for saving energy in the production process. The aim of our study was to evaluate the effect of comparably low ensiling temperature versus classical ensiling temperature under practical large scale conditions. Furthermore, the addition of another by-product namely malt dust was tested (further reading Schiefer, 2013).

Materials and Methods

Pressed brewer's grain was ensiled by track bagging in silos of about 26 t each. The following treatments were applied: ensiling at 56 °C (HIGH) without and with malt dust (about 1 kg/t brewer's grain) and ensiling at 35 °C (LOW) without and with malt dust. Silos were opened after 4 to 6 weeks anaerobic storage and samples taken from different spots as indicated in Figure 1. Fermentation quality, aerobic stability and nutritive value were determined.
Results were analyzed statistically by SPSS 17.0 (SPSS Inc.), by the procedures GLM GEN or GLM MULT respectively, using a linear model.

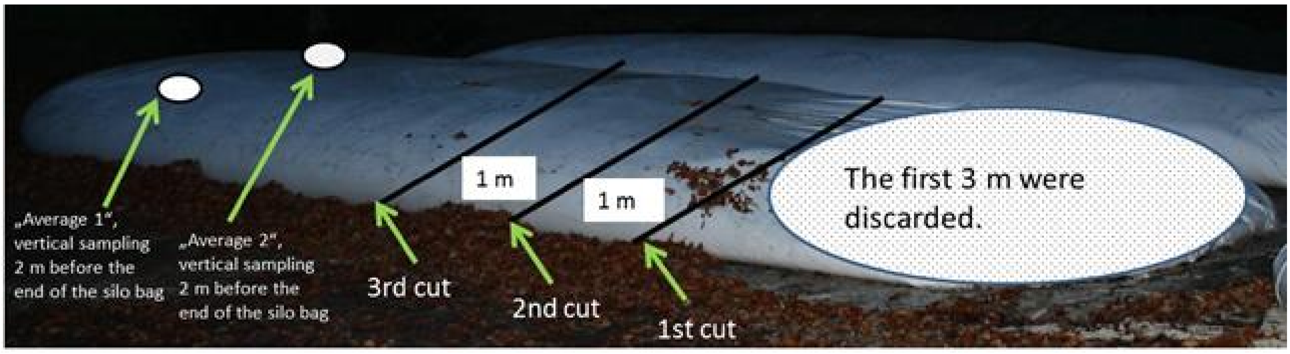

Figure 1 Sampling sites within the silo. From the first, second and third cut, three subsamples of the upper and lower layer were taken at any one time and mixed to one upper and one lower sample per cut, resulting in 6 samples per cut.

Results and Discussion

Pressed brewer's grain silage had a crude protein content of around 230 g/kg DM (Table 1) and could thus be regarded a good nitrogen source for ruminants.

Table 1 Nutritional value of pressed brewer's grain silage ensiled at low and high temperature, without and with malt dust (values in g/kg DM if not indicated differently)

°C	Malt dust	DM g/kg FM	CA	CP	CF	WSC	Starch
35	0	223 (13.2)	50.8 (9.6)	235 (5.3)	173 (6.2)	5.6 (2.0)	20.8 (3.5)
	1	221 (19.5)	52.9 (7.9)	238 (5.7)	168 (5.1)	6.6 (1.8)	22.9 (4.2)
56	0	244 (15.5)	48.4 (6.4)	231 (8.3)	175 (6.3)	10.6 (1.7)	20.5 (3.2)
	1	247 (22.4)	46.5 (0.8)	237 (3.5)	163 (3.4)	3.6 (1.2)	19.3 (2.5)
P	Temp.	0.001	0.088	0.280	0.399	0.104	0.117
	Malt dust	0.900	0.960	0.023	0.000	0.000	0.718
	Temp.xMalt dust	0.734	0.425	0.576	0.086	0.000	0.170

DM dry matter, CA crude ash, CP crude protein, CF crude fiber, WSC water soluble carbohydrates, P significance of effect, multivariate model; numbers in brackets represent the standard deviation

The fermentation quality according to the German Agricultural Society's (DLG, 2006) evaluation scheme was good to very good in all silages (Table 2). The ammonia-N content was below 1 g/kg N in all cases and proteolysis thus negligible. Malt dust seemed to enhance lactic acid fermentation with regard to pH and lactic acid content (Table 2). The main constituents of malt dust were starch (355 g/kg DM) and NDF (353 aNDFom g/kg DM) with 84 g/kg water soluble carbohydrates and 139 g/kg crude protein without microbial abnormality. Aerobic stability was slightly higher when ensiled at lower temperature. The clear difference that stood out between low and high temperature ensiling was the butyric acid content, being in accordance with the presence or absence of clostridia. While at high temperatures no butyric acid was detected, low temperatures led to butyric acid fermentation. This can be explained by the heat intolerance of clostridia.

Table 2 Fermentation quality of pressed brewer's grain silage ensiled at low and high temperature, without and with malt dust (values in g/kg DM if not indicated differently)

°C	Malt dust	pH	Aer. Stability d	Acetic acid[1]	Butyric acid[2]	Lactic acid	Clostridia MPN/g FM	DLG
35	0	4.3 (0.1)	4.5 (0.9)	6.8 (2.7)	6.2 (4.1)	7.9 (3.9)	1.8 (2.1)	75 (14.6)
	1	3.9 (0.3)	4.5 (0.8)	2.7 (1.5)	2.8 (1.9)	10.1 (4.4)	0.7 (1.2)	91 (10.8)
56	0	4.2 (0.4)	3.1 (1.7)	4.2 (4.0)	0.0 (0.0)	8.8 (5.4)	0.0 (0.0)	95 (4.6)
	1	3.7 (0.3)	2.6 (1.4)	1.8 (2.4)	0.0 (0.0)	18.4 (4.9)	0.0 (0.0)	99 (2.3)
P	Temp.	0.100	0.003	0.080	0.000	0.010	0.007	0.000
	Malt dust	0.000	0.260	0.002	0.045	0.001	0.175	0.006
	Temp.xMalt dust	0.904	0.887	0.787	0.045	0.035	0.175	0.072

[1]Sum of acetic and propionic acid, [2]Sum of butyric and valeric acid, MPN most probable number, DLG German Agricultural Society, quality points up to 100 (=very good), <30 = very bad, P significance of effect, univariate model; numbers in brackets represent the standard deviation

Conclusions

Further repetitions have to statistically confirm the findings. However, even under high hygienic standard as assured by the track bagging procedure without intermediate storage, a risk of butyric acid fermentation is indicated when ensiling below 40 °C, although a good overall quality was achieved in our study. As a preventive measure, it is thus recommended to ensile brewer's grains at > 40 °C to prevent the growth of clostridia which have their optimal growth temperature between 35-37 °C (Zigová, 1999) and to aim for a pH < 4.1 (Muck et al., 2003).

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EFFECT OF WHEAT AND CORN GRAIN APPLICATION ON TOMATO PULP SILAGE FERMENTATION QUALITY

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Introduction

Tomato pulp is a by-product from the processing of tomato fruit, it consists of water, seeds and peels. Its high water content limits its length of storage, that's why it is often dried. However, drying increases its price. Tomato pulp can be fed to ruminants without spoilage, if it is ensiled with additives. Hadjipanayiotou (1994) found that ensiled tomato pulp could be a potential protein and energy source in animal nutrition. Hasimoglu et al. (1979) reported that digestible crude protein content of tomato pulp is similar to that of good quality grass hay. Tahmasbi et al. (2002) found that increasing tomato pulp level in corn silage increased the crude protein digestibility of the silage. Derek and Can (2006) used wheat straw and wheat grain as additives, and they found that tomato pulp silages fermented and preserved well with these addition, and this type of silage can be a source of good quality roughage for sheep. According to his results, the aim of the present study was to determine the nutrient content, fermentation quality and microbial status of wet tomato pulp silage after applying different treatment in two consecutive years. In the first year, dried whole grain wheat (20%) was applied in order to reduce the hazard of effluent production and undesirable fermentation processes and to increase energy content of tomato pulp, as a winter feed for game (deer and wild boar). In the second year, dried ground corn (20%) was applied for the same reasons as before and to increase nutritive value of the by-product. In addition 0.5% salt application was used to exploit its antibacterial and antifungal effect.

Materials and Methods

Experiments in the first year

Ensiling of tomato pulp was carried in metal barrels with a capacity of 150-180 kg/barrel. Treatments were designed as follows: (T1) tomato pulp as control, (T2) tomato pulp covered with 1 kg/barrel of salt (NaCl) in order to reduce aerobic spoilage on the top surface, (T3) mixture of tomato pulp and dried whole grain wheat (20%) covered with 1 kg/barrel salt (NaCl), (T4) mixture of tomato pulp and dried whole grain wheat (20%) covered with 1 kg/barrel salt (NaCl) and treated with silage inoculants (*Lactobacillus acidophilus* and *Enterococcus faecium*; dose 10 kg/ton, 10^5 CFU/g fresh material). Samples (2 kg/sample) were taken from the barrels. Chemical composition, starch, total sugar, total carotene, pH, lactic and volatile fatty acid composition, aerobic mesophylic bacteria and moulds were analysed (n=5) on the 100^{th} day of fermentation according to the Hungarian National Standards (Hungarian Feed Codex, 2004).

Experiments in the second year

The appropriate large-scale ensiling technology is a problem in the case of wet by-products, but a special baling technology described by Orosz et al. (2008) could solve this problem. Baling was carried out by a Göweil LT Master fixed-chamber baler-wrapper machine. Nominal size of the bales was 1.20 x 1.22 m. A pressure of 130 bar was applied during the baling process. Film wrap was applied 70% pre-stretched, with 6 layers (by 28 turns). Experimental treatments were as follows: (T1) mixture of tomato pulp and dried ground corn (20%), (T2) mixture of tomato pulp and dried ground corn (20%) treated with 0.5% salt, (T3) mixture of tomato pulp and dried ground corn (20%) treated with Sil All 4x4 silage inoculant (*Enterococcus feacium, Pediococcus acidilactici, Lactobacillus plantarum, Lactobacillus salivarius,* and amylase, hemicellulase, cellulase, pantosanase; dose: 5 g/ton, 10^5 CFU/g fresh material, sprayed in 2 litre water/ton). Chemical composition, starch, total sugar, total carotene, pH, lactic and volatile fatty acid composition, aerobic mesophylic bacteria and moulds were analysed (n=5) on the 70^{th} day of fermentation according to the Hungarian National Standards (Hungarian Feed Codex, 2004).

The chemical compositional data and microbial counts were analysed for their statistical significance (ANOVA and Tukey post test) with SPSS (version PASW Statistics 18), while microbial counts were log10 transformed to obtain log-normal distributed data.

Results and Discussions

Results and discussions from the first year experiment

In the case of fresh tomato pulp an adequate fermentation was found (pH 4.35±0.22; total acid content 55.91±8.54 g/kg DM; lactic acid:acetic acid ratio 1.89±0.28, butyric acid 0.64±0.17 g/kg DM) with a good hygienic status (4.03±0.56 log10 CFU/g aerobic bacteria; 3.81±0.07 CFU/g moulds) after 100 days of ensilage. Treatment T2 (salt on the top) had no significant effect on fermentation on microbial status of the tomato pulp silage either on the top or in the core. Presumably due to the high density of the tomato pulp (208.7 kg DM/m^3), the aerobic spoilage of the surface (3-5 cm on the top) had no effect on the fermentation in the core (50 cm depth). Mixing of 20% dried whole seed wheat reduced significantly the acetic acid ($P \leq 0.05$) and the volatile fatty acid ($P \leq 0.05$) concentration, while increased the lactic acid:acetic acid ratio in the core of the silages as compared to T2 (T2: 1.72±0.07 vs T3: 3.25±0.09). In treatment 3 (T3) a lower fermentation intensity was found in combination with a better volatile fatty acid profile, presumably due to the higher DM content (375.8 g/kg DM), than in T2 (288.8 g/kg DM). However, aerobic spoilage was found in the top 20 cm of the mixed silages compared to T2, where the spoiled layer was just 3-5 cm. Therefore it is not recommended to add whole seed wheat to the wet by-product due to the negative effect on the top layer (20 cm). It is suggested using dried ground cereals as fine structural and hygroscopic additive. Dried whole seed wheat (used at 20%) increased the net energy content for maintenance of tomato pulp (NEm: 4.88 MJ/kgDM; NEg: 2.53MJ/kgDM; NEl: 4.46MJ/kgDM) by 38.7% (NEm: 6.77MJ/kgDM; NEg:4.20 MJ/kgDM; NEl: 6.18MJ/kgDM), which has an important role in game feeding during the winter. The calculated lactation net energy content was similar to the maize silage harvested with approx. 25-30% starch content.

Results and discussions from the second year experiment

It was confirmed that the new baling system was able to form well-shaped and stable bales such a wet by-product as fresh tomato pulp with a small particle size (initial dry matter range of the mix was varied between 362.6 and 375.7 g/kg. Extreme bale weight (1120±12.6 kg/bale, n=6), high density (355±4.0 DM kg/m3, n=6) and low density-deviation were achieved with the new technology due to the high pressurization (130 bar) and the small particle size of the tomato pulp. Effluent amount range was 6-10 litres per bale. High density and quick wrapping (within 120 sec after bale-formation) have a beneficial effect on fermentation quality. However, low fermentation intensity was found in the case of control tomato pulp (mixed with 20% ground corn) baled silage (total acid content 42.1±1.9 g/kg DM; pH 5.0±0.2; butyric acid 1.5±0.8 g/kg DM). An undesirable fermentation process was found in the case of 0.5% salt treatment in the mixed tomato pulp baled silage (total acid content 55.5±15.2 g/kg DM, pH 5.1±0.1 P=0.034; lactic acid:acetic acid ratio 1.7±0.2; butyric acid 1.5±0.8 g/kg DM P=0.042), therefore application of salt is not recommended. Inoculation effectively inhibited the production of butyric acid (total acid content 42.3±2.1 g/kg DM, pH 4.6±0.0, butyric acid 0.0 g/kg DM), and reduced the protein loss by 6% as compared to the control. It is highly recommended to apply as silage inoculant during the ensilage of the wet by-product. The nutritive value of the tomato pulp silage ensiled with 20% dried ground corn increased the net energy content for maintenance of tomato pulp by 40% (tomato pulp 4.88 MJ/kg DM NE_m; 2.53MJ/kgDM NE_g; 4.46MJ/kgDM NE_l; the mixed tomato pulp silage 6.84 MJ/kg DM NE_m; 6.33 MJ/kg DM NE_l and 4.26 MJ/kg DM NE_g). The increased net energy content has an important role in game feeding in the winter time (roe deer and red deer, wild boar). The calculated lactation net energy content is similar to maize silage harvested with approx. 30-35% starch content.

Conclusions

The first year experiment showed that wet tomato pulp had a limited fermentation capacity, but under anaerobic conditions it was possible to store for long term (100 days) with a good microbial status. It is recommended to use dried ground cereal as an additive (20%) to increase dry matter and energy content, moreover to improve volatile fatty acid composition of the wet tomato pulp silage. It can be concluded based on the second year experimental results, that the new bale-forming technology provides stable wet tomato pulp silage (with 20% ground corn) for long term storage. Moreover, the transportable baled silage with considerable energy and protein concentration and as carotene source can have beneficial effects in game feeding during the winter time. Application of biological additive is recommended in order to inhibit undesirable fermentation processes in the baled tomato pulp silage.

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TOMATO PULP BALED SILAGE MAKING AND FEEDING IN A GAME RESERVE

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Introduction

Supplementary winter feeding of game species is a common practice in Europe and parts of North America. According to Putman and Staines (2004) feeding is associated with maintaining or increasing body weights and condition, increasing overwinter survival, improving fertility and reproductive performance, and reducing damages caused to agriculture and forestry by games during winter. Supplementary food can be very expensive, but secondary products from the food industry can provide potential winter extra-food for game species due to their relatively low price and valuable nutrient contents. Hadjipanayiotou (1994) found that the ensiled tomato pulp can be a potential protein- and energy source in animal nutrition. Hasimoglu et al. (1979) reported that digestible crude protein content of tomato pulp is similar to that of good quality grass hay. According to these results baled tomato pulp silage was made. The aim of the study was to determine the nutrient content, fermentation quality and microbiological status of the baled silage mixed with dried ground corn (20%) before fermentation. Additional aim of the recent study was to investigate the proportion of tomato pulp silage in the consumed diet of different large game species in an intensively managed game reserve during winter.

Materials and Methods

Tomato pulp baled silage Tomato pulp baled silage was made from tomato pulp mixed with dried ground corn (20%) before fermentation. In addition, 0.5% salt application and a microbiological inoculation (Sil All 4x4) were applied as treatment, respectively. Wet by-products have so high moisture content that the appropriate large-scale ensiling technology can be a problem, but a special baling technology described by Orosz et al. (2008) could solve it. Baling was carried out by a Göweil LT Master fixed-chamber baler-wrapper machine. Applied pressure was 130 bar during the baling process (70% pre-stretched film, 28 turns/bale, with 6 layers). Experimental treatments were as follows: (1) mixture of tomato pulp and dried ground corn (20%) as control, (2) mixture of tomato pulp and dried ground corn (20%) treated with 0.5% salt, (3) mixture of tomato pulp and dried ground corn (20%) treated with Sil All 4x4 silage inoculant (Enterococcus *feacium, Pediococcus acidilactici, Lactobacillus plantarum, Lactobacillus salivarius*, and amylase, hemicellulase, cellulase, pentosanase; dose: 5g/ton, 10^5 CFU/g fresh material, sprayed in 2 litre water/ton). The purpose of salt addition was to increase the mineral content of the silage fed during winter time and to determine the possible antibacterial and antifungal effect of the salt in the wet by-product silage.

Study area Feeding experiments were conducted at a game preserve in Bodony. The game preserve is located at Mátra, which is part of the North Hungarian Mountains. The area of the game preserve is 275 ha. Four game species were present during our studies: the red deer (*Cervus elaphus*, 60 individuals estimated) the fallow deer (*Dama dama*, 35 individuals) the mouflon (*Ovis aries*, 150-180 individuals) and the wild boar (*Sus scrofa*, 120 individuals). The forest cover for the area is about 40% (primarily black locust and pine), the rest of the area contains reeds, grass fields and game plots. The dominant shrubs are blackthorn (*Prunus spinosa*) and hawthorn (*Crataegus monogyna*).

Feeding experiments Feeding experiments were conducted between November 2009 and March 2010. During this period, 23 baled tomato pulp silages (about 1000 kg/bale) were placed on three different feeding plots in the game preserve. Faecal droppings of different large game species were collected around feeders. The diet composition and proportion of the tomato pulp silage consumed by different game species (red deer, roe deer, follow deer, mouflon) were determined by microhistological faeces analysis (Katona and Altbäcker, 2002). Composite faecal samples were made for each sampling period for each feeding plots for each species by making a homogenised mixture from ten pellet groups. After acidic boiling plant (epidermis) fragments were removed from the faecal samples and placed in slides. Microscopic slides were examined by systematic scanning under 100X and 400X magnifications. One hundred epidermis fragments were identified on slides using a reference collection of plant species collected from the study area. Proportion of diet components were estimated as the number of fragments for a particular forage class relative to the total number of fragments. Identified categories were: tomato, maize, corn, grasses, forbs and browsed species. Statistical analyses were made with InStat program. The normality of data was determined by Kolmogorov-Smirnov tests. Parametric unpaired t-test or one-way ANOVA test with Tukey post-hoc test or nonparametric Kruskal-Wallis test with Dunn post hoc test were used to make statistical comparisons.

Results and Discussion

Baled tomato pulp silage It was confirmed that the new baling system was able to form well-shaped and stable bales such a wet by-product as fresh tomato pulp with a small particle size (initial dry matter range of the mix was 362.6-375.7 g/kg). Extreme bale weight (1120±12.6 kg/bale, n=6), high density (355±4.0 DM kg/m^3, n=6) and low density-deviation were achieved with the new technology due to high pressurization (130 bar) and small particle size. Effluent amount range was 6-10 litres per bale. High density and quick wrapping (within 120 sec after bale-forming) have a beneficial effect on fermentation quality. However, low fermentation intensity was found in the case of control tomato pulp (20% corn) baled silage (total acid content 42.1±1.9 g/kg DM; pH 5.0±0.2; butyric acid: 1.5±0.8 g/kg DM).

An undesirable fermentation process was found in the case of 0.5% salt treatment in the mixed tomato pulp baled silage (total acid content 55.5±15.2 g/kg DM; pH 5.1±0.1 P=0.034; LA:AA: 1.7±0.2; butyric acid: 1.5±0.8 g/kg DM P=0.042), therefore application of salt is not recommended. Inoculation effectively inhibited the production of butyric acid (total acid content 42.3±2.1 g/kg DM; pH 4.6±0.0; butyric acid: 0.0 g/kg DM), and reduced the protein loss by 6 % as compared to the control, therefore it is highly recommended to apply as silage inoculant during the ensilage of the wet by-product.

Feeding experiment After ensiling and analytical process, 63 composite faecal samples were analysed. All of these samples contained tomato. In 57% of these samples tomato was the dominant food component (36-89%). The red deer consumed the tomato pulp in the highest, while mouflon in the lowest proportion (Kruskal-Wallis test: KW=12.754 $p<0.01$, Dunn post-hoc test: red deer vs. mouflon: $p<0.05$, wild boar vs. mouflon: $p<0.05$, others: ns.) There was no significant temporal change in the consumption of tomato pulp, however it was near to the significance level (Kruskal-Wallis test: KW=9.342 p=0.053). The mouflon consumed the grasses in highest proportion (average: 39%) and the wild boar in the lowest proportion (Kruskal-Wallis test: KW=22.129, p=0.0001, Dunn post-hoc test: fallow deer vs. wild boar $p<0.01$, mouflon vs. wild boar $p<0.001$, others: ns.). Browse species were also consumed in the highest proportion by the mouflon (average: 27%) and in the lowest proportion by the wild boar (Kruskal-Wallis test: KW= 11.380, p= 0.0098, Dunn post-hoc test: mouflon vs. wild boar $p<0.05$, others: ns.). The rate of the maize silage consumption was always less than 5%.

Conclusions

Fresh tomato pulp was mixed with 20% hygroscopic dried ground corn in order to reduce the risks of effluent production and an un-desirable fermentation processes, moreover to increase nutritive value of the by-product. Dried ground corn (used in 20%) increased the net energy content for maintenance of tomato pulp by 40% (tomato pulp 4.88 MJ/kg DM NE_m; 2.53MJ/kgDM NE_g; 4.46MJ/kgDM NE_l, baled tomato pulp silage ensiled with 20% dried ground corn: 6.84 MJ/kg DM NE_m; 6.33 MJ/kg DM NE_l and 4.26 MJ/kg DM NE_g), which has an important role in game feeding in the winter time (roe deer and red deer, wild boar). Our results suggest that supplementary winter feeding could be very important for large game species in intensively managed game preserves with dense game populations. It was found that in the area the studied species consumed the tomato pulp in high proportion. This rate of consumption was much higher than we found earlier in free-living deer populations (less than 10%; Katona et al., 2010). However, our result does not necessary mean that the tomato pulp is an optimal food. It is also possible that tomato pulp was a food, which was available in a greater amount in the game preserve and its consumption did not cause any significant wildlife health problem. Large herbivores generally forage on different shrubs of understory, e.g. elderberry (*Sambucus nigra*) or blackberry (*Rubus* spp.). Hawthorn and blackthorn, the dominant species of the studied area, are not among the usually preferred species (Katona et al., 2011). Overall the tomato pulp could provide suitable quality supplementary food for large game species, but further analyses are necessary to prove its suitability. However, we emphasise the fundamental importance of the natural food resources of the habitat.

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QUALITY OF MAIZE SILAGE WITH SUPPLEMENT OF FOREST TREE - POTENTIAL SUPPLEMENTAL FEED FOR RED DEER (*CERVUS ELAPHUS*) AND OTHER WILD RUMINANT SPECIES

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Abstract

Damages caused by red deer and other wild ruminants in forest and agriculture plantations in Slovakia are intensive. Supplementary feeding is one of the possibilities used to reduce damages. Forest tree species are natural feed for wild ruminants and therefore their admixture to maize can represent appropriate feed with sufficient content of structured fibre and other nutrients. Logging waste from forest (twigs of broadleaves and conifer tree species) can be utilized in this way, too.

The fermentation process in maize silage (control) was quite intensive. On the contrary, the concentration of fermentation products in silages with 30 % additive of forest woody species decreased. We detected decreased creation of lactic acid; content of volatile fatty acids was on the same level and pH increased. Maize silages with 30 % additive of twigs from spruce and oak were incorporated into quality class I and II (excellent to very good) according to the content of the fermentation products (by the Decree of the Ministry of Agriculture of the Slovak Republic No. 2136/2004-100).

Introduction

The objective of this work was to test the possibility to ensilage mixture of maize and twigs from forest tree species as a potential feed for wild ruminants. Twigs of broadleaves and conifer tree species represent natural feed for free living ruminants. We enriched the maize silage with structured fibre and other nutrients by adding this natural feed to it. Questions of nutrition and impact on the environment are interesting in connection with high density of free living ruminants. Damages caused by game in forest and agriculture plantations in Slovakia are intensive. Supplementary feeding of wild ruminants is one of the possibilities used to reduce these damages. Putman and Staines (2004), and also Rajský et al. (2008) demonstrated that proper supplementary feeding markedly decreased the rate of the forest tree browsing. Rajský et al. (2011) reported digestibility values of forest tree twigs by roe deer in connection to fibre content.

Material and Methods

The experiment started in the first week of September. We created mixtures of maize and detritus of twigs from tree species spruce and oak. Mixture 1 consisted of 70 % maize and 30 % DDH1; Mixture 2 consisted of 70 % maize and 30 % DDH2 in fresh wight. DDH 1 consisted of 75 % oak twigs and 25 % spruce twigs; DDH2 consisted of 50 % oak twigs and 50 % spruce twigs in fresh weight. Content of nutrients in g/kg dry matter of maize matter was as follows: dry matter (DM) 287.32, organic matter (OM) 952.51, crude protein (CP) 78.37, crude fibre (CF) 190.41, ADF 213.47, NDF 512.64, hemicellulose (H) 299.17, nitrogen-free extract 659.14, sugars total (ST) 110.25, reducing sugars (RS) 106.32, fat 24.59, ash 47.49. Content of nutrients (g/kg DM) in DDH 1: DM 485.98, OM 947.81, CP 63.50, CF 367.25, ADF 447.63, NDF 602.00, H 154.37, nitrogen-free extract 154.37, ST 39.78, RS 31.78, fat 27.68, ash 52.19, and in DDH 2: DM 457.69, OM 940.39, CP 76.29, CF 349.56, ADF 429.86, NDF 528.99, H 99.13, nitrogen-free extract 474.28, ST 39.82, RS 38.84, fat 40.25, ash 59.61. Chopped and homogenized matter was filled in glass laboratory silos with a volume 1.7 litre. We did not use ensilaging preservatives. Each silage variant was produced in six repetitions. The silos were stored in a dark room at a temperature 22 ± 1^{0}C. Changes in weight of silages were observed during the fermentation process and on their basis were calculated losses in dry matter in %. The experiment finished 180 days since ensilaging. Chemical analyses were carried out according to the same methodology by the Regulation of the Commission (EC) No. 152/2009 (2009), in accordance with AOAC (2005).

Results and Discussion

We noticed increase in dry matter content by 34.16 and 58.31 g/kg fresh food when twigs from forest trees were added to maize. Concentrations of crude protein and sugars in mixture 1 and 2 were lower compared with maize. Content of the whole fibre complex was also markedly higher compared with maize. Concentration of fat and ash in mixtures 1 and 2 was higher compared with pure maize. The fermentation process in maize silage was quite intensive (tab. 1). Lower pH level, higher content of lactic and acetic acids gives evidence of it. The silage was incorporated into quality class I as excellent. The additive of twigs from spruce and oak to maize increased the dry matter content and this influenced the fermentation. Concentration of fermentation products in silages in Mixture 1 and Mixture 2 decreased. We detected decreased creation of lactic acid, the content of volatile fatty acids being on the same level. Lower content of fermentation products in mixed silages was reflected also in pH, which increased. Silage produced from Mixture 1 was incorporated into quality class I and silage produced with Mixture 2 into quality class II. Nutrient content in individual silages is in table 2. Dry matter losses, which arise during the fermentation, varied from 8.14 to 9.98 %.

Table 1 Parameters of fermentation process in ensilaged feeds

Parameter (n = 6)	Maize		Mixture1		Mixture 2	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
pH	3.74	0.02	4.13	0.09	4.27	0.06
Acids (g/kg dry matter)						
Acetic acid	18.85	1.08	18.10	1.23	19.69	1.76
Propionic acid	0.18	0.02	0.52	0.14	1.18	0.24
Butyric acid + i. b,	1.08	0.32	1.34	0.38	1.69	0.20
Valeric acid + i. v.	0.14	0.02	0.23	0.05	0.05	0.01
Caproic acid + i. c.	0.10	0.01	0.03	0.01	0.03	0.01
Volatile fattid acids total	20.35	1.35	20.22	1.58	22.64	2.83
Lactic acid	67.05	1.60	45.31	3.12	36.26	3.21
Fattid acids totall	87.40	1.34	65.53	6.09	58.90	5.85
Alcohol (g/kg dry mater)	5.17	0.33	6.26	0.56	7.89	0.64

Table 2 Content of nutrients in ensilaged feeds in g/kg dry matter

Parameter (n = 6)	Maize		Mixture1		Mixture 2	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Dry matter	266.60	2.69	295.71	4.38	299.75	5.09
Dry matter losses (%)	8.14	1.03	9.23	1.36	9.98	1.58
Organic matter	953.31	0.32	948.66	1.61	946.71	2.34
Crude protein	79.14	1.17	78.05	2.09	80.30	0.89
Crude fibre	204.03	5.94	260.16	3.55	272.19	5.84
ADF	252.37	4.56	304.08	8.77	330.71	6.12
NDF	497.59	6.67	534.16	10.52	558.65	8.75
Hemicellulose	245.22	3.13	230.08	5.94	227.94	3.27
Nitrogen-free extract	639.77	5.22	580.65	7.82	561.78	4.56
Sugars total	3.93	1.26	1.46	0.01	3.82	0.55
Reducing sugars	2.01	1.13	1.01	0.01	2.43	0.95
Fat	30.37	1.12	29.80	0.91	32.44	0.70
Ash	46.69	0.32	51.34	1.61	53.29	2.34

Conclusion

We tested the possibility to ensilage the mixture of silage maize with twigs of oak and spruce as potential supplemental feed for wild ruminants. The additive of forest tree species to maize increases the content of fibre complex, fat and ash in the arising mixed feed; it decreases the concentration of crude protein, yielding nitrogen-free extracts and sugars compared with pure maize. Results of the experiment confirmed that in spite of the investigated nutritive changes it is possible to ensilage the mixture of maize with tree twigs in the ratio 70 % : 30 %.

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Session 3 – Conserved feeds in nutrition of animals

Oral presentation

Performance of lactating dairy cows fed maize silage with increased dosages of *L. buchneri*

Kleinshmitt C., Morais G., Custódio L., Fernandes F., Santos M.C., Daniel J.L.P., Nussio L.G.*

Poster presentations

Comparative description of apparent nutrient digestibility of maize silage derived from 16 different maize hybrids (*in vivo* method)

Lehel L., Hajda Z., Orosz S., Fébel H.

Influence of genotype and ensiling of whole maize plants on starch digestibility

Richter M., Křížová L., Pavlok S.

Performance of feedlot steers fed corn and wheat silage

Jobim C.C., Neumann M., Oliveira M.R., Três T.T., Marafon F., Silva M.S.J., Oliveira T.M.

Comparative description of long chain fatty acid composition in different maize hybrids

Lehel L., Hajda Z., Orosz S., Fébel H.

Strategy of silage feedout and forage inclusion on the performance of lactating dairy cows

Pasetti M., Carvalho P.A., Custódio L., Morais G., Lima J.R., Daniel J.L.P., Santos M.C, Nussio L.G.*

Corn silage as a potential feed in young horses nutrition

Gálik B., Selická A., Bíro D., Rolinec M., Juráček M., Šimko M., Halo M.

Comparison of *in vivo* organic matter digestibility of feed estimates in horses

Kubelková P., Blažková K., Jančík F., Homolka P.

Microhistological faeces analysis as method to estimate tomato pulp silage preference during winter feeding in a game reserve

Fernye C., Galló J., Orosz S., Szemethy L., Katona K.

PERFORMANCE OF LACTATING DAIRY COWS FED MAIZE SILAGE WITH INCREASED DOSAGES OF *L. BUCHNERI*

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Introduction

In the last decade, the use of silage inoculants containing *Lactobacillus buchneri* strains increased steeply, targeting high quality silages with proper aerobic stability during the feedout phase. However, the benefits of *L. buchneri* inoculation seems to be dose-dependent (Kleinschmit and Kung, 2006), at least for silage preservation. On the other hand, there is a claim for possible deleterious effects of acetic acid accumulation on feed intake in silages inoculated with *L. buchneri*. Thus, the objective of this study was to evaluate the effect of *L. buchneri* inoculation rates on quality of maize silages stored in farm-scale silos and on the performance of lactating dairy cows.

Material and Methods

Maize crop was grown at the Department of Animal Science ("Luiz de Queiroz" Campus), and whole plants were mechanically harvested (10 mm theoretical length of cut) when reached 350g DM/kg. Chopped forage was treated and packed in bag silos (1.5 m i.d. by 60 m length, Pacifil®) as follows: no additive (control) or inoculated with *L. buchneri* CNCM I-4323 at a theoretical application rate of 1×10^5 cfu/g of fresh forage (LB1), 5×10^5 cfu/g of fresh forage (LB5), and 1×10^6 cfu/g of fresh forage (LB10). After a 60-d storage period, silos were opened for sampling and fed to dairy cows. Silage samples were analyzed for fermentation end-products by GC and HPLC. To determine the aerobic stability of silage, a portion of the silage mass from each silo (~3 kg) was placed in 20 L buckets, incubated in an environment with 21 to 22°C and monitored for temperature every 15 min. Aerobic stability was defined as the time needed to increase the temperature of the silage 2.0°C above the ambient temperature.

For the lactation trial, 20 lactating Holstein cows (4 primiparous and 16 multiparous) housed in a Tie-stall barn were grouped in five 4 × 4 Latin Squares and randomly allocated in the following treatments: Control diet, LB1 diet, LB5 diet, and LB10 diet. Silages were unloaded twice daily (08:00 and 18:00 h), mixed with concentrates and fed to cows as total mixed rations (53% maize silage, DM basis). Concentrate feeds were corn grain ground, citrus pulp, whole linted cottonseed, soybean meal and mineral-vitamin premix.

Each experimental period had 22 days, with 16 days for adaptation and 6 days for sample collections. Milk yield and dry matter intake were recorded daily, and milk samples were collected for analysis of fat, protein, casein, lactose, urea-N, and somatic cells count at a local laboratory (Clínica do Leite, Piracicaba, Brazil). Milk energy content (Mcal/kg) was calculated as milk $NE_L = 0.00929 \times$ fat (g/kg) + $0.00547 \times$ protein (g/kg) + $0.00395 \times$ lactose (g/kg) (NRC, 2001). Daily excretion of milk energy (Mcal/d) was calculated as milk $NE_L \times$ milk yield.

Data were analyzed using the Mixed procedure of SAS (2001). The degrees of freedom for treatment effect were partitioned into 3 single degree-of-freedom orthogonal contrasts: additive effect (Control vs. LB1 + LB5 + LB10), linear effect of *L. buchneri* dosage, and quadratic effect of *L. buchneri* dosage.

Results and Discussion

The effects of *L. buchneri* on fermentation profile and aerobic stability of maize silages are shown in Table 1. As expected, silages treated with *L. buchneri* had higher concentrations of acetic acid and were more stable during the feed out phase. Similarly, Kleinschmit and Kung (2006) reported higher concentrations of acetic acid and increased aerobic stability in silages treated with increasing levels of *L. buchneri*. The higher concentration of acetic acid in inoculated silages is due to the ability of *L. buchneri* in converting sugars and lactic acid to acetic acid (Pahlow et al., 2003). The current results also showed that silages treated with *L. buchneri* had higher concentrations of propionic acid and propanol and tended to have lower concentration of lactic acid in comparison with untreated silages.

Cows performance, however, was not enhanced with *L. buchneri*. Unlikely, there was a trend for lower feed intake with *L. buchneri* which diminished milk yield and milk constituents (Table 2). Energy efficiency (milk NE_L/DMI) was similar across treatments, thus lower milk yield was related to lower DM intake rather than any difference in silage nutritive value. Several studies have reported the negative impact of diets with high acetic acid concentration on feed intake (Hutchinson and Wilkins, 1971; Daniel et al., 2013), whereas few ones have addressed the impact of *L. buchneri* on DM intake (Kleinschmit and Kung, 2006).

Conclusions

Despite of the typical responses of *L. buchneri* inoculation on maize silage, including increased acetic acid content and higher aerobic stability, cows performance was not enhanced. Unlikely, there was a trend for lower feed intake with

L. buchneri which diminished milk yield and milk constituents. More studies are need to better fine-tuning the optimal dosage of *L. buchneri* to fulfill both silage management and animal requirements.

Table 1 Fermentation profile and aerobic stability of maize silages inoculated with *L. buchneri*.

	Treatment					P-contrast[1]		
Item	Control	LB1	LB5	LB10	SEM	Additive	L	Q
Dry matter, g/kg as fed	332	341	345	339	5.39	0.16	0.76	0.49
pH	3.87	3.85	3.87	3.89	0.03	0.77	0.19	0.98
Lactic acid, g/kg DM	47.0	35.4	31.8	40.0	4.54	0.06	0.46	0.34
Acetic acid, g/kg DM	28.5	40.0	44.4	48.0	4.01	0.01	0.20	0.88
Ethanol, g/kg DM	16.4	9.00	7.00	6.88	1.12	<0.01	0.23	0.46
1,2-Propanediol, g/kg DM	10.5	8.38	15.8	16.3	2.99	0.43	0.12	0.30
Propanol, g/kg DM	3.73	4.83	9.28	9.13	1.62	0.05	0.12	0.20
Propionic acid, g/kg DM	1.55	5.25	4.18	5.80	1.33	0.05	0.74	0.44
Aerobic stability, h	21.5	25.6	67.6	93.9	14.7	<0.01	<0.01	0.16

[1]Additive effect: Control vs. (LB1 + LB5 + LB10), L: linear effect of *L. buchneri* application rate, Q: quadratic effect of *L. buchneri* application rate.

Table 2 Responses of dairy cows fed diets based on maize silages inoculated with *L. buchneri*.

	Treatment					P-contrast		
Item	Control	LB1	LB5	LB10	SEM	Additive	L	Q
DM intake, kg/d	25.63	25.11	25.28	24.57	1.22	0.08	0.19	0.28
Milk, kg/d	35.66	34.13	34.36	33.65	2.43	0.12	0.68	0.68
Fat corrected milk, kg/d	36.43	34.01	34.79	33.69	2.51	0.05	0.78	0.43
Fat, g/kg	36.4	35.1	35.8	35.3	1.19	0.24	0.83	0.51
Fat, kg	1.29	1.19	1.23	1.18	0.09	0.04	0.86	0.34
Protein, g/kg	34.9	33.9	34.8	35.5	0.73	0.74	0.01	0.62
Protein, kg	1.24	1.15	1.20	1.18	0.08	0.08	0.48	0.29
Casein, g/kg	26.8	26.0	26.8	27.3	0.64	0.85	0.02	0.61
Lactose, g/kg	45.5	45.9	45.8	45.4	0.60	0.72	0.39	0.81
Total solids, g/kg	127	125	126	126	1.80	0.23	0.49	0.50
Free fatty acids, mmol/10 L	1.59	1.41	1.42	1.41	0.17	0.29	0.98	0.96
Urea-N, mg/dL	13.22	13.11	13.50	13.34	0.39	0.75	0.56	0.36
SCC, x1000/mL	189	179	149	150	37.2	-	-	-
Log SCC	2.14	2.14	2.05	2.04	0.09	0.48	0.33	0.61
Milk NE_L, Mcal/d	25.26	23.50	24.24	23.50	1.72	0.05	0.95	0.35
Milk NE_L/DMI, Mcal/kg	0.95	0.93	0.95	0.95	0.05	0.84	0.48	0.62

[1]Additive effect: Control vs. (LB1 + LB5 + LB10), L: linear effect of *L. buchneri* application rate, Q: quadratic effect of *L. buchneri* application rate.

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COMPARATIVE DESCRIPTION OF APPARENT NUTRIENT DIGESTIBILITY OF MAIZE SILAGE DERIVED FROM 16 DIFFERENT MAIZE HYBRIDS (*IN VIVO* METHOD)

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Summary

Aim of the study was to determine apparent nutrient digestibility of different maize silage derived from 16 maize hybrids (FAO 420-560) in sheep. The field experiment was executed in farm circumstances (experimental plot: 1 ha/hybrid, 30 cm stubble height) between October 2009 and September 2010. The 16 different types of hybrids were ensiled into plastic barrels (theoretical chop length: 15 mm, net weight: 140 kg/barrel, density range: 168-220 kg DM/m^3, n=5). Authors determined apparent digestibility of dry matter, organic matter, crude protein, crude fiber, crude fat, N-free extract, NDF and ADF of the 16 different maize hybrids in wethers (merino wethers in experimental cages, n=4).

Introduction

Maize silage is the most important feedtsuff from the different type of preserved forages in Hungary. Generally, the maize silage has 30% ration (on dry matter base) in the diet of lactating dairy cows.

The most important parameters what we have to consider during hybrid selection: the green- and dry matter yield, nutrient content and nutrient digestibility. *Carter et al. (1991)* summed up the high-quality corn silage hybrids desirable characteristics: high dry matter yield, preferential crude protein, high energy, good digestibility of nutrients and optimal dry matter content under the harvest. These parameters are essential for appropriate fermentation and feed value.

The study was designed to determine apparent nutrient digestibility of maize silages (dry matter, crude protein, ether extract, crude fiber, nitrogen free extract, organic matter, NDF, ADF) derived from 16 different hybrids (FAO 450-550) grown on the same field (1 ha/hybrid).

Matherials and Methods

The field experiment was performed on Experimental Farm of Szent István University in Hungary (Józsefmajor) between October 2009 and September 2010. Hybrids were grown, cultivated, harvested and ensiled with the same technology (experimental plot: 1 ha/hybrid). Harvest was carried out with a precision chopper harvester on the 1st of September in 2010. The 16 different types of hybrids were ensiled into plastic barrels (theoretical chop length: 15 mm, net weight: 140 kg/barrel, density range: 168-220 kg DM/m^3, n=3).

Apparent nutrient digestibility of maize silage was investigated by the Research Institute of Animal Breeding and Nutrition in Herceghalom (Hungaty). Nutrient digestibility of the different maize silages for ruminants were determined with adult wethers aged between 1-6 years. The mean live weight ranged between 60 and 80 kg. The numbers of animals were 4 regarding one feed. Animals were individually weighed at the beginning and at the end of the trial. The digestibility trial lasted for 17 days, including 10 days of preliminary and 7 days of collection periods. During the collection period feed was fed in measured quantities, the faeces and the urine were collected and the total quantity was weighed once a day. Feeds fed during the digestibility trials were sampled three times, at the beginning of the preliminary periods, at the beginning and at the end of the collection periods. Apparent digestibility of dry matter, crude protein, ether extract, crude fiber, nitrogen free extract, organic matter, NDF, ADF were calculated according to the results.

Results

Results of appearent nutrient digestibility of 16 different maize silages are shown in Table 1. The order of the maize hybrids in Table 1 based on apparent digestibility of organic matter.

Authors have found that the values of apparent digestibility of crude protein (19.1 – 42,2 %), crude fiber (28.9 – 60.7 %), NDF (26.6 – 59.4%) and ADF (24.0 – 50.3%) varied over a wide range.

The apparent digestibility of dry matter had a strong positive correlation with apparent digestibility of crude fiber, NDF, ADF, nitrogen free extract and organic matter. The apparent digestibility of crude protein had a strong positive correlation with apparent digestibility of crude fiber, NDF and ADF.

Conclusion

The authors have found considerable differences among the maize silages derived from 16 different maize hybrids with similar breeding period (FAO 420-560), grown, cultivated, harvested and ensiled with the same technologies.

Table 1 Apparent nutrient digestibility of maize silages derived from 16 different maize hybrids and their correlations (n=3, 2010, Józsefmajor, Hungary)

Hybrid		Dry matter	Crude protein	Ether extract	Crude fiber	Nitrogen free extract	Organic matter	NDF	ADF
2	Mean, %	**64.2**	**39.2**	**78.8**	**59.7**	**72.0**	**66.8**	**59.4**	**50.3**
	SD	1.48	1.98	2.37	7.12	1.40	1.50	2.85	3.55
9	Mean, %	**63.9**	**29.9**	**72.6**	**40.2**	**75.7**	**66.0**	**40.6**	**39.3**
	SD	2.22	5.64	2.08	5.58	2.14	2.51	4.82	5.05
1	Mean, %	**63.5**	**36.7**	**73.6**	**53.3**	**73.0**	**65.9**	**52.4**	**44.6**
	SD	2.39	0.68	4.90	4.36	2.30	2.53	4.48	3.02
3	Mean, %	**62.8**	**40.0**	**82.6**	**60.7**	**69.7**	**65.8**	**55.0**	**45.4**
	SD	1.62	2.78	2.47	4.45	0.92	1.59	3.41	2.42
8	Mean, %	61.2	32.6	75.9	46.7	72.2	63.7	44.6	40.4
	SD	2.35	10.77	2.60	4.54	1.49	2.05	7.63	1.94
11	Mean, %	61.2	32.6	75.9	46.7	72.2	63.7	44.6	40.4
	SD	5.24	3.13	0.99	11.77	3.90	5.55	10.18	9.56
7	Mean, %	60.9	31.2	86.5	38.9	72.4	63.1	37.5	31.4
	SD	1.31	7.75	1.08	2.99	1.51	1.34	2.65	3.27
4	Mean, %	59.8	42.2	85.1	47.2	69.2	62.4	45.8	40.9
	SD	2.29	6.83	5.94	4.84	1.62	2.39	4.82	3.76
6	Mean, %	59.9	27.4	81.7	43.7	71.1	62.4	43.5	35.3
	SD	3.60	3.06	1.19	10.35	2.83	3.99	7.60	8.74
12	Mean, %	58.1	21.9	74.1	43.4	70.5	61.4	53.8	34.5
	SD	4.11	2.22	1.67	5.61	3.92	4.19	6.47	9.29
5	Mean, %	57.8	31.1	81.9	41.1	69.7	61.2	44.4	31.3
	SD	2.29	6.83	5.94	4.84	1.62	2.39	4.82	3.76
14	Mean, %	57.4	22.3	72.7	41.0	69.0	59.8	38.1	36.1
	SD	4.96	3.60	1.88	10.69	4.15	5.48	14.38	8.67
15	Mean, %	56.7	35.3	74.5	33.9	69.0	58.7	40.3	28.9
	SD	2.73	7.29	12.06	5.49	2.22	2.87	5.63	4.45
10	Mean, %	54.6	31.6	81.7	30.7	67.5	56.9	33.6	24.0
	SD	3.81	3.52	5.01	8.41	2.84	4.10	7.72	6.21
13	Mean, %	54.0	19.1	78.4	28.9	67.4	56.3	26.6	26.1
	SD	1.62	5.95	0.61	3.07	1.27	1.64	2.38	2.55
16	Mean, %	54.5	30.8	69.3	37.1	63.9	55.1	41.6	30.3
	SD	0.42	3.17	4.56	1.55	2.39	1.45	1.05	1.59
Minimum		54.0	19.1	69.3	28.9	63.9	55.1	26.6	24.0
Maximum		64.2	42.2	86.5	60.7	75.7	66.8	59.4	50.3
Mean		**59.4**	**31.5**	**77.8**	**43.3**	**70.3**	**61.8**	**43.9**	**36.2**
Standard deviation		3.39	6.54	5.00	9.10	2.76	3.64	8.36	7.35
CV%		5.71	20.75	6.43	21.00	3.93	5.88	19.05	20.31
Correlations (R)									
Dry matter		-							
Crude protein		0.53	-						
Ether extract		0.11	0.32	-					
Crude fiber		**0.81**	**0.61**	0.12	-				
Nitrogen free extract		**0.85**	0.18	0.07	0.43	-			
Organic matter		**0.99**	0.50	0.18	**0.82**	**0.86**	-		
NDF		**0.68**	0.55	-0.03	**0.90**	0.34	**0.70**	-	
ADF		**0.88**	0.57	-0.02	**0.95**	0.56	**0.87**	**0.81**	-

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INFLUENCE OF GENOTYPE AND ENSILING OF WHOLE MAIZE PLANTS ON STARCH DIGESTIBILITY

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ABSTRACT

The objective of this trial was to confirm the effects of genotype (flint, intermediate, dent) and ensiling on the extent of starch digestion of maize whole plants. The field experiment with six maize hybrids from Syngenta company of kernel types: flint (1), intermediate (3) and dent (2) was realized. Fourteen plants of each hybrid with harvest dry matter content of 35 - 40 % from 4 plots were collected. They were cut and a part of matter was ensiled in micro silos. There were determined contents of basal nutrients and starch in the samples of fresh plants and silages. Starch digestibility in both materials was determined using combined in situ – in vitro method. The effect of genotype (flint, intermediate, dent) on starch digestibility (82.2 vs. 91.4 vs. 95.9 %, resp.) was confirmed ($P < 0.01$) only in the case of fresh matter. The silage process generally increased significantly ($P < 0.01$) starch digestibility (91.4 vs. 99.0 %) despite of genotype.

Introduction

Flint maize has a greater proportion of vitreous endosperm than dent maize. Increased kernel vitreousness was associated with decreased ruminal degradation (Philippeau and Michalet-Doureau, 1997) and total-tract digestibility (Bal et al., 1997) of starch. In experiment of Philippeau and Michalet- Doureau (1998) ruminal starch degradability was found to be higher for dent maize than for flint maize before and after the ensiling processing. The objective of this trial was to confirm the effects of genotype (flint, intermediate, dent) and ensiling on the extent of total tract starch digestion of whole maize plants using combined in situ – in vitro method.

Materials and Methods

The field experiment (4 plots (replications)) with six maize hybrids from Syngenta company was realized. Genotypes and names of evaluated hybrids were as follows: flint - NK Cooler, intermediate - NK Silotop, NK Cubic, SY Mascotte and dent - NK Olympic, NK Thermo. Fourteen plants of each hybrid with harvest dry matter content of 35 - 40 % from each plot were collected. They were cut and a part of matter was ensiled (2 months) in micro silos. Dried samples (55 °C, 48 h) were ground through 1 and 5 mm screen for chemical analysis and starch digestibility determination respectively. There were determined contents of selected nutrients (dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), starch) in the samples of fresh plants and silage (Tab. 1). In the case of silage determined content of dry matter was corrected for the loss of volatiles using equation DMcorr [%] = 2,45 + 0,980 DMdet (Weißbach, 2008). Total tract starch digestibility in both materials was determined using combined in situ – in vitro method according to Sapienza (2002) modified by Ngonyamo-Majee et al. (2008). Data of starch digestibility were analyzed using the model $Y_{ijkl} = \mu + G_i + P_j + GxP_{ij} + e_{ij}$ where μ = overall mean, G_i = effect of genotype (i = 1 to 3), P_j = effect of silage process (j = 1 to 2), GP_{ij} = interaction of G by P and e_{ij} = residual error.

Results and Discussion

Average values of nutrient contents in fresh and ensiled maize plants where not statistically compared however we can point out some numerical differences (Tab. 1). Content of harvest DM in flint genotype (394 g/kg) was higher in comparison to intermediate and dent (366 and 360 g/kg, resp.) which could influence monitored parameter: starch digestibility. In the case of starch contents higher values appear generally in ensiled than fresh maize matter (406 vs. 370 g/kg, resp.). Similar tendency (291 vs. 273 g/kg) was found out in work of Cherney et al. (2007).

Table 1 Mean content of selected nutrients in fresh and ensiled matter of whole maize plants with regard of kernel type (standard deviation in parentheses)

Kernel type	DM[1] (g/kg)		OM[2] (g/kg DM)		CP[3] (g/kg DM)		NDF[4] (g/kg DM)		Starch (g/kg DM)	
	Fresh	Ensiled	Fresh	Ensiled	Fresh	Ensiled	Fresh	Ensiled	Fresh	Ensiled
Flint (n = 4)	394 (12)	374 (13)	963 (2)	962 (2)	87 (6)	86 (4)	336 (24)	352 (15)	346 (14)	411 (23)
Intermed. (n = 12)	366 (13)	356 (14)	962 (5)	960 (1)	80 (5)	81 (5)	361 (21)	358 (18)	373 (36)	409 (52)
Dent (n = 8)	360 (10)	358 (14)	959 (2)	961 (1)	75 (4)	75 (3)	381 (27)	368 (17)	377 (33)	399 (38)
Mean (n = 24)	369 (16)	360 (15)	961 (4)	961 (1)	80 (6)	80 (5)	364 (27)	360 (17)	370 (33)	406 (43)

[1] dry matter, [2] organic matter, [3]crude protein, [4] neutral detergent fiber

The effect of genotype (flint, intermediate, dent) on starch digestibility (82.2 vs. 91.4 vs. 95.9 %, resp.) was confirmed (P < 0.01) only for fresh matter (Tab. 2). Very low value found in flint genotype was probably caused by higher harvest DM in consequence of higher vitrousness at later maturity (Philippeau and Michalet-Doureau, 1997) as mentioned above. Our results are in agreement with lower effective ruminal starch degradability of fresh maize grains of flint (61.6 %) against dent (72.3 %) genotype harvested at silage maturity determined by Philippeau and Michalet-Doureau (1998). In the case of silage no difference in starch between genotypes digestibility was detected which is however in disagreement with results of Philippeau and Michalet-Doureau (1998) who found out difference in effective ruminal starch degradability between ensiled flint (67.0 %) and dent (78.6 %) maize grains. Despite of genotype the silage process generally increased starch digestibility (91.4 vs. 99.0 %, P < 0.01) as was confirmed by Jensen et al. (2005).

Table 2 Influence of genotype and ensiling of whole maize plants on starch digestibility

Kernel type	**Starch digestibility (%)**		**P**
	Fresh	**Ensiled**	
Flint (n = 4)	82.2^{a}	99.1	< 0.0001
Intermed. (n = 12)	91.4^{b}	98.9	< 0.0001
Dent (n = 8)	95.9^{c}	98.9	0.0406
Mean (n = 24)	91.4	99.0	0.0026
P	< 0.0001	0.7931	

[a, b, c] Means within a column with different superscripts differ (P < 0.05)

Conclusions

The effect of genotype (flint, intermediate, dent) on starch digestibility was confirmed only for fresh whole maize plants with increasing values in rank from genotype flint to dent. Despite of genotype the silage process generally increased starch digestibility

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PERFORMANCE OF FEEDLOT STEERS FED CORN AND WHEAT SILAGE

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Introduction

In the south of Brazil there are extensive agricultural areas that are left idle during the winter. So, the production of wheat silage can play an important role, since, in addition to enabling more efficient use of the land, it can ensure the production of high quality roughage.

However, in Brazil, the cultivation of winter cereals for silage production is still little explored. There are few studies that assess the potential effects of wheat silage on the animal performance.

The aim of the study was to evaluate the replacement of corn silage by wheat silage in diets of feedlot steers, as well as the effect of the use of inoculant in the winter cereal ensilage.

Materials and Methods

The experiment was conducted in the State University of the Midwest (UNICENTRO) and the State University of Maringá (UEM).

For the silages production, cv. BRS Umbu wheat (spike without awn) and corn (hybrid AG-8088) were cultivated. The roughage was harvested and processed with the aid of a silage cutter machine with adjustment for medium size particle, between 8 and 12 mm. The silages were stored in three trench type silos, measuring 3.5 m wide, 1.2 m high and 11 m long.

Were used 24 steers (Charolais x Nellore) with an initial average age of 12.3 ± 1.1 months, initial body weight of 384 ± 2.1 kg, fed ad libitum and distributed by weight and body condition in an completely randomized experimental design. The experiment lasted 100 days, with 16 days of adaptation and four periods of 21 days.

The evaluated treatments were the use of wheat silage (WS), wheat silage with bacterial inoculant (*Lactobacillus plantarum* and *Pediococcus acidilactici*, with 1.0×10^5 CFU.g^{-1}) (WSI), and corn silage (CS), in a diet with 50% roughage and 50% concentrate (based on the diet DM). The adjustments in dry matter offered for the steers were performed daily, considering an additional of 5% over intake observed, in order to maintain the constant inclusion of roughage and concentrate.

The evaluated variables were dry matter intake (DMI), neutral detergent fiber intake (NDFI) and crude protein intake (CPI). On animal performance efficiency and feed conversion, average daily weight gain (ADG), feed efficiency (FE) and protein efficiency (PE) were evaluated.

The design was completely randomized with four replications. The collected data for each variable were subjected to variance analysis with means comparison at 5% of significance, through the SAS (1993).

Results and Discussion

Wheat silages were nutritionally inferior (P <0.05) to corn silage, justified by changes in the morphological components of the plants, which is directly related to the fiber fraction and energy density of the silages (Table 1).

Table 1 Chemical composition of corn silage and wheat silages with and without inoculant (g DM / kg DM)

Variable	Silage			
	WS[a]	WSI[b]	CS[c]	MSE[1]
Dry matter	400	417	404	0.01
Neutral detergent fiber	526a	530[a]	467b	9.67
Crude protein	100a	96[a]	60b	0.20
Starch	183b	192b	295[a]	2.34

Means followed by different letters in the line are statistically different (5% of probability); [a] WS = wheat silage; [b] WSI = wheat silage with inoculant; [c] CS = corn silage; [1]MSE – mean standard error

There was higher (P <0.05) DMI, NDFI and CPI for corn silage in relation to wheat silages with and without inoculation (Table 2). The higher consumption observed for the corn silage, may possibly be explained because it is a feed with higher energy density and fiber digestibility. However, Walsh et al. (2008) studied diets with inclusion of wheat silage and corn silage and did not found differences in relation to DMI. On the other hand, Addah et al. (2011) reported that the use of inoculants in barley and corn silage did not affect DMI, ADG and feed efficiency for feedlot steers. Faced with these situations, possibly part of the variations to the results found in the literature could be attributed to differences in the nature of diets, such as the roughage quality used and potential gain of the animal.

There was no significant effect of treatments (P> 0.05) on ADG, FE and PE. The results show that the higher energy density in corn silage produced an increase in CMS, without effect on ADG.

Table 2 Nutrient intake and performance of feedlot steers containing corn silage and wheat silage with and without inoculant as roughage.

Variable	DIET			MSE[1]
	WS[a]	WSI[b]	CS[c]	
Intake				
Dry matter (kg)	10.19b	11.03b	12.79a	0.48
Neutral detergent fiber (kg)	4.03b	4.41b	5.07[a]	0.03
Crude protein (kg)	1.39b	1.27b	1.64[a]	0.02
Performance and feed efficiency				
Final weight (kg)	476.00	485.00	498.00	0.04
Average daily gain (kg/animal)	1.57	1.58	1.81	0.03
Feed efficiency (kg ADG/kg DM)	0.15	0.15	0.14	0.05
Protein efficiency (kg ADG/kg CP)	1.14	1.24	1.11	0.02

Means followed by different letters in the line are statistically different (5% of probability); [a] WS = wheat silage; [b] WSI = wheat silage with inoculant; [c] CS = corn silage; [1]MSE – mean standard error.

In the present study, the replacement of corn silage by wheat silage decreased DMI, but did not affect the other studied variables.

Conclusions

The replacement of corn silage by wheat silages in diets of feedlot steers provides corresponding animal performance.

The use of microbial inoculant on wheat silage, showed no beneficial effect on the performance of feedlot steers.

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COMPARATIVE DESCRIPTION OF LONG CHAIN FATTY ACID COMPOSITION IN DIFFERENT MAIZE HYBRIDS

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Summary

The aim of recent study was to compare 16 different maize hibrids (FAO 420-560) according to the actual long chain fatty acid composition. Dry matter range was found 292-386 g/kg. Total fatty acid content was found between 6.14-13.27 mg/g in the case of 13 different hibrids, while it was considerably higher in four special maize hibrids (20.6-31.0 mg/g). Linoleic acid was the dominant long chain fatty acid with range of 1.95-4.79 mg/g, oleic acid content was between 2.62-8.89 mg/g, palmitic acid concentration was found in the range of 1.95-4.79 mg/g, while linolenic acid content was found 0.98-1.93 mg/g in the 16 different maize hybrids.

Introduction

In the dry continental Central-European area, the key forage crop is silage maize. Generally, the ratio of maize silage in the dairy cow diet is approx. 30% (on dry matter base) in Hungary. Therefore key issue is to use modern maize hybrids adapted to the dry ecological conditions, hybrids should be heat- and drought-tolerant, providing high yield and adequate nutrient composition for cost effective milk production. Maize silage fed in approx. 20 kg/day/cow has hugh effect on ruminant digestive physiology, metabolic processes and reproductive biology.

Most of the unsaturated fatty acids in the rumen are saturated by rumen microflora. The rumen microorganisms produce conjugated linoleic acid (as an intermediate product) according to the linoleic biohidrogenization pathway. The long chain fatty acids are not absorbed in the rumen, digestion and absorbtion will happen in the abomasum and small intestine. Therefore, the digestible fat is not energy source for rumen microorganisms.

Total ether extract (crude fat) intake is approximatelly 800-1500 g/day/cow in Hungary. Generally, 7 kg dry matter of maize silage is fed by a lactating dairy cow, therefore the daily diet contains 200-250 g ether extract/day/cow derived from maize silage, as natural fat source. It is 15-25% of the total ether extract intake. Silage from a high-oil blend increased fat-corrected milk yield in a trial compared to the conventional hybrid (*Weiss and Wyatt, 2000*). However, there is no evidence that high-oil silages are consistently nutritionally superior to silages made from normal hybrids (*Allen et al., 2003*). There is limited information regarding the amount and ration of saturated and unsaturated long chain fatty acids in the silage maize plant. Not well known, what happpen with the saturated and unsaturated long chain fatty acids during the fermentation in the silage and its effect on by-pass profile in rumen of the different long chain fatty acids.

The study was designed to compare the long chain fatty acid composition of 16 different maize hybrids (FAO 420-560) derived from the same filed (experimental plots: 1 ha/hybrid). The different maize hybrids were grown, cultivated and harvested with the same technology. There were 12 commercial hybrids in the trial (1, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, and 17), while 4 hybrids were specially developed for higher long chain fatty acid composition (2, 3, 4, 5).

Materials and Methods

The field experiment was performed on the Experimental Farm of Szent István University in Hungary (Józsefmajor) between October 2009 and September 2010. Hybrids were grown, cultivated and harvested with the same technology. Harvest was carried out with a precision chopper harvester on the 1st of September in 2010.

Analysis of the long chain fatty acid composition of the16 green maize hybrids were carried out in the Research Institute of Animal Breeding and Nutrition in Herceghalom. The fatty acid methyl esters were directly chromatographed.

Results and Discussion

Long chain fatty acid composition of the 16 different maize silage hybrids are shown in Table 1 and 2.
Dry matter range of the different hybrids was found 292-386 g/kg. Total fatty acid content was found between 6.14-13.27 mg/g in the case of 13 different hibrids, while it was considerably higher in four special maize hibrids (20.6-31.0 mg/g).

Linoleic acid was the dominant (6.14-13.27 mg/g forage) among the long chain fatty acids. The oleic acid (2,62-8,89 mg/g forage) was the second, while palmitic acid was the third most abundant long chain fatty acid (1,95-4,79 mg/g forage) in the green plant. The fourth most important fatty acid was the linolenic acid (0,98-1,93 mg/g forage).

Table 1 Long chain fatty acid composition of 8 different maize hybrids (2010. Józsefmajor, Hungary)

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**
				mg/g forage				
C12:0 (Lauric acid)	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04
C14:0 (Mirisztic acid)	0.05	0.08	0.06	0.06	0.06	0.05	0.05	0.05
C15:0 (Pentadekanoic acid)	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01
C16:0 (Palmitic acid)	**2.29**	**3.73**	**3.25**	**4.29**	**4.79**	**2.39**	**2.26**	**2.17**
C16:1n-7 (Palmitoleic acid)	0.07	0.11	0.09	0.12	0.08	0.06	0.06	0.07
C17:0 (Heptadekanoic acid)	0.04	0.07	0.06	0.07	0.06	0.04	0.04	0.04
C18:0 (Stearic acid)	0.32	0.61	0.56	0.78	0.69	0.34	0.33	0.36
C18:1n-9c (Oleic acid)	**3.08**	**5.99**	**6.15**	**8.71**	**8.89**	**3.38**	**3.14**	**2.62**
C18:2n-6c (Linoleic acid)	**7.14**	**10.05**	**9.10**	**13.27**	**15.13**	**8.11**	**7.30**	**6.14**
C18:3n-6 (γ-Linolenic acid)	0.11	0.19	0.17	0.21	0.19	0.12	0.11	0.12
C18:3n-3 (α-Linolenic acid)	**1.42**	**1.93**	**1.09**	**1.24**	**1.10**	**1.09**	**1.07**	**1.25**
Total fatty acid	**14.57**	**22.83**	**20.59**	**28.80**	**31.03**	**15.63**	**14.42**	**12.87**

Table 2 Long chain fatty acid composition of 8 different maize hybrids (2010. Józsefmajor, Hungary)

	9.	**10.**	**11.**	**13.**	**14.**	**15.**	**16.**	**17.**
				mg/g forage				
C12:0 (Lauric acid)	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05
C14:0 (Mirisztic acid)	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06
C15:0 (Pentadekanoic acid)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C16:0 (Palmitic acid)	**2.98**	**2.41**	**2.57**	**2.59**	**2.82**	**2.25**	**1.95**	**2.41**
C16:1n-7 (Palmitoleic acid)	0.05	0.07	0.07	0.07	0.07	0.08	0.06	0.07
C17:0 (Heptadekanoic acid)	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05
C18:0 (Stearic acid)	0.38	0.32	0.30	0.34	0.36	0.35	0.35	0.35
C18:1n-9c (Oleic acid)	**4.58**	**2.78**	**3.61**	**3.62**	**3.98**	**2.89**	**2.77**	**2.98**
C18:2n-6c (Linoleic acid)	**9.42**	**6.93**	**8.18**	**8.00**	**8.47**	**6.74**	**6.40**	**7.27**
C18:3n-6 (γ-Linolenic acid)	0.13	0.10	0.11	0.11	0.12	0.12	0.12	0.12
C18:3n-3 (α-Linolenic acid)	**1.10**	**1.59**	**1.49**	**1.00**	**0.98**	**1.24**	**1.18**	**1.48**
Total fatty acid	**18.78**	**14.38**	**16.48**	**15.86**	**16.93**	**13.82**	**12.98**	**14.87**

Conclusions

It was found that the linoleic acid, oleic acid, palmitic acid and linolenic acid presented in the highest amount in the green maize hybrids among the other long chain fatty acids. The palmitic acid, as saturated long chain fatty acid may have a positive effect on milk fat production theoretically, but concentration was very low in the tested 16 maize silages.

Authors summmarized that there were no significant differences in long chain fatty acid composition among the tested commercial maize hybrids grown, cultivated and harvested with the same technology. Total fatty acid content, consequently linoleic acid, oleic acid, palmitic acid and linolenic acid concentration was higher in the four special maize hibrids developed for high-oil content compared to the commercial hybrids.

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STRATEGY OF SILAGE FEEDOUT AND FORAGE INCLUSION ON THE PERFORMANCE OF LACTATING DAIRY COWS

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Introduction

Corn silage is the most important forage source in dairy farms and much of this silage is stored in horizontal silos (Savoie and Jofriet, 2003). However, silos design allows large surface areas to be exposed to the environment and prone to spoilage, especially in the upper layer (Ashbell and Kashanci, 1987). Thus, silage from upper parts of silo might be of poor quality compared to those from bottom zone, and may have a negative impact on the animal performance. Therefore, the aim of this study was evaluate performance of dairy cows fed diets containing corn silages from different zones of the silo face with two dietary levels of forage inclusion.

Material and Methods

Twenty lactating Holstein cows were housed in a tie-stall barn and allocated in five 4×4 Latin Squares, with a 2×2 factorial arrangement (silage from top vs. bottom; 500 g/kg vs. 600 g/kg DM forage). Silages were unloaded twice daily, mixed with concentrates and fed to cows as total mixed rations twice daily (08:00 and 18:00 h) allowing at least 100 g/kg as orts. Concentrate ingredients were corn grain ground, soybean meal, citrus pulp, whole linted cottonseed and mineral-vitamin premix. Milk yield and dry matter intake were recorded from d-14 to d-21 in each period. Milk samples were collected from d-15 to d-19 for analysis of fat, protein, casein, lactose, urea-N, and somatic cells count at a local laboratory (Clínica do Leite, Piracicaba, Brazil). Milk energy content (Mcal/kg) was calculated as milk NEL = 0.00929 × fat (g/kg) + 0.00547 × protein (g/kg) + 0.00395 × lactose (g/kg) (NRC, 2001).

Results and Discussion

The influence of silage source and forage:concentrate ratio on performance of cows are shown in Table 1. As expected, the lower F:C ratio improved the DMI and, in turn, increased the milk yield. Furthermore, high concentrate diets reduced milk urea-N concentration, which could indicate a lower N excretion to the environment (Powell et al., 2011). However, energy efficiency, indicated as milk NEL/DMI, was enhanced by increased forage level.

Likewise, silage feedout strategy changed the performance of the animals. Contrary to the expectation, cows fed diets based on silage from the bottom zone had lower DMI and, hence, lower milk yield compared with cows fed silage from the top layer. Curiously, energy efficiency (milk NEL/DMI), which is an indicator of nutritive value of the diets, was similar across silage sources. Thus, silage from the top was not worse than the silage from the bottom. As it might be expected, in the current study, ensiling and sealing processes were very efficient, probably, mitigating silage spoiling in the top zone. Anyhow, animals fed bottom silage had lower DMI, which may be associated with the higher ($P<0.01$) acetic acid content in bottom silage (25.3 vs. 21.3 g/kg DM; data not shown). Previous studies have reported the negative impact of high acetic acid concentration on feed intake and the ingestive behavior of ruminants (Hutchinson and Wilkins, 1971; Hetta et al., 2007; Daniel et al., 2013).

Conclusions

In well preserved silages, differences between top and bottom zones of the silo are negligible due to the good sealing conditions. One more kilogram of dry matter intake with 1.4 kg higher milk yield were achieved by reducing forage inclusion from 600 g/kg to 500 g/kg DM in dairy cows.

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Table 1 Performance of dairy cows fed corn silage from top or bottom of bunker silo within forage inclusions rater.

Silage source	Top		Bottom			P-value[1]		
Forage:concentrate ratio	50:50	60:40	50:50	60:40	SEM	S	F:C	S × F:C
DMI[2], kg/d	23.2	22.5	22.2	21.2	0.91	<0.01	<0.01	0.82
Milk yield, kg/d	31.6	31.0	30.8	29.5	3.63	<0.01	0.04	0.38
Fat, g/kg	35.4	35.3	35.8	36.7	1.27	0.16	0.50	0.44
Fat, kg/d	1.10	1.07	1.09	1.07	0.12	0.81	0.34	0.70
Protein, g/kg	33.2	33.0	33.4	33.5	0.78	0.17	0.83	0.43
Protein, kg/d	1.03	1.01	1.01	0.97	0.11	<0.01	0.40	0.55
Casein, g/kg	25.4	25.3	25.8	25.8	0.75	0.11	0.90	0.90
Lactose, g/kg	452	453	448	448	0.78	0.13	0.89	0.99
Total solids, g/kg	123	123	124	125	1.61	0.22	0.58	0.43
SCC[3], ×1000 mL	134	131	152	134	28	-	-	-
Log SCC	1.96	1.98	2.07	1.98	0.10	0.14	0.35	0.20
MUN[4], mg/dL	14.9	15.8	14.7	15.5	1.23	0.38	0.01	0.73
Milk NE_L, Mcal/kg	0.690	0.690	0.690	0.700	0.014	0.17	0.59	0.37
Milk NE_L, Mcal/d	21.6	21.2	21.2	20.9	2.40	0.13	<0.01	0.86
Milk NE_L/DMI[5], Mcal/kg DM	0.930	0.970	0.950	0.970	0.101	0.37	<0.01	0.83

[1]S = silage source (top vs. bottom zone), F:C = forage:concentrate ratio (500 vs. 600 g/kg DM), S × F:C = interaction.
[2]Dry matter intake.
[3]Somatic cell count.
[4]Milk urea nitrogen.
[5]Energy efficiency.

CORN SILAGE AS A POTENTIAL FEED IN YOUNG HORSES NUTRITION

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Abstract

The aim of the experiment was to study the digestibility of some organic nutrients of corn silage for young horses. Crude fibre, total sugars, starch, acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined. In the trial 4 young horses was used, Slovak warm-blood bred, average body weight 350±25 kg. Apparent digestibility, total faeces collection was analysed. Corn was harvested at the period of the milk-wax corn maturity; average length of cut was 20 mm. Silage was conserved in silage bunker without additives. Any health problems or metabolic diseases were observed during the experiment. In crude fibre faecal digestibility ranged from 24.61 to 55.19 %, in average crude fibre digestibility was 42.35 %. In total sugars was found faecal, apparent digestibility 78.73 % in average. Starch faecal digestibility coefficients were detected between 97.71 and 100 %. In ADF was found faecal apparent digestibility coefficient 38.34 % in average, in NDF was found average faecal digestibility coefficient 46.36 %. On the results base, the corn silage is useful feed in young horses nutrition, especially as a part of feed ration.

Keywords: *nutrition, equine, forages, corn silage, digestibility*

Introduction

Horses performance is affect by several factors. Important exogenous factor is nutrition, mainly the quality of feed represent in nutritive value and digestibility. There are many methods for feeds digestibility evaluation in horses nutrition. Generally, *in vivo* methods are essential for their validity (Miraglia et al., 1999). Corn silage as a feed for horses is unusual in central Europe. In this region is sometimes use in cold-blood horses feeding (Halo et al., 2009; Gálik et al., 2011), however Blažková et al. (2009) reported, that maize silage with adequate quality is suitable feed in nutrition of horses.

Materials and Methods

The aim of the study was to determine corn silage digestibility for horses. The experiment was realized in University Experimental Farm Kolinany of the Slovak University of Agriculture in Nitra. Total faeces collection method was use. In the experiment were 4 stallions observed (bred Slovak warn-blood, average age 2.5±0.5 years, average body weight 350±25 kg). Stallions were housed individually in boxes with *ad libitum* water intake. After the preparatory period (7 days) were stallions fed only with corn silage per 5 days; feed rations were formulated according daily nutrient requirement (NRC, 2007). Corn was harvested at the vegetation period of the milk-wax maturity of corn, at the dry matter content 36.23 %. Corn silage was analyzed for nutrients content by standard methods (AOAC, 2000). Nutritive value of maize silage was: digestible energy 11.66 $MJ.kg^{-1}$, crude protein 74.1 $g.kg^{-1}$, crude fat 27.1 $g.kg^{-1}$, crude fibre 198.3 $g.kg^{-1}$of dry matter.

Crude fibre, total sugars, starch, ADF and NDF faecal digestibility was performed. In average sample of corn silage and daily faeces (individually) were these nutrients analysed by standard laboratory methods (AOAC, 2000). Daily was analysed feed intake.

Coefficients of digestibility were calculated by the formula:
%D = (Intake-Faecal Excretion)/ Intake x 100

To calculate basic statistic characteristics, determine significance of differences and compare the results the analysis of variance, one-way ANOVA and t-test were performed using a P level less than 0.05. The SAS statistical package was used (SAS Inc., New York City, USA).

Results and Discussion

There are many factors, which could affect feed digestibility in diet for horses, such as diet composition, level of intake, content of digestible and non-digestible nutrients and others (Radicke et al., 1991; Gálik et al., 2011). Generally, in the world there are few studies about corn silage digestibility for horses. Coefficients of digestibility of observed nutrient are shown in Table 1.

In crude fibre, we found average faecal digestibility coefficient 42.35 %. Similar crude fibre digestibility coefficient was found by Santos et al. (2002) in similar trial, but with growing horses and with high moisture corn silage, a feed with lower crude fibre content. Starch is in horses nutrition important source of energy (Gálik et al., 2011). Santos et al. (2002) reported, that starch from corn silage in by horses digestible at 100 %. In our experiment, we found faecal starch digestibility coefficients from 97.71 to 100 %, in average 99.71 %. Corn is rich in total sugars also (Bíro et al., 2010), which is easy to digestibility for horses. During the experiment with young horses, which were fed by corn silage diet only, we found faecal total sugars digestibility 78.73 % in average. In ADF faecal digestibility we found coefficients from 19.77 to 49.60 %. Santos et al. (2002) analyzed high moisture corn silage digestibility for growing horses. These authors reported, that in average is ADF from high moisture corn silage digestible in 32.31 %, which is in congruence with our results. One factor of the quality of feed in horses nutrition is content of NDF. In nutrient we found faecal digestibility for young horses in 46.36 % in average. Very similar NDF digestibility coefficient for horses was publish by Santos et al. (2002).

Table 1 Faecal digestibility coefficients of corn silage for young horses (in %)

	Crude fibre	**Starch**	**Total sugars**	**ADF**	**NDF**
Mean	42.35	99.71	78.73	38.34	46.36
S.D.	8.70	0.59	11.26	7.93	15.35
Min.	24.61	97.71	60.88	19.77	13.07
Max.	55.19	100	100	49.60	62.69

ADF: acid detergent fibre, NDF: neutral detergent fibre, S.D.: standard deviation

Conclusions

The target of study was to analyze crude fibre, starch, total sugars, ADF and NDF digestibility of corn silage for young horses. During the trial we didn´t find health or metabolic problems of animals. We found high digestibility of starch and total sugars, as an energy nutrients for horses. In this way, corn silage with adequate nutritive and hygienic quality can be use in young horses nutrition as a potential feed, mainly as a part of feed ration.

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COMPARISON OF *IN VIVO* ORGANIC MATTER DIGESTIBILITY OF FEED ESTIMATES IN HORSES

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Introduction

Horses are normally fed a mixture of hay and cereals to meet the high energy requirements. Grass hay has been traditionally used as a basal diet for horses. Grass silage is considered to be too low pH and too high moisture content for horse feed (Pillner, 1992). However, recent research has found no negative effects of grass silage on digestive efficiency and health in horses (Moore-Colyer and Longland, 2000; Miyaji et al., 2003). So, silage and haylage can replace dry hay partially or totaly in horse diets and their use has increased. Oats are highly palatable and have a higher fiber and lower energy content (NRC, 2007; DE 3.67).

The objective of this study was to compare nutrient content in feeds, fed to horses, and then to compare organic matter digestibility, obtained from *in vivo* experiments.

Material and Methods

Two groups with unequal number (5 and 8 horses) were used for 14-days lasting adaptation followed by two experimental periods, lasting 3 days. Tested diets were maize silage, hay and oat, grass silage and grass hay. All feeds were grown and made in farm of Institute of Animal Science and were provided in 2 equal meals. Orts were collected and weighed daily throughout the adaptation phase to monitoring of consumption. During each 6-d collection phase, offered feed and remaining orts were measured daily to determine intake. Additionally, feces were collected each day, weighed and mixed. Ten percent of feces were taken away, immediatelly frozen for subsequent laboratory analysis.

Freeze-dried and milled samples was analysed according to AOAC (2005) methods. Residual moisture of the samples was determined by oven drying for 6 h at 105°C. Ash was determined after 6 h at 550°C and ether extract (EE) after 6 h extraction with petrleum-ether. Nitrogen was determined using a Kjeldahl method according to method 976.05 by Association of Official Analytical Chemists (AOAC, 2005) and crude protein (CP) was calculated as N x 6.25. The NDF concentration (Van Soest et al., 1991) of feed samples, residues and faeces was analyzed in the presence of sodium sulphite and α-amylase treatment and is presented ash-free. The ADF and lignin was determined according to AOAC Official Method 973.18 AOAC, 2005) and is presented also ash-free. Detergent analyses were performed in an Ankom 220 Fiber Analyzer (Ankom Technology Corporation, NY, USA). A fresh silage sample was analyzed for fermentation quality (pH, concentrations of lactic, acetic and butyric acids) according to Kvasnička (2000) using IONOSEP 2001 analyzer (RECMAN – laboratory systems, Ostrava, Czech Republic).

Normality of values was evaluated with the Shapiro-Wilk test (SAS Institute, 2000). The whole data were analysed with MIXED procedure of SAS and when differences among variables were significant at the 0.05 level, Tukey's *post hoc* test was used to compare means among groups.

Results and Discussion

The amount of organic matter (OM) and crude protein (CP) didn't differ between tested diets. The higher CP content in grass silage, compared with hay, was observed in study of Bergero and Peiretti (2011). This difference could be ascribed to the presence of legumes in the permanent meadow and to a greater loss of leaves as a consequence of haymaking. The amount of dry matter (DM) in maize silage was the lowest and differed from other diets; no variations were observed between grass hay with or without oat.

Table 1 Assessment of parameters of chemical composition and organic matter digestibility of tested diets of horses.

	Feed				
Parameter	Maize silage	Hay and oat	Grass silage	Grass hay	se
DM (g/kg)	346^{a}	867^{c}	488^{b}	844^{c}	9.5
OM (g/kg DM)	947	918	853	905	22.2
CP (g/kg DM)	94.2	104	116	98.4	3.6
CF (g/kg DM)	185^{a}	318^{b}	257^{b}	313^{b}	9.5
NDF (g/kg DM)	395^{a}	526^{b}	517^{b}	653^{c}	17.1
ADF (g/kg DM)	223^{a}	286^{b}	318^{c}	373^{d}	4.6
ADL (g/kg DM)	31.5^{b}	52.1^{d}	27.7^{a}	37.2^{c}	0.5
EE (g/kg DM)	23.3^{b}	18.8^{ab}	18.3^{ab}	15.0^{a}	0.9
OMD (g/kg)	659^{b}	524^{a}	649^{b}	519^{a}	11.5

^{a,b,c,d} Within a row, estimates lacking common superscripts differ ($P < 0.05$).

Also content of neutral (NDF) and acid detergent fiber (ADF) was the lowest in maize silage; hay and oat and grass silage had the similar amount of NDF. All diets differed in amount of ADF – the lowest had maize silage and the highest grass hay. By contrast, the smallest content of acid detergent lignin (ADL) was observed for grass silage samples and the highest for diet with hay and oat.

The organic matter digestibility of silages (grass and maize) was higher (statistically significant) than digestibility of diets, based on grass hay. This may be caused by lower part of lignin in these diets. Morrow et al. (1999) reported that, for ponies, grass silage is a more digestible fodder as compared with hays.

Conclusions

Amount of organic matter and crude protein in feed didn't differ; differences were observed in amount of fiber fractions and ether extract. Higher organic matter digestibility was observed in non-typical feeds for horses (maize and grass silages) compared to typical (hay and hay and oat) rations.

Acknowledgments

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MICROHISTOLOGICAL FAECES ANALYSIS AS METHOD TO ESTIMATE TOMATO PULP SILAGE PREFERENCE DURING WINTER FEEDING IN A GAME RESERVE

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Introduction

The supplementary winter feeding is a widespread practice in Europe and parts of North America. The role of feeding are maintain the high game population density, maintain their body condition, increase the hunting success, achieve bigger trophies or reduce the winter mortality. Feeding may also be carried out to reduce the environmental damages caused by game species during winter (Putman and Staines 2004). However the role of feeding is not always clear. Investigations in free-ranging populations showed that only a part of red deer individuals consumed the supplementary feed, and only in a low proportion (Katona et al. 2010). Supplementary food can be very expensive, and it is a basic question whether the animals consume it or not. The secondary products from the food industry can provide potential winter extra-food for game species due to their relatively low price and valuable nutrient contents. To know whether the tomato pulp can be utilisable food for game we have to “ask the animals” and collect information about their diet composition. This secondary product was considered as a waste of the manufacturing process. However, it has a high lycopene, ascorbic acid and antioxidant content (Toor and Savage, 2005). Therefore it can become potential food for ungulates. Our research team carried out an investigation about the utilisation of tomato pulp silage as a supplementary feed for game.

Materials and Methods

Study area

The study was carried out in a game preserve in Bárna. The preserve located in the North Hungarian Mountains. In the game preserve (300 ha) five game species were present: the red deer (*Cervus elaphus*, 60-70 individuals estimated) the fallow deer (*Dama dama*, 30-40 individuals) the mouflon (*Ovis aries*, 30-40 individuals) the Pere David’s deer (*Elaphurus davidianus*, 8-9 individuals) and the wild boar (*Sus scrofa*, 200 individuals). The forest cover in the area is 82%. The main tree species are the turkey oak (*Quercus cerris*, 30%), the Scots pine (*Pinus sylvestris*, 25%) and the black locust (*Robinia pseudoacacia*, 15%). The dominant shrubs are blackthorn (*Prunus spinosa*), hawthorn (*Crataegus monogyna*) and blackberry (*Rubus* spp.).

Field studies

The study was conducted from December 2010 May 2011. In this period 44 bales of tomato pulp silage (each was about one ton) were placed on six feeders in the game preserve. Faecal droppings were collected within a transect line of five meters width between the feeders five times during the feeding period. The faecal pellets were taken into plastic bags and kept in a freezer until further processing.

Diet composition analysis

The diet composition of game species was determined by microhistological faeces analysis (Katona and Altbäcker, 2002). For analysis the samples were thawed at room temperature. A small subsample of these faeces was boiled in 2 ml of HNO_3 for 3 minutes. Epidermis fragments were removed and dispersed into a mixture of 0.1 ml glycerine and 0.05 ml of 0.2% Toluidin-Blue and placed in slides. Microscopic slides were covered and examined by systematic scanning under 100X and 400X magnifications. One hundred epidermis fragments were identified on slides using a reference collection of plant species collected from the study area. Proportion of diet components were estimated as the number of fragments for a particular forage class relative to the total number of fragments. Identified categories were: tomato, maize, corn, grasses, forbs, browse species. Statistical analyses were made with the InStat program. The normality of data was determined by Kolmogorov-Smirnov tests. Statistical comparisons were carried out by parametric unpaired t-test or one-way ANOVA test with Tukey post-hoc test or nonparametric Kruskal-Wallis test with Dunn post hoc test.

Results

In Bárna area 57 individual faecal samples were analyzed. All of these samples contained tomato. In 64 % of these faeces tomato was the dominant food component (36-87%). The Pere David’s and red deer consumed the tomato pulp in highest proportion, while mouflon in the lowest proportion (Kruskal-Wallis test: KW=15.818, $p<0.001$, Dunn post-hoc test: red deer vs. mouflon: $p<0.01$, Pere David’s deer vs. mouflon: $p<0.01$, others: ns.). The proportion of tomato has significantly decreased in the diet during the feeding period (Kruskal-Wallis test: KW=29.920, $p<0.001$, Dunn post-hoc test: May vs. February: $p<0.001$, May vs. April $p<0.001$, others: ns.). At the same time the proportion of forbs has significantly increased in the diet (Kruskal-Wallis test: KW=32.428, p<0.001, Dunn post-hoc test: May vs. December: p<0.001, May vs. January: p<0.001, May vs. February: p<0.001, May vs. April: p<0.001, others: ns.).

Conclusions

Our results suggest that supplementary winter feeding could be very important for large game species in intensively managed game preserves with dense game populations. We found that the studied species consumed the tomato pulp in high proportion. This rate of consumption was much higher than we found earlier in free-living deer populations (less than 10%, Katona et al., 2010). However, our result does not necessary mean that the tomato pulp is an optimal food. It is also possible that tomato pulp was a food, which was available in a greater amount in the game preserve and its consumption did not cause any significant wildlife health problem. Large herbivores generally forage on different shrubs of understory, e.g. elderberry or blackberry. Hawthorn and blackthorn, dominant species of the studied preserve, were not among usually preferred species (Katona et al., 2011). Overall the tomato pulp could provide suitable quality supplementary food for large game species. However, we emphasise the fundamental importance of the natural food resources of the habitat.

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Session 4 – Technologies in production of silages and energy production in biogas plants

Oral presentation

Poster presentations

THE COMPARISON OF TWO CHEMICAL APPLICATION TECHNOLOGY ON THE TOP LAYER OF ENSILED MAIZE

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Introduction

The spoilage of ensiled maize in summer, particularly on their surface, starts causing more and more problems in practice. There are multiple reasons for the spoilage: low consumption of ensiled feed (big ensilage trough, feed for fewer animals), high day temperatures, insufficiently tamped chaff, inadequate application of ensilage preservatives, inadequate mechanization for taking the silage out of the trough, insufficient insulation against penetration of air under the ensilage foils. The spoilage is accompanied by increasing temperature of the silage and by loss of energy and nutrients. The microorganisms cause decomposition of organic nutrients and creation of toxic products (mycotoxins), which may have negative impact on the health of the animals and on the quality of animal products (Bolsen et al., 1993).

The goal of the experiment was to assess the influence of application of a chemical ensilage agent intended to restrict the aerobic degradation of silages and, at the same time, to assess the difference between two methods of application of the agent.

Materials and Methods

The experiment was carried out in the experimental farm of the Institute of Animal Science Uhrineves at Netluky. The experimental material was the maize hybrid Ronaldinio (FAO 260, Stay green, KWS Osiva s.r.o., Velké Meziříčí, The Czech Republic). The hybrid was harvested on 24.8.2012 and stored in a silage clamp. During stacking of the cut material and subsequently after filling the trough, samples of chaff for analysis were always taken in the six different locations and labelled FM (fresh material). One part of the top of silage in the clamp was treated with chemical additive (based on sodium nitrite, sodium benzoate and potassium sorbate) sprayed by applicator in the cutter in a dose of 4 litres per tonne (S1), while the second part was treated by tractor sprayer in the clamp (S2). The third part (control) was not treated (C). The samples in the centre of the silage was named F = Face (control with biological aditive *L. plantarum, L. salivarius, P. acidilactici*, 1.25 x 10^{11}). After the application of preservative, and the mass poaching, the silage was covered with transparent varnish film and black and white canvas Dualen. Gravel bags were loaded around the perimeter of the sheet and in the joints. Other surfaces can be loaded with tires (or in gravel bags, which divide the surface of the parts). After at least 7 month the fermentation of silage samples for analysis occurred: T (top) = 0-15 cm, U (under top) = 30-40 cm. The silages were stored for more than 6 month, about 200 days. The samples were analysed accordance with the methods of AOAC (1995). The digestibility of organic matter (DOM24) was measured 24 hours by *in situ* method with cows fistula. 6 replications were taken for each option. The statistical procedures were performed using Statistica 9.1 (StatSoft, Tulsa, OK, USA).

Results and Discussion

The effect on the nutritive characteristic caused by treating the silage by the chemical additive is shown in the table 1. The silages treated by chemical or biological additives were lower in NDF and starch content than the untreated ones. The samples taken from the top layer (T) of silage (0 – 15 cm) were lower in NDF and starch content than the samples taken under (U) the top layer of silage (30 – 40 cm). The digestibility of organic matter was higher in silage than in fresh matter (FM); it was the highest in silage in the face (F, with biological additive) and also in the top of the silage treated by the chemical additive by the harvestor (S1T). DOM24 were higher in the silage treated by the chemical additive than in the untreated silage. DOM24 of the silage treated by the additive were higher in the top (T) then in the silage 30-40 cm under the top (U).

Table 1 Nutrients of fresh material (FM) and silages (F, C, S1, S2)

Index	FM	F	CT	CU	S1T	S1U	S2T	S2U
DM (%)	38,96	36,28	36,12	38,33	37,20	38,75	39,21	39,33
NDF (%DM)	46,19	41,73	52,54	46,87	43,90	42,52	41,20	40,14
Starch (%DM)	28,82	34,46	32,70	35,50	30,40	31,28	32,77	33,95
DOM24 (%)	65.72	70.56	65.74	69.48	70.58	68.37	68.12	66.40

FM = fresh material, F = face, CT = control in the top, CU = control under the top, S1T = application by cutter, sample in the top, S1U = application by cutter, sample under the top, S2T = application by sprayer, sample in the top, S2U = application by sprayer, sample under the top, DOM24 = digestibility of organic matter 24 hours

The effect of treating the silage by the chemical additive on the fermentation characteristic is shown in table 2. The silages treated by the chemical additive were higher in pH as compared to silages with any additives. The higher pH did not influence the chemical quality of the silages. The higher pH was found in the top layer of the silages treated by the chemical additive by sprayer in the clamp (dose 2 l/m^2) than pH of the silage in the under layer (30-40 cm). The highest lactic acid level and also the ratio of lactic acid and volatile fatty acid (LA/VFA) were found in the silage F and lowest in the control silage in the top (CT). The silages treated by the chemical additives were lower in the bacteria content as compared to the silage F, CT and CU. The lowest content of bacteria was found with silages S2T treated by tractor sprayer in the top of ensiled maize cutting material.

Generally, the quality of the fresh matter (and also of silages) was at a high level as compared to all characteristics of the silages of the database of the Czech Republic 2010-2012 (Loucka et. al., 2012).

Table 2 Quality of fermentation of silages

	F	CT	CU	S1T	S1U	S2T	S2U
pH	3,07	3,30	3,24	3,40	3,26	3,82	3,43
Lactic acid (%)	2,50	1,20	1,92	1,48	1,50	1,87	1,55
Acetic acid (%)	0,51	1,08	0,67	0,58	0,46	0,51	0,52
LA/VFA	4,12	1,02	2,50	2,18	2,68	3,09	2,51
Alcohol %	0,21	0,19	0,25	0,24	0,21	0,19	0,18
Molds (log)	5,67	3,29	4,35	4,14	4,18	4,18	4,14
Yeast (log)	3,44	3,65	3,41	3,74	3,78	3,94	3,92
Clostridie (log)	4,34	2,10	2,10	2,67	1,67	2,10	2,33
Bacteria (log)	8,19	8,09	8,22	6,13	7,19	5,20	6,16

LA = lactic acid, VFA = volatile fatty acids

The effect of treating the silage by the chemical additive on the aerobic stability is shown in table 3.

The aerobic stability (when the silage temperature exceeds the surrounding temperature by 2°C) of untreated silage was short, only 48 hours in a depth of 15 cm, and 51 hours in a depth of 30 to 40 cm; the stability of the silage treated by the bacterial inocculant was 69 hours; the stability of the silage treated by the preserving agent was higher than the 168 hours measured. The quality differences of the silage between the application of the chemical additive by the applicator at the cutter or by the sprayer in the ensilage trough were not significant.

Table 3 Stability of silages

	F	CT	CU	S1T	S1U	S2T	S2U
Stability+2°C (hours)	69	48,5	50,75	>168	>168	>168	>168
Max Temp (°C)	30,7	33,5	32	<23,5	<23,5	<23,5	<23,5
SumaTemp7days (°C)	4130	4307	4335	3189	3271	3162	3213

Conclusions

- Better results of the quality of fermentation and the aerobic stability were found when the ensiled matter (maize) was treated by the chemical additive than when it was untreated.
- The quality of the silages treated by the chemical additive in dose of 4 l/t by harvestor (the cutter) in the field were not different from the silages treated by the additive in dose of 2 l/m^2 by sprayer.
- The use of the chemicals to reduce the aerobic degradation is recommended. In order to save the financial costs of investigation; it should be planned so that silage at the point of application of the preservatives is fed during the summer months.

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ESTIMATION OF LOSES AT THE SURFACE OF SILOS WITHOUT SEALING

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Introduction

Sometimes silos will not be sealed after filling, mostly at silos for using the silage in biogas units. In such cases the degradation of dry matter (DM) at the surface of the silo is increased. To estimate the amount of dry matter losses a calculation model was developed, which describes the time-dependent course of dry matter degradation at the surface of unsealed silos. In a first step definitions to degradation and enrichment are given, then observed values of degradation are presented. After describing assumptions and results of the model it is shown with an example, how the loss of dry matter can be estimated from analysis of silage material.

Material and Methods

The degradation of the dry matter in the degradation horizon is defined with the degradation rate and describes the losses of dry matter as quotient of mass of dry matter at the end to the beginning point:

degradation rate = degraded dry matter / beginning dry matter.

Degradation of dry matter leads to an enrichment of not degradable fractions. Crude ash or crude protein can be considered as not degradable fractions like a tracer to calculate enrichment factors. The definition is as follows:
enrichment factor = content at end / content at beginning

Alternatively, the enrichment factor can be calculated from the change of the mass of dry matter at beginning to end: enrichment factor = dry matter at beginning / dry matter at end

The relationship of dry matter degradation and enrichment factor can be described as follows:
degradation rate = (1 – (1 / enrichment factor))
enrichment factor = (1 / (1 – degradation rate))

The relationship of dry matter degradation and enrichment factor will be shown with an example, which starts with 1000 g dry matter containing 100 g not degradable fraction (crude ash for instance) at beginning. When during the process 400 g dry matter are degraded, the remainder is 600 g dry matter with again 100 g not degradable fraction at the end of the process. The degradation rate of dry matter is calculated from the dry matter masses:
degradation rate = 400 g / 1000 g = 0.4

To calculate the enrichment factor, the content of the not degradable fraction at beginning and end are to be determined:
not degradable fraction at beginning = 100 / 1000 = 0.1
not degradable fraction at end = 100 / 600 = 0.167

With these values the enrichment factor out of the not degradable fraction is as follows:
enrichment factor = 0.167 / 0.1 = 1.67

Alternatively, the enrichment factor can be determined from the dry matter at the beginning and the end:
enrichment factor = 1000 g / 600 g = 1.67

The degradation rate of dry matter can be calculated from the enrichment factor:
degradation rate = (1 – (1 / 1.67)) = 0.4

The enrichment factor can be calculated from the degradation rate of dry matter as follows:
enrichment factor = (1 / (1 – 0.4)) = 1.67

The model describes the degradation of dry matter at the surface of not sealed silos over time in steps of 1 month. Some of the variables in the model have to be set (independent variables), whereas other variables are obtained as result from the calculations (dependent variables). The extend of the degradation horizon at the starting point, the density of dry matter per cubic meter or the degradation rate of dry matter are independent and set in the model. Dependent variables are the starting and remaining dry matter in the rotting horizon (kg/square meter) for instance.

The results at the end of a month after the model calculations are the starting points of the following month. The model is built by comparison of the enrichment factors and degradation rates, calculated in the model with measured values at comparable time. In the following listing the material, time and conditions of fermentation and the analyzed fractions with the resulting enrichment factors and degradation rates are shown. The silage material has been investigated at the own institute, the results of horse manure originate from literature.

Material	time	layer	fraction	enrichment	degradation
sorghum silage	3 months	upper layer of 20 cm	crude ash	1.6	0.38
			crude protein	2.0	0.50
mais silage	12 months	upper rotting horizon	crude ash	2.1	0.52
			crude protein	2.1	0.52
mais silage	7 months	nets in upper layer	dry matter	4.5	0.88
			crude ash	1.5	0.33
			crude protein	4.1	0.86
horse manure	some months during summer		crude ash	2.4	0.59
			nitrogen	1.5	0.32
			phosphor	1.8	0.45
			potassium	1.8	0.45
			magnesium	2.0	0.51

Results and Discussion

Some important data of the model are shown in table 1 for some selected months. At the starting point, thickness of the rotting horizon is set to 30 cm. It reaches by time about 22 cm due to change of the volume by degradation. The degradation rate is set to 0.3 at the first month, 0.2 and 0.175 in the following two months and 0.15 in the later months. The height of rotting horizon and its change is related to the volume density (kg dry matter per m^3). At the beginning a density of 140 kg DM/m^3 is assumed, which reaches about 110 kg DM/m^3 after 3 months. The remaining dry matter in the rotting horizon decreases from 42 kg to about 22 kg per square meter. It is assumed, that a layer of 2.5 cm (lower rotting horizon) with 4.5 kg DM/m^2 (density 180 kg DM/m^3) adds every month to the rotting horizon. From this lower rotting horizon with a degradation rate of 0.3, 3.15 kg DM/m^2 migrate to the upper rotting horizon. The degradation process leads to a lowering of the surface in the silo as described in the table. The amount of degraded dry matter is added up every month and gives accumulated rates of dry matter degradation and enrichment factors. The model includes the unavoidable losses with correct sealing, so the pure effect of not sealing is a little lower.

Table 1 Values of the degradation model, dry matter kg/m^2 surface of a silo (per month or accumulated)

Month	1	2	3	6	9	12	15
High of rotting horizon, cm	30	29.6	27.1	24.3	22.6	21.5	20.7
Lowering of surface, cm	2.7	7.5	11.4	21.0	29.9	38.4	46.6
Dry matter in rotting horizon, kg	42	32.6	29.2	25.5	23.8	22.7	22.0
Degradation rate	0.3	0.2	0.175	0.15	0.15	0.15	0.15
Remaining dry matter, kg	29.4	26.0	24.1	21.7	20.2	19.3	18.7
Degraded dry matter, kg	12.6	6.5	5.1	3.8	3.6	3.4	3.3
Cumulated degr. dry matter, kg	14.0	21.8	28.3	44.2	59.1	73.6	87.6
Cumulated degradation rate	0.3	0.428	0.509	0.640	0.717	0.766	0.800
Cumulated enrichment	1.43	1.75	2.04	2.78	3.53	4.28	5.0

Conclusions

With the chosen model after 12 months an accumulated degradation of 74 kg dry matter per square meter surface is calculated. Distributing the degradation over 15 months of removal, a weighted loss of 53 DM kg/m^2 results. This loss of dry matter can be evaluated for the total surface of a certain bunker silo and compared with the expenses for sealing the silo. Because the conditions can be very different, the losses of dry matter can vary in a wide range. Compared with the calculated losses of the model, differences greater than factor 2 could be seen as possible in practice.

To estimate the loss of dry matter at the surface of a not sealed silo, the presented formula with chemical analysis of silage material can be used. The thickness of the rotting horizon must be measured and the rotted material analyzed for crude ash and crude protein (N). As content at beginning the analysis of (middle) silage material or usual mean values are used for the enrichment factor. The calculations will be shown by an example with maize silage:

Height of the rotting horizon (measured): 20 cm, mean density of dry matter (suggested): 110 kg DM/m^3.
Amount of dry matter in the rotting horizon: 110 (kg/m^3) * 0.2 (m) = 22 kg DM/$m^{2.}$.
Crude ash in the rotting horizon (analyzed): 90 g/kg DM, mean value in maize silage (feeding table): 40 g/kg DM.
Enrichment factor: 90 (g/kg DM) / 40 (g/kg DM) = 2.25, degradation rate = (1 – (1 / 2.25)) = 0.556
So the 22 kg DM/$m^{2.}$ in the rotting horizon came from 22 (kg) * 2.25 (enrichment factor) = 49,5 kg DM/$m^{2.}$.

The difference of 27.5 kg or calculated with the degradation rate: 49,5 (kg DM m^2)* 0.556 = 27.5 kg DM/$m^{2.}$ is the estimated loss at the surface of the silo without sealing during the given time of storage in this example.

THE QUALITY OF SILAGE FROM *SIDA HERMAPHRODITA* (L.)

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Introduction

Virginia Fanpetal (*Sida hermaphrodita* Rusby) is one of plants aimed at energetic purposes and it can be cultivated on lands not suitable for food production (Bujak, 2004). This plant has a high dynamics of stem lignification so it is cultivated primarily to gain dry biomass aimed for burning. Green biomass of Virginia Fanpetal can be processed in the process of methane fermentation, but its disadvantage is high content of lignin. Thanks to its ability to grow back after cutting during the growing season it is possible to reduce the amount of lignin and gain a valuable source of co-substrate for biogas production plants. Biogas production requires a constant supply of biomass which is connected with its effective storage. Ensiling is a trusted method of preserving and storing plant material. Reduction of energy loss and improvement of the quality of ensiled biomass can be achieved through addition of additives during the process of ensiling. Current international studies on storage of biomass for biogas production include mainly maize (Amon et al., 2007). There is little information regarding the use of Virginia Fanpetal for biogas production, particularly in the preserved form as well as the characteristics of its storage. The aim of the present study was to evaluate preservation capabilities of Virginia Fanpetal and to evaluate the quality of preserved biomass depending on harvest management and preserving additives.

Materials and Methods

Virginia Fanpetal materials came from experimental cultures run in north-eastern Poland. The biomass of Virginia Fanpetal was collected in two systems: two-cut system - 1st cut (27.06.2012) and 2nd cut (24.09.2012) as well as one-cut system – one harvest on 24.09.2012. Each type of biomass was preserved in the form of strands (theoretical length 15 mm), in microsiloses (3 x 3 l), without and with additives: formic acid, hemicellulose and cellulose with activity of 94 I.U, molasses (40 g/kg). Additionally, the 2nd cut and one-cut system were ensiled with whole crop maize in the wax phase (1:1 FM).

Fresh and ensiled (120 days) biomass from Virginia Fanpetal were examined for: DM, crude ash, total protein (AOAC, 2005) and fractions of structural carbohydrates (NDF, ADF, ADL)-Van Soest et al. (1991) and water-soluble carbohydrates (WSC) (Thomas, 1977). Moreover, the herbage was examined for buffer capacity (McDonald and Henderson, 1962), in silages: pH, the content of lactic, acetic, butyric in water extract with the High Performance Liquid Chromatography (HPLC) with Shimadzu apparatus with the use of MetaCarb 67H VARIAN column. The impact of additives on the chemical composition of the silage was processed statistically by ANOVA and the significance of differences was verified by Duncan's test (Statistica 9.0, software Soft Incorp.).

Results

Ensiling of every type of biomass from Virginia Fanpetal lowered the content of DM and OM and increased the amount of cellulose with simultaneous lowering of WSC when compared to fresh biomass (Table 1.). Used additives had a greater impact on the chemical composition of silages from the 1st cut (DM, OM, hemicellulose, WSC– $P<0.01$; cellulose - $P<0.05$) and 2nd cut (DM, hemicellulose, WSC $P<0.01$; OM, cellulose – $P<0.05$) than from the one-cut harvest (WSC - $P<0.01$; DM - $P<0.05$). Formic acid reduced butyric fermentation in silages from the 1st and 2nd cut and increased the production of lactic acid (2nd cut). A greater impact of addition of formic acid was observed with regard to biomass containing more water (1st cut). The use of enzymatic additive improved the fermentation profile and acidification in the biomass from the 2nd cut and one-cut harvest. In the case of material collected in the 1st harvest, the enzymatic additive did not eliminate secondary fermentation. In the silages with molasses one observed: lower pH (1st cut - $P<0.01$ and 2nd cut - $P<0.05$), greater concentration of lactic acid, WSC and lower level of butyric acid with regard to silages without growth additives. Silages from mixed biomass had the most beneficial proportion of carboxylic acids and the lowest pH ($P<0.01$) and the biggest content of hemicellulose ($P<0.01$).

Discussion

All silages from Virginia Fanpetal had a relatively high pH, which resulted from the high buffer capacity and high content of butyric and acetic acids, i.e. acids with low acidifying potential and relatively low level of lactic acid assumed to be the main factor acidifying the ensiled biomass. The silages from the 1st cut, as a result of higher water content in the material, had an extensive course of fermentation and a worse acid profile. High content of butyric acid in the stored biomass from the 1st cut is the evidence of the occurrence of secondary fermentation. The use of enzymatic additive, through increasing the supply of substrates for fermentation resulting from the hydrolysis of structural carbohydrates, improved the fermentation profile and acidification. These observed positive effects of adding molasses confirm the thesis claiming that the main factor limiting the appropriate process of preservation of biomass from Virginia Fanpetal is the deficiency of water-soluble carbohydrates and the buffer capacity. Introducing additional supply of WSC effectively improved the fermentation profile when ensiling the material from the 1st cut, i.e. the most difficult to silage. In the material from one-cut harvest, the fermentation was limited despite using the additive, which is confirmed by a significant amount of remaining WSC in the biomass stored with this method. Ensiling of the biomass from the 2nd cut and the biomass collected in one-cut harvest with green fodder from whole maize plants (wax maturity of grains) in 1:1 proportion had a positive effect on the chemical composition of the stored biomass. This resulted from a more beneficial composition of carbohydrates and lowered buffer capacity.

Conclusion

The biomass from Virginia Fanpetal turned to be a difficult preserving material, in all types of preserved biomass one observed an unsatisfactory level of acidification, low level of lactic acid as well as high content of acetic and butyric acids. The harvest system had an impact on the process of fermentation in the stored biomass. A higher content of DM in the biomass from 2nd cut and the biomass collected in one-cut harvest limited all types of fermentation, including butyric fermentation. Among the additives which were used, molasses was the most effective in improving the quality of ensiled biomass. Ensiling of biomass from Virginia Fanpetal in 1:1 proportion with maize produced the best effects. Therefore, co-ensiling of these two plant materials can be an effective method of improving the conditions of preserving biomass from Virginia Fanpetal**.**

Table 1 Chemical composition of herbage and silage from Virginia Fanpetal (g/kg DM), buffer capacity (ml/kg DM)

	BC	DM g/kg	OM	CP	NDF	ADF	ADL	Hemi-cellulose	Cellulose	WSC
Herbage										
1st cut	9.56	200	922	130	404	325	54.9	79.6	270	59.2
2nd cut	5.67	274	916	94.1	468	409	75.8	58.6	334	44.7
One-cut	5.32	382	943	48.6	642	554	101	88.4	453	58.4
Silage	T	DM	OM	pH	Lactic acid	Acetic acid	Butrytic Acid	Hemi-cellulose	Cellulose	WSC
1st cut	0	145^{B}	895^{B}	5.39^{A}	22.1^{B}	14.8^{Aa}	25.7^{A}	71.5^{A}	355^{a}	14.0^{B}
	FA	156^{B}	888^{B}	5.06^{A}	17.2^{B}	8.63^{b}	6.08^{B}	81.4^{A}	350	13.2^{B}
	E	145^{B}	872^{B}	5.18^{A}	14.1^{B}	15.4^{A}	4.50^{B}	74.3^{A}	336	18.0
	MO	164^{A}	928^{A}	4.18^{B}	57.9^{A}	4.73^{B}	5.57^{B}	33.6^{B}	333^{b}	20.5^{A}
SEM		2.95	5.53	0.13	4.56	1.15	2.20	5.75	5.06	1.55
2nd cut	0	245^{A}	893^{b}	5.65^{Aa}	$27.4^{\mathbf{B}}$	11.6^{B}	11.6^{A}	71.0^{B}	372^{a}	13.7^{B}
	FA	258^{A}	916	5.07	27.7^{B}	6.72^{B}	2.27^{B}	92.9^{B}	340	22.5^{b}
	E	238^{B}	893^{b}	4.71^{b}	26.6^{B}	10.8^{B}	6.75^{B}	53.4^{C}	354	17.0^{B}
	MO	267^{A}	933^{a}	4.65^{b}	38.1^{A}	21.9^{A}	2.63^{B}	55.2^{C}	326^{b}	39.8^{Aa}
	MA	290^{A}	944^{a}	4.47^{B}	25.4^{B}	9.73^{B}	3.12^{B}	104^{A}	335^{b}	16.9^{B}
SEM		2.93	4.66	0.12	1.44	4.41	1.07	5.60	5.12	2.51
One-cut	0	352^{ac}	940	5.55^{Aa}	5.90^{Bb}	3.48^{B}	1.79	148^{B}	447^{A}	14.2^{B}
	FA	370^{a}	941	5.11	16.9	7.12	2.00	131^{B}	438^{A}	18.5
	E	356^{ac}	937	5.05^{b}	20.7^{a}	12.3^{A}	2.67	123^{B}	441^{A}	11.9^{B}
	MO	318^{b}	959	5.17	22.0^{a}	3.70^{B}	1.85	137^{B}	442^{A}	41.5^{A}
	MA	307^{b}	948	4.90^{B}	30.3^{A}	5.77	1.87	193^{A}	320^{B}	8.4^{B}
SEM		6.40	2.29	0.07	1.68	0.96	0.23	4.78	3.91	3.14

T–treatment; FA–formic acid; E–enzyme; MO–molasses 40 g/kg fresh matter; MA–whole crop maize 1:1 fresh matter; BC–buffer capacity; DM-dry matter; OM-organic matter; CP-crude protein; NDF-neutral detergent fiber; ADF-acid detergent fiber; ADL-acid detergent lignin; WSC-water-soluble carbohydrates; SEM-standard error of the mean; means in the same column with different superscripts differ significantly at: ^{ABC} ($P < 0.01$), ^{abc} ($P < 0.05$)

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