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Research Institute of Animal Production, Praha Uhřiněves, CZ
NutriVet Ltd., Pohořelice, CZ

## 10th INTERNATIONAL SYMPOSIUM

# FORAGE CONSERVATION

10. - 12. SEPTEMBER, 2001

Brno, Czech Republic

**2001**

Conference Proceedings

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**ISBN80-7157-528-3**

Published for the 10th International Symposium of Forage Conservation, 10. - 12. September, 2001,
by MZLU Brno (Mendel University of Agriculture and Forestry, Brno, CZ)

Editors: V.Jambor, P. Doležal, L. Zeman, R. Loučka, Š Rudolfová, P. Procházka

# 10th International Symposium of Forage Conservation, Brno, 2001

## CONTENTS

**2. THE CONTROL OF THE FERMENTATION PROCESS OF FORAGES AND THEIR AEROBIC STABILITY**



**3. THE TECHNOLOGY OF FORAGE HARVEST, PRESERVATION AND STORAGE**

## The conference organisers wish to thank organizations presented on the following pages for the generous contributions and financial support

**medipharm**

*Czech-Swedish company* MEDIPHARM CZ, *s.r.o. specialise on producing new biologicals - probiotics, which are actually used in agriculture and food industry as a replacement for antibiotic chemical or pharmaceutical additives, that were being used till not long time ago. Enormous concern in biological relates closely with the world trend aimed to improve the quality of food products and decrease the level of animal products contamination by residual organic and unorganic substances in environmental conditions.*

MEDIPHARM GROUP *(Medipharm Sweden, USA, U.K., Czech and Hungary) manufacture these probiotics and sell them successfully at the markets in different countries many years. Medipharm probiotics - feed additives for poultry, pig, fish industry and calves breeding can help to improve production and quality of final products.*

*Our probiotics are moreover very effective for ensilage fodder plants (silages) and other areas of agriculture and food industry. Ensilaging preparations are polyvalent probiotics preserving products designed for preparation of silage and haylage using carbohydrate containing voluminous green fodder as well as voluminous forage the ensiling of which is more difficult, protein and semiprotein forage etc. Preparation of less valuable or worthless materials for feeding is another field of possible use.*

**AGRO-best**

The company **AGRO-BEST spol. s r.o.** (limited liability company) **Běstovice** was founded by the partners Agriculture Services Běstovice a.s. and ZOD Žichlínek on September 30th 1994.

Main activities are the licence production and sale of feed supplements MEGAPRO and MEGALAC and their analogs for dairy cattle which started on 29th January 1996 and feeding service for customers. Our products are produced for the domestic market and for export to the former Eastern Block and former Yugoslavia, Turkey, Greece, Germany and Austria.

Sales of products connected with nutrition and health state of cattle is a supplementary activity Our company has Certified Quality System according to ISO 9002.

Alltech is a pioneer in the development, manufacture, application, and support of biotechnology for livestock and poultry production. Alltech is one of the most widely recognized and fastest growing feed ingredient suppliers in the world. According to surveys conducted by leading industry publications, most feed manufacturers, nutritionists, and livestock producers are familiar with Alltech and an overwhelming number incorporate the company´s products in their feeds. Alltech s sales of yeast cultures and extracts, silage inoculants, enzymes, organic minerals, biologically-active proteins, flavours, and direct-fed microbials have increased by an average of 25% per year

The company´s first product was Yea-Sacc$^{1026}$, an active yeast culture specifically for livestock and poultry feed. It is still the most widely sold yeast culture in the feed industry Yea-Sacc$^{1026}$ was soon joined by other biotechnology-derived feed ingredients, including silage inoculants (Sil-All and Maize-All), organic trace minerals (Bioplex series), organic selenium (Sel-Plex), mannan oligosaccharides (Bio-Mos), esterified glucomannans (Mycosorb), and yeast extract (NuPro). Currently, Alltech manufacturers nearly 150 feed ingredients. It is the only ingredient company which manufactures its own enzymes. All of the company´s ingredients are ACE: Friendly to the Animal, Consumer, and the Environment.
Alltech s Lexington, Kentucky headquarters boasts a state-of-the-art production facility – the core of which is an ultra-modern fermentation system – a world-recognized development laboratory and research farm, and the North American Marketing Centre. Although Alltech is headquartered in the U.S., the company has maintained a global perspective. Alltech has sales and distribution offices in more than 65 countries.

Alltech understands the serious challenges facing animal agriculture – whether they be the impact of intensive livestock and poultry production on the environment or consumer fears about antibiotic resistance, or the struggle for producers to improve the efficiency of animal production and the profitability of their operations. Alltech will continue to develop the ingredients and strategies that will help animal agriculture meet these challenges and quickly get these tools into the hands of the animal producers. Alltech s innovative products provide real benefits to the feed manufacturer, animal producer, and ultimately, the consumer.

OSEVA UNI, a.s. is the biggest Czech seed and breeding company Business activities of OSEVA UNI, a.s. covering whole territory of the Czech Republic are based on five branches, large selling network and on two filial companies.

OSEVA UNI, a.s. produces, processes and sells seed of all main field species like winter and spring wheat, winter and spring barley, winter rye, winter and spring triticale, oats, peas, fodder peas, winter and spring canola, white mustard, poppy, caraway, oil and fibre flax, potatoes and fodder beet.

- Plant breeding programme of OSEVA UNI, a.s. is focused on breeding of forage and amenity grasses and on breeding of clover species especially on red clover OSEVA UN , a.s. offers wide assortment of grass turf and forage mixtures and grass-clover-mixtures in different types of packing from small paper boxs or plastic bags to 50 kg bags.
- OSEVA UNI, a.s. makes also business with commodities (winter canola, sunflower, white mustard, poppy, caraway and peas) for humane consumption and for industrial processing.
- Main effort of all employees of OSEVA UNI, a.s. is to supply all requirements of inland and foreign customers in the as much as highest degree.

## Force Limagrain

In 1997 was based company Force Limagrain s.r.o. in the Czech republic to be one of the most important player in the Czech seeds market. This company is a part of the groupe Limagrain, the 4th largest seeds producer in the world. Groupe Limagrain has shown the viability and strength of the co-operative model to build tomorrow's agriculture.

Groupe Limagrain

- Consolidated sales stood at 5 807 million francs in the financial year 1999/2000.
- Field seeds represent 40 % of the total sales. Vegetable and flower seeds account for 36 % (23 % in the professional sector and 13 % in the home garden sector) and other garden products 7 %. Bakery products represent 12 % and cereal ingredients 5 %.
- Research expenditure now stands at 463 million francs.
- On June 30th 2000, the Group comprised a staff of 4807 representing more than forty different nationalities.

The ambition of the groupe Limagrain is to improve plants and develop tomorrow's agriculture for the benefit of mankind.

## MIKROP

minerálně-vitamínová výživa zvířat

We would like to introduce our-joint company MIKROP Čebín. The company has a long-standing tradition in manufacturing high-quality mineral vitamin premixes and mixtures for all types and categories of farm animals.

A characteristic feature of our company has always been our clear manufacturing and business philosophy, basal on three main precepts.

First, the top-noth quality of input raw materials of a domestic as well as foreign provenience, intensified by the high professional level of our formula creation.

Second, the high profesional standard of our approach to business partners within the scope of supplier-consumer relations.

Last but not least we have a very favourable peice policy

The above-mentioned factors will help in utilizing fully the genetic potencial of your animals, while taking into full consideration the enviromental issue.

Our businesspolicy is based on the ability to adapt ourselves to our markets requirements, which means offering comprehensive services to our custumers. We can arrange free–of-charge visits by experts in nutrition who are ready to advise which suplementary mixtures and premixes you should choose so that you will achieve the optimal composition of feed.stuffs with a high production efficiency and a minimum cost, with regard to your technical potential and commercial viability

BIOFERM

*BIOFERM CZ is trading company established in 1995 in Brno. Main areas of business are raw material and feed additives for production of premixes and compound feed mixtures, biological and chemical preservatives for conservation of silage, grain and concentrated feed.*

*BIOFERM CZ is holder of authorization for production and distribution of veterinary medicaments*

*BIOFERM CZ represents in the Czech Republic companies Kemira Phosphates, Kemira Chemicals, Chr Hansen Biosystems, Intervet International, Bioferment Cerbios-Pharma, Bioquimex, Pancosma, Axiss and Aventis Animal Nutrition.*

*BIOFERM CZ is member of BIOFERM INTERNATIONAL GROUP with daughter companies in Poland BIOFERM PL and Slovakia BIOFERM SK.*

# PLENARY PAPERS

# Production, Composition, and Quality of Perennial Forage on Arable Land

**K. Buchgraber[1] and F. Hrabě[2]**

[1]Institute for Plant Production and Cultural Landscaping, BAL Gumpenstein
[2]Mendel University of Agriculture and Forestry Brno

## 1. Introduction

Regardless to a decrease in forage consumption by cattle. perennial forage crops on arable land still remain and important part of feed production as well as an significant factor contributing to soil fertility. In future, our main objective will be their intensive production and increase in their quality. As mentioned by Buchgraber et al. (1997), intensity and efficiency of production will be based on the minimum application of mineral N-fertilisers and on the maximum use of biological N-fertilisers and manure. An increased quality of forage will result not only from a wider application of clovers but also on introduction of new intergeneric and interspecific grass hybrids with an increased content of nutrients (e. g. WSC, crude protein etc.), better health condition of stands, and increased durability (Fojtík et al. 1993, Kuncl et al. 1993). From the viewpoints of science and practice as well as of the construction of commercial grass-clover mixtures, it will be desirable to continue in explanatory studies on competitive and allelopathic relationships existing among individual grass species. In this way it will be possible to contribute in a biological way to an intensive and top-quality production of forage (Hrabě et al. 2001). Attention should be paid also to practical aspects of crop management and tillage operations, especially to a repeated undersowing of clovers into temporary grass stands (Kohoutek 1998). Very important will be also the problem of eradication of sorrel (*Rumex* sp.) in perennial clover-grass stands (Pötsch et al. 2001).

## 2. Acreage of forage crops. production and stand composition

### *2.1. The present acreage of perennial clovers and clover-grass stands on arable land*

In 1999, perennial forage corps on arable land, i. e. *Medicago sativa* L.. *Trifolium pratense* L. and their mixtures with grasses (clover-grasses) and/or pure grass stands were grown on the total acreage of 388 thous. hectares, i. e. on 12.5 % of arable land of the Czech Republic. Data about their structure (Tab. 1) indicate a dominating position of clover-grasses (5.2 %) and a tendency to extend their acreage. In 1990, the proportion of acreage of pure stands of lucerne (*M. sativa*) and white clover (*T. pratense*) were 3.3 % and 3.0 %. resp.; since that time, their acreage has decreased from 155 thous. to 105 thous. hectares (i. e. by 1/3) and from 193 thous. to 92 thous. hectares (i. e. nearly by 1/2),respectively.

**Table 1.** Acreage and structure of perennial clover stands in the CR

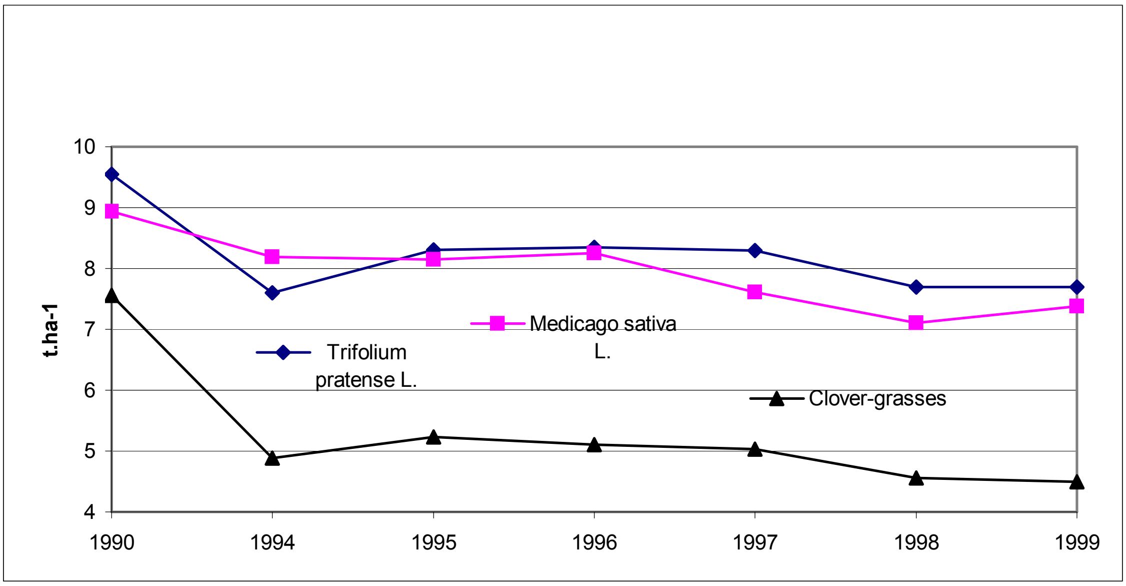
| Culture | 1990 | | 1999 | |
|---|---|---|---|---|
| | Thous. ha | % (acreage) | Thous. ha | % (acreage) |
| *M. sativa* | 155.8 | 4.7 | 104.9 | 3.3 |
| *T. pratense* | 192.7 | 5.8 | 92.2 | 3.0 |
| Clover-grasses | 119.0 | 3.6 | 161.1 | 5.2 |
| Other crops (seed production) | 37.9 | 1.2 | 29.8 | 1.0 |
| Total | 505.4 | 15.3 | 388.0 | 12.5 |

Source: Statistical Yearbook of the Czech Republic, 2000

*2.2 Perennial crops and forage production*

As one can see in Fig. 1, there is a general decrease in DM production in all major species of perennial forage crops. The decrease in DM production of lucerne and white clover to present 8.0 metric tons per hectare is relatively low, mainly due to the supply of biological N and ranges between 12 and 16 %. In clover-grass stands, there was a decrease from ca. 7.5 to 5.0 tons per hectare (i. e. nearly by 1/3) within the last decade, especially after a decrease in percentage of clover and due to a low supply of mineral N. Mainly within the first three years it is possible to see the importance of clover and its contribution to forage production of clover-grass crops. As compared with pure grass stands, production of DM of clover-grass crops was higher by 8.2 to 10.4 % (a six-year average). Already in the 4th year of production, i. e. after the retreat of clovers, there is an obvious decrease in forage production to the level (or under the level) of a pure grass stand. The production potential of clover-grasses is considerably higher, especially if the percentage of clovers is preserved, even at a low level of N-supply. This is indicated by a six-year average of obtained results (Tab. 2).

**Figure 1.** Changes in DM production of perennial fodder crops on arable land in the Czech Republic (1990 – 1999)




Source: Statistical Yearbook of the Czech Republic, 2000

**Table 2.** Production of temporary grass and clover-grass stands on arable land. Vatín 1994 – 2000 (Hrabě et al. 2001)

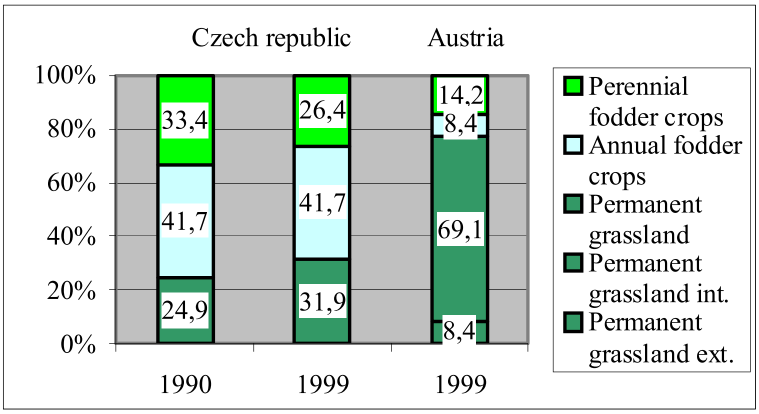
| Association | | DM yield ($t.ha^{-1}$) and weight proportion of clovers (%) in the first cutting | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | Mean |
| Grasses<br>(100 %) | $t.ha^{-1}$<br>% of clover | 12.59<br>- | 8.24<br>- | 10.89<br>- | 9.22<br>- | 11.97<br>- | 9.44<br>- | 10.39<br>- |
| Clover-grasses (30 % *T.p.* + 70 % grasses) | $t.ha^{-1}$<br>% of clover | 14.64<br>13.2 | 11.46<br>29.1 | 12.25<br>27.0 | 9.43<br>8.53 | 11.38<br>0.1 | 8.26<br>3.2 | 11.24<br>- |
| Clover-grasses (30 % clovers + 70 % grasses) | $t.ha^{-1}$<br>% of clover | 8.73<br>14.82 | 11.81<br>29.2 | 12.27<br>22.8 | 9.79<br>9.2 | 11.90<br>0.2 | 8.24<br>6.0 | 11.47<br>- |

Note: Clover-grasses – *T. pratense* 15 %, *T. hybridum* 7.5 %, *T. repens* 7.5 %

*2.3. Position of perennial fodder crops within the system of production of feeds*

In the period of 1990 – 1999, the total volume of fodder DM production decreased from 10,696.1 thous. tons to 7,96.6 thous. tons. i. e. by 29.0 %. This decrease in production is illustrated in Fig. 2. As one can see. within the period of 1990 – 1999. the percentage of fodder production on arable land decreased from 75.1 % to 68.1 % while that of forage on permanent grassland increased from 24.9 % to 31.9 %.

**Figure 2.** Structure of forage DM production in the Czech Republic and Austria




As far as the fodder crops on arable land are concerned. the proportion of annual fodder crops remained to be on the level of 41.7 % (of this. maize 36.1 %). The total volume of production of perennial fodder crops decreased from 4.132.7 thous. tons to 2.372.6 tons, i. e. to 57.4 %. The proportion of annual fodder crops in the total volume of forage production decreased from 33.4 % in 1990 to 26.4 % in 1999. In this group of fodder crops, the percentages of individual crops in the total volume of production was significantly changed. As shown in Tab. 3, total production and the proportion of *Trifolium pratense* L. in this total production decreased while that of clover-grass mixtures increased. At present, the proportion of major clover species and/or clover-grass mixtures is nearly the same, i. e. 1/3 of the total volume.

**Table 3.** Volume of production (in tons of DM). structure and percentages of individual perennial crops in the Czech Republic in years 1990 and 1999)

| Crop | Volume of production and percentage | | | | Index 1990/99 |
|---|---|---|---|---|---|
| | 1990 | | 1999 | | |
| | t | % | t | % | |
| *M. sativa L.* | 1,392.8 | 33.7 | 829.7 | 35.0 | 59.6 |
| *T. pratense L.* | 1,840.3 | 44.5 | 742.2 | 31.3 | 40.3 |
| Clover-grass mixtures | 899.6 | 21.8 | 800.7 | 33.7 | 89.0 |

*2.4 Situation in Austria*

In Austria, forest stands cover 48 % of the total area. Percentages of permanent grassland and fodder crops on arable land are 32 % and 18 %. resp. Vineyards and orchards cover less than 1 % of agricultural land.

- The total acreage of fodder crops is 2.1 mil. hectares, i. e. 60 % of agricultural land. Of this:
- intensive fodder production (> 4 cuttings) makes 12 %,
- normal fodder production (2 to 3 cuttings) makes 36 %,

extensive fodder production (1 to 2 cuttings) makes 13 %, and

- alpine meadows and pastures made 39 %.

The total DM production of forage is 6,783 mil. tons. Of this. fodder crops on arable land (without maize). permanent grassland and extensive pastures make 961 thous. tons; 5.253 mil. tons and 569 thous. tons. respectively. For feeding of farm animals,

- 32 %. are consumed in fresh condition,
- 28 % dried and in the form of hay, and
- 40 % as silage.

*2.5. Species composition of clover-grass mixtures*

In the past, the approach of growers to the species composition of clove-grass stands was based on the principle of high yields of forage. For that reason the proportion of clovers in the mixture was low, the abundance of grasses was small (so that only a few of high producing species were used), and the supply of energy was high (i. e. in the form of N + PK fertilisers).

According to Svěráková et al. (1998) the proportion of clover species in one or two-year-old crops was high (70 to 80 %) and the species composition narrow (1 clover species and 1 to 2 grass species, usually ryegrasses). After the selection of tetraploid forms of white clover it is recommended to use only 30 to 40 % of clover species in contemporary clover-grass mixtures with the production period of 4 to 6 years (i. .e *T. pratense* and/or *T. hybridum*). Of grass species the following are recommended: *Festuca pratensis* Huds., *Phleum pratense* L., *Dactylis glomerata* L., and/or *Arrhenatherum elatius* L. Applied was also the system of a differentiated supply of N, i. .e 60 to 80 kg N per hectare in the first year, 100 to 120 kg N in the second year, 129 to 150 N in the third year, and more than 150 kg N after the fourth year. However, as mentioned by Meinsen (1982), the doses of 120 – 150 kg N per hectare are not sufficient for the utilisation of production potential of grasses after the decrease in the proportion of clover species in the stand.

The second stage of intensification of production of clover-grass mixtures was characterised by the selection of new cultivars of intergeneric and interspecific grass hybrids. In this stage, attention was paid also to quality of fodder, especially to its suitability for ensiling. Short-term clover-grass mixtures with predominating *T. pratense* L. and with intergeneric hybrids of loloid type (cv. Bečva. Perun) enabled to harvest the crop continuously, step-by-step, and in the optimum stage of maturity. The content of WSC was also increased. In stands of more perennial nature (4 to 6 years), hybrids of festuloid character (cv. Felina. Hykor) were more frequent because they showed not only good production potential and fodder quality but also better health condition, better durability, and suitability for both cutting and grazing. Advantages of growing clover-grass and lucerne-grass mixtures are well documented in studies by Kuncl (1993), Fojtík et al. (1993), and Vorlíček et al. (1996).

**Table 4.** Production of dry matter and proportion of clover component in production of total DM in mixtures of intergeneric grass hybrids with *T. pratense* L. (Svěráková et al. 1998)

| Clover-grass association | DM ($t.ha^{-1}$) | | | | | Proportion of *T. pratense* in the total weight of the 1st cutting (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | Mean | % | 1993 | | 1994 | | 1995 | |
| | | | | | | 1st cut. | 2nd cut. | 1st cut. | 2nd cut. | 1st cut. | 2nd cut. |
| Intergeneric hybrid cv. Perun + *T.p.* cv. Kvarta | 8.74 | 11.53 | 7.46 | 9.24 | 100 | 19.7 | 72.4 | 70.0 | 78.2 | 0.7 | 0.6 |
| Intergeneric hybrid cv. Hykor + *T.p.* cv. Kvarta | 10.70 | 10.67 | 13.00 | 11.47 | 124.1 | 27.7 | 70.6 | 53.4 | 63.8 | 5.6 | 5.8 |
| Intergeneric hybrid cv. Felina + *T.p.* cv. Kvarta | 9.21 | 10.79 | 11.56 | 10.52 | 113.8 | 19.0 | 65.9 | 39.5 | 54.7 | 4.2 | 3.4 |

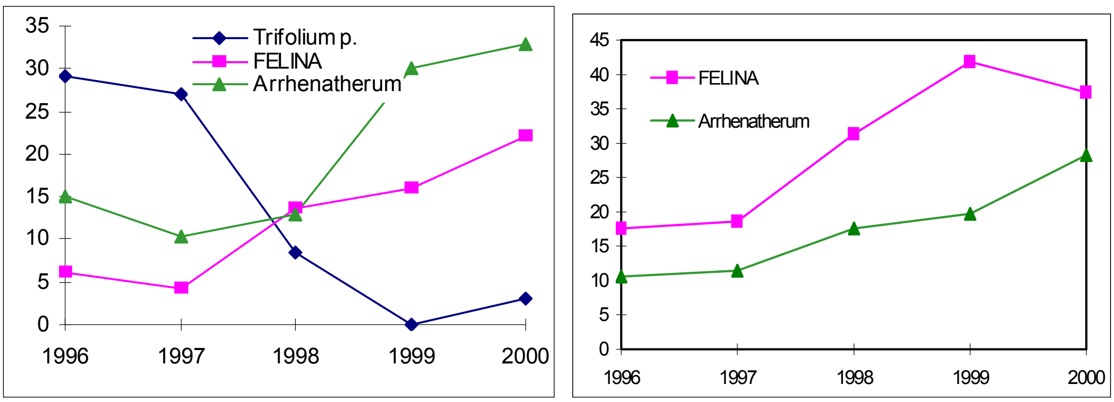
At present, it is emphasised that when developing clover-grass mixtures, it is necessary to pay attention – both because of ecological and economical reasons – to an optimum balance of production and quality traits as well as to the production durability of stands (Buchgraber et al. 1994). Today, production is not characterised as gross or net production but as yield quality of produced forage, i. e. as the amount of nutrients per hectare and consumed by cattle. An example of such evaluation is presented in Tab. 5.

**Table 5.** Gross and net production and yield quality of perennial fodder crops in Austria (Buchgraber 1994).

| Culture | DM and energy production ($t.ha^{-1}$) | | | Energy concentration MJ NEL per kg of DM |
|---|---|---|---|---|
| | Gross | Net | MJ NEL.$ha^{-1}$ | |
| Wet meadow - 1 cutting | 35 | 30 | 11,000 | 3.2 |
| Cultural meadow – 2 cuttings | 55 | 40 | 21,000 | 5.2 |
| Cultural meadow<br>3 cuttings (normal)<br>4 cuttings (intensive) | <br>75<br>85 | <br>60<br>70 | <br>34,000<br>40,000 | <br>5.6<br>5.7 |
| Clover-grass mixture (acreage) | 100 | 85 | 51,000 | 6.0 |
| Lucerne-grass mixture (acreage) | 90 | 70 | 39,000 | 5.5 |
| Temporary grass stands | 85 | 70 | 41,000 | 5.8 |

As mentioned by Hrabě et al. (2001), it is necessary to pay attention also to different ”competitive” behaviour of individual species in the stand when constructing the clover-grass mixtures of temporary nature (i. e. 4 to 6 years of production). So. for instance. the intergeneric hybrid Felina (*F. arundinacea* Schreb.) is more competitive in a pure grass association than in a mixture with *T. pratense* L. (Fig. 3) while the behaviour of *A.elatius* L. is quite opposite.

**Figure 3.** Weight proportions (%) of *F. arundinacea* L. cv. Felina and *A. elatius* L. in a mixture with *T. pratense* L. and in a pure grass stand (Hrabě et al. 2000).




Besides the principle of a wide ”diversity” of species and cultivars, the system of the so-called minimisation of N-fertilisation is applied as well, i. e. supply of N only in the form of symbiotic N and/or use of semi-intensive fertilisation (supply of 50 % of standard doses) in accordance with natural production capacity of each site. In this system, organic forms of fertilisation are preferred (slurry, manure and/or composted manure, composts).

Partial results of the joint research (project Aktion) concerning production characteristics of clover-grass mixtures grown without mineral forms of N and with the application of 15 tons of manure are presented in Tabs. 6a, 6b, and 6c.

**Table 6a.** DM production of Austrian and Czech clover-grass mixtures grown on arable land in Gumpenstein and Piber in 1998 – 2000 (100 $kg.ha^{-1}$)

| Mixture | PK dressing | | | Manure + PK dressing | | |
|---|---|---|---|---|---|---|
| | Austrian origin | Czech origin | Difference (%) Austria = 100 % | Austrian origin | Czech origin | Difference (%) Austria = 100 % |
| Intensive clover-grass mixture | 84.4 | 83.6 | - 1 % | 96.1 | 91.5 | - 5 % |
| Clover-grass mixture | 92.2 | 89.7 | - 3 % | 97.6 | 93.0 | - 5 % |
| Lucerne-grass mixture | 98.2 | 94.2 | - 4 % | 101.2 | 101.1 | 0 % |
| Clover-grass mixture – alternative use | 82.1 | 89.0 | + 8 % | 93.3 | 90.0 | - 4 % |
| Mean | 89.2 | 89.1 | 0 % | 97.1 | 93.9 | - 3 % |

**Table 6b.** Energy production of Austrian and Czech clover-grass mixtures grown on arable land in Gumpenstein and Piber in 1998 – 2000 (GJ $NEL.ha^{-1}$)

| Mixture | PK dressing | | | Manure + PK dressing | | |
|---|---|---|---|---|---|---|
| | Austrian origin | Czech origin | Difference (%) Austria = 100 % | Austrian origin | Czech origin | Difference (%) Austria = 100 % |
| Intensive clover-grass mixture | 43.7 | 35.7 | - 18 % | 47.3 | 35.8 | - 24 % |
| Clover-grass mixture | 47.1 | 45.7 | - 3 % | 50.4 | 45.5 | - 10 % |
| Lucerne-grass mixture | 44.3 | 42.9 | - 3 % | 44.3 | 45.0 | + 2 % |
| Clover-grass mixture – alternative use. | 40.3 | 43.5 | + 8 % | 45.9 | 43.5 | - 5 % |
| Mean | 43.9 | 42.0 | - 4 % | 47.0 | 42.5 | - 10 % |

**Table 6c.** Crude protein production of Austrian and Czech clover-grass mixtures grown on arable land in Gumpenstein and Piber in 1998 – 2000 ($kg.ha^{-1}$)

| Mixture | PK dressing | | | Manure + PK dressing | | |
|---|---|---|---|---|---|---|
| | Austrian origin | Czech origin | Difference (%) Austria = 100 % | Austrian origin | Czech origin | Difference (%) Austria = 100 % |
| Intensive clover-grass mixture | 1614 | 1370 | - 15 % | 1718 | 1391 | - 19 % |
| Clover-grass mixture | 1805 | 1635 | - 9 % | 1812 | 1570 | - 13 % |
| Lucerne-grass mixture | 1722 | 1578 | - 8 % | 1675 | 1625 | - 3 % |
| Clover-grass mixture – alternative use. | 1451 | 1554 | + 7 % | 1589 | 1558 | - 2 % |
| Mean | 1648 | 1534 | - 7 % | 1699 | 1536 | - 10 % |

## 3. Fodder quality of clover-grass mixtures

*3.1 Problems of formation of quality clover-grass associations*

In Austria and in the Czech Republic, the present assortment of various species and, especially, cultivars suitable for the formation of clover-grass mixtures with a good quality and production potential is very good both from the viewpoints of their intended use and durability (Tab. 7).

**Table 7.** Survey of cultivars of clover and grass species suitable for clover-grass mixtures on arable land

| Species | Number of registered cultivars | | |
|---|---|---|---|
| | Czech Republic | Austria | |
| | | List of registered cultivars | ÖAG-List of cultivars |
| *Trifolium pratense* | 22 | 21 | 12 |
| *Trifolium hybridum* | 3 | - | - |
| *Trifolium repens* | 15 | 7 | 8 |
| *Lotus corniculatus* | 3 | - | 2 |
| *Medicago sativa* | 15 | 15 | 10 |
| *Lolium perenne* | 59/33 * | 30 | 15 |
| *Lolium multiflorum* | | | |
| • *ssp. italicum* | 6 | 12 | 6 |
| • *var. westerwold* | 5 | 8 | - |
| **Lolium hybridum** | 1 | 9 | 4 |
| *Phleum pratense* | 6 | 9 | 6 |
| *Arrhenatherum elatius* | 2 | 1 | 2 |
| *Trisetum flavescens* | 2 | - | 1 |
| *Dactylis glomerata* | 9 | 5 | 11 |
| *Festuca pratensis* | 9 | 10 | 8 |
| *Festuca arundinacea* | 7/2 * | - | - |
| *Festuca rubra* | 36/4 * | 4 | 6 |
| *Poa pratensis* | 22/3* | 4 | 9 |
| *Alopecurus pratensis* | 2 | 2 | 2 |

Note: *Suitable for fodder production.

Not only the assortment of species and, above all, cultivars but also their genetic variability, for example tetraploid and diploid forms of *T. pratense* L., robust and intermediary types of *T. repens* L., and new interspecific and intergeneric grass hybrids (Bečva. Perun. Hykor. Felina) enable to project and/or form mixtures adapted to the climatic conditions of different micro-regions as well as to form stands of an earlier and/or later character that enables to harvest them in the optimum stage of fodder maturity.

In Austria, in addition to the system of recommended ”commercial” clover-grass mixtures well adapted both to ecological conditions and to the use in feeding of cattle. the farmers can buy also the so-called ”certified” mixtures with tested economic traits (especially with the durability of 6 years). ÖAG is the guarantor of quality of these products. When constructing these clover-grass mixtures, attention is paid not only to an increased proportion of clovers but also to the number of their species, forms and especially cultivars. A wider assortment of grass species is also taken into account.

In the Czech Republic, such a system of model clover-grass mixtures has not been developed yet. Although the seed producers try to respect the basic methodological principles of formation of these mixtures and to supply a relatively wide assortment of cultivars, it cannot be warranted that they are suitable for a longer period of growing (i. e. 5 to 6 years) under different ecological conditions. Very positive, however, is a widening offer of species and cultivar assortment of seed material for extensive and/or non-production use (e. g. energetic crops).

Czech scientific and research institutions, governmental bodies and the Central Institute for Testing and Supervision in Agriculture should join their efforts and develop a uniform methodology of construction of type commercial clover-grass mixtures and to assure their exact testing under different ecological conditions. NAZV research grants represent one of the possible ways. The formation of these mixtures requires a good theoretical knowledge of competitive and/or allelopathic behaviour of individual species in plant associations. This need is documented by the aforementioned differences in the behaviour of the intergeneric hybrid Felina and of *A. elatius* L. in a mixture with *T. pratense* L. as well as by the aggressive dominance of *T. repens* L. in newly established stands of pastures on arable land (Opitz von Boberfeld 1993).

*3.2 Problem of sorrel (Rumex sp.) propagation in clover-grass stands*

The "sorrel problem" and its effect on fodder quality is well documented in Tab. 8.

**Table 8.** Content of nutrients. organic matter digestibility and content of energy in sorrel (*Rumex obtusifolius* L.) and dandelion (*Taraxacum officinale* L.) (Pötsch 2001)

| Nutrient | *Rumex obtusifolius* | *Taraxacum officinale* |
|---|---|---|
| Crude fibre | 25 % | 28 % |
| Crude protein | 18 % | 13 % |
| Ash | 9% | 10 % |
| Fat | 2 % | 2 % |
| Digestibility | 67 % | 82 % |
| MJ NEL (kg $DM^{-1}$) | 5.3 % | 6.9 |
| N (g.kg $DM^{-1}$) | 28 | 20 |
| K (g.kg $DM^{-1}$) | 27 | 36 |

As far as the content of nutrients is concerned, sorrel (harvested at the same time as dandelion) contained more crude protein and less fibre. However, its low digestibility was manifested in a low content of energy. Cattle does not graze sorrel because of its high content of oxalic acid and for that reason it can freely propagate and further deteriorate the quality of grass stand on the pasture. In Austria, altogether 29 species of the *Rumex* sp. were identified. The future danger of degradation of grass stands is associated also with differences existing between the Austrian and EU standards for seed materials. The strict Austrian standard does not allow no sorrel seeds in 100 g of seed material while a more tolerant EU standard permits the presence of:

| | |
|---|---|
| 5 seeds of *Dactylis glomerata* L. | per 30 g of seed material |
| 5 seeds of bastard hybrids | per 60 g of seed material |
| 2 seeds of *Poa pratensis* L. | per 5 g of seed material |
| 5 seeds of *Festuca pratensis* L. | per 50 g of seed material |
| 5 seeds of *Phleum pratense* L. | per 10 g of seed material |
| 10 seeds of *Trifolium repens* L. | per 20 g of seed material |
| 10 seeds of *Trifolium pratense* L. | per 50 g of seed material |

This means that, if calculated for Austrian type clover-grass mixtures, the number of sorrel seeds per hectare would be 4,300 and 9,200 in intensive crops on arable land and in permanent meadows, respectively.

### *3.3. Evaluation of the content of nutrients*

Evaluation and/or estimation of the content of nutrients in clover-grass forage represents another serious problem, especially from the methodological point of view. Effects of objective factors (e. g. geological conditions, level of NPK fertilisation, number of cuttings per year and differences in percentages of legumes and grasses) on the content of nutrients are sufficiently documented. The physical method NIRS enables a rapid, simple, and not very expensive method of estimation of nutrients in feeds and for that reason it is often used in practice. Within the framework of a joint project ”Action”, the Faculty of Agronomy. MUAF Brno and BAL Gumpenstein try to compare results obtained by means of this method with those of the classical ”wet” Wender analysis and, in case of estimation of organic matter digestibility, of Tylley and Terry method. The partial results are presented in Figs 4a – f and indicate that similar data can be obtained especially in case of crude protein estimation.

#### Crude protein (CP)

The estimation of crude protein in forage is currently very important especially wit regard to the ban of the use of meat and bone meals resulting from the BSE crisis. A direct comparison of a conventional wet method of estimation with the Czech NIRS method showed that both methods are similar and that they give comparable results ($R^2$ = 75 %). However, the Czech NIRS method overestimates in the range below 150 g of CP and therefore overestimates the actual contents of CP in fodder (Fig. 4a).

#### Crude fibre (CF)

In general, the Czech NIRS method underestimates the actual content of CF; in young crops with CF contents of ca 200 $g.kg^{-1}$ DM the obtained results are similar as those of the wet chemical analysis but with CF contents about 300 $g.kg^{-1}$ DM, the results of the NIRS method are lower so that the CF contend can be underestimated by as much as 70 g (Fig. 4b). The value of coefficient of determination (53 %) is also very low and determines the digestibility and energy content of the feed.

#### Digestibility of organic matter (OMD)

As compared with results obtained *in vivo*, data about OMD, as measured by the Tilley and Terry method, are very satisfactory. The Czech NIRS method showed only a weak coincidence with this method (Fig. 4c). When using the NIRS method,. the digestibility was overestimated in the range below 75 % and at 60 % the actual value was overestimated by 10 %. In case of the most frequent type of fodder. i. e. the crop harvested in the stage of heading n and the onset of flowering, the values of OMD ranged from 68 to 70 % so that the NIRS method overestimated the actual CF content by approximately 5 %. However, in the range of OMD above 75 %, the actual values were underestimated. This means that there is no coincidence between results obtained by means of the Tilley and Terry method and the NIRS method.

#### Energy content (MJ of NEL per kg of DM)

This parameter is very important from the viewpoint of animal feeding because the content of energy in feed determines the requirement of supplementary concentrates at a given level of milk performance. The comparison of the estimation on the base of OMD (Tilley and Terry) with the Czech NIRS method was performed using 350 forage samples and the results were completely different. This means that results of the

NIRS method are absolutely unsatisfying. The coefficient of determination ($R^2 = 0.0012$) and the course of correlation curves showed to be negative in case of results of the Czech NIRS method (Fig. 4d).

In Gumpenstein. the coincidence of results obtained by means of the NIRS and Tilley and Terry methods were much more correlated (Fig. 4e). The correlation existing between NIRS results (obtained in the Czech Republic and in Gumpenstein) indicated that the Czech NIRS data were markedly higher than those from Gumpenstein (Fig. 4f).

**Recommendation**

New methods of estimation of nutrients (e. g. of NIRS) are suitable for the application in practice only if their results are calibrated by 30 % of results obtained for samples analysed by means of the wet chemical method. Good calibration curves can give reliable results for CP while in case of CF and ash the results are either underestimated or overestimated. The repeatability of NIRS values of energy content will be possible only in the case that there will be enough reference data available.

**Fig. 4a** Crude protein – results of wet chemical analysis in Gumpenstein and NIRS method in the Czech Republic 310 samples (Gumpentein and Piber 1998, 1999; Vatín 1999)

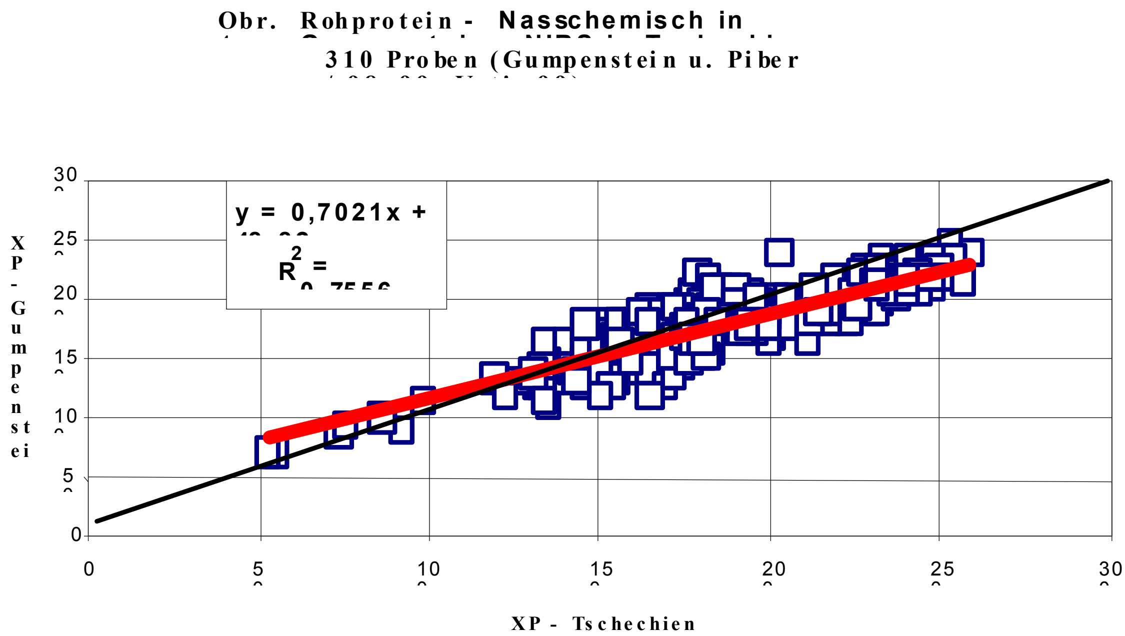
**Fig. 4b** Crude fibre - results of wet chemical analysis in Gumpenstein and NIRS method in the Czech Republic 310 samples (Gumpentein and Piber 1998, 1999; Vatín 1999)

**Fig. 4c** Organic matter digestibility – results of Tilley + Terry method in the Czech Republic 350 samples (Gumpentein and Piber 1998, 1999; Vatín 1998, 1999)

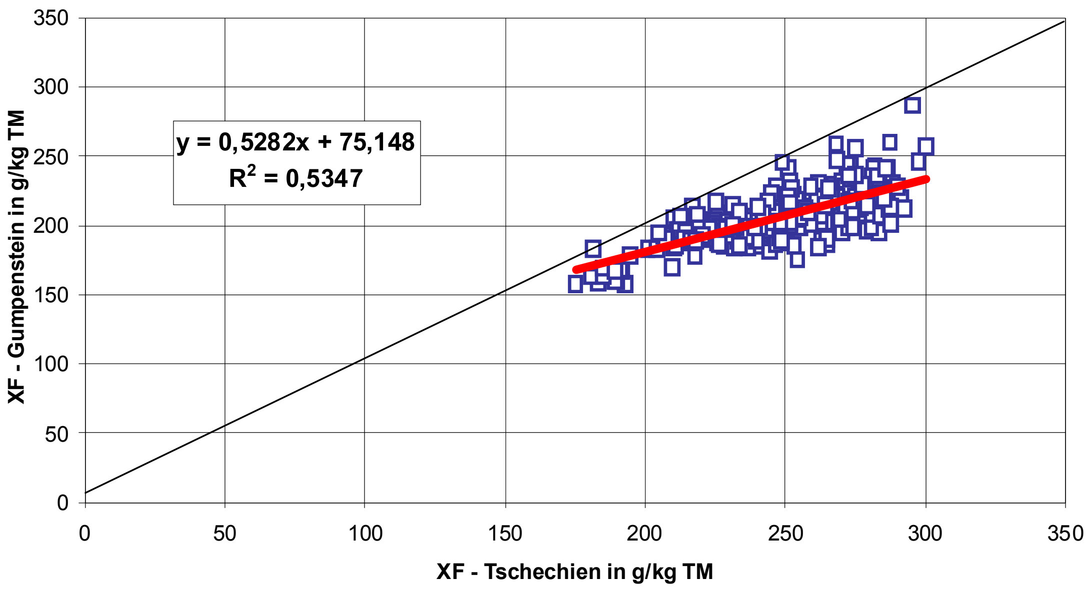
**Fig. 4d** NEL - results of Tilley and Terry method in Gumpenstein and NIRS method in the Czech Republic 350 samples (Gumpentein and Piber 1998, 1999; Vatín 1998, 1999)

**Fig. 4e** Results of Tilley + Terry method in Gumpenstein and NIRS method in Gumpensteinepublic 78 samples (Gumpentein and Piber 1998)

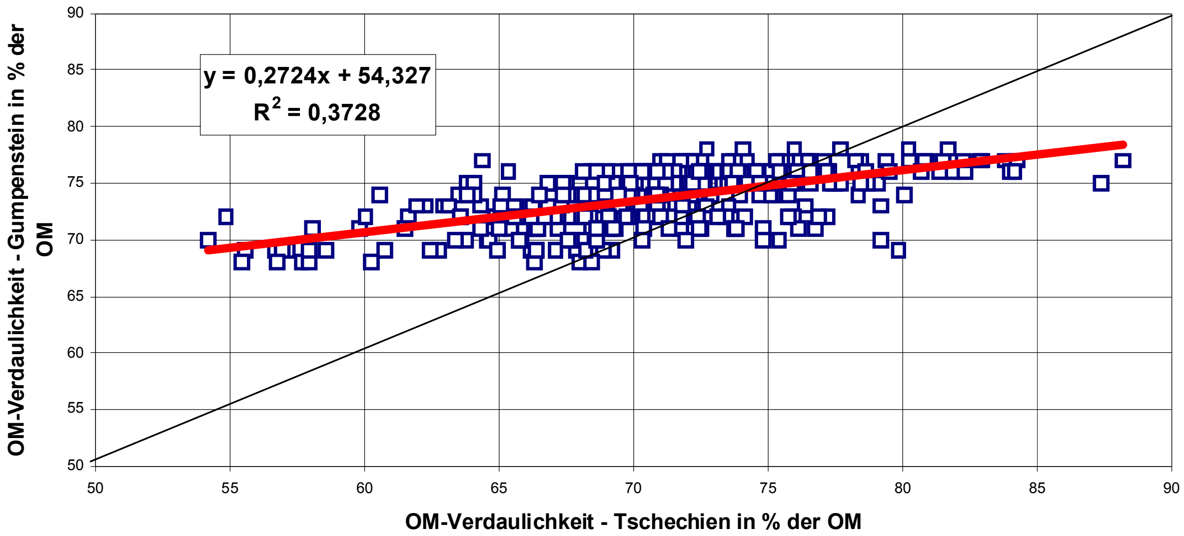
**Fig. 4f** NEL – NIRS in Gumpenstein and NIRS in the Czech Republic 78 samples (Gumpentein and Piber 1998)



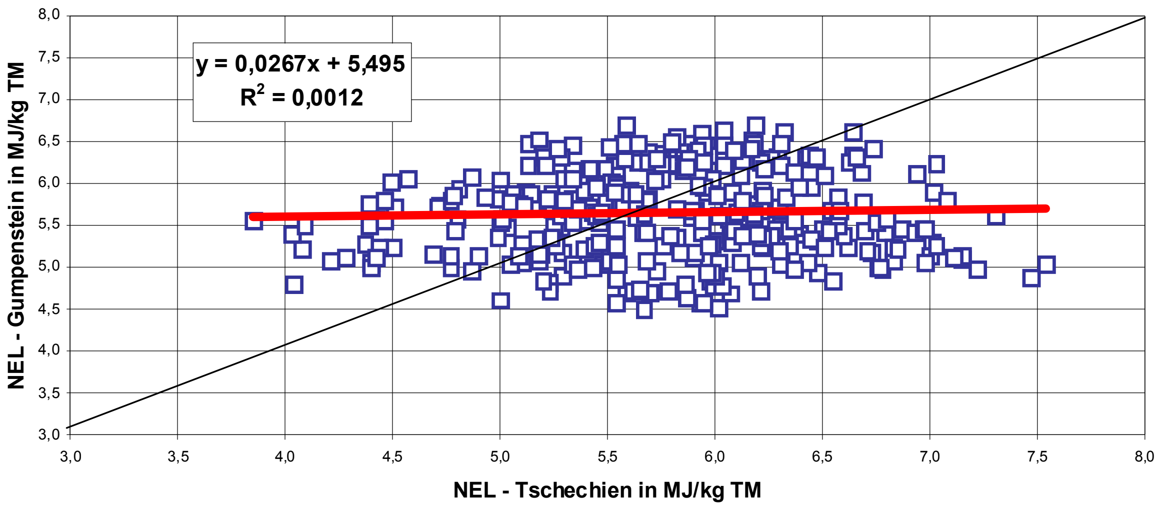
Obr. 4b: Rohfaser - Nasschemisch in Gumpenstein : NIRS in Tschechien
310 Proben (Gumpenstein u. Piber / 98, 99; Vatin 99)



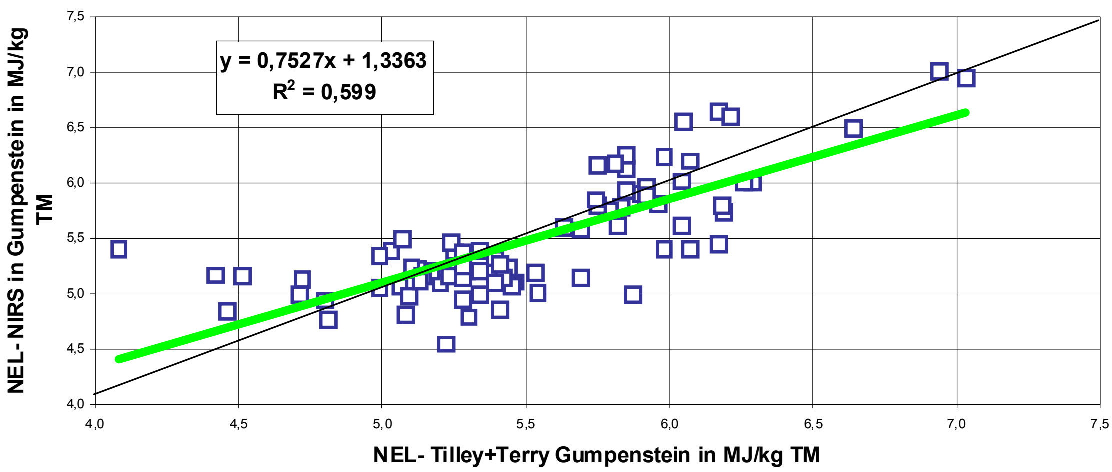

Obr. 4c: OM Verdaulichkeit - Tilley + Terry in Gumpenstein : NIRS in Tschechien
350 Proben (Gumpenstein u. Piber / 98, 99; Vatin / 98, 99)



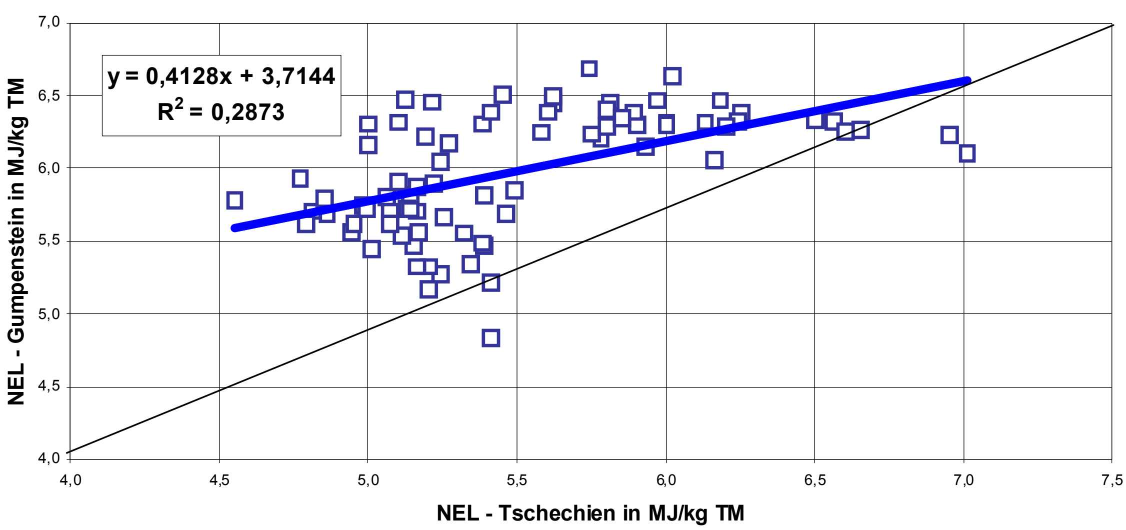
**Obr. 4d: NEL - Tilley + Terry in Gumpenstein : NIRS in Tschechien**
**350 Proben (Gumpenstein u. Piber / 98, 99; Vatin / 98, 99)**




**Obr. 4e: NEL - Tilley + Terry in Gumpenstein : NIRS in Gumpenstein**
**78 Proben (Gumpenstein u. Piber / 98)**




**Obr. 4f: NEL - NIRS in Gumpenstein : NIRS in Tschechien**
**78 Proben (Gumpenstein u. Piber / 98)**



*3.4 Quality of ensiled forage as related to the stages of growth and development*

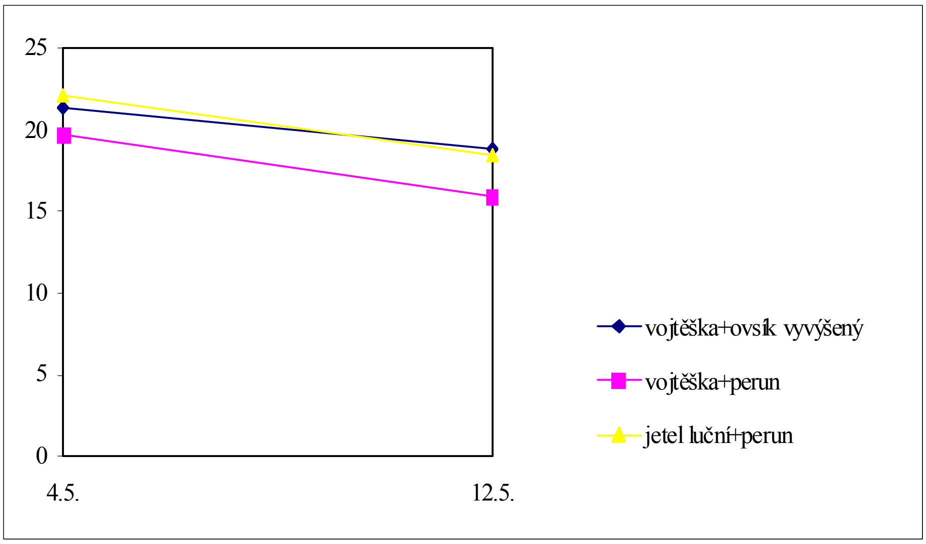
The necessity and importance of harvesting the crops in the optimum stage of development as related to the dynamics of changes in forage quality and yield of nutrients per unit area are documented in Tab. 9.

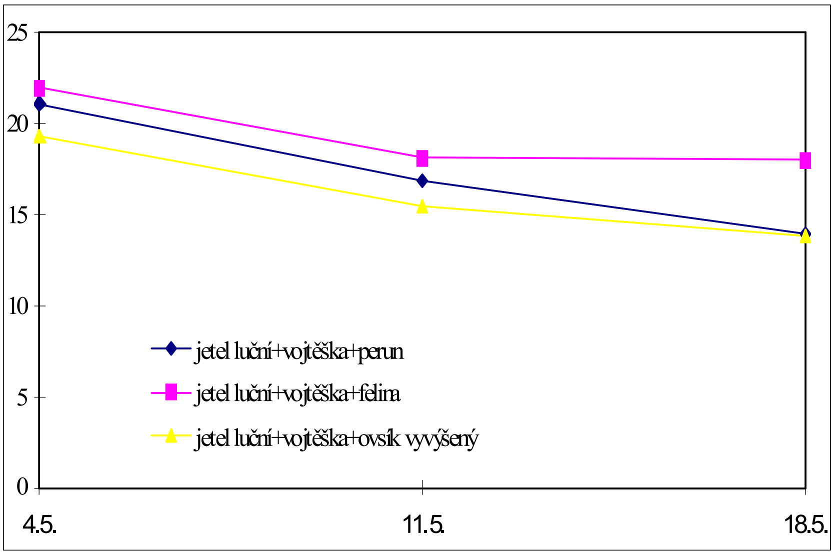
**Table 9.** Quality of ensiled forage in relation to the stage of development at the moment of harvest (Buchgraber et al. 1998 – modified)

| Nutrient | Cutting | Concentration of nutrients (g.kg $DM^{-1}$) in the developmental stage of: | | | | |
|---|---|---|---|---|---|---|
| | | heading | onset of flowering | flowering | end of flowering | old crop |
| DM | 1st | 322 | 356 | 343 | 335 | 321 |
| | 2nd | 361 | 429 | 389 | 349 | 328 |
| OM | 1st | 868 | 891 | 903 | 896 | 901 |
| | 2nd | 883 | 894 | 900 | 901 | 893 |
| CP | 1st | 169 | 166 | 146 | 143 | 125 |
| | 2nd | 177 | 176 | 164 | 153 | 137 |
| CF | 1st | 232 | 255 | 287 | 314 | 351 |
| | 2nd | 226 | 255 | 286 | 312 | 349 |
| DOM | 1st | 77 | 76 | 74 | 72 | 69 |
| | 2nd | 73 | 68 | 62 | 57 | 49 |
| NEL | 1st | 6.25 | 6.29 | 6.12 | 5.85 | 5.56 |
| (MJ.kg $DM^{-1}$) | 2nd | 6.04 | 5.58 | 5.09 | 4.60 | 3.85 |

In perennial temporary stands, favourable concentrations of major nutrients occur between the end of heading and the beginning of flowering of the dominating grass species. If the harvest is delayed, concentrations of CP, DOM and NEL significantly decrease. The principle of a timely harvest is important above all in case of the first cutting as this forage is mainly ensiled. In temporary stands (1 to 3 years) with only several species, a marked decrease in the content of nutrients and DOM takes place (Fig. 3). There are also differences in forage quality due to the inclusion of different species of *Viciaceae* (*M. sativa* and *T. pratense*) and *Poaceae* (*A. elatius* and festulolium hybrids) or different types of intergeneric hybrids (festuloid x loloid). The inclusion of cv. Perun resulted in an overall and a more rapid decrease in concentration of nutrients.

**Fig. 5** Comparison of changes in the content of CP in lucerne-grass, clover-grass and lucerne-clover-grass mixtures






—●— *T. pratense*+*M. sativa*+Perun
—■— *T. pratense*+*M. sativa*+Felina
.......*T. pratense*

*3.5 Quality of forage from pure stands of clover species and clover-grass mixtures*

Basing on results of analyses of samples of ensiled clover-grass forage (Buchgraber et al. 1997; Tab. 10) it can be concluded that, as compared with the pure stands of *T. pratense* and *M. sativa*, the forage shows a lower content of CP but a higher digestibility of OM (by 3 – 7 %) and a higher concentration of energy (0.57 *vs.*0.36 MJ.kg $DM^{-1}$).

**Table 10.** Differences in quality of ensiled forage from *T. pratense* L. and clover-grass mixture and *M. sativa* L. and lucerne-grass mixture in the 1st cutting (Buchgraber et al. 1998 – modified)

| Crop | Concentration of nutrients (g.kg $DM^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | DM | OM | CP | CF | DOM | NEL (MJ) |
| *T pratense.*<br>Clover-grass mixture | 305<br>335 | 885<br>897 | 169<br>144 | 279<br>304 | 66<br>73 | 5.36<br>5.93 |
| % | 111.7 | 101.3 | 85.2 | 109.0 | 110.6 | 110.6 |
| *M. sativa*<br>Lucerne-grass mixture | 387<br>350 | 882<br>891 | 183<br>167 | 294<br>301 | 63<br>66 | 5.00<br>5.36 |
| % | 90.4 | 101.0 | 91.2 | 102.4 | 104.7 | 107.2 |

The level of qualitative production of nutrients (Q-yield) per hectare is in case of ensiled forage related also to the observation of technological principles of harvest (cutting, wilting etc.). The differences in concentrations of nutrients in fresh and preserved forage (Tab. 11) are determined not only by objective factors (e. g. respiration losses during the period of wilting) but also by contamination of forage with soil after the harvest in wet weather.

**Table 11.** Content of nutrients, digestibility and content of energy in fresh and preserved forage within the stages of heading and onset of flowering

| | Ash $g.kg\ DM^{-1}$ | Fat $g.kg\ DM^{-1}$ | CP $g.kg\ DM^{-1}$ | CF $g.kg\ DM^{-1}$ | DOM % | NEL $MJ.kg\ DM^{-1}$ |
|---|---|---|---|---|---|---|
| Fresh clover-grass | | | | | | |
| Heading | 178 | 240 | 107 | 5.9 | 25 | 72 |
| Onset of flowering | 167 | 266 | 105 | 5.7 | 25 | 70 |
| Clover-grass silage | | | | | | |
| Heading | 159 | 244 | 125 | 5.4 | 34 | 72 |
| Onset of flowering | 145 | 258 | 131 | 5.1 | 36 | 70 |

Note: Complete data about concentrations of all nutrients in fresh and preserved forage from various types of grass associations in the Alpine region are available in the publication: Buchgraber et al. 1998 – Futtertabellen fuer das Grundfutter im Alpenraum. ÖAG, Vol.2, 1998, 11 pp

In the Czech Republic, the data about concentration of nutrients in forage and other feedstuffs are available in the publication Krmivářské tabulky (Zeman et al. 1998).

### *3.6. Number of harvests per year*

Intensity of production, as characterised by the number of harvests per year is an important problem not only with regard to the concentration of nutrients in forage but also to the level of total production per hectare and to the overall economic effect. Results of evaluation performed in BAL Gumpenstein (Gruber et al. xxxx, Tab. 12) indicate the necessity of a complex approach to the estimation of intensity of crop use. These results demonstrate that under conditions of an ecological application of fertilisers (only organic manure) and the same level of dressing, the highest yield of energy per hectare (39.6 GJ NEL) can be obtained with three cuttings per year. In spite of an increased concentration of nutrients and a higher intake of DM by dairy cows in the system of 4 cuttings, the total production of milk and calculated (converted) production of milk from forage produced per hectare are higher in the classical system of three cuttings (Tab. 10). When using the system of intensive and differentiated application of mineral forms of N-fertilisers it is necessary to evaluate also the profitability of investments into the production and application of N-fertilisers in the overall balance sheet of milk production efficiency.

**Table 12.** Forage quality, animal production and production per unit area in systems of various intensity of use (number of cuttings) and fertilisation of grass stands

| System of fertilisation | Organic manure | | |
|---|---|---|---|
| Number of cuttings | 2 | 3 | 4 |
| CP (g.kg $DM^{-1}$) | 122 | 142 | 165 |
| OMD (%) | 59.1 | 65.7 | 70.2 |
| NEL (MJ.kg $DM^{-1}$) | 4.61 | 5.22 | 5.61 |
| Intake of: | | | |
| Forage (kg DM) | 11.92 | 14.30 | 15.13 |
| Concentrates (kg DM) | 3.47 | 2.82 | 3.20 |
| Total (kg DM) | 15.46 | 17.19 | 18.37 |
| FCM (kg) | 17.80 | 21.00 | 22.40 |
| Milk from forage (kg) | 5.80 | 11.90 | 13.90 |
| Yield (DM $t.ha^{-1}$) | 79.40 | 75.80 | 63.50 |
| Yield (GJ $NEL.ha^{-1}$) | 36.60 | 39.60 | 35.70 |
| Stocking density(dairy cows/heads) | 1.82 | 1.45 | 1.15 |
| Milk production (kg FCM/ha) | 9.875.0 | 9.314.0 | 7.848.0 |
| Milk from forage (kg FCM/ha) | 3.252.0 | 5.250.0 | 4.881.0 |

*3.7 Content of minerals and microelements in clover and clover-grass forage*

Concentration of mineral substances in DM of clover and clover-grass stands cultivated on arable land is very high. This is due to a high supply of individual nutrients into the soil in mineral form and (in case of potassium) also in the form of slurry and manure with a low proportion of straw and last but not least also due to the ability of clover species to absorb minerals from deep layers of soil profile. The effect of soil conditions cannot be neglected as well (Tab. 13).

**Table 13**. Concentration of nutrients in forage from the 1st and 2nd cutting

| Fodder crop | Concentration of nutrients (g.kg $DM^{-1}$) in the 1st and the 2nd cutting | | | | |
|---|---|---|---|---|---|
| | Ca | P | Mg | K | Na |
| *T. pratense.* | 11.9/12.7 | 3.2/2.9 | 2.7/2.9 | 31.9/25.7 | 0.3/0.2 |
| Clover-grass mixture | 8.2/9.8 | 3.2/3.4 | 2.2/2.6 | 28.6/28.0 | 0.3/0.2 |
| *M. sativa.* | 14.1/15.4 | 3.5/3.0 | 2.5/2.4 | 29.1/24.2 | 0.4/0.4 |
| Lucerne-grass mixture | 11.3/12.1 | 3.5/3.3 | 2.4/2.6 | 28.8/25.8 | 0.4/0.4 |

As compared with pure stands of clovers, clover-grass mixtures show a lover content of Ca, Mg and K, especially in the 1st cutting. Lucerne-grass mixtures also show higher concentrations of minerals than clover-grass mixtures.

When evaluating the requirements of minerals and trace elements for cattle nutrition it is necessary to consider the losses occurring during the preservation above all due to break off of young leaves containing high amounts of nutrients. In summer and autumn, the content of Cu and Zn in the harvested forage is higher than in the 1st cutting. In grass stands, a delayed time of harvest also results in a marked decrease in the content of minerals (Tab. 14)

**Table 14.** Changes in the content of nutrients in crops of different age

| Nutrient | Concentration | Decrease in concentration (%) in the period | |
|---|---|---|---|
| | Heading – onset of flowering | End of flowering | Too old stand |
| Ca | 9.3 | 22 | 25 |
| P | 3.5 | 19 | 23 |
| K | 23.9 | 12 | 18 |
| Mg | 3.1 | 16 | 24 |
| Na | 0.5 | 20 | 46 |

Source: Buchgraber (xxxx)

As mentioned by Gruber et al. (1995), there are the following requirements of minerals for milk production in dairy cows (Tab. 15):

**Table 15.** Nutrient requirements of dairy cows with the different performance levels (mg.kg $DM^{1}$)

| | DM intake (kg) | Ca | P | Mg | Na |
|---|---|---|---|---|---|
| 15 kg of milk | 14.0 | 66 | 41 | 22 | 18 |
| 30 kg of milk | 19.5 | 114 | 71 | 32 | 28 |

It is generally known that there is a surplus of K in forage but its concentration in clover-grass mixtures should not exceed the level of 30 g.kg $DM^{-1}$. As far as the requirements for Ca are concerned, its concentration in forage produced in clover-grass mixtures seems to be sufficient and it should be supplemented only in high performing dairy cows (25 – 30 kg of milk). Concentration of P (ca 3.5 $g.kg^{-1}$ seems to be sufficient and covers its requirements at lower levels of milk performance ((10 – 20 kg). In high producing dairy cows it is necessary to supply it, especially in the form of concentrates. There is a permanent deficit of Na in forage and the daily deficit ranges from 13 to 22 g. The requirements of trace elements are as follows (mg.kg $DM^{-1}$):

| Mn | Zn | Cu | J | Co | Se |
|---|---|---|---|---|---|
| 50 | 50 | 10 | 0.5 | 0.1 | 0.15 |

When feeding the clover-grass forage, the requirements of Mn are fully satisfied but in combination with silage maize it is necessary to supplement the feeding ration with this trace element. The supply of Zn and Ca is always inadequate and for that reason it is necessary to supplement the feed with 200 – 500 mg Zn and 10 – 70 mg Cu. The supplement of Se is always desirable.

## 4. Conclusions

Basing on data concerning cultivation of clover-grass mixtures on arable land the following recommendations may formulated:

- it is necessary to test experimentally under different ecological conditions composition of clover-grass mixtures constructed on the principle of a wider species and, especially, cultivar diversity and also to evaluate the quality of seed material (no sorrel admixtures);
- when growing clover-grass mixtures, it is recommended to prefer biological forms of N (symbiotic bacteria and supply of N+PK in organic form); supply of mineral forms of N (fertilisers) should be reduced because of ecological and economical reasons;
- forage should be harvested in optimal stages of crop maturity (heading of the dominant grass species) and with regard to quality of crop (production of GJ NEL and CP per hectare);
- it is necessary to introduce and use faster and more efficient methods of estimation of nutrient content and digestibility in DM of produced forage;
- it is also necessary to pay increased attention to proper methods of feeding, especially with regard to the intake of forage in general and carbohydrates in particular.

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*Acknowledgement:*

These results were obtained within the framework of the research order No. MSM 432100001 solved at the Faculty of Agronomy, Mendel University of Agriculture and Forestry Brno and Czech-Austrian joint projects Aktion No. 23p10 and No. 27p5.

# Growing of Silage Maize

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The most important annual fodder plant grown on arable land is silage maize. The evaluation of its growing under the current conditions of the Czech Republic has to be based on the state of cattle breeding and the position document for negotiations with the European Union. In milk cows without market milk production the quota of 230 thousand cows and the volume of milk quota would, in compliance with yields, correspond with approx. 544 – 593 thousand milked cows. In 2000 the actual state in cows with market milk production amounted to 515 380 cows and in cows without market milk production to 82 326 cows.

Now as before, the cattle nutrition in the Czech Republic shall be based on maximum biomass use. For cattle, and for milk cows in particular, it is essential to provide high quality diet rich in energy. From this point of view, silage maize has been and shall be the pilot fodder crop and its growing will have to represent an intensive production process focused on high quality and cheap energy.

Silage maize growing in the Czech Republic developed in several phases. Some of these phases are related to the existence of Czechoslovakia and phases after 1989 are connected with the transformation of agriculture and the foundation of the Czech Republic.

In the beginning of the first phase maize was grown exclusively for greed feed. Maize for silage purposes was introduced later. The period, in which maize for silage started to dominate over maize for green feed purposes, can be dated in 1955.

The second phase (1955 – 1962) represents the period when a significant growth of acreage with maize grown for fodder purposes was recorded. In this period silage maize areas exceeded those with green feed maize. In 1962 silage and green feed maize were grown on 391 thousand ha (59 percent silage maize and 41 percent greed feed maize). For this period, a significant increase of growing areas with less favourable temperature conditions was characteristic.

In the third period (1963 – 1966) the growing areas decreased to 236 thousand ha.

In the fourth period, in 1967, an increase of silage and green feed maize growing areas could be recorded again. In 1974, the growing area of 400 thousand ha was exceeded. Within this period, the highest mean yield from the total sowing area amounting to 33 t . $ha^{-1}$ could be achieved.
The fifth phase (1975 – 1989 sowing areas with silage and green feed maize stabilized at the growing area of 400 thousand ha, yields did not drop below 30 t . $ha^{-1}$

The development of silage maize growing until 1989 depended on a broad range of factors:

1. Biological material – maize hybrids were cultivated, which made a significant growth of silage maize areas even under less favourable temperature conditions possible

2. Higher quality production and seed treatment

3. A broader range of pesticides helped to solve the weed control problem

4. Mechanization represented a significant contribution, sowing machines for precise sowing

5. The agricultural technology standards were improved, growing, harvest and conservation techniques were optimized.

6. Application of research results and knowledge in farming

The period after 1989 can be divided into two phases. In the first phase 1990 – 1998 a gradual decrease in areas under silage maize cultivation from 384 867 ha in 1989 to 249 436 ha in 1998 was recorded in the Czech Republic. The main reason has to be found in reduced cattle herds.

In the second phase after 1999 areas under silage maize cultivation were stabilized at 240 thousand ha showing a mean yield growth amounting to approx. 40 t. ha $^{-1}$.

In the period 1991 – 2000 an increase of milk yields in dairy cows from 4 031 kg/year to 5 755 kg milk per year was recorded. This suggests that silage maize as the pilot fodder crop represents a significant source of high quality and low price energy. In comparison with other fodder crops, silage maize shows a higher economic profitability. The mean yield in the Czech Republic in 2000 was 37 t. ha $^{-1}$ but, in order to achieve zero cost-effectiveness, yields amounting to 45.5 t. ha $^{-1}$. are necessary. With dry substance in biomass equaling 30 per cent, yields of 13.5 t. ha $^{-1}$ can be achieved. This makes it possible to produce approximately 80 to 85 thousand MJ from 1 ha in dependence of energy concentration.

**Basic measures aiming at high yields and ripeness reliability**

1. Status within crop rotation:

- principally the main crop
- sowing after winter mixed crop – not recommendable (short vegetation period, choice of hybrids with a lower FAO)

2. Choice of site:

- the requirements of maize have to be respected – site exposition, water erosion danger

3. Cultivation of the soil:

- autumn – high quality seeds and early sowing, application of organic fertilizers
- spring - soil surface leveling, soil moisture management, support of weed germination, soil warming, pre-sowing preparation only within the sowing depth

4. Correct hybrid selection:

- the length of the vegetation period (earliness) is reflected in FAO
- hybrid selection process should ensure high yield and required ripeness
- the range of hybrids is very broad
- new hybrid qualities – “stay green” types and types with increased digestibility of non-corn plant parts
- hybrids should be selected in compliance with cultivation conditions

5. Silage maize sowing:

- date of sowing in dependence of soil temperature of min. 6 – 8 °C , maize seed corn should be subjected to “cold tests”
- sowing depth of 50 – 60 mm recommended, regular sowing depth is essential a precisely working sowing machine ensures an even distribution of corns
- the correct sowing density results in high yields and required ripeness, differentiation in compliance with the given hybrid is essential
- row distance should not drop below 0.5 m

6. Well-balanced nutrition:

- nutrition is based on organic fertilizers
- pH regulation
- harmonious NPK nutrition in compliance with harvests
- fertilizing “on leaf” is questionable

7. Weed control:

- application of pre-emergent herbicides should be preferred
  - weed are damaged directly after germination
  - maize plants are not shaded
  - maize growth does not get damaged
- application of post-emergent herbicides
  - local and corrective measures
- option of the application of the mechanical cultivation “fertilizing by air”
- some weeds can be damaged in the pre-plant

8. Silage maize harvest:

- achievement of the required dry substance content – optimum 27 to 32 per cent
- in divided harvest dry matter of corncobs amounts to 55 to 60 per cent
- short chaff

The high yield rate of farm animals is based on sufficient energy supplies in the diet accompanied by low energy production costs. The operations of grower of silage maize or divided harvest maize have to be focused on intensive production of quality and cheap energy.

Silage maize in the Czech Republic.

| year | 1989 | 1990 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|
| area (ha) | 384 867 | 381 925 | 259 093 | 240 436 | 241 200 | 240 000 |
| yield ($t.ha^{-1}$) | 30,99 | 27,60 | 32,90 | 34,56 | 35,6 | 37,1 |

Economic of fodder crops in the Czech Republic (Komberec, 1999).

| parameter | fodder beet | lucerne | red clover | silage maize | meadows |
|---|---|---|---|---|---|
| costs per 1 ha | 30 069 | 15 845 | 14 085 | 22 135 | 11 909 |
| yield ($t.ha^{-1}$) | 40,0 | 7,11 | 7,70 | 34,56 | 3,18 |
| price of 1t of product (Kč) | 520 | 1 000 | 900 | 400 | 700 |
| price of production per ha (Kč) | 23 680 | 7 110 | 6 930 | 13 824 | 2 226 |
| rate profitability (%) | -21,2 | -55,1 | -50,6 | -37,5 | -81,3 |
| limit of the crops by zero profitability ($t.ha^{-1}$) | 48,48 | 11,03 | 11,61 | 47,52 | 5,76 |

Area of silage maize in production regions.

| year | country | area (ha) | growing area in production region (%) | | | |
|---|---|---|---|---|---|---|
| | | | A | B | C | D |
| average 1969-1971 | Czecho-slovakia | 291 198 | 29 | 32,9 | 36,4 | 2,7 |
| | CR | 180 995 | 6 | 44,8 | 48,2 | 1,0 |
| | SR | 110 163 | 62 | 18,0 | 15,2 | 4,0 |
| 1980 | Czecho-slovakia | 418 341 | 21 | 31,0 | 43,0 | 5,0 |
| | CR | 281 981 | 6 | 37,0 | 53,7 | 3,5 |
| | SR | 136 360 | 52 | 19,5 | 22,5 | 6,0 |
| 1989 | Czecho-slovakia | 547 404 | 19 | 34,0 | 41,5 | 5,5 |
| | CR | 376 438 | 6 | 35,0 | 55,0 | 4,0 |
| | SR | 170 966 | 49 | 21,0 | 24,0 | 6,0 |

Note: A maize-growing region, B beet-growing region, C potato-growing region, D mountain growing region

# Aerobic Deterioration of Silage: A Review

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## Introduction

During the ensiling process, plant substrates such as sugar and starch, are converted by anaerobic microorganisms to organic acids. Those acids lower the pH sufficiently to inhibit further microbial activity. Dry matter (DM) loss during anaerobic fermentation is inevitable, but minimal. Any air that remains in the ensiled material after packing, enters through an unsealed surface during storage, or penetrates the exposed “face” during feedout, results in aerobic microbial metabolism, which converts substrates to carbon dioxide, water and heat – a process that can lead to extensive DM loss.

The efficiency goals for every silage are to minimize losses during the aerobic, fermentation, storage, and feedout phases and to maximize silage DM recovery to be ultimately consumed by livestock (Ruppel, 1997). Losses can be 20% or more when silages are fed in warm, humid weather encouraging aerobic metabolism during feedout; when inadequate sealing allows air to penetrate and/or to remain entrapped in the ensiled material; when horizontal silos have large surface areas and feedout "faces" allowing air entry and/or rain damage; when unloading machinery and methods allow air penetration, and when fermentation is restricted limiting pH decline and preservation (Ohyama et al., 1975; Rees, 1982; Honig, 1991).

While the efficiency of the fermentation phase has been improved over the past years, the same cannot be said about aerobic stability during the feedout phase (Honig et al., 1999). This improvement in silage quality, which has prevented butyric acid production and minimized acetic acid, has, in fact, increased the risk of aerobic instability during feedout. Thus, well-preserved silages are generally more prone to aerobic deterioration than their poorly fermented counterparts (Cai et al., 1999b).

All silages, when exposed to air, sooner or later deteriorate as a result of aerobic microbial activity (Bolsen et al., 1996). Silage deterioration on exposure to air is inevitable and usually results in high losses of DM (Bolsen, 1997) and important nutritional components (Kung et al., 1998) through the oxidation of lactic acid and water-soluble carbohydrates (WSC). This in turn reduces the preservation potential, degrades nutrients, and leads to indigestible Maillard products because of excessive heating. The accumulation of degradation products can reduce palatability and lead to feed refusals (Holzer et al., 1999). Some of the resulting aerobic microorganisms such as molds, bacilli, and Listeria monocytogenes (Driehuis et al., 1999) can be harmful to livestock, and further aerobic deterioration can result in the formation of potentially lethal mycotoxins. Preventing aerobic deterioration during feedout is an essential goal in every silage program.

Most data suggest that fungi, particularly yeasts, have a predominant role in the deterioration process (Woolford et al., 1982; Spoelstra et al., 1988; Jonsson and Pahlow, 1989). Lactic acid assimilating yeasts can initiate deterioration in all types of silage exposed to air. In whole-plant maize silage, acetic acid-producing bacteria can play a complementary role in aerobic deterioration (Woolford, 1990; Honig et al., 1999).

Mold growth alters the palatability and nutrient profile of silage (Driehuis et al., 1999). There is a loss of carbohydrates and an erratic change in vitamin content. But the protein degradation that accompanies mold growth has, perhaps, the greatest economic impact (Schlatter and Smith, 1999). The decrease in feed intake together with the reduced nutrient content has a negative impact on livestock performance. Hoffman and Ocker (1997) reported that cows fed spoiled high moisture corn (HMC) produced 3.2 l less milk per cow per day during a 14-day period than cows fed fresh, well-preserved HMC.

In addition to the loss of nutrients, mycotoxins can reduce feed intake, alter nutrient digestibility and absorption, have a toxic effect on the animal, and can be responsible for, as yet, unidentified diseases (Clarke, 1988). The presence of molds does not always mean that mycotoxins are produced. However, under certain conditions the production of mycotoxins can be rapid, and their stability allows them to stay in the feed long after active mold growth has ceased (Schlatter and Smith, 1999).

**Factors involved in aerobic deterioration**

Aerobic deterioration of silage is a complex process, influenced by factors such as oxygen (both amount and exposure time), composition of the microbial population, substrate type (e.g., nutrient content of the silage), stage of maturity of the forage at harvest, density of the silage, ambient temperature, and temperature of the silage mass (Ohyama et al., 1975; Woolford, 1978).

Silage pH. Aerobic deterioration in a silage can be monitored by measuring pH. Unless the original silage pH is already high (ca >5.0), the initial deterioration processes result in an increase in pH. Under anaerobic conditions, the low silage pH inhibits the growth of undesirable microorganisms (e.g., clostridia). However, low pH, *per se*, is not sufficient to prevent aerobic deterioration, because yeasts can grow under fairly low pH conditions (Ohyama et al., 1975).

Forage DM content. It has been assumed that aerobic deterioration would be more serious in drier forages with low packing densities because air can invade the silage rather easily. Huber et al. (1968) reported greater storage loss in more mature, dryer silage (44% DM) compared with silage of more conventional DM (36%). However, the results of Ohyama et al. (1975) did not support this assumption.

Pessi and Nousiainen (1999) reported that well-fermented silages that were either low in DM content or slightly prewilted, and preserved with or without a bacterial inoculant appeared to be prone to aerobic spoilage. Pitt et al. (1991) observed that high DM silages were less stable during the feedout phase, because they had high pH's and low acid concentrations. Furthermore, the trend toward increasing the degree of prewilting has made it more difficult to consolidate forages and prevent the exchange of gases (e. g., allowing air to infiltrate the silage mass).

Data from Wyss (1999) showed that prewilted grass silages were more aerobically unstable than those with a lower DM content. The author concluded that the higher sugar content, lower concentration of acetic acid (e.g., from a less intensive fermentation), higher yeast population, and lower consolidation in the prewilted silages compared to their low DM counterparts contributed to the differences in aerobic stability.

Residual WSC content. When silage is removed from the silo, an increase in the temperature of the silage mass is an indication of aerobic deterioration (Ohyama et al., 1975). Heating is caused by the aerobic metabolism of sugars and organic acids by yeasts and bacteria (Spoelstra et al., 1988). The end products are carbon dioxide, water and heat. The concentrations of lactic acid and WSC usually decrease very rapidly as they are used as substrate by the aerobic microorganisms.

Because fungal growth is rapid when WSC are available as a substrate compared to organic acids, aerobic stability decreases when high residual WSC levels are present (Pitt et al., 1991). Ohyama et al. (1975) reported cases where silages remained stable in spite of high levels of WSC. However, once deterioration occurred, losses were high in silages with high WSC contents.

The WSC content depends upon crop species, climate, stage of maturity, and the level of nitrogen fertilizer. A reduction in light intensity lowers sugar content, and there is a positive correlation between stage of maturity and plant WSC content. In grasses, nitrogen fertilization promotes plant growth and lowers WSC content (Henderson et al., 1987).

Crop species. The influence of forage type on aerobic stability is indirect through differences in fermentability (Woolford, 1984). Whole-plant maize and small grain cereal silages are generally more prone to aerobic deterioration than grass or legume silages (Bolsen et al., 1996).

Aerobic spoilage of corn silage is well-documented, and generally occurs through a series of fungal and bacterial interactions (Muck and O'Kiely, 1992; Pahlow et al., 1999). Since the whole maize plant has an adequate reserve of readily available fermentable sugars, it ensiles without difficulty and achieves a low, stable pH quite rapidly. The high "ensileability" of maize is attributed to a combination of both substrate availability and a relatively low content of organic acids, whose salts buffer against acidification (Woolford, 1984).

Temperature. Although high ambient temperatures (e.g., 30-40°C) generally favor the microbial activity that leads to rapid aerobic deterioration, it is important to note that during feedout, deterioration can occur even at ambient temperatures of 10-15°C. However, some silages are aerobically stable even at high temperatures (Pitt et al., 1991).

Ohyama et al. (1975) observed that silages that were stable at 25-30°C contained relatively high concentrations of propionic acid (0.28-0.46% of the DM) or butyric acid (0.56-0.92% of the DM). Rees (1982) found that when ambient temperatures increase by 10°C above 21°C the losses due to aerobic deterioration were 1.7% of the DM per day.

Silage density. Spoilage due to air infiltration depends on the rate at which air will move into the silage mass, which is related to the porosity of silage. Porosity in turn depends on such characteristics such as density, compaction, stage of maturity (e.g., more mature forages contain a higher proportion of fiber and are more rigid), moisture content, and chop length. Density and porosity are inversely related (Muck and Holmes, 1999). Research into the mechanisms of air infiltration suggests that shorter chopped forages can offer less resistance to gas movement than longer chopped material, despite a higher density in the shorter forage (McGechan, 1990).

Ensuring sufficient consolidation is important, especially in view of the increased capacities of modern silage harvesters (e.g., tons of DM harvested per hour). Depth of air penetration is largely determined by harvesting, filling, storing, and feedout practices. In general, as density decreases, depth of air ingress increases. The progression of the feedout "face" through the silo is important, and depends on the height and width of the silo, herd size, and the amount of silage fed per animal per day (Honig et al., 1999). Lindgren et al. (1988) reported fewer aerobic spoilage microbes as silage depth increased.

Oxygen infiltration is reduced with higher densities. Ruppel et al. (1995) observed increased aerobic stability in silages exposed face at higher densities. This is consistent with results from Pitt and Muck (1993), who also found fewer aerobic organisms at high densities.

Microbial factors. A diverse flora of yeasts, bacilli, and Enterobacteriaceae have been observed in fermented silage, and because different species vary from year to year and from silage to silage, it is impossible to generalize the microbial dynamics during the fermentation, storage, and feedout phases. However, the range of genera of yeasts and bacteria involved in the aerobic deterioration of widely differing silages appears to be very restricted (Woolford, 1990).

The population dynamics probably depend on the establishment and/or survival of the aerobic spoilers during the fermentation and storage phases. Little is known about the factors that influence their establishment. Oxygen diffusion during storage appears to be important for the establishment of lactate-assimilative yeasts (Lindgren et al., 1985).

Yeasts. Most yeasts grow well at temperatures between 0ºC and 37ºC, and a few are adapted to temperatures above 45ºC. Jonsson and Pahlow (1989) reported that yeast counts decreased as the temperature during aerobic deterioration exceeded 40ºC. Yeasts are more sensitive to higher temperatures than are clostridia.

Yeast numbers increase during wilting, and it is particularly evident for lactate-utilizing (LAY) and fermentative yeasts (Woolford, 1990). In a study by Henderson et al. (1972) LAY counts, which were below the limit of detection at the time of cutting (about 200 cells per g of DM), increased to more than 10,000 cells per g of DM during the wilting process. This might explain why aerobic deterioration appears to occur more frequently with drier forages, which were ensiled at relatively low densities (Ohyama et al., 1975).

Soil contamination (e. g., soil picked up during mechanical tedding) likely contributes to the increased yeast counts (Jonsson, 1989). The low pH of most silages inhibits the survival of few yeasts; as some can grow within a pH range of 3 to 8 (Woolford, 1976). The optimum pH for the growth of most yeast is between 3.5 to 6.5. Under aerobic conditions yeast tolerate organic acids better than most other microorganisms (Woolford, 1975a). Yeasts isolated from silage consume organic compounds such as lactic, acetic, citric, malic, succinic, and propionic acids and ethanol under aerobic but not under anaerobic conditions (Ashbell et al., 1991). In studies by Henderson et al. (1972) and Jonsson (1989) yeasts were favored by the addition of formic acid at ensiling because of increased amounts of residual sugars.

The majority of epiphytic yeasts on forage crops are non-fermentative, and belong to the genera Sporobolomyces, Cryptococcus, Rhodotorula, and Torulopsis; which can range in population density from less than 10 to $10^{6-7}$ cells per gram of fresh material (FM) (Lindgren et al., 1985, Middlehoven and van Baalen, 1988).

After anaerobiosis has been established in the ensiled forage, aerobic yeasts are succeeded by a fermentative flora of yeasts (Middlehoven and van Baalen, 1988). The dominating species usually are C. lambica, C. krusei, H. anomala, Torulopis spp. and Saccharomyces spp. These species have also been found in other fermented products (Reed, 1983 as cited by Jonsson, 1989). These species can assimilate and a few carbohydrates. In addition, C. lambica, together with Hansenula anomala, belong to the class of yeasts that assimilate xylose. This property becomes especially important in the later stages of silage fermentation when the readily available sugars are depleted, and xylose becomes available as the result of either acid hydrolysis of hemicellulose or the action of natural-occurring hemicellulases (McDonald et al., 1991). The yeast species found during this phase of the ensiling process have frequently been isolated from aerobically unstable silages.

The presence of air during the ensiling process promotes the development of a different population of yeasts. They have been classified into two groups: those that can use acids (Candida, Endomycopsis, Hansenula, and Pichia) and those that use sugars (Torulopsis) (Middlehoven and Franzen, 1986; Woolford, 1990). Candida and Hansenula are able to metabolize lactic acid and consequently increased silage pH which in turn creates conditions suitable for mold growth during extended feedout. Yeasts can also inhibit the fermentation process because they can compete with lactic acid bacteria (LAB) for available WSC (Ruxton and McDonald, 1974).

Yeast numbers vary (fresh basis) from less than 10 per g in well-preserved silage to $10^{12}$ per g in aerobically deteriorated silage (Lindgren et al., 1985). Daniel et al. (1970 as cited by Spoelstra et al., 1988) stated that silages with at least $10^5$ yeasts per g of DM were very susceptible to aerobic spoilage, especially if that number was made up of lactate-utilizing organisms.

The microflora population on whole-plant maize is usually characterized by a high number of microorganisms, particularly yeasts, which might be 100 to 1000-fold higher than numbers observed on grasses or legumes. It has been suggested that because yeasts on maize account for a substantial proportion of the microflora, they play a major role in its ensiling process (Woolford, 1984). The predominant yeast flora of 13 different maize silages was shown to consist of Candida lambica, Saccharomyces dairensis, Saccharomyces exiguus, Candida holmii, Candida milleri and Candida krusei (Middelhoven and van Baalen, 1988). All of these species, except S. dairensis, tolerated acetic acid at pH 4.0. Lactic and acetic acids and ethanol were readily assimilated at pH 4.0 in the presence of 1 g yeast extract per liter.

Molds. Oxygen is vital for the growth of molds, so the silage management practices that eliminate air will prevent molds from having an active role in the ensiling process (Schlatter and Smith, 1999). Conditions that favor mold growth include: 1) a moisture content above 13%, 2) a relative humidity above 70%, 3) a temperature above 13ºC, 4) readily available nutrients, 5) a pH greater than 5, and 6) the presence of oxygen.

Mold development in silage is inhibited by a low pH but is encouraged by the presence of unfermented sugars. Simply stated, mold growth occurs when there is adequate moisture, warmth, and air. The growth of fungi increases the pH of the ensiled material, which creates ideal conditions for other microorganisms to grow. Because development of molds is typical where anaerobic conditions are not maintained, mold contamination can be extensive near the surface of the ensiled forage, in poorly sealed silos, in poorly sealed wrapped-bale silage, which is not sealed properly, where the wrapping material is damaged, or in silages with a low packing density (Clarke, 1988).

Whole-plant maize, sorghum, or small cereal grain silages are more prone to mold growth than silages from grasses or legumes. Molds include a wide range of genera (Fusarium, Aspergillus, Mucor, Penicillium, Monilla). Some proliferate while the crop is growing in the field prior to harvest, others propagate during the storage phase, and still others have been found in aerobically deteriorating silage (Grajewski et al., 1999). Some are thermophilic, but because they generally grow slower than yeasts, they molds are considered incidental and of little influence in aerobic deterioration (Woolford, 1990).

Penicillium rockefortii, which is suspected of suppressing the immune response in cattle, was recently isolated in silage that was within 25 cm of the surface in "horizontal" silos (Sundberg and Häggblom, 1999).

This mold is also capable of growing at a low pH and in a nearly anaerobic environment (Detmer et al., 1999).

Bacteria. While the majority of evidence favors fungi and especially yeasts, as being responsible for aerobic deterioration in silage, results of other investigations suggest that bacteria might also initiate the process (Woolford et al., 1982).

Spoelstra et al. (1988) suggest that aerobic deterioration is often started by a simultaneous build-up of populations of yeasts and acetic acid-producing bacteria. However, when silage was inoculated with acetic acid producing bacteria (genus Acetobacter) no growth of yeasts was observed, suggesting that acetic acid bacteria can be solely responsible for initiating aerobic deterioration. The preferred substrate for those bacteria is ethanol, followed by lactic and acetic acids (Woolford, 1990).

Barry et al. (1980) attributed the onset of heating in the feedout phase to acid-tolerant aerobic bacteria. The thermotolerant Bacillus spp., gradually replaces the less thermotolerant yeasts as the temperature of the silage increases during deterioration. Besides, the organisms identified in silages (e. g., Bacillus spp. and Monascus ruber) are able to effectively utilize lactic acid. Monascus sp. has previously been found in aerobically deteriorated maize silage (Hara and Ohyama, 1979 as cited by Jonsson, 1989) and Bacillus spp. considered to be the cause of aerobic deterioration in maize silage (Woolford, 1978 and 1984).

The deterioration process in maize silage can be initiated by aerobic bacteria (such as Bacillus spp.) followed by an increase in yeast populations (Jonsson, 1989). The reverse is generally true in legume, grass, and cereal silages. Further, Woolford and Cook (1978) found that an antimycotic agent did not prevent aerobic deterioration in maize silage.

Clostridium and Listeria can be hazardous to livestock health and degrade the nutritional value of silage (Woolford, 1990). So far, only seven clostridial species have been identified as playing a role in the fermentation phase (C. butyricum, C. tyrobutyricum, C. paraputrificum, C. sporogenes, C. bifermentans, C. perfringens, and C. sphenoides). Clostridia can be found in silage primarily because of soil contamination. They can be either saccharolytic or proteolytic and can consume lactic acid, which in turn may raise the pH of the silage. Clostridial growth in silage is favored by a low DM content, a low WSC content, a high buffering capacity, and a high ambient temperature (>25 to 30°C). The pH level below which clostridia stop growing decreases with decreasing DM content of the ensiled forage. As with the clostridia that are of significance to silage, *per se*, a high DM and/or low pH can limit the growth of C. botulinum; however, its presence has been reported in silage that has undergone extensive secondary fermentation (Woolford, 1990). Clostridia, as well as Bacillus, can form spores that can survive pasteurization.

Listeria monocytogenes is commonly found in soil, vegetation, water, and several animal species. Many strains of most species of Listeria have been isolated from silage, particularly near the surface and especially from silages that have undergone aerobic deterioration.

Aerobic deterioration creates conditions suitable for the growth of Listeria. Contamination with Listeria usually penetrates a few centimeters into the silage mass. This layer can contain up to $10^6$ bacteria per g of silage. Its growth is markedly decreased in acid medium (critical pH of 5.5) (Fenlon, 1988; Woolford, 1990).

**The effect of additives on aerobic deterioration**

The ideal ensiling process is one that reduces fermentation losses and maintains an acceptable degree of aerobic stability during storage and feedout. Proper management and an effective silage additive play a key role in balancing these important silage traits. But often the most poorly preserved silages that have a high content of nonprotein nitrogen (NPN) and acetic or butyric acids are the most aerobically stable, and well-preserved silages are the more prone to aerobic deterioration (Woolford, 1990).

The two primary reasons for using an additive to improve aerobic stability are: 1) to prevent heating and resultant DM losses and 2) to prevent the reduction in livestock performance associated with feeding spoiled silage (Bolsen et al., 1996). An efficacious silage additive should prevent one or both of these problems (Kung Jr. et al., 1998). Many additives have been developed to improve the ensiling process and the nutritive value of an ensiled forage (Weinberg et al., 1993; Muck, 1996). Additives are expected to ensure a more efficient fermentation phase as well as reduce the risk of aerobic deterioration (Jonsson, 1989). They should not only promote a rapid acidification via lactic acid production, but should also prevent the growth of spoilage organisms.

Chemical preservatives. Various chemicals have been used to prevent spoilage during feedout (Britt et al., 1975; Kng et al., 1998). Significant improvements in the fermentation process, silage nutritive value, and in aerobic stability during feedout can be achieved by the use of chemical additives such as organic and inorganic acids, salts of acids, and NPN (Bolsen et al., 1996).

Acetic, propionic, and butyric acids and higher volatile fatty acids (e.g., valeric, caproic, and heptylic) are good inhibitors of yeast and mold growth and can increase silage stability (Ohyama and McDonald, 1975; Woolford, 1975a; Detmer et al., 1999). Acetic acid in combination with lactic acid has been found to inhibit the growth of yeasts (Moon, 1983). Propionic acid, a combination of acetic and propionic acids, and ammonium isobutyrate have been shown to inhibit the growth of molds (Britt et al., 1975). Henderson et al. (1979) reported that silages tended to be more aerobically stable when total VFA content was high.

The ability of organic acids to inhibit mold and bacterial growth is species and acid specific. It does not depend on pH, but rather the specific acid anion. For example, sorbic acid is quite effective in preventing the growth of Monascus sp., while acetic acid is totally ineffective. Furthermore, the effect of organic additives on preventing aerobic deterioration has been found to vary, and the antimicrobial activity of organic acids increases with chain length and low silage pH (Woolford, 1975a).

Of the short chain fatty acids, propionic acid has the greatest antimycotic activity (Woolford, 1975a; Kung Jr. et al., 1998; Kung et al., 2000). However, Ohyama et al. (1975), observed cases where the presence of large amounts of propionic acid failed to prevent aerobic deterioration. No explanation was given for this contradictory finding; but the authors mentioned that it did not depend on DM content, total acids, lactic acid, WSC, or pH.

Unbuffered propionic acid-based additives have been used to improve aerobic stability of maize silage. The corrosive nature of propionic acid has been reduced by buffering, and buffered propionic acid can be used with other antifungal agents such as benzoic and sorbic acids (Kung et al., 2000).

Ohyama et al. (1975) reported that silages containing various amounts of butyric acid or higher VFAs were generally aerobically stable. Because butyric acid production is an indication of poor fermentation quality, it is not recommended that making silages with a high butyric acid content be a practice. It has been reported that the addition of isovaleric or caproic acids can prevent or delay aerobic deterioration (Ohyama and McDonald, 1975).

Formic and sulfuric acids have also been used as silage additives (Muck, 1988). Yeasts are particularly tolerant to formic acid (McDonald et al., 1991), and its use can result in unstable silages partly because of the high yeast counts in the silage (Henderson et al., 1972; Ohyama and McDonald, 1975), and because of the restricted fermentation that leads to a higher residual sugars content (Bolsen et al., 1996; Rammer et al., 1999). Formaldehyde application also leads to high residual WSC in silages. Di Menna et al. (1981) reported that formaldehyde-treated silage that was exposed to air underwent severe heating and had high counts of aerobic organisms, both bacteria and yeasts. In fact, formaldehyde-treated silage was less stable during feedout than untreated silage. The poorer aerobic stability of the treated silage was caused by the higher pH and greater WSC content that supported rapid microbial growth when the silage was exposed to air.

Henderson et al. (1972) also observed an increase in the growth of yeasts in formic acid-treated silages. Barry et al. (1980) reported that the initial temperature increase in silages with formaldehyde-containing additives was caused by bacteria (probably acid-tolerant) and molds appeared secondarily.

Adding ammonia raises the pH of the crop to 8 to 9 instantly. The effect of the ammonia and the resulting high pH reduce yeast and mold populations, and increases aerobic stability (Bolsen et al., 1996). Although moderate levels of ammonia added at ensiling have improved the aerobic stability of maize silage (Kung et.al., 2000), Bolsen et. al. (1992) summarized data showing that ammonia addition decreased DM recovery, resulting in lower livestock performance per tonne of ensiled forage compared with untreated silages.

Aerobic stability of grass and whole-crop cereal silages increases when hexamethylene-tetraamine (HMTA), sodium nitrite ($NaNO_2$), sodium benzoate, and sodium propionate are used alone or in combination. Potassium sorbate and sodium benzoate inhibit yeast and mold growth. Benzoic acid is considered to be a stronger mold inhibitor than propionic acid. Yeasts have a high resistance to $NaNO_2$, and at higher pHs its effectiveness against spore-bearing bacteria is minimal. However, HMTA is effective under those conditions. Sodium benzoate, a commonly used food preservative, is effective against mold growth even at pH 5 (Lättemäe and Lingvall, 1996; Lättemäe et al., 1999; Rammer et al., 1999). Most of these compounds are more effective with declining pH of the ensiled forage, as has been reported with straight chain VFAs (Woolford, 1975a).

Bacterial inoculants. At present biological additives are preferred for silage preservation because they are non-toxic, non-corrosive to machinery, do not present environmental hazards, and are regarded as natural products (Weinberg et al., 1993; Bolsen et al., 1996; Muck and Kung, 1997). Although inoculation with homofermentative LAB has improved silage quality, aerobic stability has often been worse compared to heterolactic fermentations (Weinberg and Muck, 1996). The main advantage of homofermentative strains of LAB is their ability to promote fast and efficient lactic acid production, which results in a rapid decrease in pH (Rammer et al., 1999). The shift in fermentation products should not only improve silage quality (Kung et al., 1999), but also improve DM recovery (Rammer et al., 1999). A homofermentative should result in very little loss of DM, while on the contrary, DM loss from heterofermentation can be substancial (Muck, 1996).

The use of biological silage additives has produced variable results for aerobic stability (Muck and Bolsen, 1991; Cai et al., 1999; Harrison et al., 1999). A possible explanation for the instability of inoculated silages upon exposure to air is that under strict anaerobic conditions, homolactic LAB produce only lactic acid, whereas in a natural fermentation various VFAs are produced (e.g. acetic, propionic, and butyric). These short-chain VFAs possess antimycotic activity, and thus inhibit the growth of yeasts and molds upon aerobic exposure. The presence of even low concentrations of oxygen results in shifting from a homolactic to a heterolactic fermentation (McDonald et al., 1991), which leads to the production of organic acids. Mayrhuber et al. (1999) reported that the best aerobic stabilities occurred in silages with high concentrations of acetic acid (up to 5.1% of the DM).

A high concentration of lactic acid does not always have a positive effect on the aerobic stability. Yeasts grow at low pH's (Lindgren et al., 1985), a few can tolerate conditions below pH 3. The inhibition of yeasts during fermentation appears to be a function of lactic acid concentration. Woolford (1975b) determined a threshold value of 250 mMol of lactic acid for the prevention of yeast growth. In Lactobacillus-treated silages, lactic acid concentrations reached 400 mMol, which might explain the decrease in yeast counts in all inoculated silages after 7 days of fermentation, when lactic acid concentration reached its highest level. After that, selection led to a predominance of acidophilic yeasts. Also, there is no doubt that in LAB-treated silages, inoculated bacteria and yeasts compete for sugars.

Cai et al. (1999b) reported a high yeast population in the LAB-treated silages, and it increased during exposure to air. Most yeast strains isolated from the deteriorated silages had a high tolerance to lactic acid, were able to utilize lactic acid and WSC for growth, and were inhibited by low concentrations of acetic, propionic, and butyric acids. The relatively high concentrations of acetic acid in the control silages likely explained their aerobic stability.

Several microorganisms that are not homofermentative LAB have been used as silage inoculants specifically for the purpose of improving aerobic stability. For example, the *Propionibacteria* are able to convert lactic acid and glucose to acetic and propionic acids. Florez-Galaraza et al. (1985) reported that the addition of *P. shermanii* prevented the growth of molds and markedly reduced the initial population of yeast in HMC when the final pH of the ensiled grain was greater than 4.5. Dawson (1994) reported similar findings in high moisture corn. Weinberg et al. (1995) found little benefit from adding *Propionibacteria* to pearl millet and maize silages (final pH <4.0), but the authors reported improvements in the aerobic stability of wheat silage, which had a slow decline in pH. Similarly, in three studies using laboratory silos, Kung et al. (2001) (unpublished data) did not observed beneficial effects on aerobic stability with *Propionibacteria* in maize silage (final pH of 3.6 to 3.8). However, Bolsen et al. (1996) reported more propionic acid, fewer yeast and mold, and greater aerobic stability in maize silage (pH of 3.6) treated with *Propionibacteria*. Some concerns regarding the use of *Propionibacteria* that have not been adequately addressed are the potential increase in loss of DM (from $CO_2$ production) and the proteolytic activity of some *Propionibacteria*. A few reasons for the ineffectiveness of these microorganisms to consistently prolong the "bunklife" of silage include: they are strict anaerobes, they are slow growing, and they are relatively acid intolerant.

Recently, heterolactic LAB have been used as silage inoculants with the intended purpose of increasing aerobic stability. Two new isolated heterolactic strains of *L. plantarum* were shown to improve the aerobic stability of maize silage by an average of 28 hours in five studies (Allman and Stern, 1999). These LAB were selected for fast growth, production of lactic and acetic acids, and the ability to suppress the growth of five major strains of yeast that cause aerobic spoilage in maize silage.

Another heterolactic bacterium having the potential to improve the aerobic stability of silage is *Lactobacillus buchneri*. Driehuis et al. (1996) reported that L. buchneri improved the aerobic stability of maize silage, and the efficacy of L. buchneri was higher under laboratory-scale than farm-scale conditions. Oude-Elferink et al. (1999) suggested that the improved aerobic stability was due to the ability of *L. buchneri* to ferment lactic acid to acetic acid and 1,2 propanediol and that L. buchneri also might produce other yet unidentified metabolites with antifungal activity.

Ranjit et al. (1998) added *L. buchneri* to maize at a rate of $1 \times 10^6$ CFU/g of forage and found decreased numbers of yeast and increased acetic acid (from 1.8 to 3.6% of the DM) in the treated silage. Aerobic stability was improved dramatically, e.g., the control silage heated after 26 hours, while L. buchneri-treated silage did not spoil after more than 144 hours of exposure to air. Kung et al. (1999) reported increased acetic and propionic acids and marked improvement in the aerobic stability when barley silage treated with *L. buchneri*.

Heterolactic fermentation is a less efficient process in terms of preservation of nutrients than homolactic, and silages with high levels of acetic acid are predisposed to a lower DM intake than silages with lactic as the dominant fermentation acid. Although DM recoveries might be lower in silages inoculated with heterolactic LAB, Ranjit and Kung (2000) have suggested that the improvements in aerobic stability during the feedout phase and possible increased livestock performance as a result might compensate the potential loss of nutrients during the fermentation phase.

## Conclusions

Present evidence gives only limited information on the potential of a forage to ensile satisfactorily or on the nutritional quality and aerobic stability of the end product. Research into the processes in the aerobic deterioration of a silage has not explained why silages differ in their susceptibility to aerobic deterioration during the feedout phase. It has been difficult to find silage traits that specifically predict aerobic instability or stability. Research has assessed how physical properties of silage affect aerobic deterioration; and although a restricted range of yeasts and bacteria have been studied, there is not a complete understanding of the microbiology of aerobic deterioration.

Generalizations about the microbial dynamics of aerobic deterioration are not appropriate. Microbial dynamics probably depend on the establishment and/or survival of aerobic spoilers during fermentation and storage, but up to now little is known about the factors that influence this establishment.

Temperature, DM and WSC content, microbial population, and concentration of fermentation products, all in interaction with silage pH, have the greatest direct effects on aerobic stability (Woolford, 1990). The groups of microorganisms that are responsible for the initiation and subsequent extent of aerobic deterioration can be affected by differences in silage traits. Silages differ in their susceptibility to the loss of nutrients during the feedout phase, depending on how they were managed up to that time

In view of the economic importance of DM losses during feedout, it is essential to give careful attention to the basic silage principles during preparation, storage, and feeding. This can help to minimize the risks for aerobic deterioration. Opportunities for future developments to decrease problems associated with microbial degradation of silage lie in improved storage techniques and in improved and/or alternative additives.

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# Silage Additive Approval Schemes in Europe – Aims, Developments and Benefits

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**Abstract**

Silage additives are used in most countries in Europe to help achieve a good preservation or to enhance aerobic stability. With over 200 additives on the market it is extremely difficult for farmers to choose the most appropriate product. Additive approval schemes have been developed in the UK and elsewhere to identify effective products and to monitor product safety. The structure of these schemes is reviewed and the benefits of using approved additives discussed.

**Introduction**

Ensiling grass, maize and other crops is the main method of conserving fodder for winter feeding in Europe with around 160 million tonnes DM ensiled in 1994 (Wilkinson *et al*, 1996).

Accurate information on additive use is not available for all countries. However in the five major silagemaking countries in Western Europe (Germany, France, United Kingdom, Italy and Ireland), which together constitute about 45% of the European total tonnage, it is estimated that in 1994 around 23% of the grass and legume silages and 6% of maize silages were additive treated. In the more demanding ensiling conditions in Sweden, Norway and Finland around 65% of all grass silage was estimated to be additive treated. The equivalent data for the Czech Republic would indicate that around 30% of grass/legume silages were additive treated and about 10% of the maize silages, while in the Slovak Republic the proportion of silages treated were estimated at around 25% and 15% for grass and maize silages respectively.

The range of additives used throughout Europe is extremely diverse. Over 200 products are marketed, varying in content, purpose of use and effectiveness. Farmers have great difficulty in selecting the most appropriate additive for their own circumstances so additive approval schemes have developed in several countries to assist with this. According to Wilkinson *et al* (1996), fifteen countries had some form of additive scheme in 1994 with registration compulsory in eleven countries and voluntary in the remainder. The schemes varied greatly in format though product safety and product efficacy were the major considerations in most schemes. In general the compulsory schemes placed a greater emphasis on safety aspects, with manufacturers being required to supply proof that their products were harmless to humans, animals and the environment. In the voluntary schemes, proof of product efficacy tended to be the main objective. There is little published information on the format and requirements of many of the schemes across Europe and despite a number of proposals progress towards even common registration of additives has been very slow.

The purpose of this paper is to describe the objectives and development of the approval scheme in the UK and outline similarities and differences in the approaches taken elsewhere. The success of product types in achieving approvals in the UK scheme is reported and some of the benefits of additive use shown in experiments and on farm considered.

**Classification of additive product type**

Silage additives tend to be classified according to their content and the role for which they are used. The classical grouping into five categories – fermentation stimulants, fermentation inhibitors, aerobic deterioration inhibitors, nutrients and absorbents was detailed by McDonald *et al* (1991).

In practice most of the additives currently on the market are used to improve fermentation. Bacterial inoculants (most containing *Lactobacillus plantarum*) encourage an efficient lactic acid fermentation while the use of sugars and enzymes is primarily designed to enhance substrate availability. Acids, mostly based on the organic formic acid, reduce pH directly and restrict the development of undesirable bacteria. Most salts are used to inhibit aerobic deterioration while absorbents are designed to reduce effluent output.

## Silage Additives in the UK before 1993

The first lists of additive products available in the UK were produced in the 1970s as Advisory Notes for farmers. At that time the list contained only 15 products marketed for silage, the vast majority acids or acid salts. By the early 1980s the number of silage products had increased to 40, including the first inoculant. The 1986 list included 72 products for silage of which nearly half were inoculants, while three years later the list had expanded to 116 products – 41 acid or acid-based, 4 salts, 51 inoculants, 6 sugar products, 4 enzymes and 10 absorbents (Weddell *et al*, 1990). Information given on the list included product content, application rate, price per tonne treated and manufacturer/supplier but there was still no guidance on product efficacy.

By now numerous studies on various product types had been reported in the scientific literature and it was apparent that there were major differences in effectiveness between products, particularly amongst the inoculants. Although approval schemes were already in place in other European countries the UK Government had no plans to introduce even a registration scheme. To help identify the more effective products and thus improve advice to farmers the Advisory Organisations in the UK set up in 1991 a voluntary scheme in which companies were invited to submit evidence of efficacy for general assessment. No guidelines on dossier content were issued and the assessment results were confidential to the Advisory Organisations. Information on about 60 products, about half the number on the market at that time, was submitted.

In 1993 the trade organisation UKASTA (United Kingdom Agricultural Supply Trade Association) initiated the Forage Additives Approval Scheme (FAAS). While still voluntary this extended the previous assessment scheme into clearly defined categories for approval and introduced product quality monitoring. A close collaboration developed between UKASTA and the Advisory Organisations who advised on the format of the Scheme and agreed to undertake the assessments for approval, thus maintaining the independence of the Scheme.

## Objectives of the Forage Additive Approval Scheme

From an advisory standpoint, the original objectives of the FAAS were:

- to improve the <u>choice</u> of additive available to the farmer by identifying the effective products.
- to improve farmer knowledge of which product or product type was best suited to his needs
- to increase the use of additives in circumstances where their use was justified.

## Original Forage Additive Approval Scheme (1994-98)

### *Structure*

In devising an additive approval scheme for the UK the Advisory Organisations were fortunate that they could draw on the experience of existing schemes in Europe and on plans at that time for EC Legislation, as outlined by Seale (1986). Most important, however, was the intention that from the outset the scheme was designed to include animal performance parameters as well as fermentation quality and other factors directly applicable to silagemaking and its profitability in the UK.

The format of the original FAAS was described by Weddell *et al* (1996). In summary, it comprised three main categories each further subdivided to provide a total of 9 approval categories. Category C included four effects relating to ensiling – improving fermentation, improving aerobic stability, reducing effluent production and reducing ensiling losses, while three animal feed effects were included in Category B – improved DM intake, improved digestibility and improved efficiency of energy or nitrogen utilisation. Category A, the most important to the farmer, represented benefit in animal gain (liveweight or carcass) or improved milk production, expressed in daily output of liquid milk or milk constituent output. The Scheme was designed to allow direct entry into any category, or progression through Categories C to A. The number of approved qualifying trials needed to achieve a category approval varied according to the route chosen. Statistical significance ($P<0.05$) against the untreated control was the benchmark for proven improvement.

**Development**

The Scheme was launched in Spring 1994, with companies encouraged to register and submit dossiers of relevant data. The November 1994 Register included 133 products of which 72 had achieved an approval in at least one of the nine categories. Two years later 51 products (38% of the original 133) were deleted from the Register having failed to submit sufficient relevant data to show product efficacy. This suggests that in the early 1990s, prior to the introduction of the Scheme, up to 40% of the products being marketed in the UK were unable to show scientific proof that they actually worked. In contrast, the products which remained within the Scheme were extremely successful in providing scientific evidence of efficacy. Of the 82 products registered in November 1996, 58 had achieved approval in liveweight gain improvement and 55 in milk production improvement.

From the outset it was always intended that the Scheme would develop and adapt to meet the changing needs of the farmer and the additive trade. The increasing importance of maize silage and high dry matter grass silage increased the requirement for products which enhanced aerobic stability and in November 1998 the aerobic stability category was revised to introduce crop differentiation with approvals in maize, grass or both crops. At this stage the scheme had proved successful in improving the quality of product on offer to the farmer: but the other objectives – improved farmer knowledge and increased use, where justified, were not being realised. Following extensive consultation throughout all sectors of the industry the Scheme was remodelled in 1999 to make it more user friendly for the farmer.

**Revised Forage Additive Approval Scheme (1999 to date)**

***Structure***

While the original 9 categories were retained, the A, B and C were simplified into two main groups, 'animal' and 'silo' and categories named instead of being letter coded. Changes were also made to the method of gaining approvals with the progressive route discontinued. Feedback from farmers had indicated that some had difficulty in relating statistically significant improvements to farm practice. 'Meaningful' responses were therefore introduced for the animal categories. For example, in milk output, an increase of 1 litre per day was considered to be a 'meaningful' response so this was incorporated into the guidelines for achieving category approvals. Other changes included the requirement that in effluent loss and ensiling loss categories at least two of the required five studies should be data from large scale (minimum 50 t) silos.

The revised scheme for category approvals is as follows:

***Animal Effects Categories***

Approval in any category within animal effects (gain, milk output, intake, feed value, efficiency of feed utilisation) can be achieved either

- by gaining approval in three studies in each of which the additive has shown a statistically significant improvement at the 5% level over the untreated control for that category or
- by gaining approval in two studies in each of which the additive has shown a statistically significant improvement at the 5% level and additionally in each of which the additive has achieved a 'meaningful' response over the untreated control for that category.

'Meaningful' responses are defined as improvements over the untreated control as follows:

- Liveweight gain. Liveweight gain to be increased by at least 90g/day in beef cattle
- Milk output. Milk yield to be increased by at least 1 litre/day or milk quality to be increased by at least 5% (by weight) of either protein or protein plus fat
- Silage intake. Silage intake to be increased by at least 8%
- Feed value. D-value to be increased by at least 2.5 units
- Efficiency of feed utilisation. In milk production an increase of at least 5% in milk output/kg DM intake. In liveweight gain an increase of at least 10% in LWG/kg DM intake.

***Silo Effects Categories***

Approval in any category within silo effects requires five approved studies. In improving fermentation and improving aerobic stability each of the five studies should show a statistically significant improvement at the 5% level over the untreated control. In reducing effluent loss and reducing ensiling loss at least two of the required five studies should be from large scale (minimum 50t fresh weight) silos. In these large scale studies, where replication and statistical analysis is often difficult, reduction in effluent output and reduction in dry matter (or organic matter) loss should be at least 10% and 4% respectively. In mini silo/laboratory studies the improvements should be significant at the 5% level.

***Qualifying Studies***

The criteria for qualifying trials remained unchanged between the original and revised schemes. All studies must be

- conducted with forage crops relevant to UK conditions
- conducted against an untreated 'control'
- conducted in scientifically designed experiments appropriate to the action claimed
- replicated adequately and analysed statistically appropriate to the design

Unlike most schemes in other countries, the FAAS Scheme allows companies to submit relevant scientific data from any source provided they meet these criteria. Research conducted at independent institutes is preferred but 'in house' studies are accepted with quality of experimentation the criterion, not source.

***Product Quality Monitoring***

This is based on approved quality control dossiers and regular independent product monitoring, and remains an integral part of the FAAS.

***Product Approvals 2000/01***

The most recently published annual FAAS Register of approved products (UKASTA, 2000) contained 76 named additives – 57 inoculants, 6 acids, 9 salts, 1 sugar, 1 enzyme and 2 absorbents. However of the 76 only 43 products are truly different, each of the remaining 33 being a 'clone' of another product but marketed under a different name for commercial purposes (Weddell, 2000). The approvals gained by the 43 products are shown in Table 1.

**Table 1.** FAAS categories of approved silage additives, November 2000

| Additive type<br>Number of Products | | All products<br>(43) | Inoculants<br>(28) | Acids<br>(6) | Salts<br>(5) | Enzyme/sugar<br>(2) | Abs<br>(2) |
|---|---|---|---|---|---|---|---|
| Category: | | | | | | | |
| Animal | Gain | 29 | 17 | 6 | 2 | 2 | 2 |
| | Milk | 26 | 20 | 4 | 1 | 1 | - |
| | Intake | 27 | 17 | 6 | 1 | 2 | 1 |
| | Digestibility | 15 | 13 | 2 | - | - | - |
| | Efficiency | 16 | 14 | 1 | 1 | - | - |
| Silo | Fermentation | 35 | 24 | 6 | 2 | 2 | 1 |
| | Aer.Stab.Grass | 12 | 5 | 4 | 3 | - | - |
| | Maize | 9 | 6 | - | 3 | - | - |
| | Effluent | 10 | 9 | - | - | - | 1 |
| | Losses | 19 | 12 | 4 | 3 | - | - |

Of the 43 products 35 (81%) had achieved approval in fermentation benefit, those without being marketed specifically to improve aerobic stability. Most products could also justify claims in improved weight gain (67%) or milk production (60%). Approvals in reduced effluent losses and reduced ensiling losses were however achieved by only 23% and 44% of products, respectively.

**Other European Additive Approval Schemes**

As previously stated, detailed information on many of the additive schemes is relatively scarce. Three schemes which show contrasting approaches to registration and approval have been chosen to illustrate alternative strategies. These schemes, from Germany, France and Finland, have been in operation for 10 years or more and all are well established within the additive industry in Europe.

***Germany***

The DLG Scheme was introduced in its present form in 1991 and is very similar in most respects to the UK FAAS. This voluntary scheme comprises five main groups:- improving fermentation, improving aerobic stability, reducing effluent, improving nutritive value/animal performance and additional effects.

In contrast to the FAAS, the group for fermentation is subdivided into four according to fermentability of the forage, as assessed by 'fermentation co-efficient'. Fermentation co-efficient (FC) combines substrate availability, buffering capacity and DM content of the crop in a single figure. Thus product efficacy can be tested across crops easy to ensile or more difficult, providing useful information for the farmer. The group for nutritive value is subdivided into three – improving feed intake, improving digestibility and improving performance (milk or meat). Compared with the FAAS the DLG Scheme has no separate category for reduced ensiling losses (though it is included as a measure within the fermentation group) and has the additional category of 'clostridial inhibition' under additional effects. The requirements to achieve approval in various groups is very similar to the FAAS but much more emphasis is placed on generating the evidence at approved research institutes within Germany. Like the FAAS the scheme is structured so that it can develop to meet changing circumstances.

Pahlow and Honig (1996) reported that 24 products had achieved the DLG Quality Seal by December 1995. Three years later the number had doubled to 50 (Staudacher *et al*, 1999) though a lower proportion had achieved the animal performance groups than in the UK.

***France***

Unlike those in Germany and the UK the scheme in France is compulsory. Another major difference is that the scheme is in two parts – provisional approval, then full registration. For a new product, a dossier is submitted in support of prior product approval (Provisional Authorisation for Sale – PAS). This may be granted for 4 years, during which time the efficacy of the product is tested through the INRA Unit of Feed Evaluation. The tests vary according to additive type. Biological products are tested only for conservation quality, using ryegrasses. Chemical additives are tested with ryegrass, cocksfoot and lucerne and are assessed for quality and digestibility. No animal performance studies are undertaken as it is considered that if a product improves silage fermentation it is likely to improve silage intake and consequently animal performance. Approvals are linked to the ensilability of the crop, with biological additives approved only for high sugar crops. To be approved a new additive has to perform similarly to or better than formic acid. Product quality is strictly monitored. In 1996 the French list contained only 27 approved products (Demarquilly and Andrieu, 1996).

***Finland***

In Finland compulsory procedures in testing additives were introduced in 1990 and only officially approved products can be marketed. As in France the scheme is in two stages, both based on improved fermentation quality. At the first stage a new product must undergo laboratory testing at an approved Institute using low sugar, high protein wet grass in a comparison with an untreated control and formic acid. Satisfactory results from this allows the product to be marketed for two years during which time it must be field tested on at least 30 farms per year. All farms on which it is used are monitored and the resultant silages must meet set criteria for analytical quality before approval for general use is granted. Health and Safety data must also be provided.

Ensiling conditions in Finland, and generally throughout Scandinavia, are extremely difficult with low DM and sugar contents in the grass. In 1996 only 7 acid-based products had achieved full approval (Mannerkorpi *et al*, 1996).

***Towards a European Scheme?***

The many differences in the crops and the conditions of ensiling throughout Europe are reflected in the different approaches in the various schemes and it is difficult to see how the requirements for proof of efficacy could easily be reconciled. Within the EU there have been a number of attempts over the last 15 years to introduce legislation governing the sale and use of additives. Seale (1986) outlined the requirements for EEC registration and efficacy tests while further EU proposals introduced in 1993 were described by Haigh *et al* (1996) though again agreement proved difficult to achieve. One major source of difficulty has been that the proposed EU schemes are based on active ingredients while most present approval schemes tend to be product based. While this poses no great difficulty for chemical additives there are major complications for biological products which may contain a number of bacterial species and strains, perhaps together with enzymes. Another difficulty is the diversity of effects and benefits for which additives are marketed, not all feed related.

Nevertheless there would be major advantages for all sectors of the agricultural industry in a European framework of common registration of additive contents, which could also encompass health and safety considerations. This would then leave individual countries the freedom to impose their own efficacy requirements and standards. No national scheme has a monopoly on best practice. However, if a Europe-wide efficacy scheme was the target then the present German or UK schemes appear to be sufficiently comprehensive and flexible to meet this.

**The benefits of additive treatment**

The use of silage additives can only be recommended in situations where they are likely to be cost effective. Wilkins *et al* (1999) estimated that the additive contribution to total silagemaking costs ranged from 5% in high DM silage to 9% in low DM silage.

**As shown in research studies**

The data contained in the dossiers submitted in support of approval claims for the FAAS give an indication of the animal performance enhancement which can be achieved by the use of additives under experimental conditions. The results come from a very diverse range of trials conducted at independent research institutes throughout Europe. The data included in this summary has been used with the permission of the additive manufacturers who supplied the dossiers.

A review of the data submitted in milk production trials, where there was a direct comparison between untreated and additive treated, showed a mean yield improvement in approved trials of 1.36 kg/day (5.8%) with means of 24.80 kg and 23.44 kg/day for treated and control silages respectively. Eighty per cent of products showed a yield improvement of 1 litre or more. Previously published reviews have also reported positive benefits, but at a lower level. In their series of trials with inoculant and formic acid treatments Mayne and Steen (1993) reported a mean benefit of only 0.3 kg/day with formic and 0.6 kg/day with inoculant treatment though milk composition was significantly improved with fat plus protein yield increased from 1.34 kg to 1.44 kg (7.5%). In a later review Wilkins (1996) reported benefits from inoculant treatment of 0.2 kg/day (1%) and 0.3 kg/day (2%) in fat plus protein yield. Formic acid treatment increased fat plus protein yield by 5%.

FAAS trials approved for liveweight gain showed a mean performance benefit in beef animals of nearly 33%, with mean liveweight gains of 0.61 kg/day and 0.81 kg/day for control and additive treatments respectively. Appleton (1991) reported gains around 17% higher through additive treatment while Mayne and Steen (1993) and Wilkins (1996) reported mean benefits of 7% and 10% respectively. Much of the benefit in enhanced performance is of course due to enhanced DM intake. In the dossiers, additive treatment increased intake by around 6% in dairy cattle and about 10% in beef cattle, in good agreement with the reviews of Mayne and Steen (1993) and Wilkins (1996). Eighty percent of the beef trials showed a feed efficiency improvement of 10% or more while 18% of the dairy trials showed more than 5% higher efficiency.

The higher performance benefits shown in the dossier studies compared with other published reviews are due to the manufacturer carefully selecting trials which demonstrate maximum benefit. While this is quite justifiable these data therefore set the upper level of performance enhancement while the lower thresholds of benefits reported by Wilkins (1996) and others are more likely to be achieved in practice.

**As shown in farm analyses**

The benefits discussed so far relate to those achieved under experimental conditions. Also of interest is whether these benefits can be achieved under commercial farm conditions. No animal performance data is available for such a study but the data from silages submitted for analyses for feed rationing purposes can give an estimate of possible fermentation benefits.

The SAC data presented in Table 2 is from primary cut clamp silages ensiled in Scotland during the summers of 1998, 1999 and 2000, and represents around 2000 analyses. As is common with data of this kind there was considerable variation within treatments and no major statistically significant differences were found. Despite this there were clear indications that additive treatments had consistently improved the quality of the fermentation within the recognised measures of fermentation quality such as lower pH, lower ammonia N content and lower percent VFA. Lactic acid content was consistently higher in the additive treated silages and there were also indications of higher energy and protein contents.

**Table 2** Effect of additive treatment on farm clamp silage, SAC mean analyses 1998 - 2000

| Additive Treatment | No additive | Acid | Inoculant | Enzyme |
|---|---|---|---|---|
| DM (g/kg) | 244 | 242 | 246 | 253 |
| PH | 4.41 | 4.24 | 4.18 | 4.08 |
| Protein (g/kg DM) | 118 | 127 | 131 | 134 |
| $NH_3N$ (g/kg TN) | 85 | 75 | 66 | 65 |
| Lactic acid (g/kg DM) | 2.08 | 2.42 | 2.64 | 2.79 |
| VFA (%) | 2.83 | 2.49 | 2.18 | 2.01 |
| ME (MJ/kg DM) | 10.2 | 10.7 | 10.7 | 10.9 |

The effects of additives on pH and ammonia N contents farm clamp silages have previously been reported from silages made in the UK in the 1970s and late 1980s (Haigh, 1987; Haigh, 1996a,b), prior to the introduction of the FAAS. The reduction in pH (0.17 units) and ammonia N (10g/kg TN) in the acid treatment in the SAC analyses is similar to Haigh's findings in his 1987 data but less than that reported in 1996 (pH 0.38 units, 20 g/kg TN).

Inoculant treatment resulted in a mean pH reduction of 0.23 units, similar to the 0.20 unit reduction reported by Haigh (1996a, b). However Haigh reported very little benefit in ammonia N content (6g kg TN) while the SAC data showed a mean reduction of 19g/kg TN. The effects of enzyme treatment were also greater in the SAC data (pH reduction of 0.33 compared to 0.21 units; ammonia N reduction of 20g/kg compared to 6g/kg TN).

It is very difficult to draw conclusions from mean figures based on variable data. However all the data indicate that the benefits of additive treatment shown so clearly in controlled experiments are also found in farm practice. The improved performance with inoculants and enzymes shown in the SAC data may be an indication of the improved products on offer in the UK in recent years, or a better understanding by the farmer of how best to use the products.

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# Management Practices that Enhance the Nutritive Value of Ensiled Forages

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**Abstract**

During the last decade the price of feed inputs has increased while the price of the saleable product (milk) has remained relatively low. The feed input that has increased in price the most is the grain portion of the diet. This situation has increased the awareness of forage quality and the role good forage management can play in minimizing the impact of feed prices at the farm level. Achieving high levels of animal productivity at minimal input costs is requiring producers to make several key changes. There continues to be a steady increase in cow numbers per farm, increased use of custom hired planting and harvesting, adoption of harvesting techniques that increase forage digestibility, and increased attention to forage quality and losses of forage during ensiling. As production units expand they are increasingly using bagged silage in lieu of traditional bunker silos. In addition to the economic pressures, additional requirements are being legislatively mandated for farms to minimize or eliminate their impact on the environment or endangered species. Advisors to producers are increasingly using sophisticated tools (computer programs) to assess alternatives and make best management decisions related to forage management, ration balancing, and nutrient management.

**Introduction**

Alfalfa and whole plant corn continue to be major forage crops in the US that are routinely harvested as silage crops. In addition, several areas of the US also rely heavily upon grass silage. The economic value of the product (milk) from the farm has not kept pace with the increased cost of inputs. This situation has increased the awareness of the importance of forage quality and producers have been quick to adopt practices that will enhance the nutritive value of their silage. In recent years information has become available that clearly shows the advantage of harvesting corn silage between ½ and 2/3 milk line if it is not mechanically processed (Johnson et al. 1999). Forage-harvesting equipment manufacturers have increased the availability of mechanical processors for harvest of whole plant corn silage for both self propelled and pull-type forage harvesters (Shinners, 1999) in response to the demand for this technology. When evaluated across a range of conditions, the mechanical processing of corn silage can be a profitable decision regardless of farm size (Rotz et al., 1999). Ensiling of forages in bags has increased in practice, particularly as farms continue to look for low cost and flexible storage alternatives (Holmes, 1998). With increasing milk production per cow, increased farm size, and a need to evaluate numerous alternatives, sophisticated computer software is now available to use in planning and strategic decision making. The CNCPS model (Fox et al., 1990) and its contemporary version called CPM, is a ration balancing tool that allows for consideration of various protein and carbohydrate fractions as well as estimated needs of amino acids. The DAFOSYM (Rotz et al., 1989) software is a simulation model that allows for evaluation of forage, feeding management, and environmental considerations at the whole farm level (http://pswmrl.arsup.psu.edu/software.html). The Ag Bag Company (Warrenton, OR) has developed decision aid software called "Farm Plan". It allows for the evaluation of whole farm storage economics for different silo alternatives.

**Factors Affecting Quality of Corn Silage**

The major factor affecting the quality of corn silage is stage of maturity at harvest. Figure 1 depicts the change in energy value of corn silage as it progresses in maturity. The initial increase in energy content of corn silage is attributed to the high fiber digestibility of the stover fraction of the corn plant and the increase in the amount of highly digestible starch accumulating in the ear. The point of inflection occurs at ~ 2/3 milk line development of the corn kernel. Beyond this point the increased nutritive value in the corn kernel is offset by a decrease in stover digestibility and passage of undigested corn kernels into feces (Johnson et al., 1999). The dashed line represents the energy value of corn silage that has been mechanically processed. The increase in digestibility (mechanically processed) past 2/3 milk line tends to plateau due to counter acting effects of increased starch digestibility and decreased stover digestibility.

At a given maturity, the nutritive value of corn silage can also be changed by altering the cutting height of the silage. This has been called hi-chop or super silage and is the result of leaving as much as 20 inches of the lower portion of the stover unharvested (Quaife, 2000). This management technique results in silage that has lower fiber content and higher starch than conventionally harvested corn silage. While a more digestible forage is harvested, there is also a loss in yield of harvested forage (see table 1). The economics of this practice needs to be determined on a farm by farm basis.

When milk production data from the 22 trials (Johnson and Harrison, 2001) was summarized, cows fed processed corn silage based diets produced 1.1 pounds more (range – -1.1 to 3.7) milk than cows fed unprocessed corn silage based diets (Figure 2). Dry matter intake was also 1.1 pounds greater (range – -3.3 to 3.1) for cows fed processed corn silage based diets (Figure 2). Milk fat composition was 0.08 % greater (range - -0.18 to 0.29) and milk fat production was 0.08 pounds greater (range – -0.15 to 0.20) for cows fed processed corn silage based diets (Figure 3). The increased milk production and milk fat production for cows fed processed corn silage based diets led to a 2 pound increase (range - -1.78 to 4.84) in 3.5% fat corrected milk production (Figure 2). Milk protein production was also 0.05 pounds greater (range - -0.07 to 0.15), on average, for cows fed processed corn silage based diets. The increased milk protein production was mainly due to the increased milk production because milk protein percent was not statistically different between cows fed processed and unprocessed corn silage based diets (Figure 3).

These results suggest that over a wide range of conditions, such as corn silage maturity and chop length, level of corn silage present in the total diet, and milk production level of the cows, that cows fed processed corn silage based diets tended to produce more milk and fat corrected milk, had a greater milk fat concentration, and increased DMI. However, there were situations, within individual trials, where cows fed processed corn silage based diets performed less well when compared to cows fed the unprocessed corn silage based diets. The reason for the decreased performance was not always obvious, however, when milk production was lower many times DMI was also lower for cows fed processed corn silage based diets. Also, when milk fat concentration and production dropped it was likely related related to inadequate effective fiber in the ration due to the decreased particle size of processed corn silage.

Many factors are involved with the improved nutritive value of processed corn silage. The process of mechanical treatment results in forage with a smaller particle size which packs more densely in the silo. The silage fermentation process occurs more quickly and generally results in silage with a lower pH and greater amounts of lactic acid, and can be more aerobically stable. We have used the Nasco particle separator or Penn State Particle separator to evaluate the effect of processing on particle distribution (see Figure 4). The typical trend is for there to be a lower percentage of particles remaining on the top sieve (> ¾”) when corn silage is processed compared to unprocessed. Therefore, there is a greater percentage of processed corn silage particles remaining on the middle (<3/4” and >3/16”) and bottom sieves. The change in particle size impacts how densely corn silage is packed in silos. Pack density in the silo is important because density and DM content determine the porosity of corn silage. Porosity determines the rate that air can infiltrate the silo, and subsequently affects the amount of spoilage that occurs at the time of feedout. Typically, processed corn silage tends to have a greater wet pack density in the silo than unprocessed corn silage harvested at the same TLC (Figure 5). Over a range of maturities (hard dough to physiological maturity) and chop lengths (1/4 inch to ½ inch) the processed corn silages had greater wet pack density measurements in the silo than unprocessed corn silages in 7 out of 9 comparisons. The increased density of processed corn silage can be partially attributed to the reduction in particle size because all silages were handled similarly when they were put into the silo. The method of ensiling (time spent packing silage into the silo, packing pressure, etc.) would have had minimal impact on pack density. The greater wet pack density for processed corn silage tends to improve aerobic stability at feedout. Aerobic deterioration occurs as a result of microbial activity. The factors that influence deterioration include; oxygen (exposure time), composition of the microbial population, substrate type, and temperature. Yeast are usually the initial cause of aerobic deterioration. As lactic acid (the major endproduct of silage fermentation) and other residual sugars are combusted and used by yeast, the temperature starts to rise. Aerobic stability can be measured by a number of parameters. Common measurements include: 1) number of hours until temperature of corn silage increases 3° F above ambient, 2) number of hours until corn silage reaches peak temperature, and 3) maximal temperature rise above ambient. Processing of corn silage enhanced aerobic stability. The number of hours for the temperature to rise 3° F above ambient was greater for processed corn silage compared to unprocessed corn silage (Figure 6), however there was no difference for the number of hours to reach peak temperature between processed and unprocessed corn silage. This indicates that the processed corn silage was more stable in an aerobic environment early on (processed silage took longer to start heating) due to increased pack density that limited exposure of processed corn silage to oxygen during the storage phase. However, it appears that once the silages were exposed to air there was nothing present in the processed corn silage that inhibited growth of aerobic microorganisms. Therefore, once the population of microorganisms began to grow, they multiplied rapidly and it took approximately the same amount of time for the temperature to peak. Relative change in temperature tended to be similar between processed and unprocessed corn silage and ranged from 11.5° to 23.6° F.

The nutritive value of forages can be estimated with the in situ technique. We have been routinely using the macro in situ technique to evaluate the effect of factors on rumen digestibility of various corn silages. Figure 7 shows the 24 hour in situ digestibility of DM, NDF, and starch as affected by mechanical processing. Increases in digestibility have been consistently noted for NDF and starch across a wide variety of maturities when corn silage has been mechanically processed (see Figure 1).

The use of processed corn silage has been quickly adopted in North America. An early field observation was that there was a need to chop the forage at a longer theoretical length of cut (TLC) to maintain adequate effective fiber in the diet. It is now common to recommend that corn silage be cut at ¾ to 1 inch TLC when it is processed. Table 2 summarizes data comparing corn silage chopped at 3/8 inch with no processing to corn silage chopped at 3/8, 5/16, and ¾ inch and processed (Bal et al., 2000). The longer lengths of cut provided for the best overall performance and resulted in less sorting of the diet.

**Storing your Silage – Bunkers vs Bags**

It has long been recognized that silo systems that minimize air penetration into the silage mass during storage will provide the highest recovery of silage nutrients (Rotz and Muck, 1994). Storage losses from bunker silos are greatest when no effort is made to provide a top seal to the silage surface (Bolsen, 1995).

When all costs for forage harvest and storage are considered on an annual basis, the bagging system usually is the least cost alternative when compared to tower, bunker or pile systems (Holmes, 1998). These evaluations only consider inputs costs and recovery of silage from storage since limited data exists where the nutritive value of forage stored in alternative silos (side by side comparison) has been evaluated (Harrison et al., 2001). In 1999 and 2000 we conducted two experiments to evaluate the nutritive value of corn silage that was stored in either bunker or Ag Bag silos. The study design involved the ensiling of corn silage at the same time into the two types of silos to minimize the impact of field variation and weather. In the first study (Harrison et al., 2001) the corn silage had a DM of ~ 38 % and was mechanically processed. With this drier silage we noted an increase in milk production of 2.7 pounds of 3.5 % FCM (see Table 3).

In the second study, we harvested corn silage that was ~ 28 % DM and mechanically processed. Cows fed the bagged silage produced 0.7 pounds more milk (not statistically different – 114.4 vs 113.7 pounds milk) when compared to cows fed the bunker stored silage. The difference between trial 1 and trial 2 is likely related to the amount of corn silage fed in the ration and the DM content of the forage at ensiling. In both trials we observed that the bagged silage was cooler during the ensiling period of ~ 6 months (see Figure 8). This difference in temperature was also observed in the face of the bunker and bagged silage during the feedout period (See Figure 9).

Another advantage to the storage of silage in bags is the recovery of amino nitrogen. Recent information suggests that bagged alfalfa has small losses of amino acid during the ensiling process (Crosby et al., 2001) in contrast to previous studies involving concrete stave silos (Merchen and Satter, 1983). In the report of Merchen and Satter (1983), ~ 18 % of the total amino acids were lost when ensiled alfalfa was compared to fresh alfalfa. In the report of Crosby et al. (2001), they observed a loss of ~ 8.6 % of total amino acids. In view of the positive responses of the high producing dairy cow to supplemental amino acids in early lactation, this observation is worthy of note.

**Decision Aid Tools to Make Best Management Decisions**

As animal agricultural continues to become increasingly complex, the need for integrated computer software has become of prime importance. Several software programs offer excellent opportunities to maximize profit while minimizing environmental risk at the whole farm level (Fox et al., 1990; Rotz et al., 1989). The CNCPS model provides a dynamic setting to assess alternative feeding strategies and maximize the use of home grown or purchased forages. The model has been adapted to handle the breadth of corn silages resulting from maturity, chop length, and processing effects. The DAFOSYM model is a good tool for evaluating the impacts of alternative forage management and nutrient management strategies at the whole farm level. It has been used to evaluate such things as: ratio of corn silage to alfalfa, type of manure handling system, and effect of crop processing. The Farm Plan software from Ag Bag is designed to evaluate the forage storage at the whole farm level. It allows the producer to use their own farm data to make an evaluation of the economics of alternative forage storage systems. These and other models will continue to be commonplace tools in the future of the progressive forage producer/consumer.

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**Table 1.** Effect of cutting height on quality and yield of corn silage

| Cutting height (inches) | Yield (tons/acre 30% dry matter) | Acid detergent fiber % | Starch content, % | Estimated milk produced per ton of corn silage dry matter (pounds) |
|---|---|---|---|---|
| 4 | 29.8 | 22.1 | 28.4 | 2,452 |
| 8 | 28.4 | 21.6 | 29.3 | 2,500 |
| 20 | 26.6 | 20.6 | 31.1 | 2,646 |

Source: Pioneer Hi-Bred International – Dairy Herd Management June 2000 (Quaife, 2000).

**Table 2.** Effect of chop length and processing on productive performance

| Item | 3/8 inch unprocessed | 3/8 inch processed | 9/16 inch processed | 3/4 inch processed |
|---|---|---|---|---|
| Particle length (mm) | 9.4 | 6.7 | 8.9 | 9.2 |
| Dry matter intake Pounds | 55.4 | 56.9 | 56.9 | 56.7 |
| Milk production Pounds | 98.6 | 102.2 | 99.7 | 101.4 |
| Fat yield Pounds | 2.95 | 3.17 | 3.06 | 3.13 |
| Protein yield pounds | 3.12 | 3.24 | 3.19 | 3.24 |

**Table 3.** Effect of silo type on milk production

| Silo | Milk, lb | Milk fat % | 3.5 % FCM | Milk protein % | Milk protein, lb |
|---|---|---|---|---|---|
| Ag Bag | 83.8 | 3.80 | 86.7 | 2.89 | 2.38 |
| Bunker | 82.7 | 3.61 | 84.0 | 2.86 | 2.35 |
| P< | .17 | .05 | .06 | .17 | NS |

**Figure 1.** Relationship between maturity of corn silage, energy content, and mechanical processing.

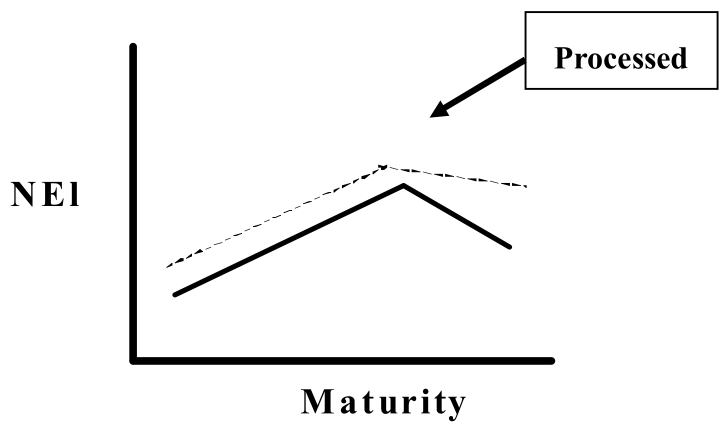


**Figure 2. DMI and Milk Production**

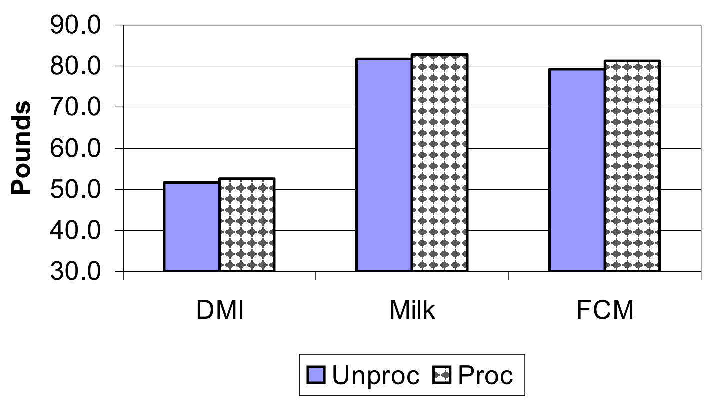



**Figure 3. Milk Composition**

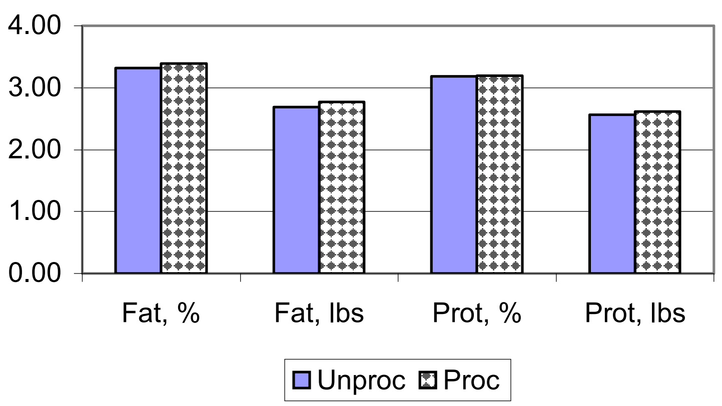
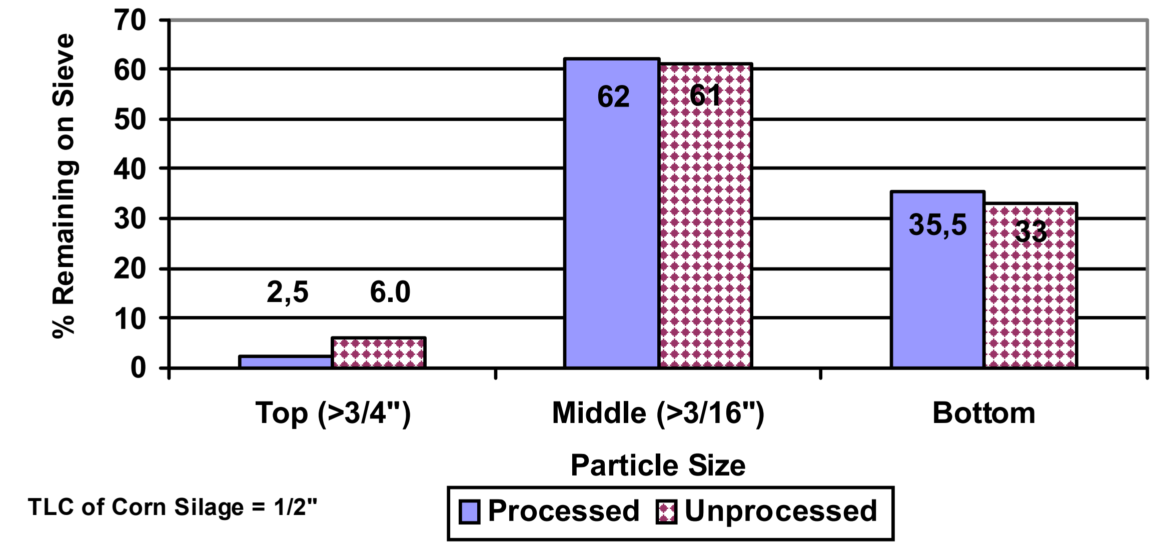


Figure 4. Particle Size Distribution of Processed and Unprocessed Corn Silage




Source: Johnson and Harrison, 2001a.

Figure 5. Wet Pack Density

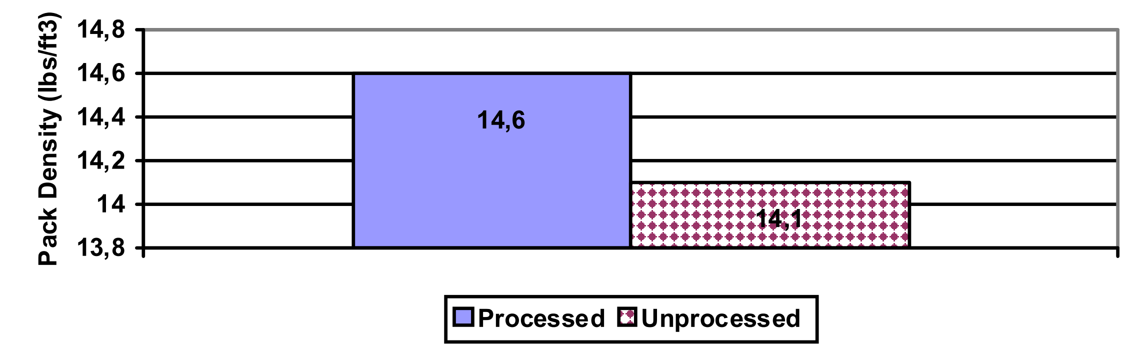


Figure 6. Aerobic Stability

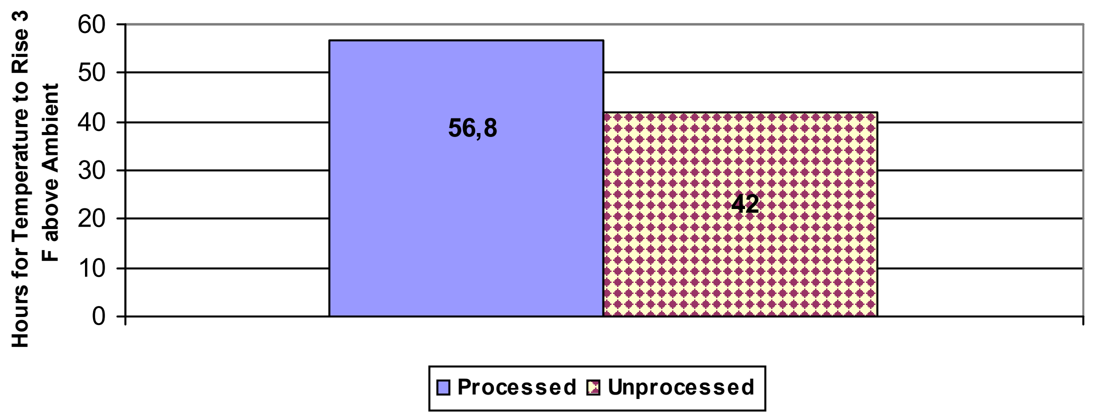
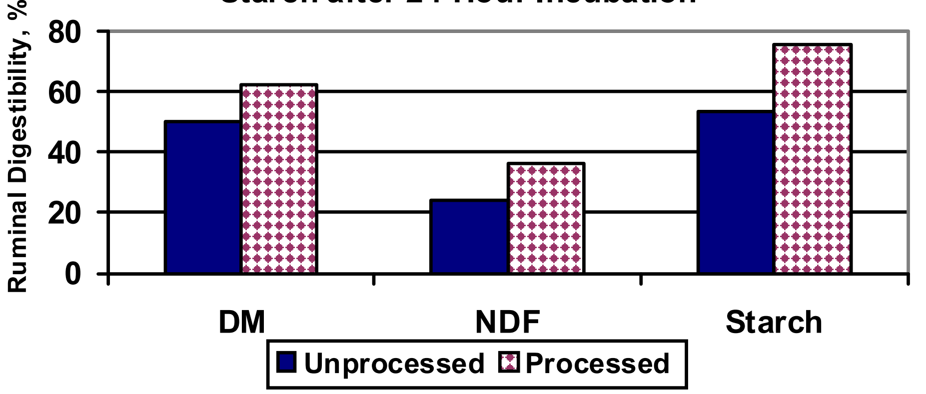
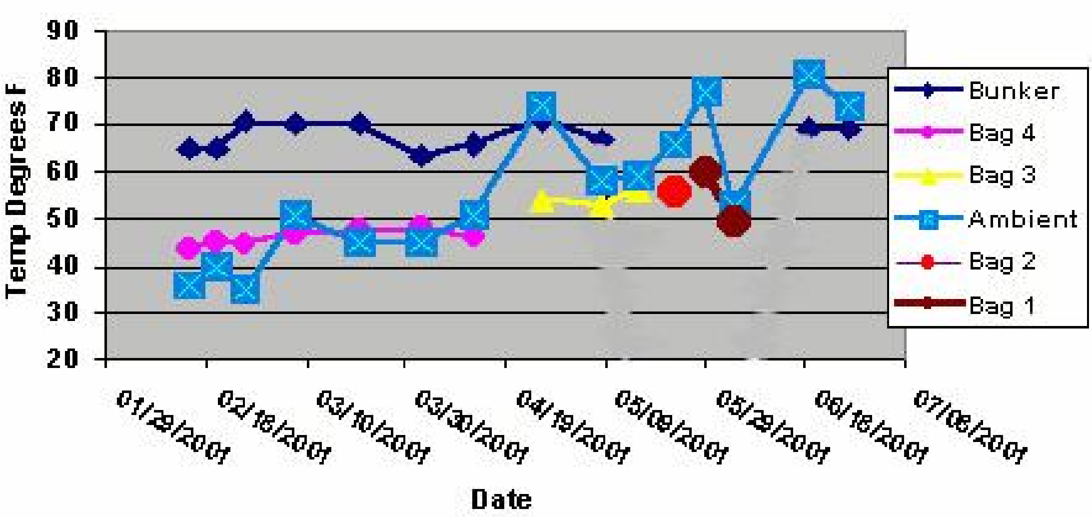



Figure 7. Ruminal Digestibility of DM, NDF, and Starch after 24-Hour Incubation




Source: Johnson, L. and J. H. Harrison. 2001b.

Figure 9 - Siloface Temperature



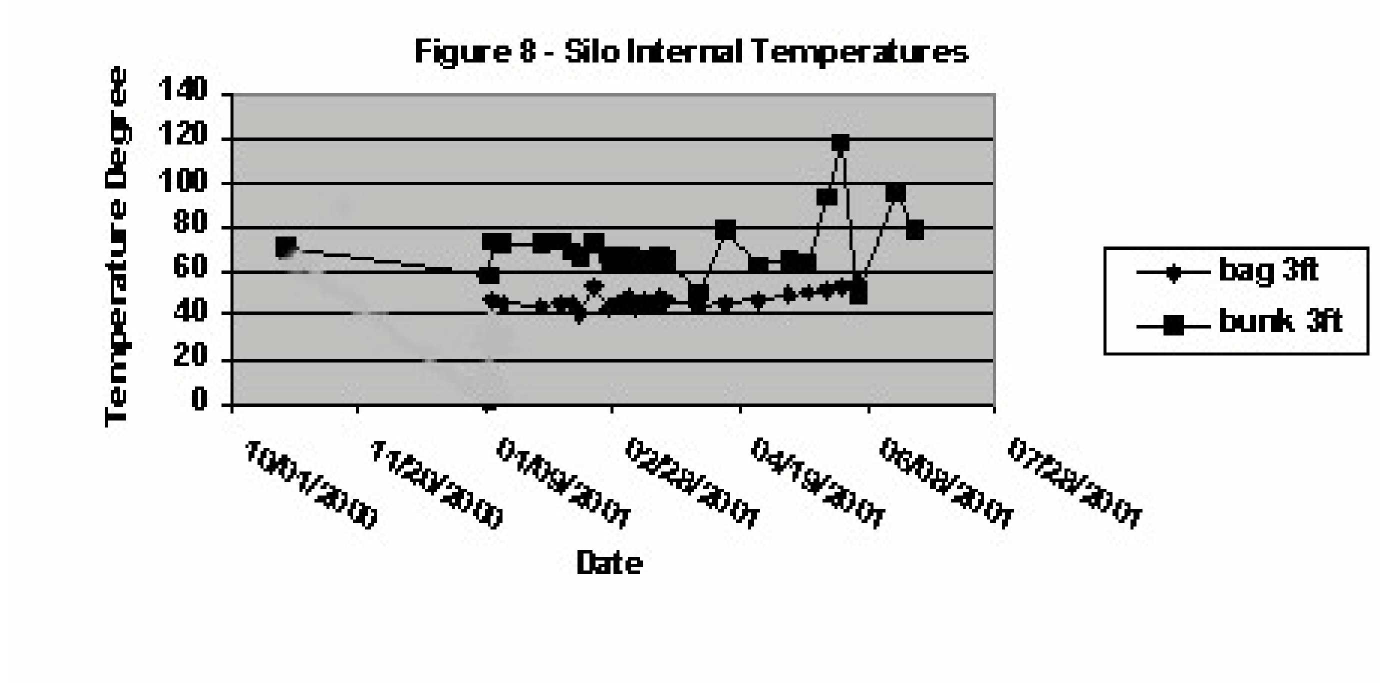


Figure 8 - Silo Internal Temperatures
Temperature Degree
140
120
100
80
60
40
20
0
10/01/2000
11/20/2000
01/09/2001
02/28/2001
04/19/2001
06/08/2001
07/28/2001
Date
bag 3ft
bunk 3ft

# Factors Influencing Intake of Grass Silage

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**Abstract**

The objective of this paper is to discuss about factors influencing grass silage intake, mainly based on statistical analyses of published data and data from studies conducted in Agrifood Research Finland (MTT). Predicting intake of grass silage is difficult, because in addition to silage characteristics many animal and management factors markedly influence intake. We have recently tried to predict relative intake potential from silage digestibility and fermentation data using relationships estimated by statistical analyses from literature data. An advantage of this approach is that rather than predicting actual intake with poor accuracy , our system predicts relative intake potential with fairly high accuracy. Silage DM intake (SDMI) has increased about 15 g/d per one unit increase in D-value (g digestible organic matter per kg DM) achieved by earlier harvesting. D-value explained about 75% of the variation SDMI within experiment. Although silage crude protein (CP) and D-value are generally positively correlated, CP is much poorer predictor of intake than D-value. Based on limited data it seems that cell wall concentration (NDF) does not improve the prediction of SDMI compared to D-value alone. SDMI decreases with increasing extent of in-silo fermentation and proteolysis. Adverse effect of lactic acid on SDMI was less than that of VFA. Propionate acid had quantitatively the most negative effect of individual VFAs. Total acid (TA) concentration was the best single fermentation parameter explaining variation in SDMI followed by lactic acid and ammonia N. Multiple regressions including TA and ammonia explained variation in SDMI slightly better than TA alone. The best multiple regressions explained about 50% of the variation in SDMI within experiment, which clearly demonstrates the importance of fermentation quality on SDMI. The relationships obtained from statistical analyses of D-value and fermentation data were combined into one equation predicting relative SDMI index (SDMI = 100 for well fermented silage with D-value of 690; one point is 0.1 kg DM) from digestibility and fermentation data. The system is now used in Finland and the values are reported for farmers in silage analyses. Increasing the level of concentrate supplementation decreased SDMI by 0.54 kg per kg increase in concentrate DMI. Depression in SDMI tend to increase with the level of supplementation. Despite reduced SDMI total DMI and ME increase with increasing level of supplementation. However, the responses to extra concentrate in ME intake are markedly smaller than expected because of the negative associative effects in digestion. When the amount of concentrates was 10 kg/d, the increase in ME intake was only 70% of the increase predicted from intake and calculated feeding values. Enhancing CP concentration of the supplement by replacing cereal grains partly with high quality protein supplements such as rapeseed meal (RSM) increases SDMI curvilinearly with smaller marginal responses at high levels of inclusion. The mean linear responses were 0.34 kg per kg RSM or 29.8 g per 1 g/kg increase in dietary CP concentration. The results suggest that the intake responses are derived mainly from postruminal metabolism rather than improved ruminal cell wall digestion, which has often been suggested to be the reason for increased SDMI with supplementary protein feeding.

**Introduction**

Performance of ruminants fed diets based on conserved forages depend mainly on voluntary intake and nutritive value of forages. Digestibility or D-value [g digestible organic matter (OM) per kg dry matter (DM)] is the most important quality parameter of forages, especially for dried forages since intake is generally closely related to digestibility and cell wall contents. This relationship is weaker for ensiled forages, probably due to formation of fermentation products during the in-silo fermentation process. Potential silage dry matter intake (SDMI) is determined by sward type, chemical composition and digestibility of organic matter at harvesting, but the extent to which this potential is achieved in practical feeding depends on supplementary feeding and modifications of carbohydrate and nitrogen fractions during in-silo fermentation.

In addition to the effects on intake, modifications of carbohydrate and nitrogen fractions during in-silo fermentation also influence the amount and composition of nutrients absorbed from the digestive tract. For optimisation of supplementary feeding of grass silage it is important to predict intake and nutrient supply from the basal silage. Relatively small differences in silage digestibility or fermentation characteristics can markedly influence the amount of concentrate needed to maintain certain production level. This review will focus on factors affecting intake of and nutrient supply from grass silage-based diets. Discussion is based mainly on statistical analyses of published data.

## Silage intake

### *Effect of silage sugestibility*

Although the modification in carbohydrate and nitrogen fractions during in-silo fermentation can influence the relationship between silage D-value and DMI, positive relationship between digestibility and SDMI has been observed in most of the studies. In recent literature studies (Rinne, 2000; Huhtanen et al., 2001) SDMI increased on average by 15.6 g per 1 g/kg increase in D-value. The relationship was linear over the whole range of D-values (589 - 756), although some earlier studies (Rook and Gill, 1990) have suggested that the responses in SDMI to improved digestibility were curvilinear with smaller increased in SDMI at high than low digestibility. In statistical analyses D-value explained about 75% of variation in SDMI within experiment, whereas the relationship between silage crude protein (CP) concentration and SDMI was much weaker ($R^2$ 0.35). It has been suggested that forage cell wall concentration (NDF) could be a better predictor of DMI than digestibility, because NDF could be more closely related to filling effect of silage than digestibility. Unfortunately only in limited number both NDF and D-value were measured. In this data set (n=36) D-value was a much better predictor of SDMI than NDF, and the parameters together did not explain the variation in SDMI better than D-value alone. The greater importance of D-value may be related to large difference in clearance rate and digestibility of some silages at similar NDF concentrations. For example, in the study of Rinne et al. (1999) harvesting silage one week later had no effect on NDF concentration (641 vs 645 g/kg DM) but was associated with a lower D-value in sheep (707 vs 639), reduced SDMI (11.65 vs 10.75 kg DM/day) and increased rumen NDF fill in lactating dairy cows.

The effect of silage D-value on SDMI decreased as the proportion of concentrate in the diet increased. In our literature study (Huhtanen et al., 2001) there was a significant interaction between D-value and concentrate level, i.e. the positive response in SDMI to D-value reduces with the level of concentrate supplementation. Calculated changes in SDMI at 4, 8 and 12 kg/day of concentrate were 17.6, 15.0 and 12.1 g/day per 1 g/kg DM change in D-value, respectively. Calculated substitution rates were 0.43, 0.46 and 0.50 when silage D-values were 600, 650 and 700, respectively. On the other hand, D-value had a more profound effect on SDMI at high rather than low levels of DM intake, indicating that the response is proportional to feeding level.

Intake of grass silage-based diet is often assumed to be limited by physical factors, i.e. fill effect. However, many studies have shown that rumen NDF-fill has been smaller for early-cut high D-value silages compared to late-cut low D-value silages despite the intake of high D-value silages has been higher. In studies at MTT harvesting four silages at one week intervals decreased D-value and SDMI considerably but rumen pool size of NDF and indigestible NDF increased with advancing maturity (Table 1). From this data it can be concluded that the intake of silages I - III was not limited by rumen fill, since rumen fill decreased despite increased SDMI. It is more likely that intake of silages I - III was constrained by energy demand of the cows rather than by physical fill of the rumen. Using a modelling approach and assuming that maximal rumen fill was achieved with silage IV, the cows given silage I should have eaten about 5 kg more silage DM to reach the same rumen NDF fill.

**Table 1.** The effects of maturity of grass ensiled on silage composition, intake, rumen NDF pool size and digestion kinetics parameters (data from Rinne, 2000). The silages were harvested at one week intervals.

| | Silage harvest | | | |
|---|---|---|---|---|
| D-value | I | II | III | IV |
| D-value (g DOM/kg DM) | 739 | 730 | 707 | 639 |
| CP (g/kg DM) | 172 | 146 | 134 | 113 |
| NDF (g/kg DM) | 486 | 541 | 641 | 645 |
| INDF (g/kg DM) | 48 | 57 | 78 | 124 |
| SDMI (kg/d) | 12.44 | 12.16 | 11.65 | 10.75 |
| Rumen NDF pool (kg) | 5.76 | 6.10 | 6.62 | 7.36 |
| DNDF *kd* (1/h) | 0.059 | 0.060 | 0.055 | 0.051 |
| INDF *kp* (1/h) | 0.0211 | 0.0235 | 0.0261 | 0.0266 |

### *Effects of silage fermentation*

Several attempts, generally using simple or multiple regression equations, have been made to estimate the effect of the silage fermentation quality on SDMI in ruminants to form prediction equations for practical ration formulation systems. The performance of the prediction equations based on silage fermentation parameters have been poor judged from low $R^2$ and high prediction errors, although e.g. using high rates of formic acid addition has increased SDMI within single studies compared to untreated silages. These prediction equations may be confounded by animal factors (breed, age, physiological stage, production level), feeding systems and supplementation (amount, type). Furthermore, between laboratory variation in determining silage characteristics could reduce accuracy of the equations. To avoid these confounding effects we (Huhtanen et al., 2001) used a statistical model, which analysed the relationship between fermentation characteristics and SDMI within experiment using data from literature (234 treatment means). The data were from studies, in which the same sward was ensiled using different additive treatments; i.e. only variable within experiment was silage fermentation.

Silage pH was poorly correlated to SDMI in our study and also in studies by Offer et al. (1988) and Steen et al. (1998). The effect of pH on SDMI tend to be quadratic with a slight positive relationship at low pH followed by a negative relationship at high pH. This could be explained by adverse effects of acidity at low pH and poor fermentation with high ammonia N and VFA concentrations at high pH.

SDMI decreased by 15.7 g/d per 1 g/kg total N increase in ammonia N concentration (Huhtanen et al., 2001). The effect tends to be curvilinear, since quadratic regression explained the variation in SDMI better than linear regression. The effect of changes in ammonia N was greater at low rather than high ammonia N concentrations. It has been suggested that decreased SDMI is not due to ammonia N *per se* (e.g. Steen et al., 1998), but be an indirect effect due to correlation of ammonia N with some other variables. Rook and Gill (1990) suggested, based on high correlation between VFA and ammonia, that VFA was the causative factor. In their multiple regression models VFA were always more important than ammonia. However, our multiple regression models do not completely support this view. In the model including linear and quadratic effects of ammonia N and total VFA, the effect of ammonia remained significant, but the effect of VFA on SDMI reduced to 5.0 g/d per 1 g/kg DM. Similarly, the effects of ammonia remained significant with lactic acid, total acids or lactic acid and VFA in multiple regression models. Our data showed that ammonia N either directly or indirectly due to correlation with some other end-products of silage proteolysis limits silage intake.

In our data lactic acid (LA) had a strong negative effect on SDMI (within exp $R^2$ = 0.313). SDMI decreased 13.0 g/d per 1 g/kg DM increase in silage lactic acid concentration. In other studies the relationship has been weaker and inconsistent. Based on beef cattle data Rook and Gill (1990) and Steen et al. (1998) reported curvilinear relationships between silage LA and SDMI with maximum intake at LA concentration of 80 g/kg

DM. Inconsistent effects of LA on intake are probably associated with the reasons of variation in LA concentration. Low LA concentrations would certainly have different effects on SDMI, when they are outcome of either restricted in-silo fermentation (positive) or secondary fermentation of LA to VFA (negative). Effects of VFA on SDMI has consistently been negative. In our study SDMI decreased 25.6 g/d per 1 g/kg DM increase in silage VFA concentration. Quadratic equations have generally increased the variation accounted for compared to linear equations, effects of the changes in VFA concentrations on SDMI being greater at low rather than high concentrations. Based on linear regressions, it appears that of individual VFAs propionate has the strongest negative effect on SDMI. The relative slopes for acetate, propionate and butyrate in our study (1.0, 5.4 and 1.6). It is unlikely that small concentrations of propionate in silage would have a direct effect on SDMI, because the highest concentrations correspond to daily propionate intake of only 110 g/d. Greater slope of VFA compared to LA in multiple regression (21.4 vs 11.8 g per g/kg DM) suggest that VFA has a greater depressive effect on SDMI than LA. However, when ammonia N was included in the model the slopes for VFA and LA were rather similar (12.7 and 10.6) suggesting that the stronger effect of VFA resulted from collinearity between VFA and ammonia N.

Total acid (TA) concentration was clearly the best single predictor of SDMI explaining more than 40% of the variation within experiment (Huhtanen et al. 2001). In other studies TA has accounted for less of the variation in SDMI than acetic acid or total VFA (Wilkins et al., 1971; Gill et al., 1988; Rook and Gill, 1990). In our study the fit of model did not improve by including both lactic acid and VFA in multiple regression equation compared to TA alone, which suggest that the depression in SDMI was more related to the extent rather than type of in-silo fermentation. On the other hand, when TA and LA/TA were included in the model, LA/TA ratio also reached significance (P=0.012). This suggests that homolactic fermentation decreased SDMI less that heterolactic fermentation. The strong relationship between both LA and TA to SDMI do not support the conclusion of Steen et al. (1998) that the concentrations of LA and VFA in silage are of little importance in determining SDMI. Our data suggest that when the extent of silage fermentation is manipulated by high rates of acid application, the extent of in-silo fermentation is the best predictor of SDMI. However, when the silages are preserved as untreated, inoculated or with low levels of acid applications, the type rather than extent of fermentation is probably more important.

**Mechanisms for decreased SDMI due to fermentation products**

Reduced silage intake of badly or extensively fermented silages can be related to (i) low palatability, (ii) reduced clearance rate from the rumen and (iii) imbalanced amino acid to energy ratio at tissue level. Direct effects of silage fermentation products on palatability have been attempted to be estimated by adding assorted fermentation products to the silage or by directly infusing them into the rumen, but the results of these studies have been equivocal. When the cows were given a choice between untreated (UT), inoculated (I) at low (LF) or high level of formic acid (HF) treated silages, they showed after a relatively short period a clear preference to restrictively fermented HF silage (0.70 of total DMI) followed by I (0.15), LF (0.12) and UT (0.03) silages (Keady and Murphy, 1998). This result suggests a direct effect of the silage quality mediated possibly through smell or taste. In an other trial, where the same silages were fed separately to dairy cows the intakes of HF, LF, I and UT silages were 10.9, 10.9, 9.9 and 9.7, respectively (Keady and Murphy, 1998). The studies cited above suggest that the smell or taste may affect the choice of a silage or termination of the first meal, but mechanisms which influence the quantitative differences SDMI between silage types are more complicated and probably related to metabolic mechanisms.

Reduced rate of clearance has been suggested to be one reason for reduced intake of badly fermented silages. However, there is limited data to support this suggestion. In a recent study in our laboratory (Shingfield et al., unpublished ) the intake of formic acid treated silage was 1.5 kg DM/d higher than the mean intake of untreated and inoculated silages and this increase was associated with proportionally 0.07 greater rumen DM fill. Huhtanen and Jaakkola (1993) fed silage and barn-dried hay from the same sward to cattle, but there were no differences in rumen pool size or clearance rate of digesta between the forage types. Both studies (hay vs silage of same digestibility; effects of silage fermentation) suggest that the intake of more extensively fermented forages is not constrained by rumen load, but some other mechanism which prevented the cows to eat these silages to the same rumen fill as formic acid treated silage.

Increased intake of low quality forages and rumen fill in response to post-ruminal casein infusion in sheep (Egan, 1970) provides evidence of the importance of the profile of absorbed nutrients on intake. Further, post-ruminal casein infusion increased SDMI more than ruminal infusion (Khalili et al., 2001), suggesting that SDMI responses to protein supplementation are often derived from post-ruminal metabolism. Protein supplementation of grass silage-based diets has consistently increased SDMI (Thomas and Rae, 1988; Chamberlain et al., 1989), an effect often being attributed to improved cell wall digestibility in the rumen. However, using rapeseed feeds as a protein supplement has increased SDMI without affecting diet digestibility (Huhtanen, 1998). Because silage fermentation acids provide little or no energy for rumen microbial growth (Chamberlain, 1987) and the efficiency of microbial protein synthesis decreases with increasing extent of silage fermentation (see van Vuuren et al., 1995), it could be argued that reduced supply of amino acids or imbalance between amino acids and energy constrain the intake of extensively fermented silages. Evidence from rumen evacuation studies (e.g. Rinne, 2000; Table 1) suggests that with grass silage-based diets containing a moderate proportion of concentrate in the diet neither the capacity to use energy nor the load ceiling limits intake, but that SDMI is regulated by an interplay between ruminal load and energy demand. In the study of Rinne (2000) SDMI increased with improved digestibility, but rumen digesta load decreased, and therefore only the intake of the silage with the lowest digestibility could be limited by rumen fill. A hypothetical model for intake of grass silages differing in digestibility and fermentation quality and fed with a constant amount of concentrate is proposed in Fig. 1. It is based on the conceptual model by Weston (1996). Thus the section A-B corresponds to silages of good fermentation characteristics (D-value improves from A to B), i.e. fermentation products are not limiting intake. Interplay between satiety and load stimulus determines intake in this range. When the extent of in-silo fermentation is increased, microbial protein synthesis in the rumen decreases leading to an imbalanced amino acid to energy ratio at the tissue level, which constrains SDMI to C-D. The relationship E-F represents a theoretical situation that could prevail with a constraint arising from a low palatability, e.g. nitrogenous compounds or organic acids related to production of propionic acid during ensilage.

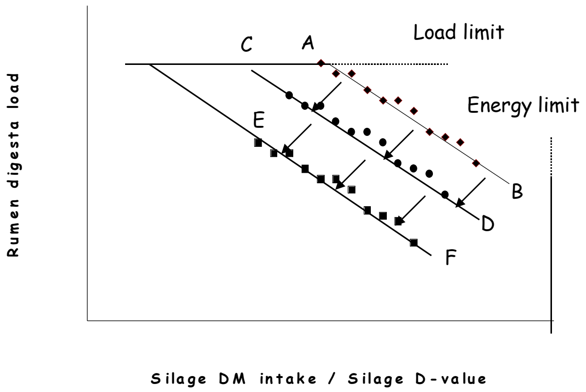



**Figure 1.** Conceptual relationships based on model of Weston (1996) for silage DM intake between rumen digesta load and limit to use energy with improving D-value without the presence of constraint (A-B), when intake is constrained by imbalanced nutrient supply from extensively fermented silages (C-D) and further by reduced palatability (E-F). The plots are hypothetical values.

### Silage DMI index and practical applications

Relationships obtained from D-value and fermentation data were combined on the basis of conceptual relationship proposed in Fig. 1 to produce SDMI index, which could be used in practice to predict relative intake based on silage analyses. The following equation is proposed for SDMI index:

*SDMI index* $= 100 + 0.151 \times (D\text{-value} - 690) - 0.000531 \times (TA^2 - 6400) - 4.7650\,[Ln(\text{Ammonia N}) - Ln(50)]$, where D-value and total acids (TA) are expressed as g/kg DM and ammonia N as g/kg total N, respectively. Regression coefficients are scaled to a mean SDMI of 10 kg DM/day and one unit in SDMI index corresponds to 0.1 kg DM. For example if SDMI was 10 kg/d and inxex value 100, improving index value to 110 as a result of better digestibility, fermentation quality or both increases SDMI to 11 kg/d. The values of 690, 80 and 50 are used as standard D-value (g/kg DM), total acid (g/kg DM) and ammonia N (g/kg N) for high quality restrictively fermented silages. The model assumes that the effects of D-value and fermentation characteristics on SDMI are additive. Experimental data is limited to confirm or reject this assumption. Only the parameters, which could be analysed reliably by NIRS (D-value) and electrometric titration (ammonia N, TA) are used in the model. More detailed characterisation of fermentation parameters could slightly improve the accuracy of prediction, but in practice analysing it is not possible to separate individual VFA by titration method. Mean prediction errors for both digestibility and fermentation data were approximately 0.38 and 0.40 kg DM/d, i.e. equivalent to 3.7 and 4.0% of the mean silage intake. These values are smaller than s.e. of prediction (7.6% of the mean intake) in the study of Steen et al. (1998). They measured intakes of 136 silages from commercial farms in the their laboratory using beef cattle. Relative SDMI potential would be modified in practice by additional animal (e.g. live weight, milk production, stage of lactation) and management (e.g. level and composition of supplements, feeding systems) factors. It can also be used as a tool in silage management to improve silage quality and optimise supplementary feeding to obtain full benefits of silage resources available at the farm.

SDMI can be used to estimate how much more concentrate should be used to compensate for the effects of reduced intake potential of grass silage. Using data from the study of Rinne et al. (1999), in which four silages harvested at one wk intervals (D-values 739, 730, 707 and 639 g/kg DM) each fed with either 7 or 10 kg/d of concentrates it can be estimated how much more concentrates are needed to compensate one unit decrease in SDMI index (Table 2). The silages practically similar fermentation quality and therefore the differences in intake can be interpreted as the effects of digestibility. SDMI decreased by 93 g/d per unit decrease in index value and the corresponding decreases in calcuted ME intake and energy corrected milk (ECM), fat + protein (F + P) were 2.0 MJ/d, 0.28 kg/d and 22.3 g/d, respectively. Based on marginal responses to additional concentrates in the same experiment 0.25, 0.44 and 0.59 kg/d more concentrates should have been fed to compensate one unit reduction in SDMI index. Higher value for ECM yield compared to ME intake could be explained by negative associative effects in digestion. When the amount of concentrates in dairy cow diets is increased the true increase in ME intake has been on average about 70% of calculated increased based on feeding values. Based on these results, it could be estimated that about 6.5 kg/d more concentrates should be fed with silage IV (D-value 639) than with silage III (D-value 707) harvested one week later to achieve he same performance. Normally the decrease in D-value during the first harvest in Finland is about 5 g/day (Rinne, 2000), which corresponds to 0.47 kg/d extra concentrates.

**Table 2.** Effects of silage D-value on concentrate saving effect calculated per unit decrease in SDMI index (data from Rinne et al., 1999).

| | D-value (g/kg DM) | | | | Change per | Extra conc |
|---|---|---|---|---|---|---|
| | 739 | 730 | 707 | 639 | unit | (kg per unit) |
| Index | 107.8 | 106.4 | 102.7 | 90.6 | | |
| SDMI (kg/day) | 12.44 | 12.16 | 11.65 | 10.75 | 0.093 | -0.181 |
| TDMI (kg/day) | 19.84 | 19.5 | 19.16 | 18.27 | 0.084 | 0.252 |
| ME (MJ/day) | 236.6 | 230.7 | 222.2 | 200.5 | 2 | 0.444 |
| ECM (kg/day) | 30.72 | 30.12 | 29.54 | 25.7 | 0.28 | 0.587 |
| F + P (g/day) | 2270 | 2235 | 2181 | 1886 | 22.3 | 0.592 |

The effects of silage fermentation characteristics on concentrate requirements can be calculated similarly. The data is taken from the study of Shingfield et al. (2001a), in which the fermentation quality of silage harvested from the same sward was manipulated by different additives. The silages were supplemented with either 7 or 10 kg/d of concentrates. Application of formic acid efficiently restricted the extent of fermentation and proteolysis in the silo, which resulted in higher SDMI compared to untreated silage (Table 3). SDMI decreased 89 g per unit decrease in index value, the value being similar to that observed with decreased D-value. However, the changes per unit SDMI index in ME intake and production responses as well as the amount of extra concentrate needed to compensate for the reduced intake potential were smaller than the corresponding effects of improved D-value. More extra concentrates was required to compensate for the reduced intake potential of untreated silage in production parameters than in ME intake, which again can be attributed to the negative associative effects in digestion with increased rate of concentrate inclusion. Differences between untreated and FA-treated silages in milk production responses were relatively large considering that more than 3 kg/d extra concentrate supplement was required to maintain the performace with untreated silage compared with FA-treated silage. Smaller changes per unit of SDMI index when fermentation quality rather than D-value was manipulated can be attributed to the fact that with improved D-value ME intake increases both in response to changes in intake and energy content of silage, whereas with improved fermentation quality only intake is increased. The effects of in-silo fermentation in silage digestibility and ME content are generally small proving that the silages do not display extensive secondary fermentation.

**Table 3**. Effect of improved silage fermentation quality on concentrate saving effects calculated per day or per unit decrease in SDMI index (data from Shingfield et al., 2001a)

| | Untreated | Untreated | FA-treated | Change per | Extra conc | Extra conc |
|---|---|---|---|---|---|---|
| Conc (kg/day) | 7 | 10 | 7 | Unit | (kg/day) | (kg per unit) |
| Index | 91.3 | 91.3 | 103.8 | | | |
| SDMI (kg/day) | 12.61 | 11.71 | 13.72 | 0.089 | -3.7 | -0.296 |
| TDMI (kg/day) | 18.92 | 20.67 | 20.02 | 0.088 | 1.9 | 0.152 |
| ME (MJ/day) | 216 | 238 | 232 | 1.3 | 2.3 | 0.184 |
| ECM (kg/day) | 27.4 | 28.9 | 29.1 | 0.14 | 3.3 | 0.264 |
| F + P (g/day) | 2006 | 2126 | 2145 | 11.1 | 3.5 | 0.280 |

The amounts of extra concentrate supplementation required to offset the differences in silage D-value and fermentation quality are more similar when intake potential is expressed in terms of relative silage ME rather than DM intake index (Table 4). SDMI index can be converted to SMEI as follows: ***SMEI index = SDMI index × D-value / 690.*** Marginal changes in ME intake (1.3 and 1.1 MJ per unit) and ECM yield (0.14 and 0.16 kg ECM per unit SMEI index) were relatively similar when intake potential was manipulated by fermentation quality or digestibility. On average about 0.3 kg/d more concentrates should be fed to maintain milk production, when ME intake potential from silage is reduced by one unit.

**Table 4.** Effects of silage D-value on concentrate saving effect calculated per unit decrease in SMEI index (data from Rinne et al., 1999)

| D-value | 739 | 730 | 707 | 639 | Change per Unit | Extra conc (per unit) |
|---|---|---|---|---|---|---|
| Index | 115.5 | 112.6 | 105.3 | 83.9 | | |
| SDMI (kg/day) | 12.44 | 12.16 | 11.65 | 10.75 | 0.051 | -0.100 |
| TDMI (kg/day) | 19.84 | 19.50 | 19.16 | 18.27 | 0.047 | 0.140 |
| ME (MJ/day) | 236.6 | 230.7 | 222.2 | 200.5 | 1.1 | 0.244 |
| ECM (kg/day) | 30.72 | 30.12 | 29.54 | 25.70 | 0.16 | 0.366 |
| F + P (g/day) | 2270 | 2235 | 2181 | 1886 | 12.2 | 0.324 |

## Effects of concentrate supplementation on SDMI

It is well-know that increasing the level of concentrate supplementation decreases SDMI. Based on analyses of data from studies conducted in MTT the mean substitution rate, i.e. decrease in SDMI per kg increase in concentrate DMI, was 0.54 (s.e. 0.02). Including quadratic effect of concentrate DMI did not improve the fit of equation significantly, but the analyses suggested that increasing the level of supplementation decreases SDMI slightly more at high than low level of supplementation. On the other hand, the effect of concentrate level on total ME intake is clearly curvilinear with diminishing returns of increased supplementation. ME intake calculated from silage D-value using feed table values for concentrates (ME.tab) increases almost linearly with the level of supplementation, whereas ME intake estimated from digestible OM intake assuming 16 MJ ME per kg DOM increases curvilinearly with increasing level of supplementation (Fig 2). At low levels of supplementation (e.g. 3 - 7 kg/d) true increases in ME intake are almost equal to expected increases, whereas with 10 kg/d of concentrates increase in ME intake based on digestibility is only about 70% of expected and with 15 kg/d of concentrates only slightly over 50%. The increased difference between ME.tab and ME.dom with enhanced level of supplementation can be attributed to negative associative effects of digestion. At high level of feeding rapidly fermentable carbohydrates in concentrate supplements decrease rumen pH, which leads to reduced rate of cell wall digestion in the rumen. In dairy cows at high level of feeding reduced rate of ruminal NDF digestion can only to small extent be compensated by increased hind-gut fermentation or increased retention time in the rumen. At low level of intake high concentrate diets can also reduce the rate of ruminal cell wall digestion, but longer rumen retention time of can offset the effects of reduced rate of digestion. In addition to partitioning more energy towards body tissues with high concentrate diets, slightly higher substitution rates and especially reduced digestibility of high concentrate diets in dairy cows explain relatively small marginal milk yield responses to additional concentrates in dairy cows fed high quality silages.

Data to estimate the effects of silage quality on substitution rate is rather limited. Based on statistical analyses of the effects of silage D-value it seems that substitution rates are slightly higher with high than low D-value silages (Huhtanen et al., 2001). The mean calculated increase in substitution rate was about 0.007 per 10 g/kg increase in D-value. The same relationship seems to apply for fermentation quality. Increasing the amount of concentrate from 7 to 10 kg/d decreased intake of untreated, inoculated and formic acid treated SDMI by 0.34, 0.39 and 0.50 kg per kg concentrate DM, respectively (Shingfield et al., 2001a). These two examples suggest that the better the quality of silage is both in terms of digestibility and fermentation qualit, the more silage intake is depressed by concentrate supplementation.

## Effects of protein supplementation on SDMI

Increasing crude protein content of concentrate supplement has generally increased silage and total DM intake. Increased silage DM intake in cows given protein supplementation has often been attributed to increased cell wall digestibility in the rumen (Oldham 1984). However, SDMI has also increased without improvements in diet digestibility when rapeseed meal has been used as a protein supplement (see Huhtanen 1998). This suggests that factors other than improved digestibility are involved. Khalili and Huhtanen al. (2001) observed a greater increase in silage DM intake with duodenal rather than ruminal infusion of casein. The cows given post-ruminal casein infusion had a higher rumen NDF fill and a longer total chewing time compared to ruminal casein infusion indicating that the cows can adjust physical fill limit and feeding behaviour when the demand of nutrients is increased in response to improved nutrient balance at the tissue level. These observations suggest that the effects of protein supplementation are mediated mainly by metabolic mechanisms, probably related to protein or protein to energy ratio.

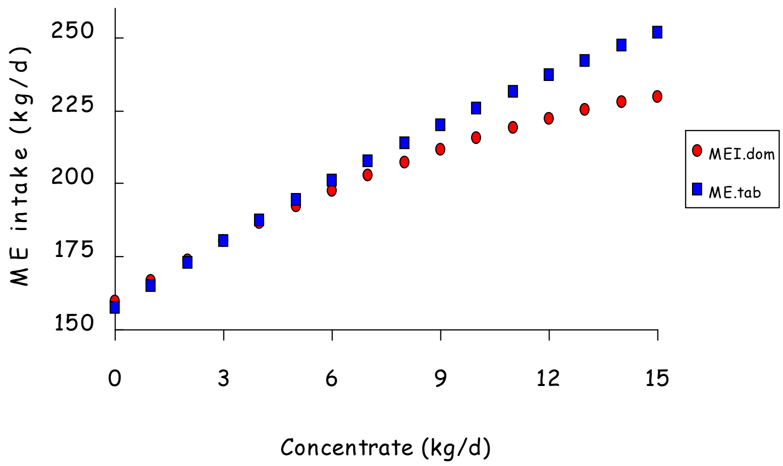
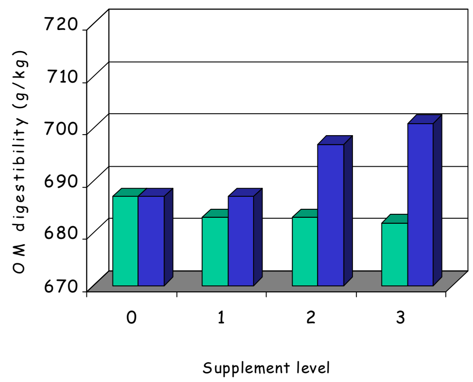



**Figure 2.** Effect of concentrate supplementation on ME intake estimated from D-value of silage (based on cellulase digestibility or in vivo) and feed table values for concentrates (ME.tab) or calculated from DOM intake in dairy cows (ME.dom). Data from studies conducted in MTT.

Based on analyses of data from Finnish studies (66 treatment means) replacing energy supplement (mainly mixtures of cereal grains) on weight basis with rapeseed meal (RSM) increased SDMI by 0.34 (s.e. 0.04) kg per 1 kg. The SDMI responses were 29.8 (s.e. 3.34) and 1.55 (s.e. 0.17) g when expressed per increase in dietary CP concentration (g/kg DM) or supplementary CP intake (g/d). These parameters explained about 70% of the variation in SDMI within experiment. Including quadratic effect of the amount of RSM slightly improved the fit of equation and the magnitude of response to protein supplementation tended to decrease with increasing level of supplementation.

If the SDMI response to supplementary protein were mediated entirely by digestibility, diet digestibility should have been increased about 3 %-units per 1 kg RSM assuming a similar relationship between digestibility and intake to that observed with silage D-value. Because of the negligible effects of RSM on digestibility, increased and more balanced supply of amino acids to the mammary gland and enhanced milk yield is the most likely reason for the increased SDMI with RSM supplementation. Although RSM does not improve diet digestibility, calculated increase in ME intake estimated from digestible OM was greater than that of calculated from silage D-value and feed table values for concentrates (12.2 vs 10.0 MJ per kg increase in total DMI). This suggest that increased supply of N components from RSM to rumen bacteria compensated for the lower intrinsic digestibility of RSM compared to cereal grains, which were partially replaced by RSM. In the study of Rinne et al. (1999) replacing 1.2 kg/d of a mixture of barley and oats increased the rate of NDF digestion from 0.058 to 0.064 per hour (Huhtanen, unpublished), which was enough to compensate for the lower potential digestibility of RSM cell walls compared to grain cell wall fraction. In our recent study soybean meal (SBM) and rapeseed cake (RSC) were compared as protein supplements for dairy cows (Shingfield et al., unpublished ). Each supplement were used at four isonitrogenous levels (SBM: 0, 0.8, 1.6 and 2.4 kg/d; RSC: 0, 1.2, 2.4 and 3.6 kg/d) to replace a mixture of grain and sugar beet pulp. RSC increased total DMI slightly more despite SBM diets had significantly higher digestibility (Figure 3). These results provide further evidence that factors other than more efficient rumen cellulolysis are involved in SDMI responses to protein supplementation. Milk yield was higher with RSC than with SBM diets, which could explain the higher metabolic energy demand and drive to eat more for RSC supplement.

The effect of N source on silage and total DMI was demonstrated by Shingfield et al. (2001b). Two silages harvested from swards fertilized with 50 and 100 kg N/ha and which contained 120 and 148 g CP/kg DM were each supplemented with 10 kg/d of cereal grain based supplement either without protein supplement of with three isonitrogenous protein supplements of urea, wheat gluten feed (WGM) and rapeseed cake. Silage CP had no effect on intake suggesting that the relationships between silage CP concentration and intake are different, when CP is increased either by higher application rate of N fertilizer or by harvesting at earlier stage of maturity. Urea and WGM increased only the intake of low CP silage, probably because the supply of rumen degradable N was insufficient. However, RSC increased the intake of both silages, but the response was greater with low rather than high CP silage. This was probably because with low CP silage the response originated both from ruminal and postruminal metabolism, whereas with high CP silage the only the postruminal mechanisms were involved.



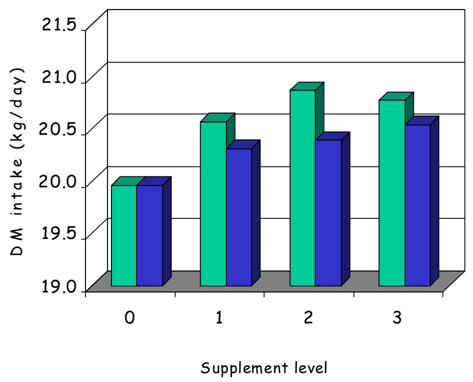




**Figure 3.** Effects of increasing level of rapeseed cake (left bars) and soybean right bars) supplementation on total DM intake (left) and diet OM digestibility (right) in cows given grass silage ad libitum (Shingfield et al. unpublished)

## Conclusions

Silage DMI is a function of intrinsic intake potential of herbage ensiled, fermentation quality and supplementary feeding. Intrinsic intake potential is mainly determined by digestibility and cell wall concentration of forages. The extent to which the intake potential can be achieved depend on the modifications in carbohydrate and nitrogen fractions during in-silo fermentation. Intake of badly fermented silage can be markedly lower compared to well fermented and especially to restrictively fermented silages. Relative SDMI index can be estimated from silage digestibility and fermentation characteristics. It can be used as a tool to improve silage quality in the farm and in ration formulation. Using silage DM or ME intake index it can be estimated how much more concentrates should be fed to maintain milk production when silage intake potential is lower than expected, or vice versa, to estimate production responses or concentrate sparing effects with high quality silages.

Increasing the amount of concentrate supplementation decreases SDMI approximately by 0.54 kg per kg DM of additional concentrate. Total DM and ME increase, but the effects on ME intake is markedly smaller than expected, especially at high level of supplementation, due to the negative associative effects in digestion. Increasing the level of concentrate supplementation from 6 to 10 kg/d on air dry basis decrease the marginal response in ME intake from about 6.2 to 4.5 MJ per kg extra concentrate DM. Substitution rates tend to increase when silage quality is improved both in terms of digestibility and fermentation characteristics. Elevating crude protein content of the supplement by replacing energy ingredients with high quality protein supplements increases SDMI in a curvilinear way. In contrast to the effects of increasing the level of supplementation protein supplementation increases ME intake slightly more than expected because of the small positive associative effects in digestion. However, most of the data suggest that silage intake responses to supplementary protein are mainly derived from post-ruminal metabolism, probably from improved ratio of amino acids and energy. Improvements in diet digestibility, if any, are too small to explain intake responses to protein supplements.

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# FORAGE PRODUCTION

# Live Stock Feeding by Forage in the Czech Republic

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Live stock feeding by forage is in Czech Republic traditionally based on leguminous or clover/grass mixtures harvested from arable land. Proportion of grasses cultivated on arable land for direct feeding was in comparison with clover lower in Czech Republic and this rate was again lowered in connection with increase of nitrogen fertiliser prices after year 1989.

Proportion of permanent grassland (pastures, meadows) was for high tillage very low before year 1989. During the last 10 years permanent grassland area increased from 705 thousand ha in year 1990 on 1,074 thousand ha in year 2000 i. e. about nearly 396 thousand. ha. Utilisation of permanent grassland for making forage is limited for both low livestock concentration and bed grassland management.

Basic leguminous species for silage production in Czech Republic seems to be alfalfa and red clover , next species are used mainly for establishment of meadows or pasture.

The alfalfa acreage was essentially lower in comparison with red clover in Czech Republic, so is area slowly decreased after year 1989 and alfalfa outnumbered red clover ones. This is coupled with rainfall decreasing and its non-uniform dividing during growing season. Lower rainfall can be a reason for higher yield of alfalfa and its widespreading in area with higher sea level (450 - 500  about the sea level), cultivated in pure stand or in mixture with red clover and grasses. Typical proportion can be: 50 % of alfalfa, 30 -35 % of red clover and 15 - 20% grasses (*Festulolium* hybrids). Mixtures of alfalfa together with red clover are not such and widespread optimal in area with not suitable soil or climatic condition - these mixtures we can use for yield increasing in areas with very low rainfall in growing season. Alfalfa/grass stand is suitable for higher WSC content and silage technology (better ensiling and welting). Grass component in such mixtures can be loloid *Festulolium* hybrids containing 16 - 20% WSC , representing maximum 10 -15 % in biomasse yield.

**Variety number development.**

During the last 10 years variety number rapidly has increased. Thanks to Czech plant breeding, number of alfalfa varieties increased three time, in red clover twice.

There are now 9 registered and released alfalfa varieties, mostly based on old landraces. The oldest released variety PALAVA, listed in current National List , was registered in year 1967, the first synthetic variety ZUZANA was registered in year 1990. Variety NIVA , registered in year 1995 , was selected according to indirect markes together with nitrogenase activity with higher symbiotic nitrogen fixation selection. Beside Czech varieties there are used imported varieties Europe, Orca, Kara and Resis.

Red clover variety list was enriched in the second part of 90s by tetraploid varieties, replacing an old but very widespread variety Kvarta, remaining on market in Germany, Switzerland and Austria. In contrast to alfalfa, foreign variety import is very low (only Slovak varieties), if we exclude diploid varieties multiplication of EU one.

Number of newly released varieties of red clover and alfalfa (Slovak inc.)

| Years | 1989 | 1995 | 1998 | 2000 |
|---|---|---|---|---|
| Red clover | 12 | 15 | 21 | 22 |
| Alfalfa | 5 | 15 | 15 | 15 |

Grass released variety list was very enriched in the second part of 90s by new varieties (including foreign amenity grasses ones) and by 23 varieties of 9 species of Czech provenience, used in arable land forage production.

Increase of newly registered Czech and Slovak grass varieties used for arable land forage production - pure stand or mixtures

| | | | |
|---|---|---|---|
| Italian ryegrass | 3 | perennial ryegrass tetrapl | 3 |
| Timothy | 5 | *Festulolium* hybrids | 3 |
| meadow fescue | 1 | oatgrass | 1 |
| cocksfoot | 5 | cocksfoot (*D. aschersoniana*) | 1 |
| bromgrass | 1 | | |

**Forage quality in perennial fodder crops**

Forage quality for conservation on principle is affected according to harvest date earliness , times between harvest and transport and times of ensilage of biomasse in appropriate place. Often there is a problem to start harvest in appropriate time in Czech Republic and quality of conserved forage is different. The level of swath processing is increasing and better thanks better farm equipment by hi-tech harvest technology.

Alfalfa forage quality is very good if are harvested young plants with high proteins content and high organic matter digestibility. Satisfactory good is red clover forage but not so high in protein level. For higher red clover N-content is necessary earlier harvest the stand. There is a remarkable difference between diploid and tetraploid varieties.

Grasses harvested on start of heading offer high quality forage modifiable by stand nutrition. Namely N support can change N-substance values and herewith NEL, NEV and WSC values. The last one decreases with increasing N-doses and vice versa. There is necessary to keep different fertilisation according to species and there earliness, eventually divided doses. In this way we can achieve not only different yield but also differences in fibre content and forage digestibility.

Table 2 and 3 present some qualitative parameters in leguminous and grass monocultures and their mixtures. Samples were taken during the first cut in the first or second production year form stands located in Hladké Životice according to their maturity. Grasses were N-fertilised by 60 kg N/ha, not leguminoses. As we can see from analyses, these doses were for ryegrass and hybrid variety Perun, too low. Some samples were analysed for phenolic acid content. NEL, NEV and PDIN values were determined by NIRS, next values “in sacco” and by chemical analyses.

**Table 1**. Leguminoses rate on total perennial fodder crops acreage taking arable stand in Czech Rep. (%)

| Year | 1985 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| red clover | 36,3 | 37,0 | 34,3 | 33,4 | 29,9 | 29,2 | 27,9 | 26,7 | 27,2 | 23,9 | 22,2 | 22,5 |
| alfaalfa | 30,3 | 32,0 | 34,4 | 33,0 | 30,0 | 30,4 | 29,8 | 28,5 | 27,6 | 27,1 | 24,5 | 24,6 |
| total | 66,6 | 69 | 68,7 | 66,4 | 59,9 | 59,6 | 57,7 | 55,2 | 54,8 | 51,0 | 46,7 | 47,1 |

**Table 2** Qualitative parameters of alfaalfa, red clover and some grasses forage, 1.cut

| Varianta/Variant | | | WSC | NL | vláknina | SOH | NEL | NEV | PDIN | fenol.kys. |
|---|---|---|---|---|---|---|---|---|---|---|
| č. | druh | odrůda | % | % | % | % | MJ/kg | | g/kg | mg/kg S |
| No. | Species | Variety | | N-subst. | Fibre | DOM | | | | phenolic acids |
| 1 | alfaalfa | ZUZANA | 3,1 | 20,5 | 26,4 | 72,0 | 6,67 | 6,70 | 131,6 | 2570 |
| 2 | red clover | VESNA | 6,1 | 17,3 | 20,0 | 80,7 | 6,08 | 6,04 | 102,3 | 1650 |
| 3 | red clover | START 2n | 6,5 | 18,1 | 19,8 | 80,4 | 6,26 | 6,25 | 100,9 | / |
| 4 | red clover | BESKYD | 6,3 | 18,1 | 20,4 | 81,3 | 6,08 | 6,06 | 104,1 | / |
| 5 | cocksfoot | NIVA | 6,2 | 14,7 | 25,9 | 79,9 | 6,03 | 5,95 | 94,0 | 4617 |
| 6 | tall fescue | KORA | 8,4 | 13,4 | 25,4 | 76,7 | 5,45 | 5,26 | 84,4 | 599 |
| 7 | hybrid | FELINA | 7,2 | 13,5 | 26,4 | 76,9 | 5,53 | 5,34 | 91,8 | 771 |
| 8 | hybrid | HYKOR | 10,3 | 12,2 | 25,3 | 77,1 | 5,30 | 5,10 | 75,7 | 747 |
| 9 | hybrid | PERUN | 21,4 | 8,1 | 24,7 | 78,8 | 5,64 | 5,52 | 45,2 | 2260 |
| 10 | per.ryegras | MUSTANG | 19,4 | 8,2 | 22,1 | 80,2 | 5,75 | 5,68 | 46,1 | 1312 |

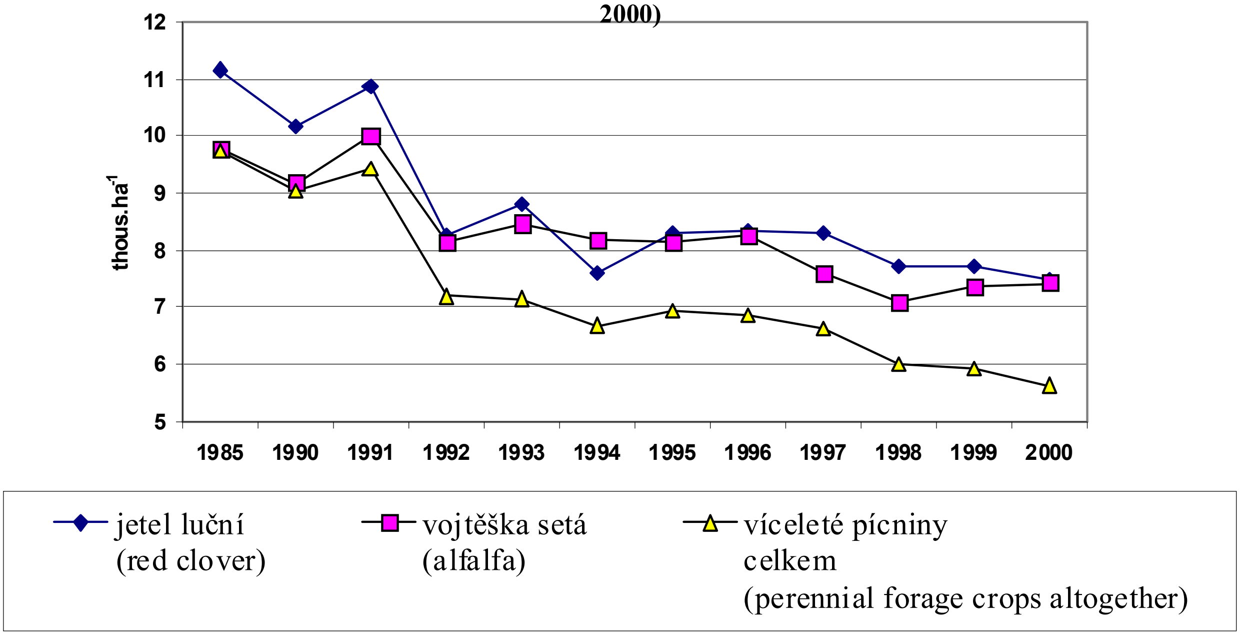
**Table 3** Qualitative parameters of leguminous/grass mixtures, 1.cut

| Varianta/Variant | | | WSC | NL | vláknina | SOH | NEL | NEV | PDIN | fenol.kys. |
|---|---|---|---|---|---|---|---|---|---|---|
| č. | druh | odrůda | % | % | % | % | MJ/kg | | g/kg | mg/kg S |
| No. | Species | Variety | | N-subst. | Fibre | DOM | | | | phenolic acids |
| 11 | alfaalfa<br>hybrid | ZUZANA<br>PERUN | 4,4 | 16 | 22,6 | 78,6 | 5,99 | 5,9 | 93,9 | / |
| 12 | red clover<br>alfaalfa<br>hybrid | VESNA<br>ZUZANA<br>PERUN | 12,5 | 13,9 | 23,6 | 80,6 | 5,29 | 5,09 | 88,9 | 2813 |
| 13 | red clover<br>alfaalfa<br>hybrid | VESNA<br>ZUZANA<br>FELINA | 11,8 | 18 | 20,5 | 83 | 5,89 | 5,82 | 113 | / |
| 14 | red clover<br>hybrid | VESNA<br>HYKOR | 15,3 | 11,1 | 27,1 | 80,5 | / | / | / | / ** |
| 15 | red clover<br>hybrid | BESKYD<br>PERUN | 17,3 | 13,3 | 22,9 | 90,8 | / | / | / | / |

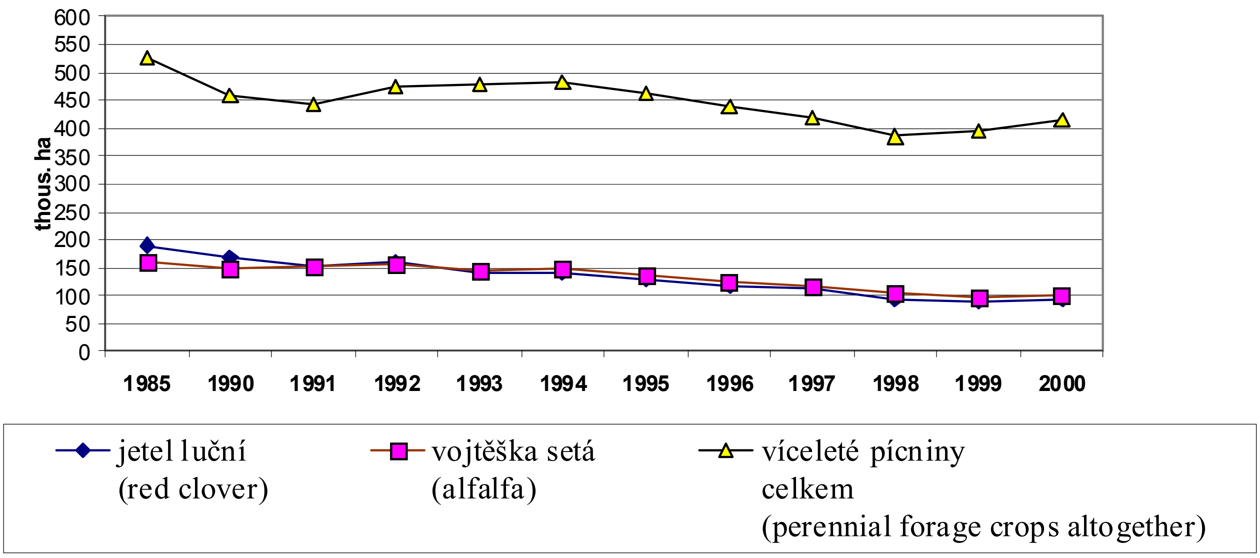
** vystínované hodnoty Var. 14 a 15 jsou ze sklizně 3.užitkového roku 1999

** shaded values, var. 13 and 14 represents 3. harvest year 1999

**Výnosy víceletých pícnin na orné půdě v ČR (1985 - 2000)**
**The yields of the perennial forage crops on the arable land in Czech Republic (1985-2000)**




**Struktura ploch víceletých pícnin na orné půdě v ČR (1985 - 2000)**
**Structure of the area of the perennial forage crops on the arable land in Czech Republic(1985 - 2000)**



# Effect of Stage of Maturity of a Range of Legumes on Forage Yield and Quality

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**Abstract**

A trial to investigate the effect of sequential harvesting of a red clover (Trifolium pratense L.) both diploid and tetraploid, lucerne (Medicago sativa) and alsike clover ( Trifolium hybridum) was established at Hladke Zivotice, Czech Republic in 1993. The trial design allowed four replications for each legume variant to be harvested at weekly intervals during an 8 week period (A, B, C, D, E, F, G, H) in both the 1st and 2nd cuts, during two harvest years. The main goal of the trial was to find out an optimum time of harvest of individual species and varieties for yield as well as forage quality. The quality (CP, WSC, CF, ME, NEL, PDIE, PDIN) was analysed by NIRS at the Research Station of a Grassland Ecosystems, Jevicko, the Czech Republic.

The lucerne produced a high forage yield and CP, ME, NEL, PDIN, PDIE contents, but WSC content was low in all maturity stages studied. Following maturity stage D it had high CF content and low digestibility. The alsike clover forage quality similar to lucerne and tetraploid red clover, but its yield was very low. As expected red clover varieties differed in both quality and yield according to ploidy level and earliness. Generally the tetraploid red clover was of better quality and higher yield than the diploid. Taking in to account that tetraploids differ in earliness, high quality forage can be obtained within a period of almost 5 weeks. Compared with lucerne, the red clover tetraploids have higher WSC that may be beneficial for silage fermentation.

**Introduction**

Forage legumes are the most important forage crops for mild climate regions and provide a high quality feed for livestock. In recent years the sown acreage is reducing in the Czech Republic compared to that used 1987 (in that year they had reached their maximum within 20 years long period). The main reason is probably due to the number of a cattle declining. The acreage of a lucerne occupies 101 820 ha and a red clover 93 329 ha, permanent meadows 659 353 ha and pastures 281 083 ha. Usually these crops are grazed as well as conserved forage, mostly as a silage. Their importance is getting higher at this time, because of their natural high protein source, as animal by products such as bone and meat powder is prohibited in Europe. The legumes can also have beneficial effects on soil structure, organic matter as well as nitrogen content in a soil leading to the lower N fertilisation of grass clover mixtures, and meadow grasses and pastures , resulting in lower production costs and improved sustainable agriculture.

**Material and Methods**

The experiment on sequential harvest of red clover (Trifolium pratense L.) diploid varieties: Start, Chlumecky and Tabor and tetraploid varieties: early Vesna, intermediate Amos, Beskyd, Dolina and Kvarta, semi late new plant breeding material Bivoj and late variety Radegast , lucerne (Medicago sativa), varieties: Europe, Zuzana and alsike clover (Trifolium hybridum) variety Taborsky were established at Hladke Zivotice in 1993. The trial design included four replicated plots for each legume variety and the plots were subdivided into 8 sub plot (3 $m^2$) to allow sequential harvests within a period of 8 weeks. The sub plots were labelled (A, B, C, D, E, F, G, H) and represented weekly maturity stages. The first sampling period started in the first week of May and went on until the end of June in both harvest years (1994 and 1995). A second cut was only harvested in 1994 during the last week of July and is not reported in this report.

The fresh matter from each sub plot was weighed by HEGE harvester, with 1 kg fresh matter sampled, oven dried at 50 ºC , then analysed by NIRS system (6500 at the Research Station of Grassland Ecosystems, Jevicko, CZ). Analysis included crude protein(CP) content, water soluble carbohydrates (WSC), crude fibre (CF), metabolised energy (ME), net energy of lactation (NEL), crude protein not degradable in rumen (PDIE, PDIN) were predicted.

**Results and Discusion**

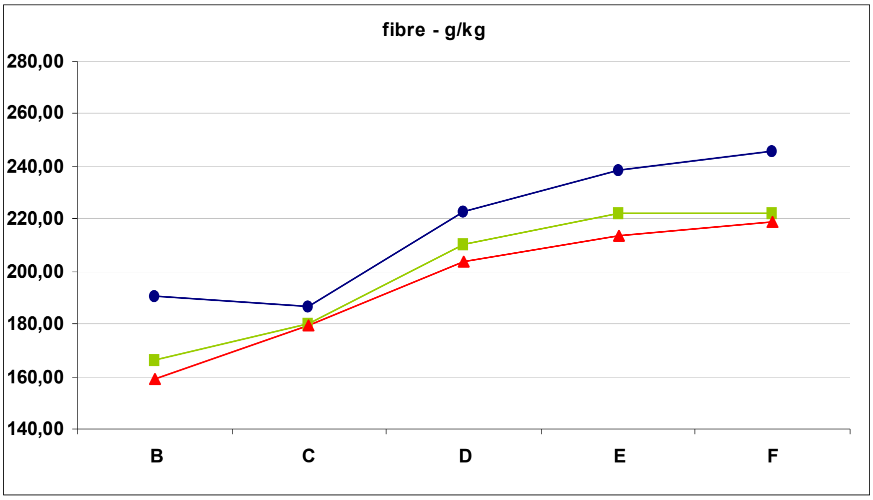
The low yields (by 2-3 t DM/ha, than maximum) obtained for all legume varieties in the first maturity stage (A) is not reported further. Maturity stages B, C, D for early and intermediate varieties were appropriate, maturity stage B for lucerne, diploid red clover and early variety Vesna of tetraploid red clover and stage C for lucerne, diploid red clover and intermediate tetraploid red clover and maturity stage D for intermediate tetraploid red clover for varieties: Amos, Beskyd, Dolina and Kvarta. Maturity stages E and F, respectively , middle late Bivoj and late Radegast were possible to harvest. The dry matter yield of tetraploid red clover and lucerne were higher than diploid red clover varieties (Tab.1).

Tab.1

| character | Yield of hay in tonnes per hectar | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | term | B | | | C | | | D | | | E | | |
| species | variety | 1994 | 1995 | prům | 1994 | 1995 | prům | 1994 | 1995 | prům | 1994 | 1995 | prům |
| M. sativa | Europe | 6,95 | 9,16* | 8,06 | 7,96 | 9,53 | 8,75 | 10,1 | 10,33* | 10,2 | 12,2 | 10,5 | 11,4 |
| | Zuzana | 7,04 | 9,67* | 8,36 | 9,17 | 9,04 | 9,11 | 9,26 | 7,96 | 8,61 | 13 | 8,77 | 10,9 |
| | | | | | | | | | | | | | |
| T. hybridum | Táborský | 5,67 | 8 | 6,84 | 7,17 | 7,7 | 7,44 | 7,87 | 6,56 | 7,22 | 8,18 | 6,32 | 7,25 |
| | | | | | | | | | | | | | |
| T. prat. 2n | Chlumecký | 7,33 | 7,04 | 7,19 | 8,11 | 7,7 | 7,91 | 9,54 | 7,36 | 8,45 | 11,6 | 6,98 | 9,28 |
| | Start | 8 | 7,05 | 7,53 | 9,16 | 7,94 | 8,55 | 10,2 | 7,87 | 9,06 | 12,8 | 9,42 | 11,1 |
| | Tábor | 6,96 | 8,32 | 7,64 | 8,71 | 8,53 | 8,62 | 9,98 | 8,4 | 9,19 | 12,3 | 8,61 | 10,4 |
| | | | | | | | | | | | | | |
| T. prat. 4n | Vesna | 7,72 | 7,52 | 7,62 | 9,64 | 8,41 | 9,03 | 10,6 | 8,23 | 9,39 | 12 | 10,4 | 11,2 |
| | Kvarta | 7,36 | 7,39 | 7,38 | 9,42 | 8,36 | 8,89 | 11,26* | 7,39 | 9,33 | 11,9 | 8,41 | 10,1 |
| | Beskyd | 8,13 | 8,18 | 8,16 | 10,13* | 9,06 | 9,6 | 10,7 | 9,36* | 10 | 12,3 | 9,12 | 10,7 |
| | Dolina | 8,11 | 7,92 | 8,02 | 10,14* | 8,8 | 9,47 | 11,33* | 8,29 | 9,81 | 12,1 | 9,07 | 10,6 |
| | Amos | 8,18 | 7,98 | 8,08 | 9,62 | 8,6 | 9,11 | 11,72* | 9,28* | 10,5 | 12,2 | 9,29 | 10,8 |
| | Taurus | 7,68 | 8,36 | 8,02 | 9,7 | 9,07 | 9,39 | 11,12* | 8,55 | 9,84 | 13,3 | 8,11 | 10,7 |
| | Radegast | 7,58 | 8,09 | 7,84 | 9,27 | 8,88 | 9,08 | 11 | 9,04* | 10 | 11,9 | 8,64 | 10,2 |

*) stat.significant diff.    standard

The average crude protein content in all varieties approached of 20% with CP yield reaching 1,5 t per hectare, NEL content ranged from 5,6 to 5,8 MJ per 1 kg of DM, ME 9,4 – 9,7 MJ. PDIE and PDIN contents were high (79 – 86 MJ). The maximum CP content (22%) was observed for alsike clover, but was low yielding. Lucerne yielded well for maturity stages B and C but the crude fibre content was greater than 22% after maturity stage D, (Fig.1), which agrees with previous data shown by VORLICEK(1985 and 1995), FOJTIK and JAKESOVA(1999) and LESAK and SVERAKOVA(1990).




alfalfa - varieties Zuzana a Europe

red clover 2n - varieties Start a Chlumecky

red clover4n - varieties Beskyd, Dolina a Amos

**Fig.1**

However, the WSC content in lucerne was low (Fig.2) for all of the maturity stages studied and confirms previous data shown by VORLICEK(1985). The tetraploid red clover varieties gave higher DM yield as well as WSC content from the early maturity stage C compared to all other legume species studied. The high yields obtained from tetraploid red clover varieties confirms previous work of VANEK, NEMECEK and TRAVNIK(1999) and VORLICEK(1985). Later maturity stages E and F harvested by the first half of June showed relatively little loss in quality ( CP 13-15%, WSC 5,7-6,9%, NEL 5,2 MJ, ME 8,9 MJ) , with exception of middle late and late tetraploid red clover Bivoj or Radegast, which showed lower CF content than 22%. The late maturity stages G and H were not evaluated in this trial as the swards were too old

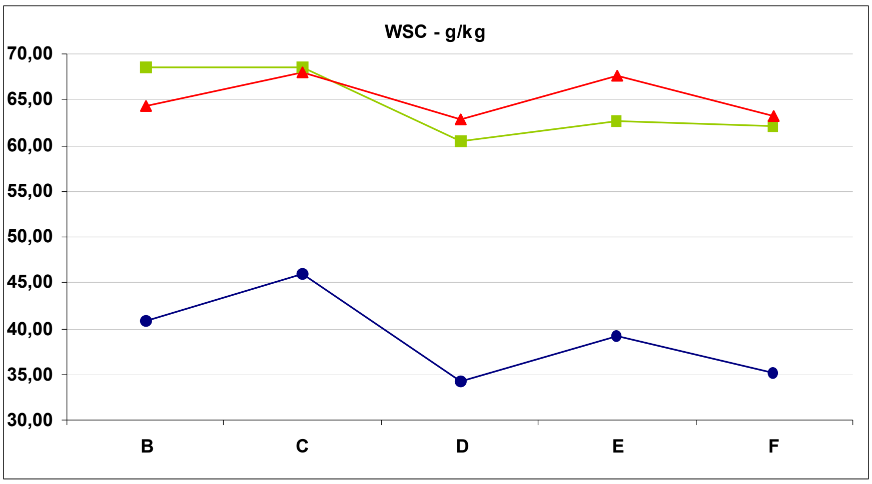



**Fig.2**

## Conclusions

Tetraploid red clover is extremely flexible crop and can be harvested from a range of maturity stages B,C,D,E and F). The quality of red clover compares well with lucerne in terms of yield of CP, NEL, ME, PDIE and PDIN but has higher levels of WSC content than lucerne.

Lucerne should be harvested earlier than tetraploid red clover. However the WSC content is low and may be a difficult crop to ensile without the use of silage additives. Lucerne showed high CF content after the maturity stage D.

It appears that diploid red clover varieties can be harvested in stages B and C but due to lower DM yield and higher DM content may be better suited for haymaking.

Alsike clover is of high quality particularly for CP content, in early stage also for WSC content. This crop matures much more slowly than other legumes studied. Main disadvantage of alsike is very low yield of DM.

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# Ensilage Capacity of Intergeneric Grass Hybrids and Their Simple Mixtures with Red Clover

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**Abstract**

The ensilage capacity of intergeneric grass hybrids (IGH) in simple mixtures with red clover (*Trifolium pratense* L.) and Italian ryegrass (*Lolium multiflorum*) cv. Jivet was investigated under laboratory conditions (n=4). The ratio of water-soluble carbohydrates (WSC) to crude protein (CP) was used to determine the coefficient of ensilage capacity (ECC). The highest ECC was recorded at the 1$^{st}$ cut, the differences between the cuts and the treatments were significant. For all 3 cuts, the highest ECC was found at *L. multiflorum* cv Jivet and the lowest one was recorded in the mixtures of IGH with *T. pratense* cv. Sigord. At the 1$^{st}$ cut, the high ECC did not result in good quality of fermentation, due to low dry matter (DM) content. At the 2$^{nd}$ and 3$^{rd}$ cuts, DM content increased and the fermentation was better. The data showed that DM content was a limiting factor at the 1$^{st}$ cut, despite the highest WSC content. High content of WSC and increased DM content at the other cuts were a prerequisite of optimum fermentation process. It is convenient to preserve IGH and their mixtures with polyploid red clover as wilted silage.

**Introduction**

Currently, simple mixtures of intergeneric grass hybrids (IGH) with red clover (*Trifolium pratense* L.) are of fundamental importance to leys grown in upland and mountain regions where cattle husbandry is considered to be a priority in Slovakia. It has been suggested that the content of water-soluble carbohydrates (WSC) is significantly higher in IGH than in herbage from semi-natural grassland and consequently their ensilage capacity is better (Žiláková and Knotek, 1997; Knotek et al., 1999). The same is true of polyploid red clover when compared with its diploid forms (Fojtík and Horák, 1991).

**Materials and methods**

Under laboratory conditions, intergeneric grass hybrids (IGH) Felina, Hykor, Perun, Lofa and Bečva in simple mixtures with polyploid *T. pratense* cvs. Sigord and Vesna were investigated. Herbage was harvested by 3 cuts at the fertilizer application level of N90, P30, and K 80 kg ha$^{-1}$, respectively. The content of water-soluble carbohydrates (WSC) was determined by the method of Luf-Shoorl and crude protein (CP) was specified in compliance with the Slovak technical standard STN 46 7093. The ratio of WSC to CP was used to determine the ensilage capacity. Chopped herbage was preserved without silage additives in 1-litre PVC jars (n=4). In the effluent leached from preserved herbage, the following parameters were analysed : pH (electrometric), the lactic, acetic and butyric acids (isotachophoresis-Agrofor), free $NH_3$ (acidimetric).

**Results and discussion**

At the 1$^{st}$ cut, low dry matter (DM) content was recorded in all IGH and in their mixtures with polyploid *T. pratense*. The differences between the treatments were significant. This low DM content ranked herbage as difficult to ensile either untreated or with chemical preservatives added (Knotek et al., 1999) despite the statistically highest coefficient of ensilage capacity (ECC) found at the 1$^{st}$ cut (0.59-1.40).The successful conservation and optimum fermentation require to enhance DM content by wilting (Fojtík and Horák, 1991; Fojtík, 1997). The content of physiological DM was significantly increasing with rising number of cuts what was reflected by improved fermentation and better quality of silage at all the treatments. The significantly highest WSC content was recorded at the 1$^{st}$ cut. The differences between the treatments were very significant. As shown by Tables 1 and 2, *L. multiflorum* cv Jivet as well as its simple mixtures with IGH Bečva and Lolita had significantly the higest WSC content and ECC (0.95 – 1.4). The highest DM content was also found in *L. multiflorum* cv. Jivet at the 1$^{st}$ cut and therefore the best fermentation was recorded. The lowest WSC content at the 1$^{st}$ cut was determined in the mixtures of IGH and *T. pratense* cv. Sigord.There were significant differences between the content of WSC and the cuts. The lowest WSC content was found at the 2nd cut, it increased at the 3rd cut but did not attain the level of the 1st cut. The significantly highest CP content was recorded at the 2nd cut what resulted also in the lowest ECC (Knotek et al., 1999). The content of DM was the most influential factor in the fermentation and final quality of silage. The higher ECC showed positive effects only at identical DM content. The quality was significantly the best in *L. multiflorum* cv. Jivet and in IGH Perun at all the 3 cuts.

## Conclusions

Ensilage capacity of IGH and their binary mixtures as well as the simple mixtures of IGH and polyploid red clover was assessed in a research experiment (Table 1). The ratio of WSC to CP was defined as ensilage capacity coefficient. It was concluded that high ECC was not sufficient for good fermentation if DM content was low (Table 2). At the 2nd and 3rd cuts, DM content increased and fermentation was better despite low coefficients of ensilage capacity. Consequently, these treatments should be preserved satisfactorily as wilted silage.

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**Table 1.** Ensilage capacity of intergeneric grass hybrids and their simple mixtures with *T. Pratense*

| Treatments | Fresh herbage DM ( $g.kg^{-1}$) | | | WSC ($g.kg^{-1}$ DM ) | | | CP ($g.kg^{-1}$ DM ) | | | ECC (WSC/CP) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cuts | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| Felina | 236.90 | 365.60 | 295.80 | 107.21 | 89.30 | 88.77 | 131.90 | 159.90 | 156.90 | 0.81 | 0.56 | 0.57 |
| Hykor | 232.90 | 358.30 | 311.90 | 103.52 | 97.73 | 104.96 | 133.10 | 157.30 | 152.50 | 0.78 | 0.62 | 0.69 |
| Perun | 242.30 | 370.12 | 310.11 | 106.20 | 101.50 | 99.01 | 145.20 | 155.70 | 162.50 | 0.73 | 0.65 | 0.61 |
| Lofa | 227.50 | 376.40 | 310.20 | 102.40 | 110.19 | 117.28 | 121.90 | 158.20 | 164.60 | 0.84 | 0.70 | 0.71 |
| Bečva | 231.52 | 348.99 | 323.72 | 114.61 | 90.36 | 101.60 | 128.10 | 162.30 | 168.40 | 0.89 | 0.56 | 0.60 |
| Jivet | 277.94 | 275.56 | 249.95 | 148.97 | 114.85 | 120.04 | 122.12 | 121.70 | 110.33 | 1.22 | 0.95 | 1.09 |
| Jivet + Lolita | 240.49 | 296.76 | 256.77 | 165.58 | 141.66 | 146.44 | 135.84 | 122.07 | 121.19 | 1.22 | 1.16 | 1.21 |
| Jivet + Bečva | 235.03 | 284.96 | 254.45 | 167.64 | 143.88 | 147.24 | 119.90 | 124.18 | 122.36 | 1.40 | 1.16 | 1.20 |
| Felina +Sigord | 208.60 | 331.80 | 298.09 | 76.69 | 82.58 | 83.87 | 129.10 | 148.90 | 152.80 | 0.59 | 0.55 | 0.55 |
| Hykor + Sigord | 207.10 | 326.14 | 300.74 | 87.17 | 89.10 | 83.79 | 119.80 | 148.90 | 144.00 | 0.73 | 0.60 | 0.58 |
| Perun + Sigord | 200.00 | 340.10 | 295.30 | 88.33 | 82.18 | 100.91 | 115.20 | 167.20 | 163.60 | 0.77 | 0.49 | 0.62 |
| Lofa + Sigord | 204.20 | 331.70 | 303.62 | 87.12 | 89.02 | 111.29 | 119.80 | 165.80 | 163.00 | 0.73 | 0.54 | 0.68 |
| Bečva + Vesna | 182.70 | 247.60 | 240.20 | 102.00 | 86.70 | 87.40 | 137.20 | 168.00 | 176.90 | 0.75 | 0.53 | 0.50 |
| Perun + Vesna | 211.30 | 236.40 | 240.60 | 102.40 | 87.80 | 104.00 | 149.70 | 181.90 | 167.50 | 0.68 | 0.49 | 0.62 |
| Felina + Vesna | 201.50 | 240.00 | 245.60 | 107.20 | 73.50 | 106.30 | 134.80 | 185.10 | 171.80 | 0.80 | 0.40 | 0.62 |
| Hykor + Vesna | 207.50 | 243.10 | 244.70 | 106.70 | 88.40 | 115.70 | 136.30 | 181.70 | 172.30 | 0.78 | 0.49 | 0.67 |
| Treatments (Tukey $P < 0.05$) | ++ | | | ++ | | | ++ | | | ++ | | |
| Cuts (Tukey $P < 0.05$) | ++ | | | ++ | | | ++ | | | ++ | | |

**2** Fermentation process indicators

| Cuts | Treatments | Organic acids ( g.kg $^{-1}$ DM ) | | | | pH | N -NH$_3$ | Quality |
|---|---|---|---|---|---|---|---|---|
| | | lactic | acetic | butyric | total | | | |
| 1$^{st}$ | Felina | 24.23 | 21.12 | 12.60 | 57.95 | 4.87 | 15.61 | III |
| | Hykor | 20.37 | 20.12 | 0 | 40.49 | 4.79 | 13.13 | II |
| | Perun | 31.35 | 22.99 | 0 | 54.34 | 5.14 | 9.26 | II |
| | Lofa | 19.97 | 9.75 | 5.18 | 34.90 | 4.94 | 15.80 | III |
| | Bečva | 25.51 | 25.60 | 9.18 | 60.29 | 5.13 | 14.99 | III |
| | Jivet | 41.25 | 19.73 | 0 | 60.97 | 4.52 | 13.46 | I |
| | Jivet + Lolita | 34.14 | 20.03 | 0 | 54.17 | 4.14 | 6.04 | II |
| | Jivet + Bečva | 39.06 | 22.52 | 0 | 61.57 | 4.09 | 7.15 | II |
| | Felina +Sigord | 9.19 | 24.05 | 0 | 33.24 | 5.00 | 21.93 | III |
| | Hykor + Sigord | 6.29 | 26.85 | 0 | 33.14 | 5.01 | 23.69 | V |
| | Perun + Sigord | 12.61 | 8.52 | 0 | 21.13 | 4.75 | 10.22 | V |
| | Lofa + Sigord | 13.96 | 15.67 | 4.87 | 34.49 | 5.21 | 21.86 | V |
| | Bečva + Vesna | 32.53 | 33.68 | 12.50 | 78.71 | 4.21 | 9.26 | IV |
| | Perun + Vesna | 10.71 | 31.89 | 0 | 42.60 | 4.72 | 15.83 | III |
| | Felina + Vesna | 11.30 | 25.50 | 0 | 36.80 | 4.23 | 18.81 | III |
| | Hykor + Vesna | 32.26 | 15.91 | 13.38 | 61.55 | 4.52 | 8.32 | III |
| 2$^{st}$ | Felina | 13.84 | 5.00 | 0 | 18.84 | 4.99 | 7.19 | I |
| | Hykor | 18.41 | 10.97 | 0 | 29.38 | 4.77 | 6.40 | II |
| | Perun | 20.35 | 9.89 | 0 | 30.24 | 4.58 | 6.40 | I |
| | Lofa | 30.05 | 18.84 | 0 | 48.89 | 4.37 | 7.98 | II |
| | Bečva | 37.08 | 12.90 | 0 | 49.98 | 4.31 | 7.37 | I |
| | Jivet | 41.14 | 17.16 | 0 | 58.30 | 4.04 | 5.82 | I |
| | Jivet + Lolita | 37.91 | 18.89 | 0 | 56.80 | 4.90 | 9.94 | II |
| | Jivet + Bečva | 29.90 | 13.98 | 0 | 40.89 | 4.81 | 9.90 | I |
| | Felina +Sigord | 14.39 | 8.43 | 0 | 22.82 | 5.08 | 8.00 | II |
| | Hykor + Sigord | 17.59 | 11.65 | 0 | 29.24 | 5.18 | 6.86 | II |
| | Perun + Sigord | 30.94 | 14.20 | 0 | 45.14 | 4.49 | 6.06 | I |
| | Lofa + Sigord | 21.07 | 10.89 | 0 | 31.96 | 4.88 | 10.38 | II |
| | Bečva + Vesna | 39.70 | 23.05 | 0 | 62.75 | 4.96 | 9.30 | II |
| | Perun + Vesna | 23.99 | 18.40 | 0 | 42.39 | 4.95 | 11.75 | II |
| | Felina + Vesna | 40.21 | 23.97 | 0 | 64.18 | 4.72 | 14.06 | II |
| | Hykor + Vesna | 47.29 | 18.41 | 0 | 65.70 | 4.66 | 11.56 | I |
| 3$^{st}$ | Felina | 31.89 | 16.32 | 0 | 48.21 | 5.21 | 6.30 | I |
| | Hykor | 34.59 | 12.50 | 0 | 47.09 | 4.95 | 7.90 | I |
| | Perun | 21.38 | 6.21 | 0 | 27.58 | 4.63 | 8.36 | I |
| | Lofa | 22.79 | 14.81 | 0 | 37.60 | 4.77 | 7.96 | II |
| | Bečva | 27.07 | 14.44 | 0 | 41.51 | 4.51 | 9.08 | II |
| | Jivet | 42.81 | 14.27 | 0 | 57.08 | 4.65 | 6.86 | I |
| | Jivet + Lolita | 49.70 | 19.95 | 0 | 69.65 | 4.21 | 6.16 | I |
| | Jivet + Bečva | 53.87 | 24.11 | 0 | 77.98 | 4.32 | 7.15 | I |
| | Felina +Sigord | 25.66 | 20.76 | 0 | 46.42 | 5.01 | 13.10 | II |
| | Hykor + Sigord | 15.80 | 10.23 | 0 | 26.03 | 5.28 | 10.76 | II |
| | Perun + Sigord | 23.42 | 14.70 | 0 | 38.12 | 4.40 | 7.62 | II |
| | Lofa + Sigord | 36.03 | 13.23 | 0 | 49.26 | 4.34 | 9.91 | I |
| | Bečva + Vesna | 70.20 | 22.00 | 0 | 92.20 | 4.57 | 6.67 | I |
| | Perun + Vesna | 64.15 | 28.10 | 0 | 92.25 | 4.54 | 6.77 | II |
| | Felina + Vesna | 41.90 | 17.67 | 0 | 59.57 | 4.71 | 7.72 | II |
| | Hykor + Vesna | 58.87 | 21.82 | 0 | 80.69 | 4.55 | 7.76 | II |
| Cuts ( Tukey $P < 0.05$ ) | | ++ | ++ | ++ | ++ | – – | ++ | ++ |
| Treatments ( Tukey $P < 0.05$ ) | | ++ | ++ | + | ++ | ++ | ++ | ++ |

# Effect of Lucerne Variety and Orchardgrass Share in Mixture on Yield and Forage Quality

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## Abstract

In field experiments the effect of lucerne variety and orchardgrass share in mixture seed rate on forage dry matter yield in the second vegetation year have been investigated. Except for the forage yield at the first harvest this year, the contents of crude protein, fibre and nitrogen free extract substances (NFES) in lucerne plants dry matter and orchargrass were found as well. The highest forage yields have been achieved on average in the variants of Regia variety. Orchardgrass share in mixture seed rate acted in different way, in average of the first harvest the lucerne monocultures had lower yields than mixtures, in the second vegetation year on the contrary, the lucerne monocultures and mixtures with orchardgrass share of 10% were more productive than ones with share of 45%. The crude protein, fibre and NFES in orchardgrass plants from first harvest and both fibre and NFES in lucerne plants have been affected by the mixture´s orchardgrass share, however the lucerne varieties affected only the fibre content in lucerne plants as well.

## Introduction

The clover - grass mixtures represent ecologically and agronomically effective way of biological nitrogen usage. However the success depends on proper component choice, proper usage and in the case of lucerne- grass mixtures especially on choice of appropriate lucerne variety.

## Materials and methods

In years 1994- 96 the field experiments were established on loamy luvic chernozem, 167 m above sea level 48°34´ N.W. and 17°45´ E.L. Experiments site has yearly long-term average temperature of 9,2°C and 593 mm of precipitation. The aim was to compare the effect of the Regia, Palava, Vali and Vanda lucerne varieties monocultures with their mixtures with three orchardgrass shares in seed rate 10-20 and 45% on first harvest yields and together in the second vegetation year. Sixteen variants were randomised in four replications. In the first harvest, the crude protein, fibre and NFES contents at lucerne and orchardgrass plants separately as well as were found. Both, the monocultures and mixtures were undersown in legume- cereal mixture (oat + field pea). Fertilization in to nurse crop with $N_{40}P_{20}K_{80}$, under trial variants only P and K according to their soil reserve level. The nurse crop was harvested at milk ripeness stage, trial variants: first harvest at the early budding the lucerne, the second and the third one in 36-38 and the fourth in 45-49 days respectively. The yields and nutrition contents obtained have been processed by variation analysis and evaluated with Tukey test.

## Results

The Regia variety had on average in the first harvest higher yield than Palava and Vanda varieties, however, in average the second of the year it surpassed all the other varieties (tab.1). The orchardgrass share caused no difference in the first harvest only on Vali yields variety, the differences among the varieties were only on of level 45% orchardgrass share. In the second vegetation year´s average the lucerne monocultures and mixtures with orchardgrass share of 10% had higher yields than the ones with 45% share. Mixture contained Regia variety had the highest yields, on the contrary this variety had the lowest yields among monocultures. Orchardgrass share in mixture had no effect on the Palava variety yield, the Vali and Vanda varieties in monoculture were better than in mixtures, conversely, the Regia variety had the lowest yield in monoculture. The orchardgrass share in mixture and lucerne varieties did no affect the lucerne plants crude protein (tab.2). Orchardgrass from the mixture with its share 10% had higher crude protein content than from the monoculture or the other mixtures. The Regia variety had in average less fibre than Palava, the lucerne from monocultures had more fibre than ones from mixtures. Orchardgrass from mixture with its 20% share had more fibre than in monoculture. The lucerne from mixtures had more NFES than from monocultures, conversely the orchardgrass originating from the monoculture had higher content of NFES than the ones from the mixtures.

## Conclusions

The orchardgrass share in mixture seed rate caused differences in the yields of tested lucerne varieties. Regia had the highest yield in mixtures and the lowest one in monoculture. The Orchardgrass share had no influence on the Palava variety yield, however it affected the Vali and Vanda yields negatively, both the varieties were the most productive in monoculture. From the viewpoint of the first harvest forage quality, the orchardgrass share decreased the fibre and increased NFES in lucerne plants. In orchardgrass plants its share in mixture decreased crude protein and increased NFES, on the contrary, the fibre was the highest at 20% share of the orchardgrass in mixture.

Table 1 Dry matter forage yields of lucerne-grass mixtures in dependence on portion of orchardgrass at seed rate of mixture $t.ha^{-1}$ (average three years).

| Lucerne variety | First harvest second year of vegetation | | | | | Second year of vegetation together | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Orchardgrass portion % | | | | | | | | | |
| | 0 | 10 | 20 | 45 | average | 0 | 10 | 20 | 45 | average |
| Regia | 4,23 | 5,76 | 5,59 | 5,78 | 5,34 | 11,84 | 15,36 | 14,05 | 13,77 | 13,75 |
| Palava | 4,44 | 5,46 | 5,02 | 5,37 | 5,08 | 12,86 | 13,56 | 11,96 | 11,75 | 12,54 |
| Vali | 4,81 | 5,10 | 5,48 | 5,03 | 5,11 | 14,13 | 11,86 | 12,65 | 11,91 | 12,64 |
| Vanda | 4,54 | 5,27 | 5,15 | 4,96 | 4,98 | 14,00 | 13,02 | 12,73 | 11,52 | 12,82 |
| Average | 4,51 | 5,40 | 5,31 | 5,29 | 5,18 | 13,20 | 13,45 | 12,85 | 12,24 | 12,94 |
| LSD at level p 0,05 | varieties. | | | 0,26 | | | | | | 0,77 |
| | orchardgrass portion: | | | 0,26 | | | | | | 0,77 |
| | interaction: | | | 0,69 | | | | | | 2,04 |

Table 2: Crude protein, fibre and nitrogen-free extract substances dry matter content of lucerne and orchardgrass plants in dependence on the portion of orchardgrass at seed rate of mixture average from three years of first harvest of second year of stand vegetation ($g.kg^{-1}$ dry matter).

| Indicator | Variety | Orchardgrass portion % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 45 | average | 10 | 20 | 45 | 100 | average |
| | | Lucerne plants | | | | | Orchardgrass plants | | | | |
| Crude protein | Regia | 223,50 | 215,40 | 218,40 | 211,80 | 216,90 | 134,60 | 108,80 | 117,90 | 107,00 | 117 10 |
| | Palava | 212,20 | 206,50 | 204,00 | 204,90 | 207,50 | 125,20 | 116,90 | 117,90 | 107,00 | 116,70 |
| | Vali | 210,20 | 216,70 | 207 10 | 210,80 | 211,60 | 127,00 | 111,10 | 108,30 | 107,00 | 113,30 |
| | Vanda | 218,20 | 203,10 | 216,70 | 205,50 | 211,10 | 121 10 | 106,70 | 104,00 | 107,00 | 109,70 |
| | Average | 215,60 | 211,60 | 211,60 | 208,30 | 211,80 | 127,00 | 110,90 | 112,00 | 107,00 | 114,20 |
| Fibre | Regia | 262,20 | 245,60 | 254,10 | 247 10 | 252,90 | 310,20 | 343,70 | 323,00 | 314,40 | 323,30 |
| | Palava | 294,30 | 268,30 | 266,60 | 262,90 | 270,80 | 328,10 | 332,40 | 335,70 | 314,40 | 327,60 |
| | Vali | 289,60 | 256,60 | 275,80 | 252,70 | 268,70 | 317,90 | 332,70 | 325,00 | 314,40 | 322,50 |
| | Vanda | 287,30 | 251,40 | 256,60 | 277,40 | 268,20 | 323,70 | 330,20 | 318,40 | 314,40 | 321,70 |
| | Average | 283,70 | 255,50 | 262,30 | 260,00 | 265,20 | 320,50 | 334,70 | 325,50 | 314,40 | 323,80 |
| Nitrogen free extract substances | Regia | 360,30 | 378,90 | 375,20 | 392,50 | 378,80 | 422,10 | 422,70 | 433,20 | 454,30 | 433,00 |
| | Palava | 359,10 | 380,10 | 382,70 | 388,10 | 377,00 | 414,70 | 421,50 | 415,10 | 454,30 | 426,40 |
| | Vali | 361 10 | 378,70 | 373,80 | 385,60 | 375,20 | 426,90 | 426,50 | 437,50 | 454,30 | 436,40 |
| | Vanda | 347,50 | 395,50 | 379,80 | 382,70 | 376,20 | 428,10 | 436,80 | 444,90 | 454,30 | 441 10 |
| | Average | 358,60 | 383,30 | 377,80 | 387,20 | 376,80 | 423,00 | 427,00 | 432,70 | 454,30 | 434,20 |
| LSD at level p 0,05 | Crude protein | N s. | | | | | orchardgrass portion 9,80 | | | | |
| | Fibre | lucerne varieties 16,30<br>orchardgrass portion 16,30 | | | | | orchardgrass portion 11,80 | | | | |
| | Nitrogen free extract substances | orchardgrass portion 11,60 | | | | | orchardgrass portion 15,00 | | | | |

# The use of legumes in Slovakia

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**Summary**

Cultivation of legumes in Slovakia is strongly influenced by the steadily decreasing numbers of farm animals, mainly cattle. In the last decade the area under alfalfa and red clover decreased by 42 and 56%, respectively. Alfalfa silages are usually of a very good quality but the quality of clover silages is often influenced by the unfavourable climatic conditions at harvest time.

**Introduction**

The current tendency to decrease the inputs and increase the effectivity of management has lead to an increased interest in legumes throughout Europe. Wilkins et al. (1998) pointed out that one part of the EU funds was intended for research into the possibilities of using clover. In addition to positive impacts on the environment an increase of the area under this crops in the northern countries of the EU could save as much as 4,000 million EURO.

Recently, the situation in growing legumes in Slovakia has been strongly influenced by the steadily decreasing number of farm animals, mainly cattle. The fodder base of polygastric animals is made of grass crops (75% of the area under feed crops), maize (11%) and legumes (9.5%). Alfalfa and red clover present 21.94 and 4.64% of the crops grown on arable land, respectively (Fig. 1). Alfalfa is mainly grown in the lowlands of southern Slovakia, red clover in the northern parts of the country.

**Materials and Methods**

The basic parameters characterizing the level of legumes cultivation on the territory of Slovakia were obtained from the Yearly statistics of the Ministry of Agriculture of the Slovak Republic and of the Central Institute of Control and Testing in Agriculture. The characteristics of the silages produced were processed on the basis of the data recorded in the three largest laboratories that provide services to agricultural enterprises. In our evaluation the results of the analysis of 184 samples of alfalfa and clover silages produced from the harvest 2000 were included. The samples were analyzed according to the valid Slovak technical standard (STN).

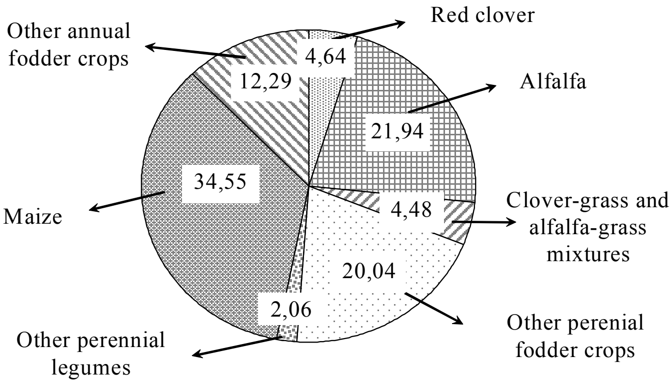
**Results and Discussion**

From the long-term view the area of land under alfalfa and red clover has substantially changed in favour of alfalfa crops (Table 1). Besides the real decrease in the area under both crops a relative increase in land under alfalfa and a constant level of land under clover was observed in the last decade when calculated per head of cattle. For a long time the yield of both crops has been balanced, reaching 7.3 and 6.2 t of dry matter per hectar alfalfa and clover, respectively. As to crop varieties, the situation is rather good: 5 national and 10 foreign varieties of alfalfa (Czech Republic, France, USA) and 6 national and 15 foreign varieties of red clover (Czech Republic) are permitted .

In Tables 2 – 5 the qualitative parameters of alfalfa and clover silages are given. In as much as 68% of the alfalfa silages the levels of dry matter surpassed 35% whereas 56% of the red clover silages contained more than 30% of dry matter. Based on the vegetation stage assessed from the crude fibre contents (Table 3) it can be stated that most silages were harvested at the time of budding up to flowerage. In as much as 70.5% of silages the levels of butyric acid were lower than 1 $g.kg^{-1}$ DM and as much as 92.4 % of the alfalfa silages contained less than 8 % $NH_3$-N of total N. In red clover silages the respective results of the fermentation process were not as good as in alfalfa silages. For fermentation different additives, in most cases biological ones, are added to both crops. Due to the insufficient offer on the market the use of chemical additives is very low.

As can be seen from the overview, alfalfa silages reveal a rather good quality. Pahlow et al. (2000) evaluated the fermentation capacity of different legumes and observed the risk of butyric acid production in non-treated silages made from legumes to decrease proportionately with the increase of dry matter content from 25% onwards. Our follow up revealed similar effects. The decreased parameters of the fermentation process of red clover are not contradictory to the findings of Pahlow et al. (2000) according to whom fermentation of this crops is easier than that of alfalfa, however, they are influenced by the fact that in Slovakia red clover is grown in higher altitudes under pronouncedly unfavourable climatic conditions which often complicate the process of withering and thus also the fermentation parameters of the silages produced.

**Figure 1.** The structure of the fodder base on arable land 2000




## Conclusion

In the last decade, cutlivation of alfalfa and red clover had a decreasing tendency in Slovakia. Both for environmental as well as economic reasons this development needs to be turned off. The alfalfa silages produced reveal a good quality. Caused by the conditions of clover cultivation the quality of clover silages is somewhat decreased.

## References

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**Table 1.** Development of area under alfalfa and red clover in Slovakia

| | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|
| Arable land (ha) | 1 761 000 | 1 683 000 | 1 516 000 | 1 509 000 | 1 457 000 |
| Alfalfa (ha) | 65 970 | 135 623 | 93 244 | 110 002 | 63 714 |
| % of arable land under alfalfa | 3,75 | 8,06 | 6,15 | 7,29 | 4,37 |
| Alfalfa harvested ($t.ha^{-1}$) | 5,51 | 6,76 | 8,77 | 7,43 | 7,32 |
| Hectares of alfalfa per head of cattle | 0,050 | 0,106 | 0,063 | 0,068 | 0,103 |
| Red clover (ha) | 129 984 | 95 530 | 38 683 | 31 015 | 13 461 |
| % of arable land under red clover | 7,38 | 5,68 | 2,55 | 2,06 | 0,92 |
| Red clover harvested ($t.ha^{-1}$) | 5,04 | 5,99 | 8,59 | 5,21 | 6,15 |
| Hectares of red clover per head of cattle | 0,099 | 0,074 | 0,026 | 0,019 | 0,022 |

**Table 2.** Percentage of silages according to dry matter content

| Silage n = 184 | Dry matter in g | | | | | | |
|---|---|---|---|---|---|---|---|
| | < 200 | 200-250 | 250-300 | 300-350 | 350-400 | 400-450 | >450 |
| Alfalfa | 0,7 | 4,0 | 13,3 | 14,0 | 26,0 | 30,0 | 12,0 |
| Clover | 3,1 | 0 | 40,6 | 15,6 | 31,3 | 9,4 | - |

**Table 3.** Percentage of silages according to crude fibre content

| Silage n = 184 | Crude fibre in $g.kg^{-1}$ DM | | | | |
|---|---|---|---|---|---|
| | < 180 | 180-220 | 220-260 | 260-300 | > 300 |
| Alfalfa | 0 | 0 | 13,2 | 36,1 | 50,7 |
| Clover | 0 | 0 | 32,4 | 47,1 | 25,2 |

**Table 4.** Percentage of silages according to butyric acid levels (harvest 2000)

| Silage n = 184 | Content acid butyric in $g.kg^{-1}$ DM | | | |
|---|---|---|---|---|
| | < 1 | 1 - 3 | 3 - 5 | > 5 |
| Alfalfa | 73,5 | 9,8 | 6,1 | 10,6 |
| Clover | 30,0 | 20,0 | 20,0 | 30,0 |

**Table 5.** Percentage of silages according to $NH_3$-N levels (harvest 2000)

| Silage n = 184 | Content $NH_3$-N of total N in $g.kg^{-1}$ DM | | | |
|---|---|---|---|---|
| | < 8 | 8 - 12 | 12 - 16 | > 16 |
| Alfalfa | 92,4 | 4,5 | - | 3,1 |
| Clover | 20 | 50 | 20 | 10 |

# The Fibre Spectrum Changes in During Ensiling of Dactylis Glomerata, Dactylic Aschersoniana and Bromus Cantharticus

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## Abstract

We have observed the fibre spectrum changes in during of ensiling of three kinds of grasses - Dactylis glomerata - variety - Ambasador, Dactylic aschersoniana - variety Tosca and Bromus cantharticus - variety Tacit. We have analysed dry mater, crude fibre, NDF and ADF in original matters and in ensilages. The content of NDF is 50 - 67 %, ADF is 25 - 35 % a share of ADF of NDF is about 50 - 60 %. The contents of single part of fibre are dependent on kind of grass, variety, vegetation stage and cutting order of grasses. The changes of fibre spectrum in during ensiling are only a little.

## Introduction

The fibre spectrum is composed of cellulose, hemicellulose and lignin and it is important nutriment part of forge plants. The fibre content and its composition is necessary for rewiewing of feed nutrition value, evaluation of feed quality and for modification and drawing up a new nutriment norms.

The fibre is not only nutriment. It is important factor for right activity of gastrointestine organ mainly for a large intestine. Long-term fibre deficit create of vessel system disorders and diabetes too.
The fibre is very important in ruminant nutrition. The part of fibre spectrum is digested in gizzards and in the large intestine with help of microorganisms. The importance of fibre is lower in non-ruminant nutrition. The digestibility of fibre is low at pigs and poultry. The fibre is necessary for health life and production. A surplus of fibre is not desirable in feed ration. The fibre surplus is cause of worse use of nutriments and weight the digestive organ. The content of fibre must be optimum in the feed rations.

They are bred highproduction dairy cows and bulls and pigs with high daily weight gains in this time. It is necessary to know very detailed fibre and its evaluation. A division of crude fibre for single fiber types - neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin is one of ways. This division of crude fibre makes possible exactly find out shares of single fibre types and analyse whole fibre spectrum. These analyse methods of fibre spectrum (NDF, ADF) are exacter than classic method Henneberg - Stohmann.

Our aim was observe shares of single fibre types - neutral detergent fibre (NDF) and acid detergent fibre (ADF) in Dactylis glomerata - variety Ambasador, Dactylic aschersoniana - variety Tosca and Bromus cantharticus - variety Tacit. Analyse values were compared with values of NDF and ADF from Dactylis glomerata - variety Ambasador ensilage, Dactylic aschersoniana - variety Tosca ensilage and Bromus cantharticus - variety Tacit ensilage. We have wanted find out the changes of fibre spectrum in during ensiling.

We can divide fibre spectrum to three basic parts - light digestible fibre (neutral detergent fibre -NDF), hard digestible fibre (acid detergent fibre - ADF) and indigestible fibre (acid detergent lignin). Neutral detergent fibre is rest of cell walls of plant tissue that was insulate after hydrolysis in neutral solution. Residue is cellulose, hemicellulose and lignin. Acid detergent fibre is rest of cell walls of plant tissue that was insulate after hydrolysis in acid solution. Residue after eliminate hemicelluloses is lignocellulase complex (Kacerovský et al.,1990).

## Materials and Methods

We have analysed NDF and ADF at samples of three grass kinds - Dactylis glomerata - variety Ambasador, Dactylic aschersoniana - variety Tosca and Bromus cantharticus - variety Tacit. We have analysed original stuffs and ensilages from the same stuffs. There are vegetation stages in harvest time and cut order in table 1.

**Table 1.** Kind and varity of grass plants - vegetation stages in harvest time and cut order

| kind and varity of grass | cut order and vegetation stages |
|---|---|
| 1A Bromus cantharticus -Tacit | sterile, height 20 cm, I$^{st}$ cut order |
| 1B Bromus cantharticus -Tacit | green maturity, height 45 cm, II$^{nd}$ cut order |
| 1C Bromus cantharticus - Tacit | straw |
| 2 Dactylic aschersoniana - Tosca | from stooling to start of flower, IV$^{th}$ cut order |
| 3 Dactylis glomerata - Ambassador | II$^{nd}$ cut order, height 15 cm |
| Dactylis glomerata - Ambassador | III$^{rd}$, from stooling to start of flower |
| Dactylis glomerata - Ambassador | IV$^{th}$ cut order, height 15 cm |

We cooperated with Plant Breeding Station Tagro Červený Dvůr. The grass plants were ensilaged in laboratory conditions. We have analysed dry matter, crude fibre, ADF and NDF. ADF and NDF have been analysed by method Kacerovský et al. (1990) Zkoušení a posuzování krmiv. Crude fibre, ADF and NDF have been analysed at apparatus Fibertec. We have analysed original stuffs and ensilages from the same stuffs. The values from original stuffs have been compared with the values from ensilages. We have wanted find out the changes of fibre spectrum in during ensiling.

## Results and discusion

We observed shares of single fibre types - neutral detergent fibre (NDF) and acid detergent fibre (ADF) in three kinds of grass plants Dactylis glomerata - variety Ambasador, Dactylic aschersoniana - variety Tosca and Bromus cantharticus - variety Tacit. Analyse values were compared with values of NDF and ADF from ensilages. The ensilages were produced from the same forage plant quality as original material. We have tested the changes in share of single fibre types during ensiling.

The carbohydrate spectrum has been evaluated at Bromus cantharticus - variety Tacit. Bromus cantharticus was observed in three cuttings. The first-cut Bromus cantharticus was harvested in stage sterile with content of NDF 56,46 % and ADF 30,62 % in 100 % dry matter. The share of ADF from NDF was 54,23 %. The second - cut was harvested in stage green maturity with content of NDF 62,65 % and ADF 34,81 % in 100 % dry matter. The share of ADF from NDF was 55,56 %. Bromus cantharticus straw - the share of ADF from NDF was 58,76 %. An index of content change of ADF and NDF in original material and ensilage is since 0,94 till 1,07. We have not fond out significant changes of ADF and NDF during ensiling.

The carbohydrate spectrum has been evaluated at Dactylic aschersoniana - variety Tosca. The fourth - cut Dactylic aschersoniana was harvested in stage from stooling to start of flower with content of NDF 59,16 % and ADF 28,34 % in 100 % dry matter. The share of ADF from NDF was 47,91 % in original material and 58,72 % in ensilage. An index of content change of NDF in original material and ensilage is 1,11 and ADF 0,91. The content of NDF is lower in ensilage about 6 % and the content of ADF is higher in ensilage about 3 %. We have fond out only low changes of ADF and NDF during ensiling.

Dactylis glomerata - variety Ambasador was observed at second, third and fourth cut. The content of NDF was 65,22 – 67.13 %, at IV$^{th}$ cut 41,38 %. The content of ADF was 34,00 % and at IV$^{th}$ cut 26,53 %. The share of ADF from NDF was 50 - 53 % in original material at second and third cut and 64,11 % at fourth cut. We have not fond out significant changes of ADF and NDF during ensiling. Jarrige (1989) write about 28.8 % ADF in 100 % dry matter.

The content of NDF is 50 – 67 % and the content of ADF is 25 - 35 % in grass plants. It is dependent on kind, variety, plant age and cut order. The share of ADF from NDF was 50 - 53 % in grass plant. We have not fond out significat changes of ADF and NDF during grass plant ensiling.

Lutonská et al. (1983) write content of ADF 33.93 % - 44.80 % in meadow hay. Jarrige (1989) write content ADF 34.80 % až 36.6 % in meadows and pastures. The content of ADF in meadow and pasture ensilages is 34.5 % - 35.4 %. The values of NDF and ADF are important for composition of feed rations in cattle nutrition. Chandler (1993) recommends feed ration with 28 % NDF and 21 % ADF for dairy cows at the start of lactation. National Research Council (1989) recommends 25-28 % NDF and 19 - 21 % ADF for dairy cows in the lactation.

## Conclusions

We have observed the fibre spectrum changes in during of ensiling of three kinds of grasses - Dactylis glomerata - variety - Ambasador, Dactylic aschersoniana - variety Tosca and Bromus cantharticus - variety Tacit. We have analysed dry mater, crude fibre, NDF and ADF in the original matters and in the ensilages. The content of NDF is 50 - 67 %, ADF is 25 - 35 % a share of ADF of NDF is about 50 - 60 %. The contents of single part of fibre are dependent on kind of grass, variety, vegetation stage and cutting order of grasses. The changes of fibre spectrum in during ensiling are only a little.

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This scientific paper made with help of grant CEZ: J 06/98: 122200002/5

# Differences between two Varieties of Alfalfa

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## Abstract

Alfalfa (Medicago sativa L.) is known as a very good source of protein for animals but a bad medium for the silage fermentation. The aim of our research was to compare two varieties of alfalfa from the nutrition point of view. Two varieties (Morava and Palava) of alfalfa (Medicago sativa L.) were grown on research area fields (each about 10 ha) near Prague Uhrineves. During the first production year (the year 2000) in every cuts the samples were collected and analysed at two dates (about a week before and at the harvesting time). Four cuttings were done. The ratio of leaf from the whole plant at the time of harvesting varied between 41.5 and 58.3 %. Alfalfa var. Morava had a higher content of protein and PDI in the third and the fourth cut, var. Palava had a higher content of protein and PDI in the first cut. The total of DM yield was 12.6 tonnes per hectare in var. Morava, and 11.4 tonnes per hectare in var. Palava. When compared alfalfa var. Palava vs. var. Morava, the total yield DM, protein and NEL was 9 %, 11 %, 6.8 % lower, resp. in Palava than in Morava variety.

## Introduction

Alfalfa is a very important source of protein for cattle and other livestock. But the higher content of protein is not so good for ensilagebility (McAllister at al., 1994). That is why researchers try to find the best variety of alfalfa for growing, ensilaging and feeding for animals. Krochko and Bewley (2000) tested (seed storage proteins were analysed) 27 varieties of alfalfa (Medicago sativa L.); these included five subspecies (glomerata, caerulea, falcata, hemicycla, praefalcafa). The consistent similarities in qualitative and quantitative expression of seed storage proteins amongst all of these taxa suggest a high degree of uniformity in both seed physiology and genetics within the alfalfa species complex. Two sets of alfalfa genetic resources were evaluated in 1993 to 1995 by Drobna (1997). 12 varieties from the whole world were included in each of these sets. Variety Palava was used as the control variety. In each variety the following economic parameters were evaluated: plant height and weight, stem number, regrowth rate after the cut, seed weight. Var. Palava was the best in the seed yield also in this set. On the basis of the results achieved from evaluations of foreign alfalfa varieties in our conditions it is possible to provide breeders with the best materials for production of new varieties with higher productivity and quality. In the Czech Republic in the year 2000 about 9 varieties of alfalfa were used. The aim of our research was to compare two varieties of alfalfa from the nutrition point of view.

## Materials and methods

Two varieties (Morava and Palava) of alfalfa (Medicago sativa L.) were grown on research area fields (each about 10 ha) near Prague Uhrineves. During the first production year (the year 2000) in every cuts the samples were collected and analysed at two dates (about a week before and at the harvesting time). Yields in all cuts were recorded during the whole year. The yield of green matter was measured using the demarcation border of one square metre six times by random access. The ratio of leaf from the whole plant was measured using a separation of leaf by hand. Both alfalfa varieties were ensiled in special plastic bags air free (Inst. Chem. Technol, Prague), at two DM contents each. This, however, will be published elsewhere. The samples of green matter were analysed using Weendese methods in the laboratory of the Res. Inst. of Animal Production in Prague.

## Results and discussion

In the table 1 we can see the analyses of two varieties of alfalfa cutted about a week before a real harvesting time. The content of protein was very high, varied from 205 to 258 g/kd DM in var. Morava, resp. 204 to 246 g/kg DM in var. Palava. But the high content of protein also predicted the low fermentability. The low content of ADF (acid detergent fibre) predicts high digestibility of organic matter and the low content of NDF (neutral detergent fibre) high intake. Alfalfa var. Morava had a higher content of protein and PDI in the third and the fourth cut, var. Palava had a higher content of protein and PDI in the first cut (harvesting time).

The comparison of the analyses of alfalfa (table 1 with table 2) cutted about a week before real harvesting time with those cutted at the real harvesting time shows the decreasing content of protein, PDI, ADF, NDF and fibre, the relatively stability of the content of energy. Alfalfa var. Morava had a higher content of protein and PDI in the third and the fourth cut, var. Palava had a higher content of protein and PDI in the first cut (harvesting time).

Leafs are most valuable in alfalfa from the nutrition point of view. Thus, in addition to yields, also proportion of leaves and stems was followed (table 2). Morava variety had 17 % lower proportion of leaves than stems in the 1$^{st}$ and 2$^{nd}$ cut. Palava variety had almost identical proportion of stems and leaves. The difference in Palava variety was found in the 3$^{rd}$ cut only, when proportion of leaves was 11.4 % lower than proportion of stems.

Table 2 also shows that alfalfa var. Morava was more productive (yield of DM and the nutrition values was higher) than var. Palava in the first and the second cut (3.73 and 4.05 t/ha vs. 3.1 and 3.72 t/ha). High content of protein (247 g/kg DM) in the first cut of var. Palava shows that the harvesting of these varieties was a little soon. So, next sequence of harvesting var. Palava was some days later than those of var. Morava.
When yields of two varieties of alfalfa Morava and Palava were compared, a difference was found only in the first cut,

when Morava yielded 7.9 t of GM more than Palava. This was reflected also in the total yield (4 cuts). In the 2nd, 3rd and 4th cut yields of both varieties were similar. The yield of DM, protein and NEL was 9 %, 11 %, 6.8 % lower, resp. in Palava than in Morava variety (table 3).

**Table 1.** The evaluation of two varieties of alfalfa about a week before harvesting

| Parameter | Alfalfa var. MORAVA | | | | Alfalfa var. PALAVA | | | |
|---|---|---|---|---|---|---|---|---|
| | 3.5. | 6.6. | 18.7. | 25.9. | 4.5. | 7.6. | 19.7. | 3.10. |
| DM (g/kg) | 172 | 170 | 175 | 224 | 175 | 157 | 191 | 200 |
| Protein (g/kg DM) | 205 | 231 | 258 | 222 | 223 | 246 | 204 | 208 |
| PDI (g/kg DM) | 92.7 | 100.2 | 108.7 | 98.3 | 97.0 | 108.4 | 99.3 | 95.1 |
| NEL (MJ/kg DM) | 5.56 | 5.90 | 5.89 | 5.81 | 5.65 | 5.87 | 5.96 | 5.86 |
| NEV (MJ/kg DM) | 5.39 | 5.72 | 5.72 | 5.68 | 5.42 | 5.74 | 5.80 | 5.76 |
| Fibre (g/kg DM) | 236 | 227 | 216 | 203 | 224 | 211 | 259 | 278 |
| ADF (g/kg DM) | 284 | 279 | 256 | 248 | 284 | 245 | 333 | 332 |
| NDF (g/kg DM) | 376 | 348 | 360 | 376 | 363 | 313 | 355 | 476 |

**Table 2.** The evaluation of two varieties of alfalfa at the time of harvesting

| Parameter | Alfalfa var. MORAVA | | | | Alfalfa var. PALAVA | | | |
|---|---|---|---|---|---|---|---|---|
| | 9.5. | 12.6. | 26.7. | 5.10. | 9.5. | 15.6. | 28.7. | 12.10. |
| Yield of GM (t/ha) | 22.9 | 19.1 | 17.4 | 7.7 | 15.0 | 19.4 | 15.8 | 8.4 |
| Yield of DM (t/ha) | 3,73 | 4,05 | 3,08 | 1,72 | 3,10 | 3,72 | 3,03 | 1,57 |
| % of leaf | 41.5 | 42.4 | 49.4 | 58.3 | 53.3 | 47.1 | 44.3 | 53.3 |
| DM (g/kg) | 163 | 212 | 177 | 221 | 207 | 192 | 192 | 187 |
| Protein (g/kg DM) | 217 | 216 | 202 | 216 | 247 | 196 | 217 | 146 |
| PDI (g/kg DM) | 97.8 | 99.3 | 95.6 | 95.2 | 101.6 | 98.9 | 99.2 | 85.4 |
| NEL (MJ/kg DM) | 5.63 | 5.91 | 5.91 | 5.80 | 5.61 | 6.04 | 5.85 | 6.03 |
| NEV (MJ/kg DM) | 5.44 | 5.81 | 5.79 | 5.71 | 5.42 | 5.93 | 5.74 | 5.98 |
| Fibre (g/kg DM) | 252 | 240 | 310 | 242 | 187 | 235 | 316 | 202 |
| ADF (g/kg DM) | 292 | 285 | 410 | 276 | 217 | 270 | 368 | 232 |
| NDF (g/kg DM) | 368 | 387 | 399 | 374 | 297 | 437 | 390 | 392 |

**Table 3.** The comparison of the yields of the green (GM) and dry matter (DM) and the nutrition value of two alfalfa varieties Morava and Palava.

| Parameter | Alfalfa var. MORAVA | | Alfalfa var. PALAVA | |
|---|---|---|---|---|
| Yield of GM (t/ha) | 67.2 | 100 % | 58.6 | 87,2 % |
| Yield of DM (t/ha) | 12.6 | 100 % | 11.4 | 90,9 % |
| Yield of protein (t/ha) | 2.78 | 100 % | 2.38 | 89,0 % |
| Yield of PDI (kg/ha) | 1.25 | 100 % | 1.12 | 91,3 % |
| Yield of NEL (tis. MJ/ha) | 73.1 | 100 % | 68.9 | 94,2 % |
| Yield of NEV (tis. MJ/ha) | 71.5 | 100 % | 65.7 | 91,9 % |

## Conclusion

Alfalfa variety Morava gives higher production of protein and energy values than variety Palava.

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Research was supported by MŠMT Kontakt ME194.

# The Changes of Dactylis Glomerata Quality During Vegetation

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### Abstract

There were observed forage quality of Dactylis glomerata during vegetation at the Breeding Station Větrov. We have taken samples – May 9$^{th}$ , May 15$^{th}$ and May 24$^{th}$ 2000. The crude protein level was decreased about 1,4 % per day during time since May 9$^{th}$ till May 24 $^{th}$. The NDF and ADF level was increased about 0,8% per day during time since May 9$^{th}$ till May 24 $^{th}$. The RFV index is decreased during vegetation too. The roughage quality is worse.

The fresh forage was preserved by ensiling during last consumption. We have analysed ensilage quality (milk acid, acid acetic, acid buttiric, pH) at single varieties of Dactylis glomerata. They have not been found out significant differences among single varieties.

### Introduction

The roughage biomatter is made by 50 - 80% carbohydrats. There are carbohydrats saved in cell walls (crude fibre - it is made by celulose, hemicelulose, lignin and small quantity of cutin) and in cell protoplasm (starch and water soluble carbohydrats) in plant feeds. The carbohydrats (celulose, hemicelulose, lignin, cutin) are very important for rumen function, pufer rumen capacity, chew stimulation and for regulation of roughage consumption. The plant is not homogen system from point of wiev of nutrient value. The most influence for the plant quality has vegetation stage in time of harvest. The high roughage quality is connected with quick fiber digestibility and with high consumption of neutral detergent fiber (NDF). The timely roughage harvest has positive influence for high production with minimum demand for grain feeds.

There was made an experiment in The Plant Breedig Station Větrov. We observed changes of the nutriment contents during vegetation of a grass species *Dactylis glomerata.* We took samples in May 9$^{th}$, May 15 $^{th}$ and May 24 $^{th}$ 2000.

### Materials and methods

There was made an experiment in The Plant Breedig Station Větrov. We observed changes of the nutriment contents during vegetation of a grass species *Dactylis glomerata.* We took samples in May 9$^{th}$, May 15 $^{th}$ and May 24 $^{th}$ 2000.

The fresh forage was preserved by ensiling during last consumption. The forage samples (dry matter 33 – 37 %) were given to the ensilage space in ensilage sacks. Their weight were 5 kg. We have analysed crude proteins, crude fiber, ADF, NDF, Relative Feed Value (RFV) and Digestible Dry Matter (DDM) in the ensilages. The samples have been analysed at the Department of Genetics, Animal Breeding and Nutrition, Agriculture Faculty, South Bohemia University in Č.Budějovice. Crude proteins, crude fibre were analysed during notice MA No. 222/1996 Sb. ADF and NDF was analysed by method Van Soest. We have analysed ensilage quality (ensilage acids and pH).

Relative Feed Value (RFV):

$$RFV = \frac{((88{,}9 - (0{,}779 * ADF\%)) * (120 / NDF\%)}{1{,}29}$$

The forage was devided to five classes according to RFV.

Classes according to RFV:

| Class | kind | RFV |
|---|---|---|
| 1. | grass | 125 –150 |
| 2. | - „ - | 103 –124 |
| 3. | - „ - | 87 - 102 |
| 4. | - „ - | 75 - 86 |
| 5. | - „ - | < 75 |

DDM = Digestible dry matter = 88,9 – ( 0,779 * ADF% )

## Results

The results of forage quality during vegetation in the table 1.

**Table 1.** The parameters of nutrition value of Dactylis glomerata / g/kg dry matter/

| Date | Variety / Ear Formation UPOV | Crupe protein g | Fibre g | ADF g | NDF g | RFV Index | DDM % |
|---|---|---|---|---|---|---|---|
| 9.5. | Dana / 3 | 211,1 | 251,1 | 301,5 | 497,2 | 122,4 | 65,43 |
| 15.5. | Dana / 6 | 188,4 | 260,3 | 308,0 | 513,2 | 117,6 | 64,91 |
| 24.5. | Dana / 8 | 129,4 | 299,2 | 355,0 | 583,4 | 97,6 | 61,25 |
| 9.5. | Vega / 3 | 192,4 | 269,7 | 315,5 | 511,1 | 115,9 | 64,32 |
| 15.5. | Vega / 5 | 186,0 | 277,5 | 326,4 | 538,3 | 109,7 | 63,47 |
| 24.5. | Vega / 9 | 150,0 | 299,2 | 354,6 | 572,4 | 99,6 | 61,28 |
| 9.5. | Velena / 4 | 150,7 | 253,6 | 325,8 | 540,7 | 105,3 | 63,52 |
| 15.5. | Velena / 8 | 133,9 | 286,4 | 329,1 | 585,6 | 100,5 | 63,26 |
| 24.5. | Velena / 9 | 123,7 | 288,5 | 345,6 | 588,2 | 98,0 | 61,98 |
| 9.5. | Zora / 4 | 123,9 | 253,8 | 304,5 | 530,7 | 114,3 | 65,18 |
| 15.5. | Zora / 7 | 98,0 | 266,4 | 328,0 | 548,6 | 107,4 | 63,35 |
| 24.5. | Zora / 9 | 83,8 | 303,8 | 349,2 | 595,3 | 96,5 | 61,70 |

The roughage quality and the nutrition value are expressed by Relative Feed Value Index (RFV). The RFV is calculated from analytic values of ADF and NDF. ADF has relationship to digestibility of roughage and NDF expresses potential for dry matter digestibility. The both values are very suitable for nutrition evaluation of single cattle categories.

## Conclusion

The crude proteins level were decreased about 1,4 % per day during time since May 9$^{th}$ till May 24 $^{th}$. The NDF and ADF level were increased about 0,8% per day during time since May 9$^{th}$ till May 24 $^{th}$. The RFV index is decreased during vegetation too. The roughage quality is worse. They have not been found out significant differences among ensilages of single varieties.

*This scientific paper was made with help of grant CEZ: J 06/98: 122200002/05.*

# The Comparison between Green and Ensiling of Maize Sorts - 3 Years Experiment

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### Abstract:

The differencis between the fresh and ensilaged silages depend on FAO number, the date of harvesting and harvesting technology. Last two years increase the maize dry matter content over 40%, ensiled maize had lower pH, maybe influenced throw second fermentation processes during conservation.

Key words: green maize, maize silage, quality

### Rewiew of literature:

The TMR are more and more used in dairy cow nutrition and allows to feed consumption in one mixture every time per day. (COENEN, 1996) Grand component in TMR is maize silage. It depends NEL value of the TMR. (PODKOWKA et al., 1998) They write that the different energy and PDI concentration is possible the technology feed ration per different groups. The different qualuity of maize sorts (after FAO number) and their silage described CERMAK and kol., 2001.

### Material and methods:

In years 1997-2000, different sorts of FAO number at the three field experiments were evaluated. We observed dry matter and nutrients yield of each sorts, experiment and yield. From these sorts we prepared silage in the small glass „silos". Rest of the plants was mixed and siled in the silage gutter. Green plants silages was with Van Soest method analyzed. Energy and PDI content were with computer program Agroconculta Zamberk evaluated.

### Results and discussion:

The results of the different FAO number, dry matter yield and their different the cob stalk and energy and DM, height of maize plants in cm in average of three years are in the table 1:

**Table 1.** The Yield of different maize sort at the more years experiments

| FAO Nr. | Yield DMt/ha 2000 | aver. | Dry matter % cob | stalk | total | Cobb % Dm of T. | MJ ME kg/DM | Cob ME % | Height cm |
|---|---|---|---|---|---|---|---|---|---|
| 190 | 180 | 158 | 48 | 20 | 31 | 60 | 10,72 | 66 | 230 |
| 220 | 184 | 160 | 46 | 22 | 31 | 56 | 11,14 | 61 | 237 |
| 240 | 157 | 152 | 44 | 24 | 32 | 54 | 10,85 | 59 | 225 |
| 250 | 152 | 153 | 41 | 25 | 32 | 50 | 10,67 | 54 | 201 |

Yield average – 1998-2000

In the table 2 there are average values of nutrient variation of corn silage.

**Table 2.** Nutrient variation in corn silage.

| In dry matter (g/kg): | x | sd | range |
|---|---|---|---|
| organic mater | 930,8 | 14,9 | 910- 940 |
| NDF | 456,2 | 48,6 | 310- 590 |
| ADF | 238,8 | 12,0 | 200- 290 |
| Starch | 184,2 | 47,4 | 160- 350 |
| Dry matter digestibility % | 70,1 | 3,0 | 65- 74 |

In the table 3 and 4 there are nutritive value of DM maize silage and values of quality.

**Table 3.** Nutritive value of feed ( in 1 kg ) DM of maize silage

| feed | dry matter g | Crude protein g | Crude fibre g | NEL | PDIE g | PDIN g |
|---|---|---|---|---|---|---|
| 1997-1999 | 205,0 | 22,03 | 60,4 | 1,84 | 17,8 | 13,3 |
| 2000 | 383 | 43,73 | 76,5 | 2,48 | 29,47 | 26,87 |

**Table 4.** Quality evaluation of silages

| silage | pH | $N\text{-}NH_3$ in N-total in % | acids in % | | | In Flieg-Zimmer scale | |
|---|---|---|---|---|---|---|---|
| | | | lactic | acetic | butyric | points | quality |
| 1997-99 | | | | | | | |
| Maize | 4,17 | 12,4 | 4,01 | 1,82 | 0,01 | 84 | VG |
| 2000 | | | | | | | |
| maize | 3,53 | 11,8 | 3,1 | 1,15 | | 91 | VG |

VG - very good

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*Supported by grant CEZ 06/98 22200002/5*

# Characteristics Some Maize Hybrids SEMPOL Holding a. s. Trnava in Czech republik

**Božena Ryšavá**

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Silage maize is a very well silageable crop. Low quality of produced silages is the evidence that not all technological principles are observed at production of maize silage.

Harvest of technologically ripe maize enables to produce feedstuff from which is starch in the reticulum more slowly decomposed as starch of other crops and its passage into the round leads to a better usage and improvement of providing milk cows with glucose with the subsequent increase in milk yield. A lower velocity of decomposition of maize starch is connected with a higher percentage of maize grain dry matter From this viewpoint, a choice of hybrids seems to be correct as one of the basic elements that can in the beginning of growing significantly effect the final success of growing. Its effect is usually admitted at 40 % of the total yield which shifts the value of field trials with maize hybrids to a pronouncedly other position as perceived. In case of silage hybrids it is necessary to lay emphasis on the total yield of dry matter, energy and organic matter digestibility

The aim of this work was to evaluate nutritive value and digestibility of organic matter and dry matter of hybrids of SEMPOL Holding a. s. Trnava – TORENA, TEREZA and MARKIZA.

The hybrids were observed on the plots of the Animal Production Research Institute (VÚ□V) in Praha-Uh□in□ves on brown soil in the beet production area, at 280 metres above sea level, with pH 6.8. As a forecrop, winter wheat had been used. Sowing had taken place on 18 April 2000. Hybrid samples for analysis were taken at stand cutting for theoretical height of 5 mm by a Class cutter on 28 August 2000 and the crop was harvested on 26 September 2000.

Parameters characterizing hybrids Torena, Tereza and Markiza were observed. Based upon the measured parameters, theoretical yields of fresh matter of whole plants and ears were calculated.

| Hybrid | FAO | Dry matter content on 28 Aug. in % | | | | Green matter yield in t.ha$^{-1}$ | | | Dry matter yield in t.ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain | Ear | Stalk | Whole plant | Whole Plant | Without ears | Ears Without husks | Whole plant | Without ears | Ears |
| Torena | 230 | 65,56 | 61,65 | 30,66 | 42,36 | 44,2 | 27,5 | 16,7 | 18,7 | 8,4 | 103 |
| Tereza | 240 | 62,75 | 63,65 | 27,73 | 41,40 | 44,1 | 27,3 | 16,8 | 18,3 | 7,6 | 10,7 |
| Markiza | 280 | 60,89 | 57,65 | 28,69 | 40,4 | 48,4 | 28,9 | 19,5 | 19,5 | 8,3 | 11,2 |

Feed values of whole maize plants with ears in 100 % of dry matter on 28 August 2000

| Hybrid | NL g/kg dry matter | PDI g/kg dry matter | Fiber g/kg dry matter | Starch value ŠJ/kg dry matter | NEL MJ/kg dry matter | NEV MJ/kg dry matter |
|---|---|---|---|---|---|---|
| Torena | 85,76 | 52,77 | 181,93 | 0,670 | 6,73 | 6,83 |
| Tereza | 83,76 | 52,47 | 191,69 | 0,669 | 6,74 | 6,85 |
| Markiza | 86,34 | 54,74 | 186,19 | 0,673 | 6,73 | 6,87 |

Feed values of maize plants without ears in 100 % of dry matter on 28 August 2000

| | | | | | | |
|---|---|---|---|---|---|---|
| Torena | 63,59 | 40,07 | 308,47 | 0,572 | 6,48 | 6,63 |
| Tereza | 58,55 | 37,68 | 335,25 | 0,565 | 6,52 | 6,67 |
| Markiza | 64,50 | 40,75 | 335,67 | 0,567 | 6,56 | 6,71 |

Feed values of ears in 100 % of dry matter on 28 August 200

| | | | | | | |
|---|---|---|---|---|---|---|
| Torena | 102,91 | 77,99 | 78,03 | 0,892 | 8,92 | 9,65 |
| Tereza | 102,86 | 79,00 | 82,78 | 0,892 | 8,90 | 9,62 |
| Markiza | 103,61 | 78,88 | 68,04 | 0,899 | 9,01 | 9,76 |

Feed values of grain in 100 % of dry matter on 28 August 2000

| Hybrid | NL g/kg dry matter | PDI g/kg dry matter | Fiber g/kg dry matter | Starch value ŠJ/ kg dry matter | NEL MJ/kg dry matter | NEV MJ/kg dry matter |
|---|---|---|---|---|---|---|
| Torena | 105,41 | 80,32 | 37,06 | 0,908 | 9,17 | 9,96 |
| Tereza | 103,93 | 80,44 | 40,54 | 0,907 | 9,17 | 9,94 |
| Markiza | 101,82 | 77,83 | 35,65 | 0,915 | 9,27 | 10,07 |

Feed values of in 100 % of dry matter LKS on 26 September 2000

| | | | | | | |
|---|---|---|---|---|---|---|
| Torena | 86,05 | 66,69 | 126,07 | 0,877 | 8,67 | 9,35 |
| Tereza | 86,45 | 66,66 | 88,08 | 0,891 | 8,88 | 9,61 |
| Markiza | 87,70 | 66,49 | 101,89 | 0,891 | 8,88 | 9,59 |

Biological yields of feed values of a whole plant in $t.ha^{-1}$ on 28 August 2000

| | | | | | | |
|---|---|---|---|---|---|---|
| Torena | 1,43 | 0,88 | 3,05 | 11217 | 11208 | 114374 |
| Tereza | 1,41 | 0,88 | 3,22 | 11250 | 112278 | 115143 |
| Makkiza | 1,53 | 0,97 | 3,27 | 11901 | 119015 | 121434 |

Yields of feed values of ears per ha on 28 August 2000

| | | | | | | |
|---|---|---|---|---|---|---|
| Torena | 2,52 | 1,92 | 1,82 | 21873 | 218733 | 237037 |
| Tereza | 2,58 | 1,99 | 2,08 | 22411 | 223668 | 241756 |
| Markiza | 2,54 | 1,94 | 1,67 | 22061 | 221097 | 239481 |

To ensure the optimal value between the volume production and content of digestible energy, it is necessary to reasonably correct the plant numbers dependent upon the thermal and humidity conditions of a plot and the corresponding hybrid earliness. To reach optimization, however, it is necessary to analyze in detail accumulation of energy and its digestibility in the individual maize organs.

Besides energy concentration in maize silage, the problem deals also with feedstuff usage since although the lignine part of biomass coming mainly from the basal part of the stalk is rich in energy, it can be used only in the minimal extent. Energy production in MJ NEL and NEV shows a very good energy production of the observed hybrids. A certain variability between hybrids in energy production is probably significantly effected by the course of climatic factors, factual location conditions, agronomic interventions, and it can be different with the same hybrid in various years.

# THE CONTROL OF THE FERMENTATION PROCESS OF FORAGES AND THEIR AEROBIC STABILITY

# "New" Fermentation Products in Grass Silage and Their Effects on Feed Intake and Milk Taste


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## Abstract

Approximately 100 samples of grass silages, most of them from practical farms, have been analysed by use of different advanced techniques in order to identify as many as possible of the fermentation products in silage. More than 50 different compounds were identified and half of them were esters. Based on information's from individual farms about feed intake and milk taste and the relative amount of the relevant component estimated as the area of the peak on the chromatogram, Partial Least Squares regressions were computed. Those calculations revealed a link between the alcohols methanol, ethanol and propane and off flavour in milk, and between the components propanol and dimethyl-sulfide and low feed intake. The effect of ethanol and propanol on milk taste is confirmed in feeding experiments with dairy cows, but not the effect on feed intake by propanol and dimethyl-sulfide.


## Introduction

Through the years different methods have been used to analyse the end products of silage fermentation, but pH, ammonia-N in percent of total N, and percent lactic, acetic and butyric acid in silage have been used as criteria for determining fermentation quality In Norway today organic acids and ethanol in silage are analysed by use of High Performance Liquid Chromatography (HPLC). By this method the components are identified and quantified as peaks on a chromatogram. Besides ethanol and those acids mentioned other peaks appear indicating that usually there are a lot of other fermentation products in silage. Most of those products have so far not been identified or quantified. The objective of this project was to identify as many fermentation products as possible by use of different methods and to test some of them with regard to feed intake in dairy cows and their effect on milk taste.

## Materials and methods

Almost 100 silage samples have been analysed in this study Most of those samples have been collected from practical farms that either had problems with feed intake or taste of milk. Other samples were from both good silages used in feeding experiments or silages where feed intake were lower than expected.

The silages are analysed by use of different techniques to identify as many fermentation products as possible. For sample preparation a head-space technique at 60° C was used among others. HPLC, gas-chromatography (GC), liquid-chromatography (LC) and capillary electrophoreses (CE) were used to separate different components, as UV-detector, refractive index (RI), mass-spectroscopy (MS) and flame ionisation detector (FID) were used to identify and quantify the products.

Due to the amount of work and for economical reasons very few products have been quantified so far. Probably most of these fermentation products have very little if any effect on feed intake, feed utilisation, milk quality or animal health and therefore it makes little sense putting to much work in general quantification of all the products.

The sample selection was based upon an "either/or" response with regard to intake and taste of milk. In order to utilise the results from the chemical analysis without identifying and quantifying all the components a Partial Least Squares regression (PLS) (Martens & Naes, 1989) was computed based on the "either/or" response and the relative amount of the relevant component estimated as the area of the peak on the chromatogram. The main difference between a PLC-regression and a Multiple Linear regression (MLR) is that a PLS-regression also can handle variables, which are correlated.

## Results

So far we have been able to identify more than 50 different fermentation products (Table 1).

**Table 1.** Fermentation products in grass silage. Listed in order of retention time using MS.

| Comp. No. | Component name | Comp. No. | Component name |
|---|---|---|---|
| 1 | Acetaldehyde | 27 | Acetic acid, propyl ester |
| 2 | Thiobismethane | 28 | Butanoic acid, 1-methyl propyl ester |
| 3 | Propanal | 29 | Pentanoic acid, ethyl ester |
| 4 | 2-methyl-propanal | 30 | 1-butanol |
| 5 | Acetic acid, methyl ester | 31 | Propionic acid, 2-methyl butyl ester |
| 6 | Butanal | 32 | 1-penten-3-ol |
| 7 | Acetic acid, ethyl ester | 33 | Butanoic acid, 2-methyl propyl ester |
| 8 | Methanol | 34 | Hexanoic acid, methyl ester |
| 9 | 2-butanone | 35 | 2-methyl-1-butanol |
| 10 | 2-butanal | 36 | 3-methyl-1-butanol |
| 11 | 3-methyl-butanal | 37 | Limonene |
| 12 | 3-ethyl-butanal | 38 | Butanoic acid, 1-methyl propyl ester |
| 13 | Ethanol | 39 | Pentanoic acid, propyl ester |
| 14 | Propanoic acid, ethyl ester | 40 | Hexanoic acid, methyl ester |
| 15 | Acetic acid, propyl ester | 41 | Butanoic acid, pentyl ester |
| 16 | Pentanal | 42 | Pentanoic acid, butyl-ester |
| 17 | Butanoic acid, methyl ester | 43 | Hexanoic acid, butyl-ester |
| 18 | 2-butanol | 44 | 1-hexanol |
| 19 | 1-propanol | 45 | 3-hexen-1-ol |
| 20 | Butanoic acid, ethyl ester | 46 | Hexanoic acid, butyl-ester |
| 21 | Propanoic acid, propyl ester | 47 | Octanoic acid, ethyl ester |
| 22 | Butanoic acid, propyl ester | 48 | Butanoic acid, 3-hexenyl ester |
| 23 | Acetic acid, butyl ester | 49 | Propanoic acid |
| 24 | Dimethyl disulfide | 50 | 2-methyl, propanedioic acid |
| 25 | Pentanoic acid, methyl ester | 51 | Hexanoic acid |
| 26 | 2-pentanol | | |

More than half of them are esters. Esters are not direct products from microbial activities, but are formed in the silo on the basis of organic acids and alcohols produced by different microbes. Esters are known to be aromatic and for that reason they can have an effect on the taste of the feed and consequently feed intake. Some of them are volatile and may be absorbed through the lungs and transferred directly via the blood to the milk and influence milk taste. Some other acids than usually analysed have been detected and different alcohols besides ethanol. Even some aldehydes and ketones have been detected, but still there are component yet not identified. Results from the PLS-regression indicated that 4-5 different fermentation products could be associated with low feed intake and 4-5 products to the taste of milk. Ethanol was one of the components linked to the taste of milk. This has been observed also in earlier experiments (Randby et al., 1999). Bad milk taste could be attributed to methanol and propanol as well. Propanol also showed a negative relation to feed intake and so did dimethyl-sulfide. The latter is known to influence milk taste, but then as a product from methionine break down in the rumen (Dunham et al., 1968; Clark & Salsbury, 1980), and not as a component of silage. The negative effect of propanol on milk taste, especially in the evening milk, has been confirmed in feeding experiments with dairy cows in Norway, but not the effect on feed intake. Dimethyl-sulfide had no specific effect, neither on feed intake nor taste of milk in those experiments.

**Conclusions**

More than 50 different fermentation products in grass silages have been identified by use of various analysing techniques. Half of them are different esters. By use of Partial Least Squares regression 4-5 compounds have be linked up with low silage intake and 4-5 with bad taste of milk. Results from feeding experiments with dairy cows in Norway have shown that both ethanol and propanol have negative effects on milk taste. Other results could not confirm the earlier findings by others that dimethyl-sulfide have a negative effect on milk taste.

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# The effect of the combination of biological and biological-enzymatic additive with sodium benzoate upon the fermentation process in red clover silages

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**Summary**

In experiments with clover the possibilities of conservation using a biological and a biological-enzymatic additive combined with sodium benzoate were verified. Application of both additives had positive effects upon the quality of the fermentation process and the nutrient composition of clover silage with a low dry matter content (24%). On the whole, the silage treated with the biological-enzymatic additive seemed to be slightly better.

**Introduction**

In Slovakia, clover is grown on 4.6% of the arable land. Due to frequent rainfall mainly during the first mowing conservation often presents a problem. It was the aim of this work to verify the possibilities of using a biological and a biological-enzymatic additive combined with sodium benzoate in clover silage conservation.

**Materials and Methods**

The experiments were carried out with crops of tetraploid clover from the third mowing (Table 1). The cut crops were homogenized and filled into 1.7 l bottles. Three different groups were examined: a non-treated control and two experimental variants treated as follows:

- ($P_1$) treated with a biological additive consisting of Enterococcus faecium, Lactobacillus plantarum, Lactobacillus casei and Pediococcus spp. combined with sodium benzoate. 4 l were applied per 1 ton of feed
- ($P_2$) treated with a biological additive consisting of Enterococcus faecium, Lactobacillus plantarum, Lactobacillus casei and Pediococcus spp. plus cellulase, hemicellulase and glucosooxidase combined with sodium benzoate. Again 4 l were applied per 1 t of feed.

The filled bottles were placed in a dark room at 20 – 25 °C. After 180 days of incubation the samples were examined for nutrient content, dry matter content losses in % of the original dry matter and electrometrically for silage extract pH. Lactic acid and volatile fatty acid levels were determined by gas chromatography, alcohol and $NH_3$ by the microdiffusion method according to Conway. Of the concentrations determined total volatile fatty acid, total acid, metabolizable energy (ME) and net energy lactation (NEL) were stated.

The results were statistically processed and compared by means of the one-factorial variance analysis using the Statgraphics 2.6 programme.

**Results and Discussion**

Both additives proved to have rather positive effects upon the fermentation process (Table. 2). In the treated silages decreased pH and acetic acid levels and increased lactic acid levels were determined. With these indices, the differences between the non-treated and the treated silages were statistically significant ($p<0.05$) and highly significant ($p<0.01$), respectively. Both additives positively influenced propionic and butyric acid levels. The differences in the levels of these acids between the untreated and treated silages were highly significant ($p<0.01$). Both additives also had positive effects upon alcohol levels and $NH_3$-N of total N. The differences observed were significant ($p<0.05$) and highly significant ($p<0.05$), respectively. Comparison of the groups $P_1$ and $P_2$ revealed lower pH and butyric acid levels, increased lactic and propionic acid and alcohol levels as well as $NH_3$-N of total N in group $P_1$. With the exception of alcohol levels no significant differences were observed between the experimental groups.

Improvement of the fermentation process in the treated silages became obvious in decreased weight and nutrient losses (Table 3). Crude fibre content, NDF and nitrogen-free extract levels revealed highly significant differences between the untreated and treated silage ($p<0.01$). As to the other indices, statistically significant or highly significant differences were only observed between the non-treated silage and the treated ones. Between the two treated silages only the differences in N-substance and hemicellulose levels proved to be highly significant ($p<0.01$).

Apart from alcohol, the differences between the treated silages concerning the quality of the fermentation process seemed to be minimal. The application of enzymes caused a decrease in the contents of crude fibre and its fractions, however, the differences were minimal. As a whole, the silage treated with the biological-enzymatic additive combined with sodium benzoate seemed to be the better one.

Observations similar to ours have been reported by Hett (1999) during grass and clover mass conservation with milk acidifying bacteria combined with enzymes and sodium benzoate. The author reported decreased pH, acetic acid and alcohol levels as well as decreased $NH_3$-N of total N and pointed at the fact that the addition of sodium benzoate to milk acidifying bacteria with enzymes changed the character of the fermentation. He observed a decrease in the contents of crude fibre and its fractions only in clover-grass silage, which coincides with our findings.

Lättemäe et al. (1999) also reported the production of butyric acid and the occurrence of fungi to decrease in silages treated with a combination of sodium benzoate and milk acidifying bacteria. Similar results were predsented by Rammer et al. (1999) who stressed that adding sodium benzoate decreased the number of clostridium spores in the silages and improved the stability of the latter.

**Conclusion**

Application of a biological and a biological-enzymatic additive combined with sodium benzoate had a positive effect upon the quality of the fermentation process and the nutrient levels in clover silage with a low content of DM (24%). On the whole, the silage treated with the biological-enzymatic additive combined with sodium benzoate seems to be the slightly better one.

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**Table 1.** Nutrient levels in red clover silage digestible organic matter

| DM | OH | DOH | CP | PDI | CF | ADF | NDF | Nitrogen-free exctract | Fat | Ash | Sugar Totals | Sugar Reduced | NEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| g | g.kg$^{-1}$ DM | | | | | | | | | | | | MJ.kg$^{-1}$ DM |
| 244,53 | 887,67 | 652,44 | 264,83 | 96,16 | 171,14 | 241,79 | 374,85 | 412,35 | 39,36 | 112,33 | 28,35 | 21,11 | 5,99 |

**Table 2.** Parameters of the fermentation process in red clover silage

| Parameter n = 6 | Untreated | | | $P_1$ | | | $P_2$ | | | Statistical significance | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | x | s | $s_x$ | x | s | $s_x$ | x | s | $s_x$ | P<0,05 | P<0,01 |
| Losses DM in % | 10,22 | 4,99 | 2,04 | 4,59 | 0,84 | 0,34 | 5,85 | 1,64 | 0,67 | 1 : 2 | |
| pH | 5,23 | 0,09 | 0,04 | 4,61 | 0,01 | 0,00 | 4,68 | 0,04 | 0,01 | | 1 : 2,3 |
| Acid in g.kg$^{-1}$ DM | | | | | | | | | | | |
| - lactic | 58,13 | 15,59 | 6,36 | 100,91 | 5,89 | 2,40 | 83,71 | 18,93 | 7,73 | 1 : 3 | 1 : 2 |
| - acetic | 35,40 | 5,19 | 2,12 | 23,24 | 6,14 | 2,51 | 25,03 | 2,85 | 1,17 | | 1 : 2,3 |
| - propionic | 2,15 | 0,30 | 0,12 | 0,85 | 1,57 | 0,64 | 0,42 | 0,12 | 0,05 | | 1 : 3 |
| - butyric + isobutyric | 12,79 | 2,10 | 0,86 | 1,65 | 1,84 | 0,75 | 1,79 | 0,65 | 0,26 | | 1 : 2,3 |
| - valeric + isovaleric | 0,04 | 0,00 | 0,00 | 0,28 | 0,43 | 0,18 | 0,04 | 0,00 | 0,00 | | |
| - capronic + isocapronic | 0,04 | 0,00 | 0,00 | 0,05 | 0,02 | 0,01 | 0,13 | 0,06 | 0,02 | | 3 : 1,2 |
| Total VFA in g.kg$^{-1}$ DM | 50,43 | 5,32 | 2,17 | 26,07 | 4,03 | 1,65 | 27,40 | 2,67 | 1,09 | | 1 : 2,3 |
| Total acid in g.kg$^{-1}$ DM | 108,56 | 15,73 | 6,42 | 126,98 | 7,37 | 3,01 | 111,11 | 19,90 | 8,12 | 1 : 2 | |
| Alcohol in g.kg$^{-1}$ DM | 3,68 | 1,71 | 0,70 | 1,00 | 0,18 | 0,07 | 2,91 | 0,32 | 0,13 | 2 : 3 | 1 : 2 |
| $NH_3$ - N of total N in % | 13,33 | 2,15 | 0,88 | 11,71 | 0,79 | 0,32 | 10,00 | 2,72 | 1,11 | 1 : 3 | |

**Table 3.** Nutrient composition of red clover silage

| Parameter n = 6 | Untreated | | | $P_1$ | | | $P_2$ | | | Statistical significance | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | x | s | $s_x$ | x | s | $s_x$ | x | s | $s_x$ | P<0,05 | P<0,01 |
| Dry matter in g | 240,50 | 16,40 | 6,69 | 249,00 | 2,21 | 0,90 | 248,23 | 4,59 | 1,87 | | |
| Organic matter in g.kg$^{-1}$ DM | 884,20 | 1,08 | 0,44 | 884,78 | 1,07 | 0,44 | 881,80 | 2,37 | 0,97 | 3 : 1,2 | |
| Crude protein in g.kg$^{-1}$ DM | 277,32 | 7,42 | 3,03 | 268,92 | 6,93 | 2,83 | 281,41 | 3,79 | 1,55 | | 2 : 3 |
| PDI in g.kg$^{-1}$ DM | 86,22 | 1,68 | 0,69 | 83,96 | 1,07 | 0,44 | 86,80 | 1,80 | 0,73 | 1 : 2 | |
| Crude fibre in g.kg$^{-1}$ DM | 190,31 | 4,87 | 1,99 | 176,41 | 6,05 | 2,47 | 173,89 | 2,63 | 1,07 | | 1 : 2,3 |
| Fat in g.kg$^{-1}$ DM | 243,28 | 10,17 | 4,15 | 228,37 | 14,36 | 5,86 | 225,63 | 6,01 | 2,46 | | 1 : 3 |
| Ash in g.kg$^{-1}$ DM | 282,28 | 5,76 | 2,35 | 270,09 | 6,27 | 2,56 | 264,18 | 5,50 | 2,25 | | 1 : 2,3 |
| Hemicellulose in g.kg$^{-1}$ DM | 39,01 | 5,10 | 2,08 | 41,72 | 10,08 | 4,12 | 38,55 | 2,50 | 1,02 | | 2 : 3 |
| Nitrogen-free extract in g.kg$^{-1}$ DM | 364,94 | 12,37 | 5,05 | 392,20 | 7,92 | 3,23 | 378,13 | 4,22 | 1,72 | 1 : 3 | 1 : 2 |
| Fat in g.kg$^{-1}$ DM | 51,63 | 4,20 | 1,72 | 47,25 | 1,99 | 0,81 | 48,37 | 3,70 | 1,51 | 1 : 2 | |
| Ash in g.kg$^{-1}$ DM | 115,80 | 1,08 | 0,44 | 115,22 | 1,07 | 0,44 | 118,20 | 2,37 | 0,97 | 1 : 3 | |
| NEL in MJ.kg$^{-1}$ DM | 5,97 | 0,01 | 0,00 | 5,97 | 0,01 | 0,00 | 5,96 | 0,02 | 0,01 | 1 : 3 | |

# Metabolites of Lactic Acid Bacteria Influencing the Aerobic Stability of Silages

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## Abstract

The aim of the presented work was to improve the aerobic stability and general quality of silages by inoculation with selected bacteria. These bacteria accumulate specific microbial substances active against spoiling microorganisms. A high quality silage can be described by a low content of ammonia-N and butyric acid.

The aerobic stability is also an important factor in practice. When silages are exposed to air before feeding, they may immediately start to deteriorate. The activity of the spoilage microorganisms not only leads to nutritive losses resulting from an oxidation of the lactic acid and the water soluble carbohydrates but also can end up in the formation of mycotoxins. This emphasises the importance of appropriate measures for improving the stability of forage. By addition of special cultures the products formed during silage fermentation can be strongly influenced. Homofermentative lactic acid bacteria have the ability to form high amounts of lactic acid in a short time. Heterofermentative lactic acid bacteria are not only capable to produce higher amounts of acetic acid and ethanol. *L. buchneri* for instance can form 1,2-propanediol from lactic acid parallel to additional acetic acid. Acetic acid is the substance which positively influences the aerobic stability. Data not only from laboratory silages but also from technical scale silos are presented.

## Introduction

The amount of acetic acid in silages is not only a very important parameter for the aerobic stability (Holzer et al., 2001) it presents further a criteria for quality of silages. In silages inoculated with *L. buchneri* strains frequently too high amounts of acetic acid were found and the evaluation, applying the DLG-scheme, led to a reduction of quality. Therefore there was the need for a measure to get high amounts of lactic acid together with a moderate level of acetic acid.

## Materials and methods

A number of lactic acid bacteria (LAB), isolated from silages, were selected by their fermentation products on MRS-media and identified by Api-CHL 50.

In small scale silos first single bacteria were tested. From the resulting fermentation patterns mixtures of homo- and heterofermentative LAB were applied on whole crop maize as well as on grass. Different formulations could be further examined parallel in laboratory and clamp silos to get an optimised silage starter. The bacteria included in the starter were *L. rhamnosus*, *Pediococcus pentosaceus*, *Enterococcus faecium, L. brevis* and *L. buchneri*. Inoculation was completed with $5*10^5$ cfu/g FM.

The chemical parameters, necessary for evaluation of silage quality, were pH-value, ammonium-nitrogen, dry matter content and organic acids. The fermentation products and substrates, like carbohydrates, alcohols and organic acids were analysed by HPLC (HP1050C, Merck Polysher OA KC column and a RI-detector - HP1047A, mobile phase 0,01 N $H_2SO_4$) from aqueous silage extracts. The Carrez-precipitation method was applied for sample preparation.

For the determination of the aerobic stability of silages (AEST), a method by Honig (1990), which based on monitoring the temperature increase, was applied. The heating of silages can be related to the microorganism activity of the spoiling process. Samples with a registered temperature rise of more than 2°C were considered to be not stable any longer.

## Results and discussion

In figure 1 the fermentation of silage (a mixture of red clover and grass) of a control (SK) is presented, which can be compared to the silage treated with the starter mixture (SI; figure 2). Much higher levels of lactic acid (SI: 6,2 g/100g DM; SK: 3,6 g/100 g DM) and acetic acid (SI: 2,3 g/100 g DM; SK: 1,0 g/100 g DM) were observed in the treated silage than in the control. Also small amounts of 1,2-propanediol could be detected only in the silage inoculated with the starter. The aerobic stability was like the acetic acid about the double than in the control after 40 days of fermentation (SI: 213 h; SK: 109 h).

In further experiments in clump silos chopped whole crop maize was ensiled. One part was inoculated with the starter (silage I) and the rest was not treated (silage K). This big scale experiments showed the same tendency as observed in the small scale. In table 1 the results of both silages are presented. After 44 days of fermentation higher amounts of lactic acid and acetic acid were detected in the treated silage. These organic acids also contributed to a higher aerobic stability. The temperature registration of the aerobic stability measurement is presented in figure 3.

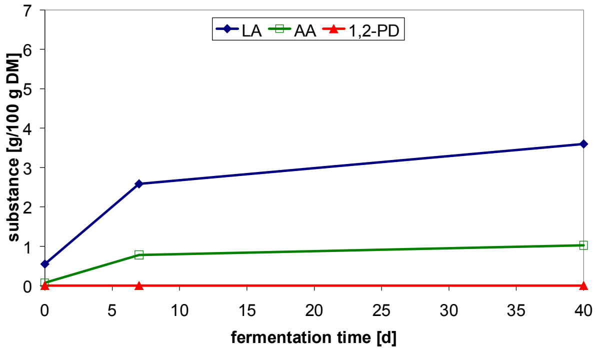


**Figure 1.** Silage control in small scale (SK)

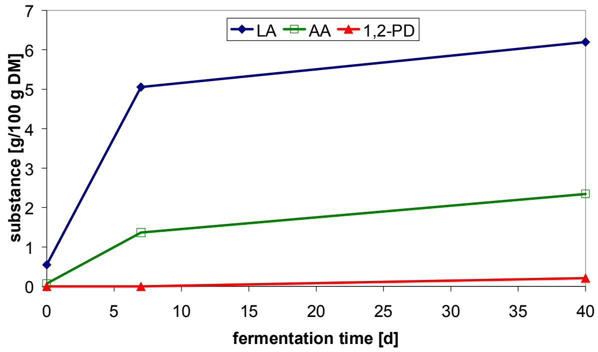


**Figure 2.** Silage treated with the new starter in small scale (SI

LA lactic acid, 1,2-PD 1,2-propanediol
AA acetic acid, ,

**Table 1.** Comparison of a whole crop maize silage in clamp silo treated with the starter (silage I) with a non-treated control (silage K).

| Sample | Silage K | Silage I |
|---|---|---|
| LA [g/100 g DM] | 4,45 | 4,66 |
| AA [g/100 g DM] | 0,98 | 1,26 |
| 1,2-PD [g/100 g DM] | 0,10 | 0,09 |
| DM % | 38,4 | 36,7 |
| pH | 4,0 | 3,8 |
| AEST [h] | 8 | 64 |

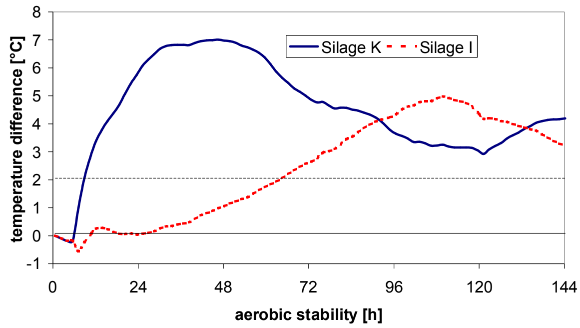


**Figure 3.** Temperature registration in measurement of aerobic stability of silage I and silage K

## Conclusions

The advantage of a controlled growth of *L. buchneri* in silage, obtained by the addition of homofermentative lactic acid bacteria, presents a saver fermentation. This means that the production of acetic acid does not exceed the required limit to get high quality silages, but still is high enough for inhibiting spoilage microorganisms. On the other side, also lactic acid does not degrade as strong as in a silage inoculated only with *L. buchneri* strains.

It could be demonstrated that a defined mixture of homo- and heterofermentative lactic acid bacteria is suitable to improve the aerobic stability of grass and maize silages.

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# Comparison of Different Heterofermentative Lactic Acid Bacteria for Silage Preservation

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### Abstract

There are several heterofermentative lactic acid bacteria known to play an important role in the preservation of forage. In literature they are described to occur naturally in silage and dominate after a certain fermentation period (Beck, 1972).

In the last years research has been focusing very much on the potential of *L. buchneri* to influence the silage fermentation process. A strain of this genera was applied to chopped whole crop maize. It could be found, that it is capable to produce high amounts of acetic acid, metabolising not only sugar sources from the ensiled plants, but also lactic acid formed during fermentation.

*L. brevis* another example of the heterofermentative group of Lactic Acid Bacteria was also tested in laboratory scale silos and showed primarily formation of acetic acid in the first phases of the ensilage process. The importance of this fatty acid lies in the strong activity in inhibiting moulds and yeasts and therefore plays a major role in the production of silages with high aerobic stability.

### Introduction

A new trend in ensiling is the use of heterofermentative lactic acid bacteria. Weinberg and Muck (1996) proposed to include heterofermentative lactic acid bacteria such as *L. buchneri* isolated from maize in starter starters. Oude Elferink et al. (2001) observed the conversion of lactic acid to acetic acid by *L. buchneri* under anaerobic conditions. The higher amounts of acetic acid should contribute to the higher aerobic stability of silages treated with this bacteria. There are very little reports on the use of *L. brevis* in silage. This work shows a comparison of these heterofermentative lactic acid bacteria as silage starter.

### Materials and methods

Different lactic acid bacteria (LAB) were isolated from clamp silages of the area of Lower Austria. The fermentation pattern of the obtained strains were tested on MRS media. The identification of selected microorganisms was completed by Api-CHL 50.

In laboratory silages several lactic acid bacteria were tested as starter cultures. The whole crop maize was stored at –20 °C and defrozen before ensiling was completed. The natural occurring lactic acid bacteria were determined with $4*10^6$ cfu/g FM. In order to see clearly the fermentation products of the added strains a quite high amount of $5*10^7$ cfu/g FM was added from each strain. Also a not inoculated charge of laboratory silages was ensiled.
For several stages of the fermentation analyses were conducted. Each investigation period included two silos. For day 1, 4 and 7 the scale was 1 L. For day 32 and 76 also the aerobic stability was measured and therefore bigger silos of 6,5 L were necessary.

Chemical parameters which were determined included pH-value, ammonium-nitrogen and dry matter content. The fermentation products and substrates, like carbohydrates, alcohols and organic acids were analysed by HPLC (HP1050C) equipped with a Merck Polysher OA KC column and a RI (HP1047A) detector from aqueous silage extracts. The mobile phase was 0,01 N $H_2SO_4$. Samples were prepared using the Carrez-precipitation method.
To determine aerobic stability of silages, a method by Honig (1990), which bases on monitoring the temperature, was applied. The heating of silages can be related to the microorganism activity of the spoiling process. Samples with a registered temperature rise of more than 2°C were considered to be not stable any longer.

### Results and discussion

The amount of acetic acid formed was much higher in silages inoculated with *L. buchneri* than in that treated with *L. brevis* or the control silage. In figure 1 the fermentation products of the different silages are presented. In the control silage (figure 1a) the main component represents lactic acid. No 1,2-propanediol was detected and the acetic acid and ethanol reached a level of about 1 g/100 g DM. In contrast to these findings, in the silage treated with *L. buchneri LAC 219* (see figure 1b) vast amounts of acetic acid were produced. 8,3 g/100 g DM were measured after 76 days of silage fermentation. Additionally 1,2-propanediol was formed (2,2 g/100 g DM after 32 days and 1,0 g/100g DM after 76 days). Lactic acid was detected in the starting phase with a maximum at day 7 of 2,5 g/100 g DM. Then this compound was converted to acetic acid and 1,2-propanediol. A relation of about 1:1 of lactic acid to acetic acid was found in the silage treated with *L. brevis LAC 199* (figure 1c) after 32 days of fermentation. The level of lactic acid formed is only slightly lower than in the control silage (day 32: control - 4 g/100 g DM; *L. brevis LAC 199* - 3,5 g/100 g DM).

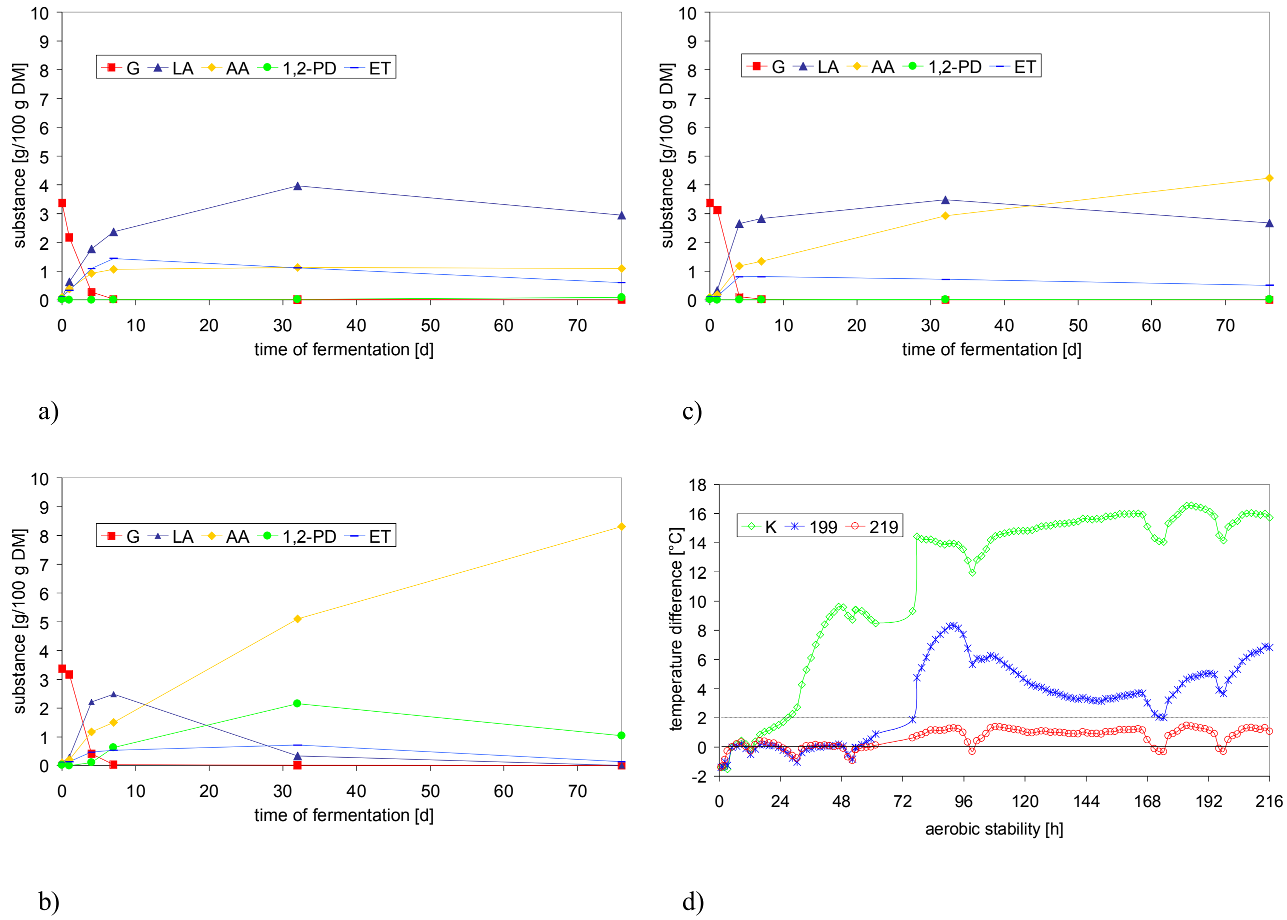


**Figure 1.** Fermentation products of: a) control silage b) *L. buchneri LAC* 219 and c) *L. brevis LAC 199*. In Figure 1 d) the influence on aerobic stabilityof *L.buchneri LAC 219* and *L. brevis LAC 199* after 76 days of fermentation are presented in comparison to the control silage without inoculation.

The sources of the acetic acid formed in the silage treated with *L. brevis LAC 199* are the sugars present in the plant material and not the lactic acid like in silages inoculated with *L. buchneri*.

In figure 1d the temperature curves of the determination of aerobic stability after 76 days of silage fermentations are drawn. The dotted line indicates the temperature limit of the aerobic stability. The control silage, containing the lowest amount of acetic acid, showed an aerobic stability of only 26 h. An about 60 h higher stability was measured for the silage with *L. brevis Lac 199* and the silage treated with *L. buchneri LAC 219* kept stable for more than 216 h.

## Conclusions

In laboratory experiments it could be demonstrated that the addition of heterofermentative lactic acid bacteria is suitable to improve the aerobic stability of whole crop maize silages due to the production of higher amounts of acetic acid. A comparison of several strains showed positive results and the benefits of the distinct Lactic Acid Bacteria in silage preservation.

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# Influence of Probiotics in Combination with Molasses on the Fermentation Process, Digestibility of Nutrients, Intake of Dry Matter and Nitrogen Rumen Degradability of Lucerne Silage.

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### Abstract

The influence of microbiological preservation additives ( Microsil and Biolsil) in combination with molasses on fermentation process was investigated in the 1 t containers, 3 t silos and compared with the same matter from 400 t functional silo. Digestibility and intake of dry mater was determined on 5 four years old wethers of the Merino breed and the nitrogen degradability was determined on three bullocks with the rumen canula.

### Introduction

Production of high quality silage's with a good digestibility of nutrients is one of the most actual problems of the ruminants nutrition. On the market is today many different probiotics for the silage making and all the producers promises big effect of the silage quality. Pahlow and Honig (1994) described better fermentation of silage with probiotics and another authors (Honig et al., 1996; Yan et al.,1996). published results of better digestibility treated silage's. But not always had the applications of biological additives expected effect (Pavelek et al., 1997).

The purpose of the present study was to evaluate the effect of new microbial silage additive - Biosil on some fermentation characteristics, in vivo digestibility, intake of dry matter and rumen protein degradability of lucerne silage, because the producer of Biosil determine positive effect on all this characteristics.

### Materials and Methods

The silage was made from the third cut of lucerne with wilting so dry matter was about 30%. Wilted material was chopped (2-3 cm) and ensiled in this variants:

a) matter treated with Biosil (2 g/t ) + molasses (50kg/t)
b) matter treated with Microsil (15 g/t) + molasses (50kg/t)
c) matter without preservative + molasses (50kg/t) (control)

Each of this variants was ensiled in 1 t containers, special silos of 3 ton capacity and the variant with Biosil was also ensiled in the same day in 400 t functional silo in local agricultural company.

„**BIOSIL**“ is a mixture of bacterial cultures Lactobacillus plantarum DSM 8862, Lactobacillus plantarum DSM 8866, from AG BAG.

**„MICROSIL“** containing mixture of lactic bacteria Lactobacillus plantarum, L. casei, L. faecium, Pediococcus spp., is provided by MEDIPHARM

After 56 days were the silage's opened and determined for all the indicators of nutrition value - dry matter (DM), organic matter (OM), crude protein, crude fat, crude fibres and starch. The DM content was determined by drying (105$^{o}$C), OM was measured by ashing at 550$^{o}$C for 4 hours. The contents of crude protein and fat were determined according to Weende methods and starch was determined by polarometric method.

Also was determined all the characteristics of the quality of fermentation process and stability for 5 days. The concentrate of ferment acids were determined by izotachoforeze. Content of ammonia was measured by Conway method.

Five castrated rams were used for the digestibility experiment. During the experiment was feed lucerne silage only - 1 kg DM per day.
For the intake treatment were use five castrated rams too, they were feed ad-libitum for 5 days.

The rumen degradability of protein was determined by method in situ (Orskov and McDonald, 1979) on three bullocks with the rumen canula at intervals of 2, 4, 8, 16, 24 and 48 h. For the calculation the protein degradability was the NEWAY program used.

## Results and Discusion

*Effect on nutritive value of silage*

The addition of biological preparation Biosil into the lucerne silage influenced the increase of crude protein content in comparison with the Microsil treated and untreated (control) variant (table 1). The differences between the given values were statistically high significant. In the other characteristics were only small nonsignificant differences.

**Table 1.** Nutritive value of green matter and all variants of silages

| | green matter | wilted mat. with molass. | 1 ton containers | | | 3 t silos | | | 400 t |
|---|---|---|---|---|---|---|---|---|---|
| | | | Biosil | Microsil | Control | Biosil | Microsil | Control | Biosil |
| Original DM | 17,7% | 30,3% | 29,5% | 31,9% | 29,4% | 31,5% | 33,2% | 32,6% | 32,8% |
| components (g/kg of DM) | | | | | | | | | |
| Crude prot. | 271,2 | 235,4 | 246,0 | 234,6 | 237,2 | 241,3 | 222,9 | 233,1 | 231,7 |
| Crude fat | 22,6 | 27,5 | 36,1 | 37,5 | 37,5 | 38,1 | 33,1 | 36,8 | 39,6 |
| Crude fibre | 231,6 | 267,3 | 249,5 | 263,1 | 262,7 | 219,0 | 250,0 | 254,6 | 253,0 |
| Crude ash | 118,6 | 121,0 | 130,9 | 128,3 | 126,0 | 165,1 | 135,5 | 125,8 | 131,1 |
| N-free extract. | 355,9 | 348,7 | 337,5 | 336,4 | 336,7 | 336,5 | 358,4 | 349,7 | 344,5 |
| Organic mat. | 881,4 | 879,0 | 869,1 | 871,7 | 874,0 | 834,9 | 864,5 | 874,2 | 868,9 |
| Starch | 22,6 | 16,5 | 13,5 | 15,6 | 13,6 | 12,7 | 12,0 | 12,3 | |
| WSC | 46,3 | 50,9 | 12,1 | 16,1 | 8,4 | 7,6 | 18,7 | 16,1 | |

*Effect on silage fermentation and stability*

Table 2 describe some fermentation characteristics in all variants of lucerne silage. All variants of ensiled forage was of high fermentation quality and we did not find many differences. High significant differences were observed between silage's with biological additives and control silage in value of UFT and pH. Addition of Microsil influenced the decrease of acetic acid content and Biosil increased content of pyruvate acid.

**Table 2.** Effect of biological additives on fermentation proces (content in g/kg DM)

| Fermentation | 1 ton containers | | | 3 t silos | | | 400 t |
|---|---|---|---|---|---|---|---|
| parameter | Biosil | Microsil | Control | Biosil | Microsil | Control | Biosil |
| pH | 4,2 | 4,2 | 4,3 | 3,5 | 3,4 | 3,5 | 4,3 |
| UFT | 25,1 | 24,8 | 27,4 | 26,7 | 25,3 | 24,5 | 24,5 |
| ammonia | 0,0 | 0,0 | 0,0 | 0,0 | 0,9 | 0,0 | 0,0 |
| Lactic acid | 94,8 | 92,3 | 96,5 | 95,2 | 99,4 | 95,1 | 86,4 |
| Acetic acid | 24,4 | 17,0 | 23,3 | 21,0 | 18,7 | 23,3 | 20,8 |
| Propionic acid | 3,7 | 3,7 | 3,6 | 3,8 | 3,0 | 4,6 | 3,3 |
| Pyruvate acid | 10,2 | 5,0 | 5,7 | 9,2 | 6,6 | 4,9 | 5,1 |
| Butyric acid | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |

We observed stability of all variants silage from 1 ton containers for 5 days (table 3). All variants of lucerne silage are very stable. We did not find presence of butyric acid. Presence of ammonia we find by Microsil treated variant after 5 days only.

**Table 3.** Running of stability process (content in g/kg silage)

| Kind of silage | Day of stability<br>1. day | 2. day | 3. day | 4. day | 5. day |
|---|---|---|---|---|---|
| **Biosil** | | | | | |
| pH | 4,21 | 4,18 | 4,25 | 4,27 | 4,35 |
| Ammonia | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Lactic acid | 28,00 | 17,00 | 18,00 | 20,00 | 23,00 |
| Acetic acid | 7,22 | 12,00 | 15,00 | 14,00 | 13,00 |
| Propionic acid | 1,10 | 2,20 | 1,10 | 0,80 | 0,80 |
| Butyric acid | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Microsil** | | | | | |
| pH | 4,22 | 4,23 | 4,28 | 4,42 | 4,45 |
| Ammonia | 0,00 | 0,00 | 0,00 | 0,00 | 0,10 |
| Lactic acid | 29,50 | 26,00 | 28,00 | 29,00 | 30,00 |
| Acetic acid | 5,83 | 6,50 | 6,20 | 6,10 | 6,60 |
| Propionic acid | 1,18 | 0,90 | 1,00 | 0,90 | 0,80 |
| Butyric acid | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Control** | | | | | |
| pH | 4,85 | 4,72 | 4,36 | 4,27 | 4,16 |
| Ammonia | 18,26 | 21,18 | 23,96 | 25,18 | 30,88 |
| Lactic acid | 4,08 | 4,83 | 6,08 | 5,97 | 6,08 |
| Acetic acid | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Propionic acid | 23,24 | 26,68 | 30,72 | 31,80 | 37,61 |
| Butyric acid | 0,00 | 0,00 | 0,23 | 0,27 | 0,22 |

*Effect on silage digestibility and intake*

The results of in vivo digestibility demonstrated Table 4. Skorko-Sajko (1993) described that using of biological additives had clearly effect on the nutritive value of silage. By Miller et al. (1990) and Jacobs and McAllan (1991) have been reported increased digestibility of organic matter of the probiotics treated silages. In our experiment we did not observed many significant differences between digestibility of individual variants of silages. Statistical significant proved is digestibility of crude protein only, which is higher by silage with Biosil.

**Table 4.** Digestibility of silages measured in vivo

| % of digestibility | Biosil | Microsil | Control | STATISTICAL TEST<br>Biosil/Microsil | Biosil/Contr. | Microsil/Contr. |
|---|---|---|---|---|---|---|
| D.of protein | 79,54 | 77,62 | 77,26 | 0,008** | 0,038* | 0,668 |
| Dig. of fat | 55,82 | 60,28 | 55,64 | 0,084 | 0,926 | 0,049* |
| Dig. of fibre | 50,70 | 52,91 | 49,01 | 0,142 | 0,444 | 0,136 |
| D.of N-free extr. | 77,53 | 76,10 | 77,30 | 0,212 | 0,844 | 0,392 |
| Dig. of org. m. | 70,09 | 69,43 | 69,01 | 0,427 | 0,411 | 0,746 |

Table 5 gives information about content of digestible nutrients of all variants of lucerne silage. The application of Biosil improved content of digestible crude protein. This effect is statistically high significant.

**Table 5.** Digestible nutrients of silages

| g/kg of DM | Biosil | Microsil | Control | STATISTICAL TEST<br>Biosil/Microsil | Biosil/Contr. | Microsil/Contr. |
|---|---|---|---|---|---|---|
| Digestible protein | 195,70 | 182,12 | 183,28 | 0,000** | 0,001** | 0,568 |
| Digestible fat | 20,16 | 22,63 | 20,84 | 0,020* | 0,306 | 0,049* |
| Digestible fibre | 126,43 | 139,32 | 128,44 | 0,013* | 0,720 | 0,118 |
| Dig. N-free extr. | 261,67 | 255,99 | 260,23 | 0,153 | 0,712 | 0,373 |
| Digestible org. m. | 609,10 | 605,28 | 603,17 | 0,584 | 0,592 | 0,854 |

**Table 6.** Intake of all variants of silage

| | daily intake of silage (kg) | dry matter of silage (%) | daily intake of dry matter (kg) | daily intake of DM on the LW (g/kg) | live weight of wethers (kg) |
|---|---|---|---|---|---|
| Biosil | 4,80 | 30 | 1,44 | 16,55 | 87 |
| Microsil | 6,30 | 32 | 2,02 | 23,09 | 87,5 |
| Control | 5,95 | 31 | 1,84 | 21,15 | 87 |

Highest intake of forage was observed at Microsil treated variant (Table 6).

*Effect on silage protein degradation*

The extend and rate of rumen degradation of silage protein are shown in Table 7. The Biosil and Microsil treated silage had slightly lower degradation in the shorter intervals (0,2,4,8) than control silage, but the final protein degradability was very similar by all variants. Marshall et al. (1993) reported that in experiment with rumen degradation of Ecosyl treated alfalfa silage was protein degradability 79,58% and without additives alfalfa silage was protein degradability also very similar - 79,23%.

**Table 7.** Rumen degradability of crude protein (%)

| Time of rumen inkubation | 0 | 2 | 4 | 8 | 16 | 24 | 48 | DEG |
|---|---|---|---|---|---|---|---|---|
| Biosil | 68,63 | 68,77 | 75,32 | 87,32 | 91,16 | 91,54 | 92,13 | 86,00 |
| Microsil | 70,15 | 69,17 | 74,10 | 87,47 | 90,55 | 90,61 | 92,16 | 85,80 |
| Control | 75,66 | 75,14 | 78,09 | 90,23 | 90,73 | 90,76 | 92,79 | 87,60 |

## Conclusion

All variants of lucerne silage from this experiment had a good quality and were very stable so the effect of the biological additives Biosil, Microsil and control were not evidential. Application of Biosil had significant effect on crude protein content in final silage and on in vivo digestibility of crude protein too. The results of forage intake not confirmed determinate efect of Biosil producer, because the untreated control had higher intake than Biosil treated silage. The degradability of protein in the lucerne silage's measured with nylon bags does not differ greatly between the Biosil treated, Microsil treated and control.

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# Nutrition Value and Organic Acid Content of the Combined Maize-Sorhum Silage Fermented with Several Kind of Biological Additives

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## Abstract

Advantages and disadvantages of co-cultivation and the combined ensilaging of maize and sorghum were investigated on the respects of fresh material, fermentation and nutritive values. It was concluded that the favourable interaction of the two plants was the most effective if they were mixed up evenly during cultivation. The most favourable combinations of row ratios were as follows: 2:1, 3:1 or 2:2 (maize: sorghum). The xerophile sorghum is able to produce 25-30 % more yield especially in drought weather. Its sugar content effected advantageously on the lactic acid fermentation. From the mixture of maize : sorghum, stable silage of high quality could be produced. As a consequence of the effect of different preservatives containing lactic acid bacteria the amount of lactic acid was increased while that of acetic acid was decreased in the silage. In vitro digestibility of silages did not alter. The crude protein and energy contents of the maize:sorghum mix silage were 10 % lower than the pure maize silage. As a consequence, sorghum increased the yield production and its sugar content favoured for fermentation and it improved the stability of silage, while its energy and protein contents were lower.

## Introduction

Good quality of maize silage is a basic food of primary importance in the nutrition of ruminants. Ensilaging maize at the end of yellow -ripe stage is optimal for its quality. Under arid weather conditions maize gets old quickly, its dry matter contents exceed the optimal 35-38 % within several days. Co-cultivation of maize and sorghum has numerous benefits and a few disadvantages. These two plants make up well each other. Sorghum belongs to plants of physiological type C4, the net productivity of its photosynthesis is much higher and transpiration rate is lower than those of other plants. Due to the waxy leaves and small number of stomas of sorghum its dry-tolerance exceeds that of the maize. Advantages of co-cultivation of the two plants make good especially under droughty weather conditions. Under such circumstances one could calculate a 20-30% over production. The two plant complement each other in chemical composition as well. The high starch content of maize provides energy, the sugar content of sorghum can be fermented quickly and easily and favours for rapid acidification.

## Materials and Methods

The variety of sorghum used: GK Ócsa, Monori édes, G1990, Róna 4, Sucrosorgó. The variety of maize used: TC3764A, TC3269, Occitan. **Biological preservatives used:** Feedtech100, Silaferm, Pioner 1132, fresh cell suspension ($10^5$ CFU/g $DM^{-1}$) of *Lactobacillus delbruckii*
Different variety of sorghum and maize were cultivated in monoculture and mixed, on field and plot experiments. In the rows 10 meters were selected. The plant density was calculated there and weights of the whole plant, leaves, stalk, cob or panicle were measured. The yields per acres were calculated. After harvesting the fresh plant material was chopped to 1.5 - 2 cm pieces, pressed in container which was suitable for stocking 200-250 kg fodder. Silage was prepared from maize (Occitan) it self and mixture of maize (Occitan) and sorghum (Monori édes), at a ratio of 3:1. Silages were untreated (control) and inoculated with biological preservatives containing lactic acid bacteria. The chemical composition of the fresh plant material and the silages were subjected to Weendei-analysis. The lactic and volatyle acid content (VFA) was analysed by gas chromatography.

## Results and discussion

It has been reported previously (Avasi et all., 1997) that there are considerable differences in the progresses, yields, chemical compositions and digestibility of the different varieties of sorghum. Consequently, the essential requirement of the successful co-cultivation is the choice of the proper sorts. The mutual ecological advantages of the two plants can be manifested if they are mixed quite homogeneously. The 2:1, 3:1 and 2:2 ratio for maize: sorghum is suggested. The relative proportion of the vegetative and generative parts of the two plants is considerable different (Table 1). The proportion of grain and cob plays essential role in the energy content and yield of maize silage. These are the more favourable in the ripped stage. By that time, however the dry matter content is in excess of 35% what is considered as optimum. The fermentable sugars condense to starch and insert into the grain, and because of the high dry matter content the possibility of compression grows worse. In the case of correct mixture of the plant varieties the dry matter content of sorghum is 10-12% lower, and the sugar content may reach 20-22% by the time of ensilaging. For the lactic acid bacteria this high amount of sugar is more rapidly fermentable carbohydrate than starch, so the rate of the acid production speeds up. Dry matter content of 35-40% can be considered optimum for the ensilaging material. Then maize has plentiful grain crop, high energy content and about 40-42% dry matter, while sorghum has high amount of sugar content and 28-32% dry matter. The nutritive values of the ensilaged maize and maize-sorghum mixture prepared without any biological preservatives and by preservatives containing different lactic acid bacteria can be seen in Table 2. The ratio of maize: sorghum was 3:1 in the ensilaging material. The crude protein and energy content were significantly lower in the silage mixture than in the pure maize silage. The crude protein by 9-10g $kg^{-1}$ DM, and the NE(I) by 0.8-0.9 MJ $kg^{-1}$ DM was lower. Table 3 shows the content and the ratio of acids. The total VFA and lactic acid content of each silage prepared by preservatives were higher than in the untreated silage. Comparing the total organic acid content and lactic acid/acetic acid/butyric acid ratio of the mixed silage to the pure maize silage treated in the same way both the amount and the ratio of the organic acids were more favourable in the case of the mixed silage. The ethanol and $NH_3$-N content was also significantly lower in the silage containing sorghum. There were no significant differences among the biological preservatives, but comparing preservatives containing lyophilised bacteria to the preservative which consisted from freshly fermented *Lactobacillus delbrückii* culture in the latter case the lactic acid content was higher by 18% in the pure maize and 12% in the mixed silage. This referees to that speed up of revitalisation in the preservatives can improve on the condition of fermentation.

## Conclusions

The advantages and disadvantages of mixing of maize and sorghum for ensilaging are as follows:
During cultivation mutual ecological advantages of the two plants develops especially if sorghum is mixed homogeneously among the rows of maize. The 2:1, 3:1 and 2:2 ratio for maize : sorghum is suggested.
Due to the high sugar content of sorghum fermentation starts more rapidly, pH decreases and the interval of autooxidation shortens. These conditions are favourable to lactic acid bacteria.
In the case of drought weather - when the dry matter content of maize increases rapidly - sorghum provides favourable dry matter for ensilaging for a long time.
Depending on the weather the yield of the mixed culture may be 10-30 % higher. Sorghum yields are more when maize yields less.
The higher fresh yield of sorghum goes with lower dry matter, so the energy or protein yields which can be harvested per acre will be higher only if the biomass production of the co-cultivated culture is at least 10% more.
The crude protein and energy contents of the mixed silage are 10% lower than those of the maize silage.
The energy and protein requirements of ruminantse can be satisfied only by feeding of more silage. The dry matter intake is especially unrealizable for the high productivity dairy cows.
The crude fibre content of sorghum is higher than that of maize. The ratio of the fibre fractions (NDF/ADF/ADL) is more unfavourable. The lower digestibility of sorghum can be explained by its unfavourable fibre constitution.

**Table 1**. Data of the co-cultivation of maize: sorghum (seeded in rows of 3:1)

| 10 meter section of the rows | | Maize (Occitan) | Sorghum (Monori édes) |
|---|---|---|---|
| | | Mean ± s | Mean ± s |
| Number of plants | | 56 ± 5.26 | 86 ± 3.61 |
| Fresh plant yield | kg | 54.3 ± 5.05 | 52.2 ± 2.51 |
| Stalk | kg | 18.6 ± 1.77 | 39.2 ± 1.84 |
| Leaf | kg | 11.4 ± 0.91 | 8.7 ± 0.47 |
| Cob / Panicle | kg | 24.2 ± 2.40 | 4.3 ± 0.21 |
| weight of one plant | kg | 0.97 | 0.61 |
| height of plant | m | 2.53 | 3.74 |

**Table 2**. Chemical composition and energy content of the maize-sorghum mixed silage.

| Treatment | DM | CP | EE | CF | NFE | Ash | NE(l) |
|---|---|---|---|---|---|---|---|
| | % | g kg $DM^{-1}$ | | | | | MJ $kgDM^{-1}$ |
| Uninoculated maize silage | 40.8 | $81.9^a$ | 47.1 | 202.9 | 628.3 | 39.7 | $6.65^a$ |
| Inoculated maize silage | 41.5 | $85.1^a$ | 44.7 | 171.7 | 659.4 | 39.0 | $6.66^a$ |
| Uninoculated mixed silage | 39.7 | $76.1^b$ | 31.0 | 172.8 | 680.3 | 39.8 | $5.80^b$ |
| Inoculated mixed silage | 38.5 | $75.6^b$ | 29.5 | 172.9 | 680.1 | 41.9 | $5.77^b$ |

DM: Dry matter, CP: crude protein, EE: ether extractCF: crude fiber, NFE: N-free extract

**Table 3**. Organic acid composition of the maize-sorghum mixed silage.

| Treatment | DM basis (%) | | | | Total acids basis (%) | | |
|---|---|---|---|---|---|---|---|
| | Total acids | Lactic acid | Acetic acid | Butyric acid | Lactic acid | Acetic acid | Butyric acid |
| Uninoculated maize silage | $4.96^a$ | $3.88^a$ | $1.03^a$ | $0.047^a$ | 78.27 | 20.78 | 0.95 |
| Inoculated maize silage | $5.82^b$ | $4.72^b$ | $1.06^a$ | $0.039^b$ | 81.11 | 18.22 | 0.67 |
| Uninoculated mixed silage | $6.05^b$ | $4.84^b$ | $1.18^a$ | $0.028^c$ | 80.03 | 19.51 | 0.46 |
| Inoculated mixed silage | $6.30^c$ | $5.06^c$ | $1.21^a$ | $0.027^c$ | 80.36 | 19.22 | 0.43 |

abc: Means in column with different superscripts are statistically significant (P>0.05)

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# Evaluation of the CRIMPSTORE 2000 Additivum Effect on the Fermentation Process and Microbial Quality of Silages from Maize and Triticale Grain Squeezed

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## Abstract

In the present study, assesed were the fermentation process quality, rumen starch degradability level and hygienic quality of silages from maize and triticale wet grain squeezed. From reciprocal comparison of fermentation products from both silages, it is evident that the triticale silage contained more LA (by 83%), higher titrating acidity (by 43%), lower pH and lower AA proportion. In this silage, a more favourable was that of LA/AA (3.51 x 1.69), better percentage of LA proportion and lower ethanol content (1.51 x 4.69 g/kg DM). In the maize grain silage, a clearly lower rumen starch degradability was found during all examinations (difference of 72.6%). In the samples of both silages, a very low total number of microorganisms (TNM), yeasts and micromycetes was determined not only at the first sampling but also 4 days after that.
silages, rumen starch degradability, yeasts, molds

## Introduction

The essential precondition of the cattle effective breeding is to ensure the preparation of feeds in high quality, to increase the consumption of voluminous feeds by animals at using successful conservation at simultaneous preservation of nutriment need and animal utility. These efforts are not done without concentration increase in feeds, therefore, without using of harvest and conservation new technologies to which, beside products of maize separate harvest (CCM, or CEM – Crushed Ears of Maize ), also ensilaging of squeezed wet grain, preserved by chemical preparations, belongs. Effects of chemical additiva on feed plants containing proteins ensilaged have been know already for long time, and they are used due to their conserving safety in a series of countries (Rooke et al., 1983, Chamberlein et al., 1982, Kiely et al., 1989, Knabe et al., 1986 and others). It was confirmed that feed plants ensilaged, using the chemical additiva and observing the other technological principles, provide a higher effect and safety than silages without additiva. To apply chemical mix additiva is indispensable also in wholegrain or squeezed cereals, since the effect of biological additiva in ensilaging this substrate is not always successful under working conditions (Mikyska et al., 2000). Cereals with starch assimilation completed are characteristic of the high content of this polysaccharide with different composition and easily dissoluble sacchars. It is reported in general (Bolsen, 1993) that bacteria of lactic fermentation (LAB) can utilize starch from cereals as energertic source only after the previous hydrolysis to simple dissoluble sacchars. As well, Wolford (2000) states that bacteria of lactic fermentation cannot utilize starch as energy source. These atypical silages with the dry matter higher content have, without effective conservation, a limited fermentation level, they are frequently warmed and are noted for aerobic unstability.
This constribution is aimed at assessing the effect of the CRIMPSTORE 2000 additivum added to squeezed cereals of maize and triticale, on the fermentation process, starch degradability level and silage microbial quality.

## Materials and methods

Wet maize and triticale grain was adjusted by the squeezer MURSKA 1400, treated with the CRIMPSTORE 2000 chemical additivum in the ration of 3 l/ t maize grain, 3.5 l/t triticale grain and ensilaged in the PE bags (AG Bag). Silages were sampled and analysed after 8 months storage for fermentation fundamental characteristics, rumen starch degradability, yeasts, fungi and total number of microorganisms (TNM). Fungi were determined using the range method on Czapek-Dox agar, yeasts on Sladinka agar. The cultivation period was 5 days at the temperature of 25 $^{o}$C.

## Results and discussion

The average fermetation characteristics of both working silages from squeezed cereals are presented in Table 1. From the results, it is evident that the fermentative process in triticale passed differently from that in maize grain squeezed. In the triticale silage not only higher acidity (4.27:4.50), higher titrating acidity but also higher content of fermentation acids were found. More favourable was also the ratio and proportion of lactic acid (LA) versus the other acids. In this sailage, also alcohol significantly lower content was found, being only 32% proportion of the maize silage content. Silages were noted for the starch high content (641-691 g/kg dry matter), which was probably the substrate for alcohol creation. It can be stated that both atypical silages, also as to their higher dry matter content (565 and 587 g/kg), are also for limited fermentation. The rumen starch degradability level of grain ensilaged is presented in Table 2. From the results, it is evident that the triticale grain silage has the starch degradability significantly higher than maize. Great differences in degradability were registered during the whole time period, when the starch degradability in triticale grain was 1.73 x higher than in maize. The difference is caused by different composition of the amylotic complex. Confirmed were findings by Sommer (2000), Čerešňáková and Sommer (2000) and Dvořáček et al. (1999) who report the low values of starch degradability in maize. From the data known hitherto, it is evident that the starch degradability of maize grain ensilaged with CRIMPSTORE 2000 additivum found by us is comparable with the values in CCM, but it is lower than that in CEM or that in maize silage. It is clear that starch slower degradability of maize silage in the animal rumen will depend on greater stabilization of fermentation processes in the rumen (Sommer, 2000). Assessments of triticale starch degradability level indicate that the starch of this cereal has other property the trend to higher hydrolysis, which, at the higher ration of this feed, can lead to faster acidification of the rumen environment, since starch disintegrates in the animal rumen to volatile fat acids (VFA). The total numbers of microorganisms, sporulating microorganisms (producing spores), yeastes and fungi are presented in Table 3. The results indicate a very low content in general not only of TNM, but also of fungi and yeasts. In fungi and yeasts colonies, the concentration of $10^5$ cfu/g was not attained , which is considered by Woolford (2000) and Daniel et al. (1970) to be the limit when silages use to be very susceptible to aerobic decay. Yeasts und fungi did not occur practically in the first samples of silages treated, which is also documented by the ethanol very low content. After 4 days from sampling, the yeasts increase to the value of 6.67 .$10^3$/g was registered in maize grain, and to 1.23 . $10^3$/g in triticale grain silaged. It can be stated that the CRIMPSTORE 2000 additivum added had disinfective and antimicrobial effects, and the hitherto partial findings indicate that it will have a positive effect also on strengthening of aerobic stability.

## Conclusions

The ensuring of fermentation process quality and silage high hygienic quality, regards the cattle nutrition, their health and voluminous feed utilization, is of fundamental importance. The quality of squeezed cereal silage is affected not only by dry matter but also by the effective additivum added. The CRIMPSTORE 2000 preparation had, even at dry matter high content and fermentation course limited, favourable effects on needed acidification, ethanol and acetic acid limited creation. The favourable effect was registered in silage microbial quality, or in resistence to aerobic degradation. The silage from squeezed maize grain conserved by CRIMPSTORE 2000 had the lower starch degradability than the triticale grain silage.

**Table 1.** Mean fermentation characters of squeezed grain silages

| | Drry matter | pH | TA | FT | LA | AA | Sum of acids | LA/AA | %LA/sum | Alcohol | Starch |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | g/kg | | mg/100 g | % | g/kg DM | | | | % | g/kg DM | |
| Maize | 587,28 | 4,5 | 860,1 | 0,101 | 15,24 | 9,03 | 24,27 | 1,69 | 62,2 | 4,69 | 691,1 |
| Triticale | 564,6 | 4,27 | 1229,8 | 0,232 | 27,9 | 7,97 | 35,87 | 3,51 | 77,78 | 1,51 | 640,8 |

TA- titration acidity, FT-formol titrartion

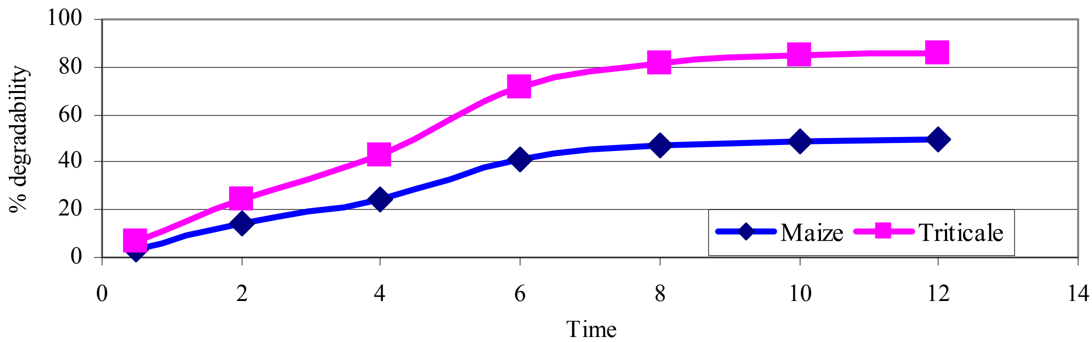
**Table 2.** Rumen starch degradability level of maize (A) and triticale (B) grain ensilaged

| Corn/Time | 0,5 | 2 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|---|
| A | 3,72 | 14,3 | 24,72 | 41,57 | 47,45 | 48,98 | 49,83 |
| B | 6,41 | 24,69 | 42,68 | 71,75 | 81,91 | 84,55 | 86,02 |

**Table 3.** Total number of microorganisms (TNM) and sporulating microorganism in silages

| Grain | TNM.$10^3$/g | Sporulative .$10^3$/g | Yeats .$10^2$/g | Mold .$10^2$/g |
|---|---|---|---|---|
| Maize | 172 | 2 | 2 | 1 |
| Triticale | 5,7 | 1,7 | 0 | 0 |
| Maize +CRIMPSTORE | 133 | 0,7 | 0 | 0 |
| Triticale+CRIMPSTORE | 5 | 1,3 | 0,7 | 0 |
| after 4 days later | | | | |
| Maize +CRIMPSTORE | 168 | 1,3 | 66,7 | 0,3 |
| Triticale+CRIMPSTORE | 12 | 0,3 | 12,3 | 0,3 |

**Figure 1.** Average level of starch degradability of silages during rumen incubation




References at the autors

*The work has been elaborated within the research design No MSM 432100001*

# Selection of Lactic Acid Bacteria and Silage Preparation of Forage Paddy Rice

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## Abstract

Tow selected strains, *Pediococcus acidilactici* CA 25 and *Lactobacillus plantarum* FG10 that were isolated from forage, and *Lactobacillus rhamnosus* SN1 from commercial inoculant, were used as additives to silage preparation of forage paddy rice. The silage treated with strains CA25, FG10 and SN1 were well preserved; had significantly lower pH values and fermentation losses; and higher contents of lactic acid compared with the control silage after 30 d of fermentation. Strain FG10 was more effective in improving silage quality than strains CA25 and SN1.
**Key words:** Lactic acid bacteria, Forage paddy rice, Silage

## Introduction

Forage paddy rice is major silage crop in Japan and it has been widely used for silage making. However, limited information is available on the characteristics of lactic acid bacteria (LAB) isolated from forage crops and their effect on the silage fermentation. In this experiment, tow selected strains of LAB, CA25 and FG10 were isolated from forage crops, and their characterization and application for silage preparation were examined.

## Materials and Methods

Paddy rice grown in a farm field (Ohtawara, Tochigi, Japan), was harvested at the ripe stage in November. Silage was prepared by using a small-scale system of silage fermentation (Cai, 1999). Strains CA 25 and FG 10, isolated from forage crops, and SN1 isolated from commercial inoculants [Snow lacto-L (*Lactobacillus rhamnosus*; Brand Seed Ltd., Sapporo, Japan)] was used as additives at $1.0 \times 10^5$ cfu/g of fresh matter (FM). Approximately 100g portions of forage material, chopped into about 20mm lengths, were packed into plastic film bags (Hiryu KN type, 180x260cm; Asahikasei, Tokyo, Japan), and the bags were sealed with a vacuum sealer (BH 950; Matsushita, Tokyo, Japan). The silage treatments were designed as follows: untreated control; CA25; FG10 and SN1. The bag silos were stored at 25°C, and three silos per treatment were used for chemical analysis of silage.

## Results and Discussion

The counts of microbiological are shown in Table 1. Overall $10^6$ (cfu/g of FM) aerobic bacteria, $10^3$ coccus-shaped LAB, $10^5$ molds and $10^4$ yeasts were found in materials. Lactobacilli were too few to found in materials to count. Strains CA 25 and FG10 were Gram-positive and facultatively anaerobic bacteria that did not produce gas from glucose and formed approximately equal quantities of L-(+)- and D-(-)-lactic acid. Strains CA25 andFG10 were identified as *Lactobacillus plantarum* and *Pediococcus acidilactici*, respectively, on the basis of DNA-DNA homology (Cai et al. 1999). Tow strains and *Lactobacillus rhamnosus* SN1 from commercial inoculant were able to grow at pH values below 3.5, fermented glucose, fructose, and sucrose. They produced high content of lactate in MRS broth.

**Table 1.** Viable numbers of microorganisms in fresh forage paddy rice.

(Log colony-forming units per gram of fresh matter)

| Aerobic bacteria | Lactobacilli | Coccus-shaped lactic acid bacteria | Yeast | Mould |
|---|---|---|---|---|
| 6.3 | nd | 3.2 | 4.2 | 5.4 |

Values are mean of three samples; nd, not detected.

**Table 2**. Fermentation quality of 60-day silage of forage paddy rice.

| | Control | CA25 | FG10 | IN-A |
|---|---|---|---|---|
| pH | 5.0$^{a}$ | 4.5$^{bc}$ | 4.1$^{d}$ | 4.6$^{c}$ |
| DM, kg/g of FM | 342.2 | 350.4 | 357.5 | 372.3 |
| Lactic acid, %FM | 0.3$^{d}$ | 0.89$^{bc}$ | 1.6$^{a}$ | 0.8$^{c}$ |
| Acetic acid, %FM | 0.4$^{a}$ | 0.1$^{b}$ | 0.1$^{b}$ | 0.1$^{b}$ |
| Butyric acid, %FM | 0.3$^{a}$ | 0.1$^{b}$ | 0.1$^{b}$ | 0.2$^{a}$ |
| Propionic acid, %FM | nd | nd | nd | nd |
| Ammonia N g/kg of DM | 0.8$^{a}$ | 0.5$^{b}$ | 0.4$^{b}$ | 0.6$^{ab}$ |
| Gas Production, L/kg of DM | 5.7$^{a}$ | 3.5$^{bc}$ | 3.1$^{c}$ | 4.0$^{b}$ |
| DM loss, g/kg of DM | 85.0$^{a}$ | 73.3$^{cd}$ | 70.5$^{d}$ | 75.2$^{c}$ |

Means in the same row with different superscripts are significantly different ($P<0.05$). CA25, *Pediococcus acidilactici*; FG10, *Lactobacillus plantarum*; IN-A, Inoculant with *Lactobacillus rhamnosus.*

The silage quality of forage paddy rice was shown in Table 2. The silage treated with strains CA25, FG10 and SN1 were well preserved; had significantly lower pH values, butyric acid, propionic acid, and ammonia N concentrations, gas production, and dry matter losses; and higher contents of lactic acid compared with the control silage after 30 d of fermentation. These results suggest that two strains used in this study were homofermentative LAB, and they may grow under low pH conditions. Therefore, inoculation with these strains may results in beneficial effects by promoting the propagation of LAB and by inhibiting the growth of clostridia and aerobic bacteria, as well as by decreasing the fermentation loss. Strain FG10 was more effective in improving silage quality than strains CA25 and SN1. The results confirmed that *Lactobacillus plantarum* FG10 is suitable as potential silage inoculant for forage paddy rice.

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# Do We Need a Common Testing System for Silage Additives?

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## Introduction

A silage additive should improve fermentation quality or aerobic stability in comparison to silage not treated. This means, the efficacy of an additive is measured by the differences in fermentation quality or aerobic stability between the untreated (negative control) and the treated forage. The forages chosen for the test should have similar ensilability characteristics as the forages the additive is recommended for.

## Type of experimental silos

Ensiling and storing techniques have largely improved over the last twenty years, in particular, silos and their seals are more or less airtight. As a consequence, the use of small laboratory silos, which can be hermetically sealed and allow fermentation gases to escape, is very much in line with on-farm conditions.
Often, the small quantity of forage used in laboratory tests is quoted as a reason against using that method, but fermentation does not depend on the quantity of forage per se.

## Temperature at storage

It is known that the growth of clostridia is encouraged by higher temperatures. A storage temperature of 25° C, normally used with laboratory silos, leads to a higher butyric acid content than with silages in farm silos. However, this is true for the negative control and the silage treated.

## Choic*e* of forages

Principally, the tests should be carried out with the forage the additive is designed for. At the very least, the ensilability of the forages used in the test should be roughly the same as that of the forages for which the additive is recommended. For example: two forages A and B, with forage A not prewilted, and with a higher sugar content than forage B, but the latter being prewilted, may have the same ensilability. There are differences as regards the osmotolerance of lactic acid bacteria in the biological additives, which is of importance with heavily prewilted forages which have a higher osmotic pressure (because of the higher sugar content in the prewilted forage). Solid chemical additives may not dissolve fast enough or completely on forages with a DM content of 30% or more. The same problem may arise with biological additives in granular form.

## Testing the effects on fermentation quality

In 1994 and 1995, a comparison was carried out in France at INRA in Theix, together with the Institute for Animal Production at Grub, between the French testing system (4 m$^3$ silos, forages directly harvested, DM content around 20%) and the German DLG system (ensiling in jars, range of DM from 20-50%). Only the results of the second year trials and from silages analysed at the Institute of Theix are shown here (for further information, see: Pflaum et al., 1996).

| | n[1)] | DM of silage[2)] | lactic acid | acetic acid g/kg DM | butyric acid | pH | $NH_3$-N[3)] |
|---|---|---|---|---|---|---|---|
| without additive | | | | | | | |
| Jar | 2 | 21,6 / 23,3 | 45 | 49 | 4 | 4,17 | 8,3 |
| Jar in silo [4)] | 6 | 22,2 / 23,6 | 38 | 25 | 24 | 4,20 | 8,2 |
| Bag in silo [5)] | 3 | 21,7 / 23,0 | 45 | 21 | 23 | 4,15 | 7,7 |
| INRA silo, 4 m$^3$ | 1 | 22,0 / 23,2 | 48 | 27 | 11 | 4,15 | 8,2 |
| with an additive (biological) | | | | | | | |
| Jar | 2 | 22,5 / 23,5 | 104 | 12 | 0 | 3,75 | 5,3 |
| Jar in silo [4)] | 6 | 21,9 / 22,7 | 95 | 10 | 0 | 3,80 | 5,0 |
| Bag in silo [5)] | 3 | 22,2 / 23,3 | 86 | 14 | 3 | 3,87 | 5,5 |
| INRA silo, 4 m$^3$ | 1 | 20,7 / 21,8 | 86 | 23 | 7 | 3,94 | 6,7 |

[1)] number of jars resp. bags or silos, [2)] first value uncorrected, second value corrected for volatiles, [3)] Ammonia N, as % of total N, [4)] Jars put into the INRA silo , [5)] Bags (nets) put into the INRA silo

The results between the different types of „silo" are rather similar, taking into account the errors of sampling and analysing. There is a remarkable improvement in fermentation quality with the use of the additive, irrespective of the type of „silo".
A summary of all the trials (8 comparisons) shows a tendency of a better fermentation quality in jars than in the INRA silos, both with the treated and not treated silages.
Because of the hermetic sealing of the jars, the conditions for fermentation may be somewhat better than in the INRA silos (and under farm conditions), but all the DLG testings in jars dit not bring about any label for biological additives

for the use of forages difficult to ensile. Even in jars a bad ensilability stays bad.

### Testing the effects on aerobic stability

Testing of the effects of an additive on the aerobic stability of silage leads to objective results in laboratory silos, when practical conditions are simulated (system Honig). Under practical conditions, there may be air ingress during storage before the silo is opened (imperfect sealing), and after opening, air ingress is unavoidable.
With the DLG testing system (system Honig) the imperfect sealing is simulated by removing stoppers from the jars, one at the bottom of the silo and one in the lid, twice for 24 hours each during the storage time. Normally, the storage time recommended for laboratory fermentation trials is 90 days. In the case of aerobic stability tests, only 42 days is recommended. Otherwise, the number of yeasts and moulds would be reduced too much during the long storage time under largely anaerobic conditions (only two days of „air stress“).
The situation after opening of the silo is simulated by putting the laboratory silo silage into small recipients (tin cans) with holes in the cover and at the bottom, so the $CO_2$ can flow out at the bottom and air can enter through the top. The recipients are surrounded by an insulating material to retain the heat produced by aerobic activity in the silage. The temperature rise is measured. In addition, cell counts of yeasts and moulds can be carried out.
Using this method, large differences can be found in aerobic stability between treated and untreated silages, but rather big differences may also occur between the repeats within treatment. This may be due to the small quantities of silage: one sample may be much more „infected“ by yeasts and moulds than the other.
This variability may also have a good side: It shows the „penetrating power“ of an additive.
Driehuis et al. (1999) carried out trials as to the efficacy of an additive (L. buchneri) to improve aerobic stability of maize silage under laboratory and farm conditions. They compared silages from jars (simulating airtight conditions), bags (simulating „air stress“ conditions, imperfect sealing) and farm silo. The improvement in aerobic stability by the additive was as follows: in jars from 245 to >336 h, in bags from 30 to 293 h, in the farm silo from 9 to 41 h. The additive improved aerobic stability significantly under all three conditions. The question is, whether the efficacy is sufficient enough under farm conditions (there is not only one farm condition!). On another farm, with a better sealing (even airtight sealing is possible in practice!) the results may have been close to the results with bags.

### Digestibility and feeding trials

The French testing system demands feeding trials with sheep (ad libitum, measuring digestibilitiy and silage intake) when chemical additives are tested, because some can decrease silage intake and others containing formol can lower protein digestibility. The French test system does not include feeding trials with cattle (milk cows, fattening animals...). The French specialists say, there is no need for trials with cattle because an improvement of fermentation quality and aerobic stability would also mean an improvement of animal performances. Most other testing systems consider also feeding trials with cattle.
For the farmer who wants to make the best choice of additive, these additional results on silage intake, digestibility, milk and growth performances confirm the potential of the additive judged by the improvement of fermentation quality and aerobic stability. In addition, these results out of feeding trials give the farmer an idea to what extent improvements of animal performances are possible by the use of additives.

### Conclusion

No testing system can claim to be the best. In addition, not only the accuracy and the objectivity of the test have to be taken into account, but also the costs. With laboratory silos the expenditure of labour is low. The costs of determinig the fermentation paramenters are rather high. The gas losses, easy to measure by weighing the jars, together with the pH, allow a good estimation of the fermentation quality. Therefore, it should be considered to carry out the silage additive tests with a higher number of forages, but with a reduced number of fermentation criteria measured.
The testing systems are no secret. When a testing system, applied in one country is acknowledged by „experts“ of another country, the test results should be used for „homologation“ respectively labelling in the „third party“ country.
There is still room for improvements in testing systems. It is recommended that persons and organisations responsible for silage additive testing work more closely together by exchanging ideas and experiences and, finally, by testing one and the same additive together, with different methods. In Europe, we do not need a common testing system, but certain guidelines should be respected.
Burocratic obstacles to the admission of silage additives in countries not having a testing system or having their own (better) system, should be abandoned. What should count most, is the efficacy and the safety of the additive.

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# The Effect of Biological Additives on Fermentation Process and

# Aarobic Stability of High Dry Matter Maize and Ears Silages

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## Introduction

The aerobic stability of maize silage that is generally initiated by yeasts (F.Driehuis et al. 1999) is a well known problem these days. When a silo is open the air has unrestricted access to the exposed feeding face. The aerobic microorganisms present in the silage can consume soluble nutrients, including lactic acid, which increases the temperature and pH of the silage (K.K.Bolsen et al.1996).

The number of cows in the Czech Republic went down very dramatically in the last 10 years (from 1.200 ths. in 1989 to 550 ths. in 2000). The size of a silo on farms is still huge. The feedout phase of silages is slower and during the summer maize silages get warm. The intake of DM of silages also goes down. The silages with high DM were a problem during summer when there is a very low aerobic stability and the content of mould and the activity of yeasts go up.

The objectives of these experiments were to determinate the effect of LAB and Bioprofit on the fermentation process and the aerobic stability of maize silage and ears silage.

## Materials and Methods

**Experiment 1** Maize at black layer stage of maturity (40 % of DM) was treated with water (Control), LAB – lactic acid bacteria (1x $10^5$ cfu.g of FM), and Bioprofit (1 x $10^6$ cfu.g of FM) and ensiled in laboratory jars.

**Experiment 2** Ears silage – 62 % DM was harvested and treated with water and Bioprofit (1 x $10^6$ cfu.g FM) and ensiled in laboratory jars.

**Exp. 1 and 2** Laboratory silos (4 l) were stored at 25° C for 90 days. After the opening samples were taken and analyzed for chemical composition (DM, pH, Lactic acid, Acetic acid, Ethanol, Yeasts and Moulds) and aerobic stability (Honig, H. 1991)

## Results and Discussion

The effect of biological additives (LAB and Bioproft) on the fermentation pattern of the whole crop maize is shown in table 1 and ears silage in table 2. The aerobic stability is shown in figure 1 and 2.

*Experiment 1*

Maize silage treated by LAB has the lowest pH (3,98), the highest content of lactic acid (50,9 g.kg DM), good ratio of Lactic acid/Acetic acid (4,89) and the lowest losses of DM (0,9 %). Maize silage treated by Bioprofit has a similar chemical composition, but a higher content of acetic acid (18,0 g.kg DM) and higher losses of DM (3,01 %). The control silage has a lower content of lactic acid and the higest losses of DM (4,67 %). The aerobic stability (figure 1) of maize silage was the best for maize silage treated by Bioprofit. During 7 days the temperature of silage was the lowest (max. 21,5°C). The worst aerobic stability was found in the silage treated by LAB. After 28 hours the temperature was 25° C and the temperature of the control maize silage was 25° C after 54 hours.

*Experiment 2*

The chemical composition of control maize silage and Bioprofit treated silage is similar. Only the content of ethanol and the losses of DM are lower in silage treated by Bioprofit (Table 2). Also the content of yasts and moulds is lower at silage treated by Bioprofit. The aerobic stability of ears silage was tested in the same way as with the maize silage (figure 2). We can see that the temperature of Bioprofit treated ears silage was the same for 96 hours but the temperature of the control silage is 25° C in only 48 hours.

These results indicate that Bioprofit is capable of improving the earobic stability of silage by the inhibition of yeasts. An important underlying principle of this effect is the production of propionic acid, which suppress as the yeast

**Table 1.** Chemical composition of maize silage (40 % DM) (62 % DM)

| | Control | Bioprofit | LAB |
|---|---|---|---|
| Dry matter g.kg | 427 | 419 | 440 |
| PH | 4,01 | 4,02 | 3,98 |
| Lactic acid g.kg DM | 41,5 | 49,2 | 50,9 |
| Acetic acid g.kg DM | 10,4 | 18,0 | 10,4 |
| Lactic acid/acetic acid | 3,99 | 2,73 | 4,89 |
| Ethanol g.kg DM | 3,2 | 1,0 | 4,0 |
| Losses of DM % | 4,67 | 3,01 | 0,92 |
| Yeasts cfu.g | 4,7 x $10^3$ | 7,7 x $10^3$ | 5,3 x $10^3$ |
| Moulds cfu.g | 3x $10^3$ | 1 x $10^3$ | 15,7 x $10^3$ |

**Table 2.** Chemical composition of ears silage

| | Control | Bioprofit |
|---|---|---|
| Dry matter g,kg | 630 | 640 |
| PH | 3,96 | 3,98 |
| Lactic acid g.kg DM | 27,5 | 26,9 |
| Acetic acid g.kg DM | 6,7 | 6,0 |
| Lactic acid / Acetic acid | 4,1 | 4,5 |
| Ethanol g.kg DM | 7,8 | 4,9 |
| Losses of DM % | 4,0 | 2,1 |
| Yeasts cfu.g | 7,3 x $10^3$ | 0,7 x $10^3$ |
| Moulds cfu.g | 2,7 x $10^3$ | 1,0 x $10^3$ |

LAB – Lactic acid bacteria

**Figure 1** Aerobic stability of maize silage (40 % DM) treated by biological additives

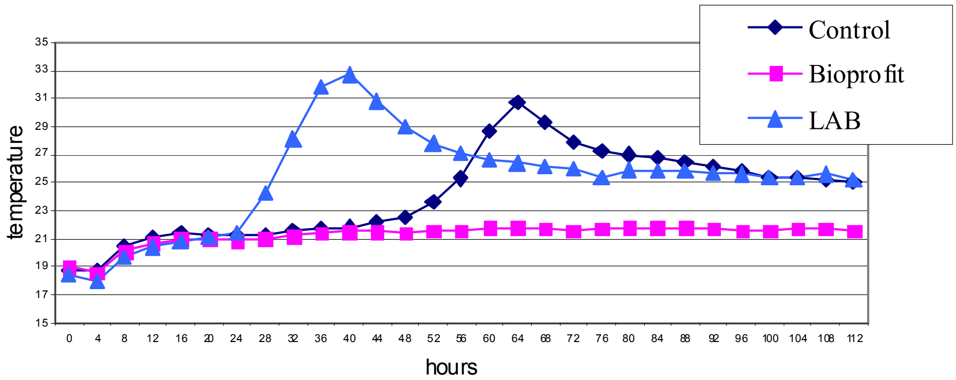
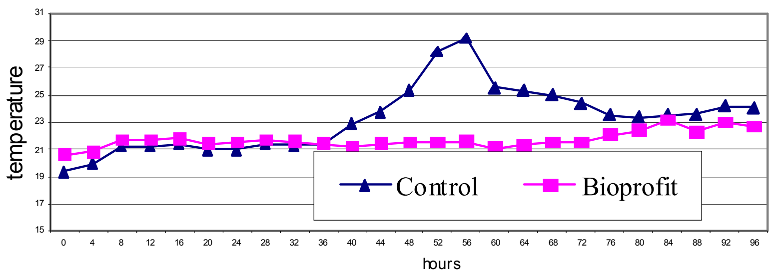



**Figure 2** Aerobic stability of ears silage (LKS 62 % DM).

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# SILA-BAC® Stabilizer Improves Aerobic Stability of Silages

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Heating of silages after opening is a wide spread problem. The process is mainly due to the activity of unwanted yeasts, that can degrade lactic acid in the presence of air. This causes an increase in pH and temperature which can lead to losses up to 40% (Honig, personal communiaction). The feed value of the silage can decrease significantly.

Good ensiling technique e.g. optimum compaction and good sealing can reduce the risk of heating dramatically. Also a clean silage face can minimize losses. In addition a feed-out rate of 1.5 m per week during winter time and 2.5 m per week during summer time is important. This means that silo size and form has to be planned depending on the number of animals.

In spite of good ensiling technique there are still instable silages. In such cases the use of SILA-BAC® Stabilizer (Pioneer® 11A44) which contains an effective strain of *Lb. buchneri* (ATCC 202118) can improve silage quality by inhibiting the spoilage organisms, the yeasts.

The stabilising effect of SILA-BAC Stabilizer was tested in a number of ensiling trials. The benefits of this product were also proven in a brought on-farm test. Gras and corn silages were very stable and therefore could conserve the high feedvalue and intake of the silage.

In ensiling trials with lab scale silos the effect of SILA-BAC Stabilizer was tested under stress conditions. Silos were air infused during the ensiling process to challenge an increase of yeast counts (Pahlow et al, 1999). Compared to untreated control SILA-BAC Stabilizer treated silages resulted even under these stressful conditions in significantly lower yeast and mould counts (Fig. 1).

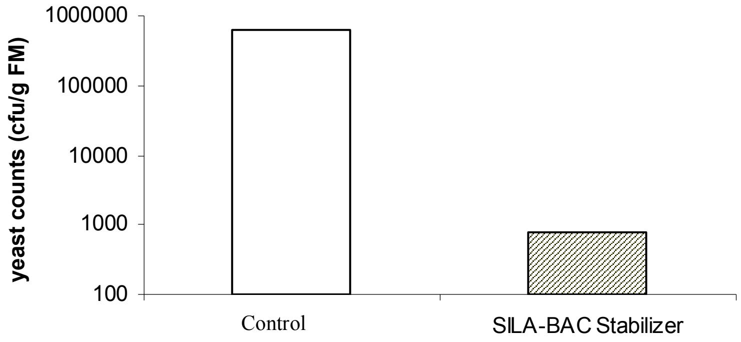


**Figure 1.** By treating silage with SILA-BAC Stabilizer (Pioneer 11A44) unwanted lactic acid assimilating yeasts can be inhibited (mean of 15 ensiling studies)

This inhibition can be explained by a specific fermentation pattern of SILA-BAC Stabilizer treated silages. On average a decrease of lactic acid from 1,8 % FM (control) to 1,5 %FM (Sila-Bac Stabilizer) and an increase of acetic acid from 0,4 (control) to 0,9 (Sila-Bac Stabilizer) could be observed. In addition Sila-Bac Stabilizer treated silages contained on average 0,4 % FM of Propandiol. The shift in fermentation acids still resulted in a lower pH of the SILA-BAC Stabilizer treated silages compared to an untreated control.

In a feeding trial with sheep feed intake of untreated and Sila-bac stabilizer treated gras was determined. No differences in intake were observed although there was a higher acetic acid content in the treated silage (Immig, 2001).

These changes led to a better storage quality of the silage during feed-out. Compared to the untreated control silages the SILA-BAC Stabilizer treated silages showed a higher stability of at least 4 days. This could be demonstrated also in trials at official German research stations. A significant improvement of aerobic stability could be observed in grass silage (Fig. 2) as well as in corn silage (Fig 3).

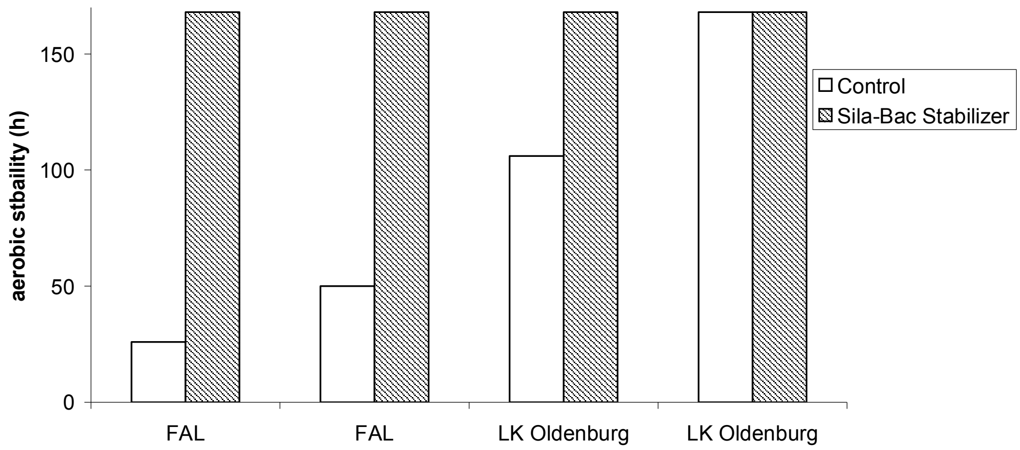


**Figure 2.** Aerobic stability of untreated and SILA-BAC Stabilizer (Pioneer 11A44) treated grass silage (4 official ensiling studies)

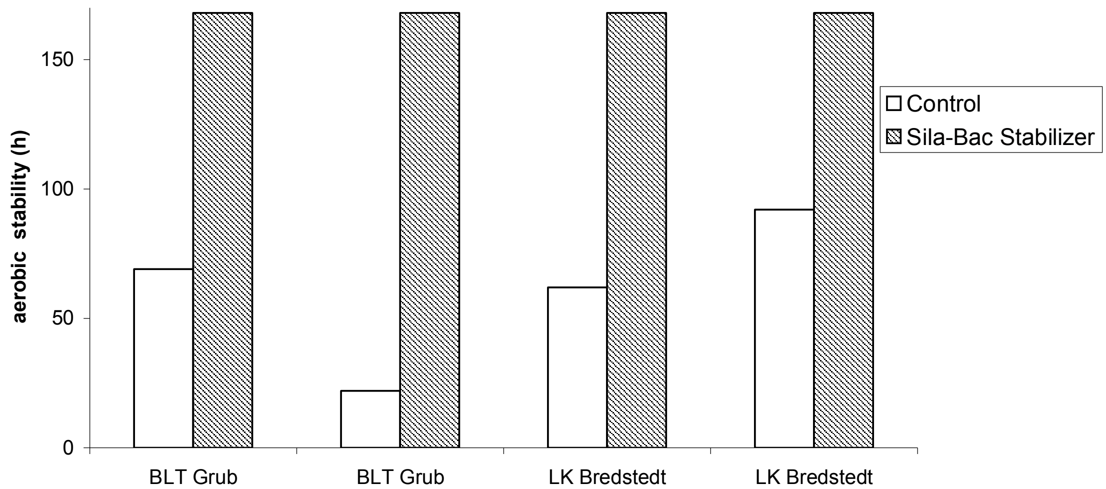


**Figure 3.** Aerobic stability of untreated and SILA-BAC Stabilizer (Pioneer 11A44) treated corn silage (4 official ensiling studies)

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# THE TECHNOLOGY OF FORAGE HARVEST, PRESERVATION AND STORAGE

# Hygienic Quality and Nutrient Losses in Round and Square Bale Silages.

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## Abstract

Within the Nordic countries the bale silage system represents 30 – 40 % of the total grass conservation .

Optimal bale ensiling and handling can easily be adopted to a high nutritive value and give low nutrient losses, ( WSC ), ( 3 – 4 % ). Wilting is the most important factor as it increases the hygenic quality, gives high density and stable bales and reduces costs of labour and plastic. The permeation and/or leakage of oxygen/ carbondioxide through or between the plastic layers must be low. A film colour that reflects the sun light / heat stress reduces the permeation, the temperature in the bale, growth of fungi and the nutrient losses. The film width influences the leakage between layers and the losses since a wider film increases the gas tightness. An optimal prestretching ( 55 – 80 %) and overlapping ( 50 % ) of a high quality white film applied in 2 + 2 + 2 = 6 layers of a 25 µm thick and 750 mm wide film is recommended to secure the hygienic quality and economicly preseve the nutrients. Use of silage additives active against both negative bacteria and fungi is necessary in wet ( < 40 % DM ) forage to avoid clostridial growth as well as in high wilted forage to avoid mould growth. A reduction in nutrient losses of 4 to 15 % is noticed when additives are used.

**Keywords:** bale silage, wrapping technology, film quality, silage additives, silage quality, losses

## Introduction

Bale silage differs from conventional silage by its long cut and uncrushed leaves and stalks which delays the fermentation rate. Low DM forage produces condense water inside the plastic and if the bale is heated, soil has contaminated the forage and nutrients are available a negative microbial production is established. (Lingvall & Lindberg, 1989 ).

The relation between hygienic quality of bale silage and the DM – content was found early ( Lingvall 1994 ) When the wrapping system was introduced in 1986, black and white film wrapped with 33 % overlapping x 3, was

compared with 25% x 4, 20 % x 5 and 2 x 33% x 3 = 6 layers. The largest difference in tightness and fungi growth was recognized between 2 x 33% x 2 and the others and the difference of negative fermentation between black and white film. (Lingvall& Lindberg, 1989). Later studies compairing film strength, oxygen permeation and nutrient losses resulted in qualification rules, used in Sweden (Lingvall et al, 1993) From 1993 we have systematicly controlled film thickness and permeation (Table 1) to find critical factors. Honig (1984 and 1987), and Pahlow, (1991 ) demonstrated the relation between fermentation products, biochemistry of silage, $CO_2$-production and nutrient losses during ensiling,storage and unloading As bale silage can be produced within 15 – 30 hours after mowing this gives us a possibility to produce a ”gas tight parcel” with lowest possible losses from cutting to feeding. Can we improve such a system based on that knowledge?

## Material and methods

Temperature stress is a factor influencing microbial growth. The hypothesis was to test whether the $CO_2$ - concentration can reduce negative fermentation and nutrient losses. The film colour has a main influence on surface temperature gas permeation and increase in temperature inside the bale. Black, dark green, leight green and white, 25µm thick, 750 mm wide and 60 –80 % prestretched films were wrapped in 2+2, 2+2+2 and 2+2+2+2+2 layers x 5 replicates of round baled ( 120 x 120 mm ) bales (MF 828 flex chamber baler, Kverneland 7556 SilaWrap ) and ensiled from grass wilted to c:a 350 g, $kg^{-1}$ DM without and with silage additives in Sweden. Black and white film colours x 6 layers x 30 replicates and 4, 6 and 8 layers of the same white film x 30 replicates were ensiled from pure rye gras wilted to 410, part 1 and 640, part 2 g,$kg^{-1}$ DM without and with nitrite based silage additives in France. Film tightness, $CO_2$ – concentration, temperature, fermentation pattern, microbial growth, surface growth of fungi and weight losses were measured on every bale. As no effluent was produced, the weight difference between the bale before and after 120 – 150 days of storage is expected to arise from loss of WSC calculated as glucose. The weight loss x 2.5 is estimated to be the nutrient loss of the bale.

A mowed grass swath varies in water activity from the ground to the top. An average DM – content of 350g DM, $kg^{-1}$

FW can vary from 200 to 500 g. By precision chopping this variation will decrease to ± 20g and reduce the risk of Clostridia growth but a silage bale will still keep the variation. Heat stress then stimulates Clostridia growth utilizing lactose, proteins etc. Conditioning the swath before baling in combination with use of additives has been compared with no conditioning in order to decrease this variation.

## Results and discussion

The gas tightness of an ordinary ( 120 x 120 cm ) round bale is defined as the leakage of< 6 ltr $O_2$ per 100 hours at 22 – 24 °C in a nitrogen filled experimental bale. The $O_2$ – limitation is determined from a number of stretch film experiments ( Lingvall, P. et al 1994 ) to avoid fungi growth on the surface and minimize the nutrient losses. The study is based on high quality polyethenebased stretch films from 15 to 35 µm thickness and 500 mm width prestreteched 55 – 70 % and overlapped 50 % in 4 – 8 layers. The optimal design was 2+2+2 layers of 25 µm white film. Thinner film was punctured / broken during wrapping. Thicker film was to stiff, caused wrinkles and leaked between layers (Table 1). Later experiments with wider films of higher gas tightness have reached < 5.5 ltr $O_2$ leakage per 100 hours.
Film colour influenced the temperature in the bales both at the surface and at 10 cm depth. Example of surface and 10 cm temperature were: black film: 55 vs. 32 °C; dark green film: 48 vs. 29 °C; leight green film: 35 vs 26 °C and white film 32 vs. 23 °C when the ambient temperature was 23 °C. The difference in permeation of $CO_2$ ranged from 4 to 1 and of $O_2$ from 1 to 0.2. This means that 10 layers of black film corresponds to 6 layers of white film to give the same tightness ( Möller et al, 1999 ).
An increase in number of layers increased the tightness between layers, reduced gas permeation and nutrient losses. 88 % of the black 4- layer bales without additive had fungi growth on their surface compared to none of the white 6- layer bales. The decrease in nutrient losses from 4 to 6 layers was 10 to 15 %. The economic value of this difference in a bale of normal energy- and protein content and wilted to 500 g $kg^{-1}$ DM covered the cost of all six layers.
Epiphytic lactic acid bacteria varies in growth related to temperature. Clostridia is stimulated by temperatures over 30 °C and can compete with lactic acid bacteria at higher pH when water is avaliable. On the other hand high wilted forage stimulates fungi growth utilizing WSC or lactate. During this process water is produced which keeps microbial growth running. Commercial lactic acid bacteria based silage additives also varies in activity at higher temperature. Therefore this factor must be controlled and specific in storing systems under heat stress. Problems with black film can be reduced by using additives active against both negative bacteria – and / or fungi. The relation between film colour, number of layers and use of additives is presented in table 2. There are significant effects of colour, number of layers and use of silage additives. Even here 6 layers of white film was enough to reduce nutrient losses ( Lingvall, 1999 ).
A comparison between one round baler ( Claas Rollant 44 ) and two square balers ( Claas Quadrant and Hesston ) demonstrated a better fermentation pattern and hygienic quality when square balers were used. This difference was specifically pronounced when whole crop barley was ensiled. A low pH, reduced ammonia production and low butyric acid content in square baled silage and higher density of bales could stimulate fermentation rate and restrict clostridia growth. Another difference occured during baling. The round baler lost kernels from the barley during bailing, but none was observed from the square bales. More studies are necessary to confirm the results.
Bale silage could be a cost effective and the most flexible conservation system of forages providing smaller farms possibilities to rotate crops in a sustainable agricultural system. Some basic fermentation, handling and storage problems still have to be solved and / or developed to secure the nutritional value and hygienic quality during European conditions. Todays knowledge of round bale silage is summarized in a handbook ( Lingvall & Mattsson 1995 ).

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**Table 1.** Relation between film qualities, film thickness / number of layers, fermentation pattern, mould growth on the bale surfaces, DM – losses and use of film. *

| Number of treatments | Layers x thickness | Surface mould % of surface | DM – losses g, $kg^{-1}$ DM | Use of film kg, $ton^{-1}$ DM |
|---|---|---|---|---|
| 2 | 4 x 15 µm | 7 | 193 | 1.6 |
| 2 | 8 x 15 µm | 3 | 102 | 3.1 |
| 4 | 6 x 25 µm | < 1 | 63 | 4.3 |
| 2 | 8 x 25 µm | < 1 | 52 | 5.5 |
| 2 | 4 x 35 µm | 2 | 74 | 3.5 |
| Mean | | 2.6 | 97 | 3.5 |
| $LSD^{p < 0.05}$ | | | 12.3 | 0.2 |

Relation between film use ( x ) and DM – losses ( Y ); $y = 35.5 – 12.3 X + 1.24 X^2$ $R^2 = 0.98$ $P = 0.02$

* Results from stretch film experiments with 4 different plastic qualities of 500 mm wide, 15 - 35 µm thick and 55 – 70 % prestretched white stretch films for bale wrapping.. A flex chamber baler ( MF 828 ) and a Kverneland SilaWrap 7655 were used. 5 replicates per treatment.

Crop Grass – clover mixture. Content per kg DM: CP 130 g; WSC 150 g; Energy 11.2 MJ ME.

Silage DM, $kg^{-1}$ FW; 475 g. Bale density 196 kg DM $m^{-3}$; pH 5.0; $NH_3$ - N 38 g, kg Tot – N;

**Table 2.** Comparisons between DM contents, stretch film variations and use of nitrite / hexamine / sodium benzoat based silage additives on fermentation patterns and nutrient losses.

Nutrient losses = Weight losses x 2.5 = kg per ton baled grass DM.

| Place / silage | Film colour x number of layers | No additive | Kofasil Ultra* | Difference | LSD $^{P<0.05}$ |
|---|---|---|---|---|---|
| Sweden | white x 6 | 128 | 79 | 49 | **20.9** |
| France A | black x 6 | 90 | 65 | 25 | |
| | white x 6 | 58 | 41 | 17 | |
| | Difference | 32 | 24 | | 5.2 |
| France B | white x 4 | 63 | 38 | 25 | |
| | white x 6 | 39 | 21 | 18 | |
| | white x 8 | 38 | 23 | 15 | **5.3** |

* Kafasil Ultra = Sodium Nitrite, Sodium Benzoate, Sodium Propinate and Hexamine.

* Results from stretch film experiments with one plastic quality of 750 mm wide, 25 µm thick and 60 – 80 % prestretched white stretch films for bale wrapping.. A flex chamber baler ( MF 828 / Sweden ) and a fixchamber baler ( Krone / France ) were used for baling and a Kverneland SilaWrap 7655 were used for wrapping. The bales were handled by a Trima Quadro grip and the bales were stored during 120 – 140 days.

SWEDEN5 bales per treatment

Crop Grass. Content per kg DM: CP 164 g; WSC 63 g; Energy 10.3 MJ ME.

Silage 305g DM, $kg^{-1}$ FW; Bale density 117 kg DM $m^{-3}$; pH 4.6; $NH_3$ -N g, kg Tot– N: no addidive 93, additive 45; Clostrida spores, number per g silage: no additive 5600, additive<10;

FRANCE 30 bales per treatment

Crop Grass. Content per kg DM: CP 107 g; WSC 117g; Energy 11.0 MJ ME.

Silage A. 420g DM, $kg^{-1}$ FW; Bale density 197 kg DM $m^{-3}$; pH 5.6; $NH_3$ -N g, kg Tot– N: no addidive 44, additive 39; Clostrida spores, number per g silage: no additive 2500, additive 50 - 100;

Silage B. 610g DM, $kg^{-1}$ FW; Bale density 216 kg DM $m^{-3}$; pH 5.6; $NH_3$ -N g, kg Tot– N 29; Clostrida spores not detected

# Assessments of Clover - Grass Silages Prepared by the Enveloped Round Big Bale System

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### Abstract

The study was aimed at assessments of foil layers different number on the fermentation process of clover-grass silage baled and, under working conditions, at finding the inoculant effect on the resulting silage quality. Silages in the first examination were prepared from wilted and not cut plant feed from the first mowing, harvested using the method of round big bale enveloped immediately with 3 or 6 layers of shrinking foil with 50% cover. In the second examination, tested was the inoculant additivum effect on the fermentation process at the same envelope kind. From the first experimental examination, it issued that, between the bales enveloped with different number of foil layers, there are statistically significant differences in fermentation parameters, pH, titrating acidity (TA), formol titration (FT), ammonia and $NH_3$-N. In the silages of dry matter below 500 g/kg, enveloped with 6 layers, lower content of acids was found than in the silage with 3 layers. Simultaneously, the trend of pH, ammonia and LA values increased, and of ethanol content, titration acidity decreased was found, going from bale surface to its middle. No micromycetes occurrence was observed.

In the second examination, it is evident that the biological inoculant added to clover-grass feed baled, of dry matter below 40%, led, as compared with the not treated control, to pH value decreased and to LA and total fermentative acids higher proportions regards total N at LA simultaneous more favorable and $NH_3$-N lower proportions. Silages also contained lower fibre content. It is confirmed that, regards the fermentation process quality, the plant feed should not have its dry matter below 30% and above 50%.

### Introduction

For preparing silages of high quality, fodder producers can use various ensilaging techniques and technological systems. For production but also economical reasons, demands are evident not only for corresponding daily performance, system flexibility, limited dependence on weather conditions, minimized losses and certain of feed quality at technological indispensable requirements observed. The silages preparation technology using the system of round bales enveloped, besides the method of ensilaging into plastic bags, is one newer and in the EU countries relatively very widespread technologies, which can be met with in a number of EU countries.

The technology of plant feed ensilaged using the method of big round bales enveloped belongs to progressive technologies, since they reduce the man factor and limit the negative influence of differently long delay in silos not covered. Even when this system is appropriate sooner to small production ensilaging, it can be utilized successfully also to preparation of summer silages or as complementary technology (Wilhelm and Wurm 1999, Loučka and Jirka 19991). Problems of enveloped silages were studied by a number of inland and foreign authors (Štastný, 1996, Loučka et al. 1996, Undi et al. 1997,Weddell 1995, Podkowka 1995, Keller and Nonn 1995, and others). Žiláková et al. (1993) studied the influence of 3 foil sorts and dry matter content (DM) on the quality of enveloped clover-grass silages. They found that the worst ones were silages enveloped with black foil at their dry matter below 300 g/kg, while the best nutrition values were found in silages of 370-g/kg dry matter content. Problems of quality in alfalfa silages, prepared by the technology of round bales with biological additive added, were dealt with by Keller and Nonn (1993). The relation of foil layers number to grass silage quality was assessed by Wilhelm and Wurm (1999), in alfalfa silages by Keller and Neitz (1993). They state coincidently that, to obtain silages of good quality, it is necessary to use 6 foil layers, and to let plant feed wilting to dry matter of 350-400 g/kg.

The contribution is aimed to assessments of the shrinking foil effect on clover-grass silage prepared by the method of enveloped bales at dry matter above 300 g/kg, and in the subsequent working examination, to the verification of inoculant effect on fermentation characteristics in enveloped wilted clover-grass as compared with not treated control variants.

### Materials and methods

In the first trial, the clover-grass growth was cut during the 1st mowing, and after 40 hours wilting (at the mean dry matter content of 500-520 g/kg), it was pressed by John Deer 575 press with the firm pressing chamber without cutting tool, i.e. in its original length. Bales were enveloped within 30 minutes, after baled in Ballpack Břežany balling press, with three and six foil layers. From the baled silage after 4 months storage, samples were taken for fermentation process analysis and quality evaluation in the whole profile from its surface to middle. During the 2nd examination of enveloped clover-grass silages, verified was the effect of biological inoculant added on fermentation process quality changes as compared with the control. Bales were enveloped always coincidently with 4 foil layers. In silages analysed, assessed were dry matter content, and in aqueous dilution pH acidometric value, titration acidity, formol titration, free ammonia by Conway method, fermentative acids and ethanol by gas chromatography. The protein decomposition degree was determined as the proportion of total $NH_3$-N. The digestibility of organic matter (DOM) was determined using the method in vitro.

## Results and discussion

Fermentation characteristics from the first trial are presented in Table 1. From the values presented, it issues that the clover-grass silage dry matter ranged from 487.5 to 522.7 g/kg, which is lower than the mean value found during harvest (545 g/kg), but it corresponds to the value recommended in the literature. Wilting, of course, was not uniform due to plant feed length, and the presence of Rumex crispus of more than 5% in plant feed had a great effect on dry matter unevenness. The results of fermentation indices differed between tested bales with foil layers different number, but they corresponded to sense assessments. Statistically different values were found in the indices of pH, titration acidity and formol titration, ammonia and $NH_3$-N. The analysed bale with higher number of foil layers had lower content of dry matter, unexpected pH higher value, but ammonia significantly lower content and lower degree of protein decomposition, which agree with better quality of N-fraction and with the previous findings (Žiláková et al. 1993, Jones and Fychan 1995). In contrast to expectations, lower content of fermentative acids, including lactic acid, was found, of course, in bale silage protected by higher number of foil layers. However, these differences were not statistically significant. It could be expected that, in the silage with foil layer higher number, better conditions would be for anaerobic fermentation, because it is known that the foil permeability rises for oxygen with the temperature. This permeability can be increased up to 200-300% more. It was confirmed that the minimum number of 3 foil layers (or 6 layers due to overlap) was sufficient regards dry matter content. The foil permeability of bale envelope was not disturbed, because in the opposite case, massive micromycetes occurrence would be found. The lactic acid (LA) high proportion (above 70%) and favorable ratio LA/AA signal the fermentation process good quality even at dry matter above 50%. It should be agreed with the conclusions by Keller and Neitz (1993), Žiláková et al. (1993), Wilhelm and Wurm (1999) and others, and in feed ensilaged with dry matter below 40%, it is suitable to apply 6 protective foil layers. In our trial with foil layer higher number, moreover, even better digestibility in vitro of organic matter by 3% was found.

The assessment results of the second trial are presented in Table 2. From this table, it issues that the added inoculant affected favorably indices and proper course of fermentation process as compared with the control. In experimental bales enveloped with 4 foil layers, determined were pH more favorable values, LA higher contents, better ratio of LA/AA, protein lower decomposition and fibre lower concentrations. The results obtained are in coincidence with the findings by Keller and Nonn (1993). Jambor and Dufková (1993), Weddel (1995), Keller and Neitz (1993) who stated the positive influence of biological additive on silage quality and stability, but they admit simultaneously that fermentation quality of baled silage can very considerably.

## Conclusions

The study presents the results of two ensilaging processes in wilted clover-grass growth using the round bale system with and without biological inoculant added. The work was aimed at assessments of the effect of foil layer different number on clover-grass fermentation process quality, of anaerobiosis degree by means of fermentation process products, or of conservative effect by biological inoculant. To obtain silages of good quality, important are not only dry matter optimum content, but also foil of good quality used, or its indispensably necessary number of layers. At dry matter lower content, the number of foil layers has to be increased. Our trial revealed that 3 layers overlapping properly, regards dry matter higher content appeared to be suitable.

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**Table 1.** Fermentation characteristtics of data from balsilages

| Specification | Average of 3 and 6 foil layers | | | | | | Conclusive difference |
|---|---|---|---|---|---|---|---|
| DM g/kg | 522,67 | ± | 19,72 | 487,50 | ± | 37,51 | |
| pH | 5,12 | ± | 0,11 | 5,56 | ± | 0,22 | * |
| TA mg KOH/100 g | 1182,23 | ± | 120,68 | 812,52 | ± | 69,68 | * |
| FT % | 0,17 | ± | 0,03 | 0,12 | ± | 0,02 | * |
| Ammoniak mg /kg | 780,57 | ± | 32,09 | 601,54 | ± | 93,48 | * |
| LA g/ kg DM | 24,00 | ± | 3,80 | 19,45 | ± | 6,44 | |
| AA g/kg DM | 8,55 | ± | 1,05 | 7,49 | ± | 1,46 | |
| Sum acids g/ DM | 32,21 | ± | 4,30 | 26,93 | ± | 7,81 | |
| LA/ AA | 2,77 | ± | 0,18 | 2,54 | ± | 0,46 | |
| %LA/sum acids | 73,40 | ± | 1,25 | 71,26 | ± | 3,89 | |
| ethanol g/kg DM | 8,56 | ± | 2,20 | 11,24 | ± | 6,57 | |
| $NH_3$-N | 6,43 | ± | 0,27 | 4,95 | ± | 0,77 | * |
| DOM % | 61 | | | 64 | | | |

**Table 2.** Fermentation parameters of clover-grass silages with enveloped big round bales without (A) and with (B) inoculant added

| Type of silages | Specifi-cation | DM | pH | LA | AA | BA | Sum of acids | LA/AA | %LA of sum acids | NH3 | NH3-N/ total N | Crude fibre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | g/kg | | g/kg DM | | | | | % | mg/kg | % | g/kg DM |
| A | **Average** | **447,8** | **4,73** | **20,1** | **21,61** | **1,06** | **42,76** | **0,98** | **47,41** | **730** | **6,2** | **272,75** |
| | sx | 47,16 | 0,11 | 3,93 | 4,82 | 1,72 | 7,7 | 0,31 | 8,21 | 75,5 | 1,03 | 17,03 |
| | s average | 54,45 | 0,13 | 4,54 | 4,57 | 1,99 | 8,99 | 0,36 | 9,48 | 87,18 | 1,19 | 19,67 |
| | VK | 10,53 | 2,28 | 19,55 | 22,3 | 162,26 | 18,01 | 31,63 | 17,31 | 10,34 | 16,61 | 6,24 |
| B | **Average** | **388,68** | **4,47** | **29,93** | **23,06** | **1,01** | **54** | **1,43** | **56,59** | **733,33** | **6** | **250,33** |
| | sx | 47,78 | 0,09 | 2,69 | 7,19 | 1,42 | 6,96 | 0,44 | 9,79 | 124,72 | 1,04 | 5,44 |
| | s average | 58,52 | 0,12 | 3,3 | 8,81 | 1,74 | 8,52 | 0,54 | 11,99 | 152,75 | 1,27 | 6,66 |
| | VK | 12,29 | 2,01 | 8,99 | 31,18 | 140,59 | 12,88 | 31,09 | 17,3 | 17,01 | 17,29 | 2,17 |

The work has been elaborated within the research project No. MSM 432100001.

# Grass Silage with the Product of Corn-Cob Industrial Processimg

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## Introduction

The satisfactory fermentation of grass can be improved by wilting, applying silage additives or by their combination. Where weather conditions are favourable there may be good reasons for practising wilting, but in an adverse climate additives would be the preferred choice. If sward composed less legumes and was harvested at the optimum time of the stage of maturity -the sward reaches 50% ear emergence- the grass may contain sufficient carbohydrate, so the improvement of dry matter (DM) content up to 30 % is reasonable to ensure a good fermentation. (Steen 1992)
Additives applied at ensiling -such as dried sugar beet pulp, straw, corn stalk- can increase the dry-matter content of the herbage. For the improvement of DM content above 30% of the mass it is needed to add 12-20% of dry by product/feed stuffs additionally. (Kakuk and Schmidt 1988, Kota and Vinczeffy 1991) The advantages of dry-feedstuff ensilage system (favourable DM, good ability of condensation, minimal warming up, no effluent) make conservation of low damage, possible and enables awoiding the pollution of the environment (Rydin 1964, Woolford 1984, O Kiely 1992, Lattemae 1997, Haigh 1999, Dordevic-et. al. 2000)
The aim of our experiment was to increase the dry matter content of the grass -mass, and absorb the effluent at the same time. The aim was also, not to reduce considerably the nutritive value of grass silage.

## Materials and methods

We used special additives which were originated from the corn-cob industrial processing after grinding and selecting by riddles of the cob. We also used the waste material of the process as well.
The treatments:
Control (grass)
Grass + 10% cob fractions mixture (CFM)
Grass + 20% cob fractions mixture
Grass + 10% cob waste material (CWM)
Grass + 20% cob waste material
We filled containers to characterise the fermentation, determine the chemical composition and nutritive value of the silage by laboratory analyses.

## Resulsts

The results are shown on tables 1, 2, 3. The additives contain high DM included in a high proportion of NDF with a relatively high ADL mainly in the corn-cob fraction mixtures (CFM). The nutritive value is quite weak. The Matabolisable Protein-N (MPN and MPE) content and UDP is better in the CFM, but the NE is higher in the cob waste material (CWM). (Table 1.)

The additives improved the fermentation of the grass through out the increasing of the DM content, reduction of the proteolysis and improvement of the conditions for lactic acid fermentation. (Table 2.)

The chemical composition and nutritive value of the silages treated with CFM and CWM compared with the control (Table 3.): The crude protein is declining, the fiber and the N-free extract content is increasing. The Matabolisable Protein-N (MPN)is poorer, but the value of the NE is almost the same in the treated silages.

The DM content of the treated silages was similar on the top and on the bottom of the containener, but there was a difference of 3,5% between the two pools of silage in the control.

## Conclusion

The additives increased the guality of fermentation and absorbed the effluent. The treated silages contained less protein, mainly in MPN, but the value of NE was almost similar to the control silage. There is a possibility for recycleing the by products of corn-cob processing. When deceding wether to use CFM or CWF the higiene conditions of CWF need to be cleared by microbiology analysis.

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**Table 1.** Chemical composition and nutritive value of corn-cob additives

| Parameters | Corn-cob fractions mixture (CFM) | | Cob waste material (CWM) | |
|---|---|---|---|---|
| | Fresh basis | DM basis | Fresh basis | DM basis |
| Dry matter % | 91,9 | 100 | 92,8 | 100 |
| Crude protein g/kg | 66 | 72 | 48 | 52 |
| Crude fat g/kg | 6 | 6 | 1 | 1 |
| Crude fiber g/kg | 304 | 331 | 333 | 358 |
| Crude ash g /kg | 89 | 97 | 22 | 24 |
| N-free extract g/kg | 455 | 495 | 525 | 566 |
| NDF g/kg | 693 | 754 | 830 | 894 |
| ADF g/kg | 400 | 435 | 471 | 508 |
| ADL g/kg | 108 | 118 | 74 | 80 |
| Cellulose g/kg | 292 | 318 | 398 | 429 |
| Hemicellulose g/kg | 293 | 318 | 358 | 385 |
| MPE g/kg | 54 | 59 | 52 | 56 |
| MPN g/kg | 39 | 43 | 17 | 18 |
| UDP g/kg | 26 | 29 | 11 | 12 |
| NEm MJ/kg | 2,72 | 2,96 | 3,56 | 3,83 |
| NEg MJ/kg | 0,67 | 0,73 | 1,44 | 1,56 |
| NEl MJ/kg | 2,95 | 3,21 | 3,44 | 3,71 |

**Table 2.** Parameters of silage fermentation

| Parameters | Control | 10% CFM | 20% CFM | 10% CWM | 20% CWM |
|---|---|---|---|---|---|
| Dry matter g/kg | 212 | 271 | 315 | 263 | 314 |
| pH | 4,4 | 3,8 | 3,7 | 4,0 | 3,9 |
| $NH_3$ mg% | 69,0 | 4,4 | 13,1 | 5,5 | 4,3 |
| Acids in silage Lactic % | 0,50 | 1,65 | 1,56 | 0,94 | 1,48 |
| Acetic % | 1,12 | 0,81 | 0,77 | 1,0 | 0,95 |
| Butiric % | 0,21 | 0 | 0 | 0,01 | 0 |
| Propionic % | 0,94 | 0,10 | 0,08 | 0,14 | 0,05 |

**Table 3.** Chemical composition and nutritive value of silages

| Parameters | Control | | 10% CFM | | 20% CFM | | 10% CWM | | 20% CWM | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh basis | DM basis | Fresh basis | DM basis | Fresh basis | DM basis | Fresh basis | DM basis | Fresh basis | DM basis |
| Dry matter g/kg | 212 | 1000 | 271 | 1000 | 315 | 1000 | 263 | 1000 | 314 | 1000 |
| Crude protein g/kg | 43 | 203 | 40 | 148 | 40 | 126 | 35 | 133 | 37 | 118 |
| Crude fat g/kg | 13 | 61 | 12 | 44 | 11 | 35 | 12 | 46 | 11 | 35 |
| Crude fiber g/kg | 59 | 278 | 79 | 293 | 93 | 296 | 74 | 281 | 85 | 272 |
| Crude ash g/kg | 32 | 151 | 33 | 122 | 33 | 104 | 34 | 129 | 39 | 125 |
| N-free extract g/kg | 65 | 307 | 106 | 393 | 138 | 441 | 108 | 411 | 142 | 450 |
| MPE g/kg | 14 | 63 | 17 | 63 | 20 | 63 | 17 | 67 | 20 | 63 |
| MPN g/kg | 24 | 111 | 23 | 84 | 22 | 71 | 24 | 92 | 24 | 75 |
| UDP g/kg | 11 | 53 | 11 | 40 | 11 | 34 | 12 | 44 | 11 | 36 |
| NEm MJ/kg | 1,12 | 5,25 | 1,44 | 5,33 | 1,7 | 5,41 | 1,39 | 5,29 | 1,63 | 5,21 |
| NEg MJ/kg | 060 | 2,86 | 0,8 | 2,96 | 0,94 | 2,99 | 076 | 2,89 | 0,89 | 2,84 |
| NEl MJ/kg | 1,1 | 5,20 | 1,43 | 5,30 | 1,67 | 5,32 | 1,38 | 5,25 | 1,62 | 5,18 |

# Determination of Stem Damage by Swath adapters

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## Abstract

The cell moisture can be removed through the cell membrane in state of water or vapour, when the water passes either through pores in plant epiderm or or diffusion through cuticle. The water loss also depends on anatomical and morphological structure of plant botanic species. The dessication process can be accelerated by increased water transfer through the surface layer (by cuticle oponed), by squeezing (plants disturbed longitudinally) and by increase of the swath surface area enabling the sun shine and air acces. The swath adjustment to higher wilting is carried out at moving with rotation movers provided with adjusting tools (with a conditioner or squeezing cylinders). The contribution presents the results of field-laboratory trials using the rotation mover – ŽTR-325 D of different rate in adaptation of red clover and sown alfalfa swaths.

## Introduction

After stem is sown off at harvest the water transport from roots is interrupted and wilting process arises. From the physical point of view, the water loos passes within three intervals: evaporation, water loos from plant vessel system and cell intersticial spaces, and loss of water fixed in cells and cell membranes. Closery after mown off, plants contain a large amount of free water which diffuses from their surface into the atmosphere, affected by the difference between partial pressures in the atmosphere and those on plant surface. The moisture further loss is the slower, since it is more demanding energetically – viz. the hydroscopical water fixed i cells and cell membranes is evaporated.

The water loss also depends on anatomical and morphological structure of a botanic species. Clover contains in its bud phase ca. 77 % of water when this is contained mainly by stems. Grass contains 73 – 74 % of water in its phase of getting into ear, stem is hollow, filled with air. The desiccation course in clovers is slower than that in grass growths. Clover plants cells die out at the water content of 55 – 60 %, grass cells at the water content of 30 – 45 %. From the above facts it is evident that, for ensuring of the minimum losses during feet plant dessication in the field, it is necessary to reach as fast as possible the limit when biological processes stop in cells.

## Materials and methods

Our field-laboratory trials were aimed at relative comparisons of red clover and sown alfalfa swatch adjusted variously by the disc mover ŽTR-325 D provided with squeezing cylinders and a conditioner. The goal of measurement and assessments was to ascertain the work quality of the mover and tools for feed plant adjustment, the adjustment effect on dessication rate, and to determine the work exploitation parameters.
The disc mover ŽTR-325 D is proveded by two tool types for swath adjustment which are attached behind the moving gear:

- squeezing tools
- conditioner (ruffler)

The squeezing tools consist of two steel cylinders, on which segments from hardened polyurethan are screwed on. Segment plofiles of one cylinder fit into the groove of the opposite cylinder segment. Squeezing cylinders are pressed to each other by springs; by spring lenght change, the cylinder pressing power and squeezing intenzity in feed mass are changed. The spring pressing power can be set up ranging from 15 to 45 $N\cdot cm^{-1}$ of the cylinder lenght.

The conditioner consists of a rotor with fixed plastic fingers in „V“ shape. The rotor is provided with side plates and in its top part with a cover, on which there is a buffer plate adjustable to five positions. By adjusting this plate, the gap between fingers and plate margins in changed. The size of this gap can be set up in the range from 15 mm (stem maximum damage) to 75 mm (stem minimum damage). At the ends of both side plates, there are adjustable rectifying sheets for settings up the needed swath width.
At the field-laboratory measurement, five variants of setting up of the mover were verified:

1 - ŽTR - 325 D + squeezing tools with cylinder minimum pressing power

2 - ŽTR - 325 D + squeezing tools with cylinder maximum pressing power

3 - ŽTR - 325 D + conditioner with the desk adjustment to the minimum effect on feed plant

4 - ŽTR - 325 D + conditioner with the desk adjustment to the maximum effect on feed plant

5 - ŽTR - 325 D + mower alone - control

(Variants for red clover are designated with „J“, variants for sown alfalfa with „V“)

To ensure the possibility of comparing the measurement results, the same swath width was set up in all variants. To accertain the damage extent in plant tissues done by squeezing cylinders and by ruffler fingers, 100 stems of red clover and sown alfalfa were taken from each variant. In each plant, the lenght was measured, and damge extent per 1 m was judged according to the sampling table [1]. The dessication course was assessed according to dry matter ancrease in swaths adapted in regular two hours intervals. The values found were registered in tables, treated statistically and evaluated graphically.

## Results and Discussion

In Figs. 1 – 4, the field laboratory trials are described graphically. For the dessiccation process in experimental and control swaths, there were highly unfavourable agrometeorological conditions (rainy weather). Despite these unfavourable conditions, a significant influence of swaths adapted versus non-adapted ones was confirmed.

**Figure 1.** Total number of red clover stem damages

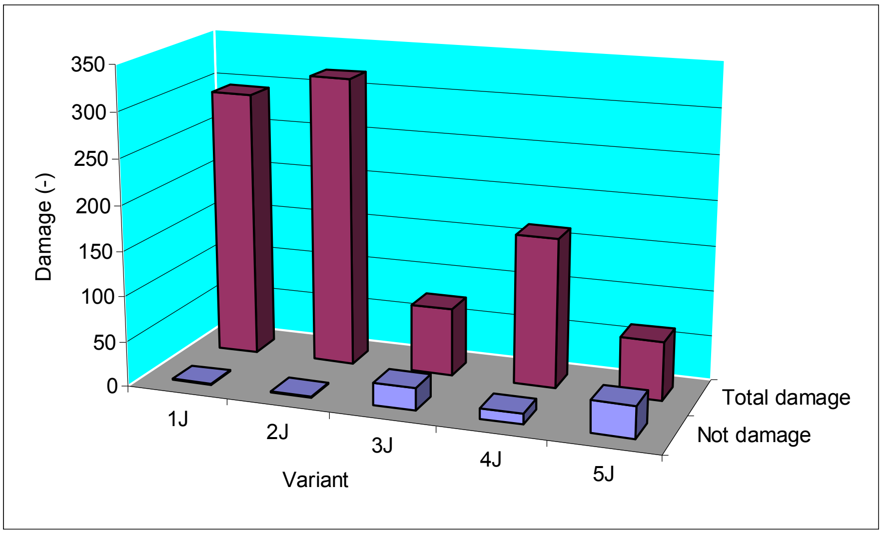



**Figure 2.** Total number of sown alfalfa stem damages

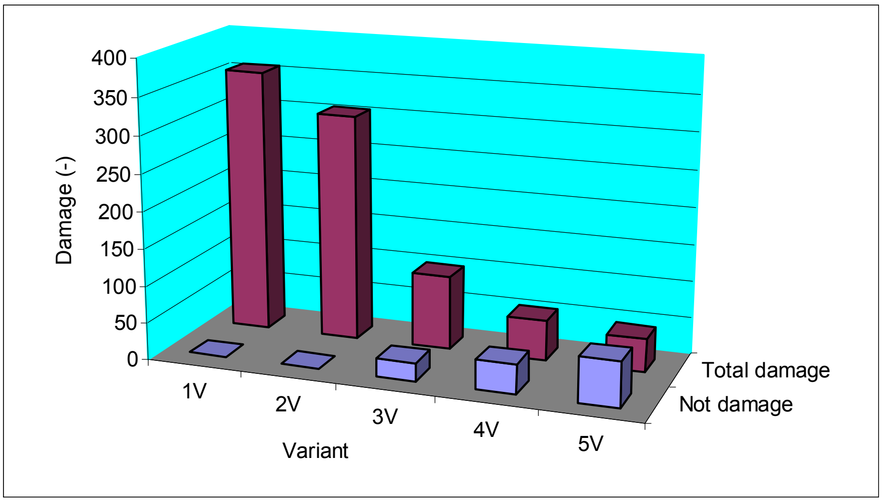


**Figure 3**. The course of moisture changes in different variants of swath adjustment (red clover)

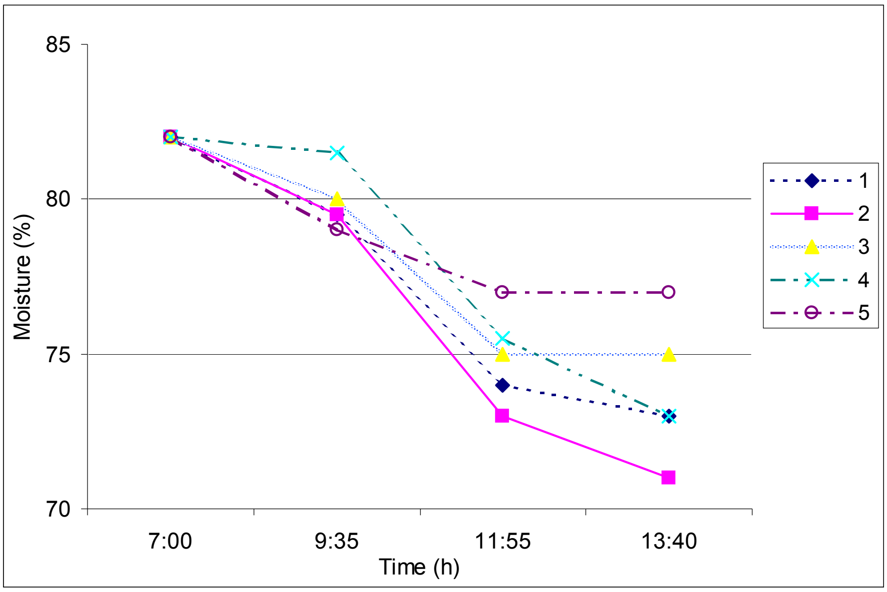
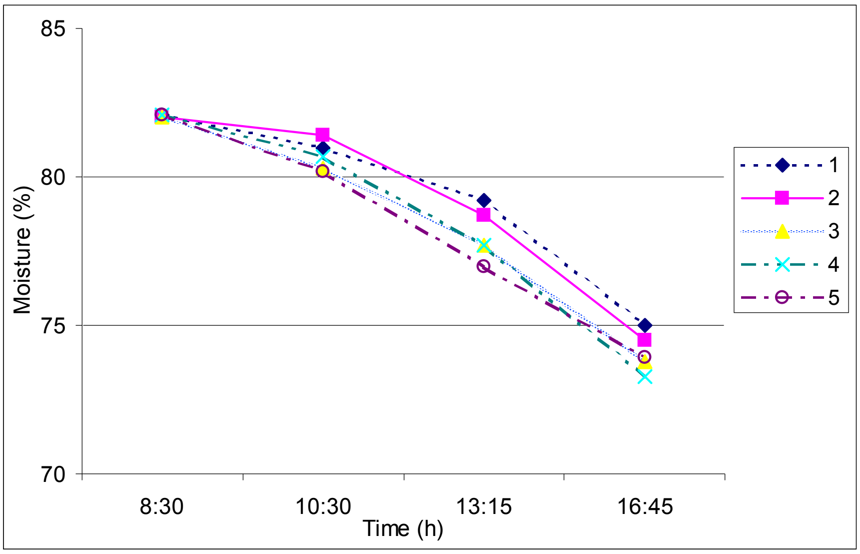



**Figure 4.** The course of moisture changes in different variants of swath adjustment (sown alfalfa)




From Fig. 1 , the difference between the variants 1J and 2J versus the variants 3J and 4J is evident. It can be seen that in the variant 2J, the damage is ca. 5 x higher than in the control (5J). In the variant 2J, a higher frequency of damage is at threefold and fourfold squeezing, which is acused by passing between aqueezing cylinder segments. In the variant 1V, the damage is morethan 9 x higher as compared with the control 5V (Fig. 2).

From Fig. 3 it is evident that the variant 2J (squeezing cylinders with the maximum pressing power) gets dry the fastest. In absulute values, the dry matter increase is 10 % higher versus the variant 5J. No significant dry matter increase ocured between the variants 3J and 5J. As well, the damage difference between these variants is not high. The dessication rate especially in red clover and regards the time is demonstrated as late as after more hours (18 – 24 hours). Even in spite of the short period of investigations on dry matter increase, it is evident that higher clover stem damage leads to the dessication rate increase.

## Conclusions

From the results of measurements performed, it issues that squeezing cylinders the most disturb stems of feed plants harvested. A change of the spring pre-stress in squeezing cylinders was manifested only by the low increase in clover swath damage. When the conditioner is used, the stem damage is essentially lower.

Most stems are damaged by squeezing, and their small proportion in both variants is damaged by imperfect cuttings and breakings, which is favourable. In alfalfa, the stem damage by breaking and imperfect cutting in the variants 1V, 2V and 3V is essentially higher. At the pressing intensity increase of squeezing cylinders with the conditioner used, leaf and vegetative top parts breaking off also occur in alfalfa. In these variants, plants are cut into smaller particles, which is not of advantage regards both dessication and subsequent operation within the harvest process, i.e.collecting of dry fodder. For the dessication rate increase, stems must be squeezed intensively, they may not be crushed into small particles; damaged should be only the surface layer, so-called cuticle in order that the physiologically fixed water might be evaporated faster.

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# Silage of Four Varieties of Grass and Their Mixture with Alfalfa

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## Abstract

The aim of our research was to study the effect of growing and ensiling alfalfa in a mixture with four varieties of grass. Alfalfa var. Bobrava (Medicago sativa L.) and four varieties of grass Sverepovka (Bromus uniloides Willd. Beauv.), Median (Arrhenatherum elatius L.P. Beauev.), Hykor (Lolium multiflorum Lam. x Festuca arundinacea Huds.) a Perun (Lolium multiflorum Lam. x Festuca Pratensis Huds.) were used for experiments. The second cut was harvested, wilted and ensiled (without additives) into the laboratory tube silos of 10 litres of cubature. After three months the silage was analysed. The best results from the fermentation process evaluation point of view were found with grass var. Perun, as a monoculture or in a mixture with alfalfa var. Bobrava. Perun, Bobrava, and Perun x Bobrava parameters were as follows: DM 353, 388, 393 g/kg resp., lactic acid 2.50 %, 2.24, 2.77 % resp., acetic acid 0.48 %, 1.44, 0.81 % resp., pH 4.13, 4.76, and 4.45, respectively.

## Introduction

Until recent time, legumes were regarded as being nearly unsuitable for ensiling, because in the fermentation were invariably dominant clostridia leading to a butyrate-type of silage. Alfalfa is a very bad medium for ensiling, especially due to their high content of protein and the low content of WSC (water soluble carbohydrate). If we want to be successful in a making silage, we need to wilt the ensiled matter (Wright at al., 2000, Dawson at al., 1999), to use additives or to mix alfalfa with another matter having the higher content of WSC (Weinberg and Muck,1996). Growing and ensiling alfalfa in a mixture with grass gives many profits, not only increasing of the fermentation process, but also decreasing the procumbent of alfalfa and the winter disease of grass (Krupinsky and Tanaka, 2001). The results of the study of Degooyer et al. (1999) suggest that alfalfa-forage grass intercrops reduce insect pest populations compared with monocultures, but additional management tactics may be needed to reduce insect pest levels below economic thresholds.

Component yields and forage quality were evaluated by Spandl at al. )1997) in established stands of alfalfa seeded alone and in binary mixtures with smooth bromegrass, orchardgrass, or timothy. Forage yields and quality were determined at three annual harvests in the third and fourth years after seeding. Weed yields in alfalfa seeded alone were significantly greater than those in the alfalfa-orchardgrass mixture. Average weed content was 24, 17, 2, and 15% for the alfalfa seeded alone, alfalfa-bromegrass, alfalfa-orchardgrass, and alfalfa-timothy, respectively.

## Materials and methods

To make the silage experiments alfalfa var. Bobrava (Medicago sativa L.) and four varieties of grass Sveřepovka (Bromus uniloides Willd. Beauv.), Median (Arrhenatherum elatius L.P. Beauev.), Hykor (Lolium multiflorum Lam. x Festuca arundinacea Huds.) a Perun (Lolium multiflorum Lam. x Festuca Pratensis Huds.) were chosen. All varieties were grown on 0.25 ha separately and as a mixture with alfalfa. The second cut was harvested, wilted and ensiled (without additives) into the laboratory tube silos of 10 litres of cubature. The fermentation process in the tube silos was carried out at the laboratory temperature. After three months the samples of silage were analysed. Laboratory measurements included chemical (Weende and van Soest methods) techniques.

## Results and discussion

From the nutrition point of view alfalfa silage had lower content of PDI (74.1 g/kg DM) and NEL (4,84 MJ/kg DM) than all of four varieties of grass silage. That means grass silage (all varieties) was evaluated to be better than alfalfa silage. But content of NDF in all of four varieties of grass silage was higher than of alfalfa silage (451, vs. 481-593 g/kg DM). Higher content of NDF signalised lower intake of grass silage.

The silage of the mixture of alfalfa with grass had higher level of NDF (481-572 g/kg DM) than alfalfa silage (451 g/kg DM). The silage of the mixture of alfalfa with grass var. Perun, resp. Hykor had better evaluation of the fermentation process than other mixtures and alfalfa silage. The best results (from nutrition or fermentation points) were found with grass var. Perun, so as a monoculture or in a mixture with alfalfa. Perun, and Bobrava, and Perun x Bobrava parameters were as follows: DM 353, 388, and 393 g/kg resp., lactic acid 2.50 %, 2.24, and 2.77 % resp., acetic acid 0.48 %, 1.44, and 0.81 % resp., pH 4.13, 4.76, and 4.45 respectively.

By Sulc and Albrech (1996) mixtures of alfalfa with early-maturing ryegrass cultivars were higher in yield and fiber fractions (neutral- and acid-detergent fiber) and lower in crude protein concentration than mixtures with late-maturing ryegrass cultivars, with greater differences observed in 1990 than 1991. The ryegrass-alfalfa mixtures usually were higher yielding but lower in forage nutritional value than alfalfa sown alone, with greater differences observed in 1990 than 1991. Our results are in a agreement with Hoveland at al. (1995).

**Table 1.** Silage analyse of alfalfa and four varieties of grass

| Unit / Plant variety: | S | M | H | P | B |
|---|---|---|---|---|---|
| DM (g/kg) | 334 | 351 | 455 | 353 | 388 |
| PDI (g/kg DM) | 77.0 | 76.2 | 76.5 | 81.5 | 74.1 |
| NEL (MJ/kg DM) | 5.68 | 5.61 | 5.72 | 5.70 | 4.84 |
| NEV (MJ/kg DM) | 5.58 | 5.50 | 5.63 | 5.58 | 4.55 |
| Fibre (g/kg DM) | 319 | 265 | 285 | 292 | 312 |
| ADF (g/kg DM) | 347 | 263 | 329 | 315 | 355 |
| NDF (g/kg DM) | 593 | 481 | 585 | 564 | 451 |
| Lactic acid (%) | 2.47 | 2.66 | 2.66 | 2.50 | 2.24 |
| Acetic acid (%) | 0.49 | 0.42 | 0.62 | 0.48 | 1.44 |
| pH | 4.07 | 4.02 | 4.13 | 4.13 | 4.76 |

Legend: grass var. S = Sveřepovka, M = Median, H = Hykor, P = Perun, B = alfalfa var. Bobrava

**Table 2.** Silage analyses of alfalfa and alfalfa in a mixture with four varieties of grass

| Unit / Plant variety: | SxB | MxB | HxB | PxB | B |
|---|---|---|---|---|---|
| DM (g/kg) | 412 | 380 | 502 | 393 | 388 |
| PDI (g/kg DM) | 78.3 | 77.1 | 74.2 | 76.9 | 74.1 |
| NEL (MJ/kg DM) | 5.45 | 5.25 | 5.37 | 5.27 | 4.84 |
| NEV (MJ/kg DM) | 5.26 | 5.01 | 5.17 | 5.06 | 4.55 |
| Fibre (g/kg DM) | 302 | 300 | 320 | 316 | 312 |
| ADF (g/kg DM) | 323 | 327 | 366 | 352 | 355 |
| NDF (g/kg DM) | 489 | 572 | 483 | 481 | 451 |
| Lactic acid (%) | 3.00 | 2.53 | 3.62 | 2.77 | 2.24 |
| Acetic acid (%) | 1.22 | 1.61 | 0.64 | 0.81 | 1.44 |
| pH | 4.68 | 4.86 | 4.55 | 4.45 | 4.76 |

Legend: grass var. S = Sveřepovka, M = Median, H = Hykor, P = Perun, B = alfalfa var. Bobrava

## Conclusion

We can recommend growing and ensiling of alfalfa in a mixture with grass var. Perun or Hykor.

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*Research was supported by MZE–MO2-99–04.*

# Influence of Corn Silage with Rape and Soya Ground Grain as well as Megapro Preparation on Fermentation Processes and Rumen Microflora

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Corn silage is the basic ingredient of cattle fodder in winter and summer. The silage with added dry fodders often eliminates green fodders from cattle food rations. As incomplete fodder it needs protein additives and with high production level even energetic additives. So far the research results indicate the effect of such additives is different, depending on their close link with fermentation processes taking place in rumen [Williams and Newbold 1990.; Strzetelski, 1995; Hristov et al. 2001]. A question arises whether the rape grain, soya grain or Megapron have such effect, and more importantly, whether they influence rumen protozoa population.

## Materials and metods

Research was done on four young bulls with fistulas in a Latin square system. Corn silage was the basic foddering ingredient of those animals, covering 55% of daily food rations required for those animals. The rest was hay (ration A), soya ground grain (ration B), rape ground grain (ration C) and Megapro protein preparation (ration D). the additives were used in quantities big enough to balance food rations with assumed weight growth at the level of 300 grams/day/animal (INRA '88). The biological material was taken through fistulas in rumen right before feeding and 1.5 and 3 hours after the beginning of feeding. Basic parameters of rumen fodder processing were established: pH, VFA, $NH_3$-N and protozoa were counted and recognized.

## Results and discussion

Animals in all food groups after foddering showed a significant growth of VFA level. The growth, though slower, was also noticed three hours after foddering, with only one exception regarding rape ground grain ration where three hours after foddering a drop in VFA level in rumen. The best proportions between acetic acid and propionic acid 1.5 hours after foddering was noticed with ration D (corn silage and Megapro). According to Barej [1990] such slowdown of propionic acid synthesis high synthesis of acetic acid causes bigger synthesis of bacteria protein. Smaller proportion of propionic acid in VFA pool in rumen may be linked with bigger production of methane, which is argued by other authors [Demeyer and Jouanny, 1991; Zawadzki and Malicki, 1995]. Food rations did not have much influence on pH reaction in rumen fluid, yet they affected N-$NH_3$. it may be added that already before foddering the amount of N-$NH_3$ was not equal and it depended on the amount of fodder eaten. Later the concentration of N-$NH_3$ in rumen of animals fed with silage with rape and soya ground grain was significantly higher than in rumen of animals fed with fodder and hay (table 1). It is worth mentioning that three hours after foddering the differences were still visible.

The number of protozoa in rumen fluid was significantly dependant of the type of food ration. 1.5 hours after the beginning of foddering in all groups there was observed a drop of that number, apparently connected with sticking of the protozoa to the fodder. Later, 3 hours after foddering it was observed that the number of the microorganisms grew a little. Among the recognized protozoa *entodinium* genus was the most numerous. As expected, that genus was reproducing the fastest in the rumen of those animals fed with silage with corn and hay.

## Conclusions

1. The best proportions between acetic acid and propionic acid 1.5 hours after foddering was noticed with ration D (corn silage and Megapro). Food rations did not have much influence on pH reaction in rumen fluid.
2. Among the recognized protozoa *entodinium* genus was the most numerous. As expected, that genus was reproducing the fastest in the rumen of those animals fed with silage with corn and hay.

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**Table 1.** Producion Volatile fatty acids and pH, concentration $NH_3$-N 1,5 hours after feeding

| Ration | VFA in mmoles/100 ml of rumen fluid | | | | | | | Acetic acid : propionic acid | Concent-ration $NH_3$-N mg/dl | pH |
|---|---|---|---|---|---|---|---|---|---|---|
| | Acetic | Propionic | i -Butyric | Butyric | i-Valerianic | Valeric | Total amount | | | |
| A | $1{,}11^{A}$ | $0{,}38^{Bab}$ | $0{,}01^{A}$ | $0{,}45^{A}$ | $0{,}03^{A}$ | $0{,}02^{A}$ | $2{,}01^{A}$ | 3,09 | 10,44 | 7,02 |
| B | $1{,}90^{B}$ | $0{,}55^{Cbc}$ | $0{,}02^{A}$ | $0{,}50^{A}$ | $0{,}04^{AB}$ | $0{,}02^{A}$ | $3{,}02^{B}$ | 3,07 | 17,30 | 7,07 |
| C | $1{,}84^{B}$ | $0{,}72^{Dc}$ | $0{,}04^{B}$ | $1{,}45^{B}$ | $0{,}05^{B}$ | $0{,}07^{B}$ | $2{,}86^{B}$ | 2,60 | 15,72 | 6,94 |
| D | $1{,}07^{A}$ | $0{,}21^{Aa}$ | $0{,}01^{A}$ | $0{,}52^{A}$ | $0{,}03^{A}$ | $0{,}03^{A}$ | $1{,}87^{A}$ | 5,00 | 11,56 | 6,82 |

**Table 2.** Numbers of protozoa in 1 ml of rumen fluid (Protozoa x $10^5$) before feeding

| Dieta | Entodinium | Diplodinium | Holotrycha | Epidinium | Ophryoscolex | suma |
|---|---|---|---|---|---|---|
| A | $1{,}93^{Cc}$ | $0{,}35^{b}$ | 0,01 | $0{,}16^{Bc}$ | 0 | $2{,}46^{Bc}$ |
| B | $0{,}98^{Aa}$ | $0{,}29^{ab}$ | 0,02 | $0{,}04^{Aa}$ | 0 | $1{,}34^{Aa}$ |
| C | $1{,}40^{Bb}$ | $0{,}34^{b}$ | 0,02 | $0{,}06^{Aab}$ | 0 | $1{,}81^{Ab}$ |
| D | $1{,}10^{Aba}$ | $0{,}25^{a}$ | 0,02 | $0{,}09^{Ab}$ | 0 | $1{,}47^{Aab}$ |

**Table 3.** 1,5 hours after feeding

| Dieta | Entodinium | Diplodinium | Holotrycha | Epidinium | Ophryoscolex | suma |
|---|---|---|---|---|---|---|
| A | $1{,}37^{Bc}$ | $0{,}24^{Cc}$ | 0,01 | $0{,}07^{b}$ | 0 | $1{,}70^{Bc}$ |
| B | $0{,}73^{Ab}$ | $0{,}22^{BCbc}$ | 0,02 | $0{,}03^{a}$ | 0 | $1{,}00^{Ab}$ |
| C | $0{,}67^{Aab}$ | $0{,}18^{ABb}$ | 0,01 | $0{,}04^{ab}$ | 0 | $0{,}90^{Aab}$ |
| D | $0{,}54^{Aab}$ | $0{,}13^{Aa}$ | 0,03 | $0{,}06^{ab}$ | 0 | $0{,}76^{Aa}$ |

# Estimation of Grass-Clover Mixtures Ensilability Parameters on the Basis of the Percentage Share of Red Clover in Them

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The grass-clover mixtures are used in cattle nutrition (feeding) as well as in the fresh and ensilage form. However conservation of this foodstuffs is difficult, because they aren't good material ensiling. The results previous experiments [Bodarski, 2000] showed that share of clover in mixture is factor which mostly modify fermentability of this feeds. That was a reason of undertaken experiments, which aim was demonstrate possibility of the estimation of ensilability parameters of grass-clover mixtures on the basis of the percentage share red clover in them.

### Materials and methods

The plant material used for investigations was two components mixture of tetraploid red clover with tetraploid grasses: perennial rye-grass, westworld rye-grass, Italian rye-grass and meadow fescue. Botanical composition of mixtures (percentage share of clover in green matter), dry matter (DM) [Skulmowski, 1974], , and content of water soluble carbohydrates (WSC) [McDonald & Henderson, 1964] was estimated as well as buffering capacity (BC) [Skulmowski, 1974]. Than, according to the equation FC=DM[%]+8 WSC/BC [Weißbach, 1999], for each silage there was calculated fermentability coefficient. The 53 samples of green matter (from 3 cuts) were taken from plants material harvested at the early blooming stage of clover and were used in statistical analysis. The correlation coefficients between clover content in mixture and estimated parameters (WSC, BC, DM) were estimated. [Żuk, 1989] For the significantly value of correlation coefficients there was estimated regression equations [Żuk, 1989]. The use of this equations make possible the estimation of value of particular parameters on the basis of botanical composition of mixtures. Established, that for good quality silage, fermentability coefficient shout achieve value at least 45 [Weißbach, 1999], there was estimated equation, by use which is possible evaluation of minimal dry matter content before ensilage: DMmin= 45-8WSC/BC. By use this pattern and estimated regression equations with regard content of water soluble carbohydrates and buffering capacity, there was evaluation correlation between botanical composition of mixtures and minimal dry matter content indispensable to achieve FC = 45.

### Results and discussion

Content of red clover in mixtures was high significantly ($P \leq 0.01$) correlated with WSC level, buffering capacity and fermentability coefficient (Table 1).

**Table 1.** The relationship (correlation coefficients) between clover content and dry matter content, clover content and water soluble carbohydrates content (WSC), clover content and buffering capaticity (BC), and clover content and fermentability coefficient (FC)

| | clover content in mixture |
|---|---|
| Dry matter | r =-0,0653 |
| WSC | r =-0,6582 ** |
| BC | r = 0,9845 ** |
| FC | r =-0,8197 ** |

**) P≤0,01

The increased of share clover in mixture caused increase of buffering capacity (positive correlation) in oppose to content of water soluble carbohydrates and fermentability coefficient (negative correlation). There was no significantly relationship between dry matter content and botanical composition of mixtures. Therefore, on the basis of the botanical composition of mixture there is possibility only estimation of: quantity of water soluble carbohydrates (Fig 1), buffering capacity (Fig 2), and fermentability of mixture (Fig 3).

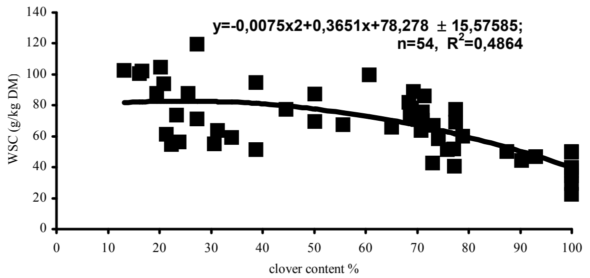


**Figure 1.** Effect of clover content in the mixture on water soluble carbohydrates content (WSC)

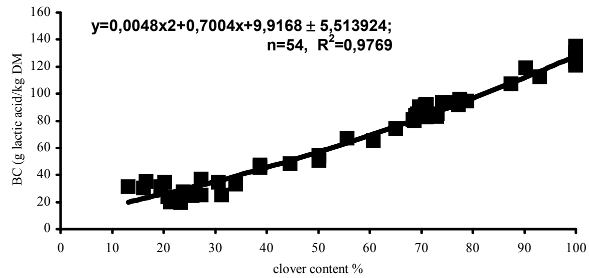


**Figure 2**. Effect of clover content in the mixture on buffering capaticity (BC)

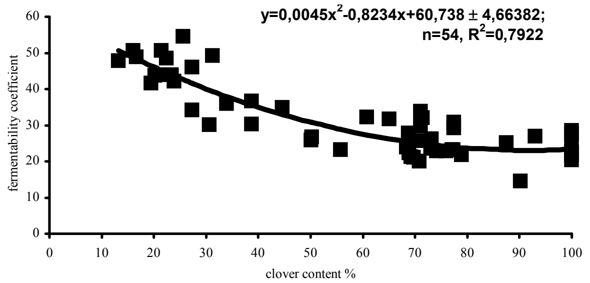


**Figure 3.** Effect of clover content in the mixture on fermentability coefficient (FC)

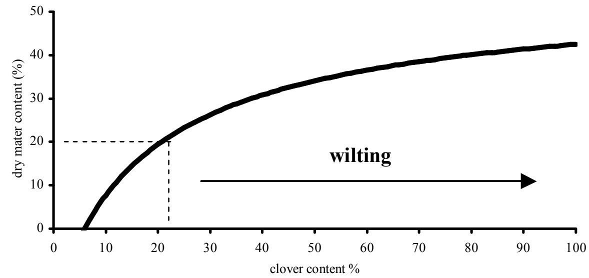


**Figure 4.** Minimal dry matter content indispensable to achieve

There is worth to note, that the estimation of buffering capacity on the basis of botanical composition of mixtures is very good prediction, because determination coefficient ($R^2$) achieve very high value = 0,9769 (Fig 2). Elaborated equations could have practical applications, 'cause on the basis the simple botanical analysis is possible evaluation of fermentablilty this mixtures. It could also make facility select definite additives, especially because there was found correlation between minimal dry matter content in mixtures for good quality fermentation and share of red clover in them. There was also shown that require pre-wilting coefficient was increasing with percentage share of red clover in mixtures (fig 4). There is also interesting that, if content of dry matter in green crops is on level 20%, pre-wilting of green matter is necessary, when red clover share in the mixture is above 20%.

## Conclusion

There is relationship between the percentage share of red clover in two components mixtures with different grasses and water soluble carbohydrates content, buffering capacity as well as fermentability coefficient of this fodder. On the basis regression equations evaluated in this paper there is possible estimation of ensilability of such mixtures. There was also indicated that, if dry matter content in green matter is on level 20%, there is indispensable pre-wilting of the mixtures, when red clover content in the mixture is above 20%.

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# THE UTILIZATION AND NUTRITIVE VALUE OF PRESERVED FEEDS AND THEIR EFFECT ON THE CATTLE HEALTH

# Influence of Nutritive Additives on Quality and Nutritive Value in Alfalfa Silages

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## Abstract

In the trials we proved influence of crushed wheat as additive to fresh and/or faded mass of alfalfa to the fermentation process and nutritive value of alfalfa silages. In the silages made from fresh or faded mass, treated by formic acid and crushed wheat there was significantly decreased content of crude fiber. The addition of crushed wheat significantly increased content of lactic acid in both series of the trials. Extremely low content of lactic acid was found in the silages from fresh mass with addition of formic acid. In the silages made from a middle faded alfalfa was recorded the lowest content of lactic acid after application of chemical inhibitor (formic acid) as well. Silages of all variants in both series of trials were noted by high content of acetic acid. Addition of crushed wheat to fresh and/or faded alfalfa mass has positive influence to the fermentation and nutritive value of alfalfa silages.

## Introduction

The role of absorbents is increased content of dry matter in the silage matter. As absorbent is usually used cut straw, crushed grains, husks or various wastes they occur in clearing of cereal grains. The crushed grains are also important source of sugars (Loučka et al., 1997). Bolsen (1993) declare the crushed grains as source of substrates which are at once the nutrition source as well. Schmidt and Wetterau (1974) recommend use the portion of crushed grain or cereal meal in amount of 40-70 kg/t of fodder. Schmidt (1989) declare to add the crushed grain as silage additive into green matter in relatively great amount (8-12 %) because they content only small amount of sugars. The aim of the experiments was to find the effect of crushed wheat to the fermentation process and nutritive value of alfalfa silages.

## Materials and methods

In the laboratory conditions was silaged alfalfa (medicago sativa) var. Palava from second cut in growing season flowering. In the first series of trials was alfalfa silaged fresh with dry matter content 228 g.kg$^{-1}$ ($K_1$-$P_1$) and in the second series of trials was silaged alfalfa middle faded with dry matter content 281,6 g.kg$^{-1}$ ($K_2$-$P_2$). Individual variants were silaged: variants $K_1$ and $K_2$ as a control – matter without treatment, A as positive control with formic acid (in the variant $A_1$ in the dose 4000 g/t of matter and in variant $A_2$ in the dose of 3000 g/t of dry matter), P with addition of crushed wheat (in the variant $P_1$ in the dose of 81 kg/t of matter and in the variant $P_2$ in the dose of 91 kg/t of the matter). The matter of alfalfa was cutted by stationary cutter to the lenght 15 mm and by pneumatic press was pressed into silage cylinders in the volume of 15 dm$^3$ and loaded by 10 kg load and hermetized. Each variant was silaged in 4 repetitions. Fermentation was carried out 8 weeks at temperature 20-25 $^{O}$C. After the silage cylinders were open and the samples of silages were analyzed for content of nutrients according to STN 46 7092 and parameters of fermentation process were tested according to STN 46 7012. The parameters of nutritive value we calculated according to Sommer et al.(1994).

## Results and discussion

In the silages of variant $K_1$ we found the dry matter content 232,7 g.kg$^{-1}$ , in the silages of $A_1$ 245,4 g.kg$^{-1}$ and in the silages of crushed wheat addition ($P_1$) 282,6 g.kg$^{-1}$ (tab.1). In the silages of $P_1$ we observed significantly higher content of crude protein in comparison to the silages of $K_1$. The addition of nutrient absorbent ($P_1$) as well as formic acid ($A_1$) significantly decreased content of crude fiber in the silages by 18,4 % ($P_1$) and 6,5 % ($A_1$). In comparison to variant $K_1$ had silages $A_1$ and $P_1$ significantly ($P<0,001$) higher content of nitrogen free extract (NFE). Similarly Jambor and Chromec (1997) after alfalfa silaging (with content of dry matter 17,3 %) with addition of 8 % crushed barley found significantly higher content of crude protein, NFE and significantly lower content of crude fiber. The fresh alfalfa altogether with crushed wheat (dry matter content 270,3 g) suddenly before silaging contained 4,88 MJ.kg$^{-1}$ NEL and in the silages $P_1$ we found value NEL 5,06 MJ.kg$^{-1}$. Increasing of NEL value of silages $P_1$ was statistically significant ($K_1$:$P_1$). Silages with formic acid ($A_1$) had significantly higher NEL and PDI values in comparison to nontreated silages ($K_1$). In the silages with addition of nutrition absorbent ($P_2$) was higher content of dry matter by 26,3 % in comparison to control silages $K_2$ (tab. 3). The silages $A_2$ had significantly higher content of crude protein than silages $K_2$. In comparison with nontreated silages ($K_2$) we found in silages $P_2$ and $A_2$ significantly lower content of crude fiber. The content of NFE was in the silages $A_2$ and $P_2$ significantly higher in comparison to silages $K_2$. Middle faded alfalfa before silaging with crushed wheat addition (dry matter content 337,6 g) contained 5,19 MJ.kg$^{-1}$ and in the silages $P_2$ we found the NEL value 5,61 MJ.kg$^{-1}$. This value NEL was the highest while differences between $K_2$:$P_2$ were significant ($P<0,001$). Either silages $A_2$ had significantly higher value NEL. In comparison to silages $K_2$ we found in silages $A_2$ and $P_2$ significantly higher value PDI. The result of fermentation process in alfalfa silages made from fresh matter is presented in tab.2 and from middle faded matter in tab. 4.

## Conclusions

In the alfalfa silages made from fresh and faded matter, addition of nutrient absorbent (crushed wheat) positively influenced nutritive value of silages. The trial silages had significantly lower content of fiber and significantly higher content of nitrogen free extract. In the trial silages made from fresh matter was significantly increased value of NEL by 9,5 % and in the silages with higher content of dry matter by 20,9 % in comparison to nontreated silages. Addition of crushed wheat significantly increased content of lactic acid in alfalfa silages what positively decreased value of pH.

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STN 46 7092, STN 46 7012

**Table 1.** Nutritive value and significance of differences of nutritive value in alfalfa silages made from fresh matter

| n = 4 | $K_1$ | $A_1$ | $P_1$ | $K_1 : A_1$ | $K_1 : P_1$ | $A_1 : P_1$ |
|---|---|---|---|---|---|---|
| | average | average | average | | | |
| Dry matter g/kg | 232,7 | 245,4 | 282,6 | + + | + + + | + + + |
| Crude protein g/kg | 157,2 | 163,8 | 163,4 | - | + | - |
| Crude fiber g/kg | 396,5 | 370,7 | 323,4 | + + | + + + | + + + |
| NFE * g/kg | 337,6 | 365,1 | 414,1 | + + | + + + | + + + |
| NEL MJ/kg | 4,62 | 4,67 | 5,06 | - | + + + | + + + |
| PDI in g/kg | 59,5 | 68,5 | 60,1 | + + + | - | + + |

* NFE – nitrogen free extract

**Table 2.** Result of fermentation process and significance of differences of indicators in alfalfa silages made from fresh matter

| n = 4 | $K_1$ | | $A_1$ | | $P_1$ | | $K_1 : A_1$ | $K_1 : P_1$ | $A_1 : P_1$ |
|---|---|---|---|---|---|---|---|---|---|
| | average | portion % | average | portion % | average | portion % | | | |
| Lactic acid g/kg | 84,1 | 57,7 | 13,7 | 23,3 | 112,3 | 58,3 | + + + | + + + | + + + |
| Acetic acid g/kg | 61,6 | 42,3 | 45,1 | 76,7 | 80,4 | 41,7 | + + + | + | + |
| pH | 4,5 | | 4,3 | | 4,1 | | - | + + + | - |

**Table 3.** Nutritive value and significance of differencies of nutritive value in alfalfa silages made from little faded matter

| n = 4 | $K_2$ | $A_2$ | $P_2$ | $K_2 : A_2$ | $K_2 : P_2$ | $A_2 : P_2$ |
|---|---|---|---|---|---|---|
| | average | average | average | | | |
| Dry matter g/kg | 277,9 | 293,6 | 350,9 | + + + | + + + | + + + |
| Crude protein g/kg | 163 | 176,4 | 168,8 | + + + | - | + |
| Crude fiber g/kg | 348,9 | 321,9 | 243,3 | + + | + + + | + + + |
| NFE * g/kg | 352,5 | 367,8 | 470,2 | + + | + + + | + + + |
| NEL MJ/kg | 4,64 | 4,85 | 5,61 | + + | + + + | + + + |
| PDI in g/kg | 60,8 | 66,3 | 66,8 | + + | + + + | - |

* NFE – nitrogen free extract

**Table 4.** Result of fermentation process and significance of differencies of indicators in alfalfa silages made from little faded matter

| n = 4 | $K_2$ | | $A_2$ | | $P_2$ | | $K_2 : A_2$ | $K_2 : P_2$ | $A_2 : P_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | average | portion % | average | portion % | average | portion % | | | |
| Lactic acid g/kg | 66,3 | 50,7 | 61,8 | 53,3 | 104,7 | 65,9 | - | + + + | + + + |
| Acetic acid g/kg | 64,6 | 49,3 | 54,2 | 46,7 | 54,3 | 34,1 | + | - | - |
| pH | 5 | | 4,3 | | 4,4 | | + + + | + + + | + + |

# Sorghum Silage for High Lactating Dairy Cows

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## Abstracts

Forage sorghum var. FS-5 was harvested at three maturation stages: flowering, milk and dough and ensiled under laboratory conditions. Results indicated the significant increase in dry matter (DM) content (34%) of the dough maturation stage, which makes it suitable for ensiling without the risk of effluent production. The highest quality silage was obtained from the dough stage. All silages were stable upon aerobic exposure. It seems that sorghum silage can replace maize silage due to its nutritional quality and ensiling properties.

## Introduction

High-yielding dairy cows demand high-quality forage. In Israel maize (Zea mays L.) for silage is the main forage crop in summer, and there is no doubt that the high quality of the maize silage matches the demands of lactating cows. In comparison with sorghum (Sorghum bicolor (L.) Moench) maize forage requires more water and fertilizers, and is more delicate and needs more attention during the growth period. Lack of water has brought many Israeli farmers to prefer sorghum to the traditional maize as a summer forage crop. This tendency will probably intensify in the future, and we can expect that sorghum will replace maize as a summer forage crop for high-yielding dairy cows in most areas of the country. Much work on forage sorghum has been done in Kansas State University, USA. (Dickerson, 1986; Smith, 1986; Dost, 1989) in order to improve the ensiling process. Meeske et al. (1993) added LAB inoculant, which improved fermentation but reduced the aerobic stability of the silage. Ashbell et al. (1999) mixed two hybrids of sorghum in order to obtain a mixture with better ensiling qualities, but this is a good option only if it is not too difficult technically. The present paper compares the preservation of forage sorghum harvested at three maturation stages.

## Materials and methods

Sorghum Var. FS-5 (De Kalb) seeded in spring on dry land, which received 630 mm winter rain. The sorghum was harvested at the flowering, milk and dough stages of maturity, after 98, 103 and 109 respectively. The crop was chopped into 15mm lengths and ensiled in 1.5l jars. Three jars from each maturation stage were opened after 1, 5, 15 and 105 days of ensiling to study the fermentation dynamics. The final silages were also subjected to an aerobic stability test according to Ashbell et al. (1991), the analyses are described in detail in Ashbell et al. (1999).

## Results and discussion

**Table 1.** Chemical analysis of the sorghum forage plants (three maturation stages).

| Maturation stage | Dry matter (%) | WSC (% in DM)[1] | NDF (% in DM)[2] | Ash (% in DM) |
|---|---|---|---|---|
| Flowering | 27.4±0.1 [b] | 12.2±2.1 [a,b] | 51.2±0.7 [a] | 5.8± 0.1 [a] |
| Milk | 28.8 ±0.8 [b] | 14.9± 0.1 [a] | 48.9± 0.1 [b] | 6.0 ±0.0 [a] |
| Dough | 34.0± 1.4 [a] | 6.9 ±0.3 [b] | 42.5± 0.3 [c] | 4.8± 0.1 [b] |

[1] Water soluble carbohydrates. [2] Neutral detergent fiber. Within a column and forage type, means followed by different letter differ significantly ($p < 0.05$). Results presented in table 1 indicate the significant increases in the DM content from the milk stage to the dough stage, and the reduction of the NDF during maturation.

**Table 2.** In situ digestibility after 12 and 24 h.

| Maturation stage | After 12h of incubation | After 24h of incubation |
|---|---|---|
| Flowering | 51.9±0.6 [b] | 60.4±1.1 [a] |
| Milk stage | 54.7±0.8 [a] | 60.7±0.9 [a] |
| Dough stage | 52.0±1.7 [b] | 61.7±0.8 [b] |

Within a column and forage type, means followed by different letter differ significantly ($p < 0.05$). It is clear that the ensilability of all three maturation stages was good. Great similarity in the digestibility was found in all stages, especially after 24h of incubation.

**Table 3.** Chemical analysis of the sorghum silage after 105 days of ensiling (three maturation stages).

| Maturation stage | Dry matter % | pH | Lactic acid [1] | Acetic acid [1] | Ethanol [1] | Ash [1] | NDF [1] |
|---|---|---|---|---|---|---|---|
| Flowering | 26.2±0.4 [b] | 3.7±0.3 [b] | 5.8±2.8 [a] | 1.3±0.4 [a] | 1.7±0.2 [a] | 6.9±0.3 [a] | 51.2±0.2 [a] |
| Milk stage | 28.9±1.6 [a] | 3.9±0.2 [a,b] | 4.5±1.2 [a] | 1.6±0.1 [a] | 1.2±0.1 [b] | 6.8±0.4 [a] | 48.6±0.6 [a,b] |
| Dough stage | 31.3±1.7 [a] | 4.2±0.0 [a] | 3.0±1.0 [a] | 0.7±0.3 [a] | 1.1±0.2 [b] | 6.2±0.5 [a] | 46.2±2.8 [b] |

[1] % in dry matter. Within a column and forage type, means followed by different letter differ significantly ($p < 0.05$).

It is clear that the ensilability of all three maturation stages was good. Microbiological test indicated that the numbers of lactic acid bacteria were alike after 24h of ensiling, and the silage was stable in aerobic condition.

## Conclusions

The results indicated that forage sorghum can be preserved in all three maturation stages. In the dough stage the dry matter content of the forage is above 30%, this can ensure fermentation without effluent production which is important for the reduction of losses and elimination of environmental pollution. It is still necessary to find better varieties of higher quality and with better lodging stability.

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# Changes of Nutrient Contents of Grass by Ensiling

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### Abstract

With the data of 226 pairs of fresh forage (FF) and silage, equations for estimating crude nutrient contents in silage were developed:

Dry matter (DM) in silage = 48 + 0.85 * dry matter content in FF (g/kg)
Crude ash in silage = 1.087 * crude ash in FF (g/kg DM)
Crude protein in silage = 11 + 0.95 * crude protein content in FF (g/kg DM)
crude fiber in silage = 12 + 1.0 * crude fiber content in FF (g/kg DM)

### Introduction

There are some advantages to analyse the fresh forage instead of the corresponding silage. Thus, the results are available before the silo is opend and the information can be used in feed ration formulation. But in this case it is necessary to have equations for the calculation of the nutrients expected in the silage

### Materials and methods

For developing the equations the data of silage conservation experiments with balance bags, carried out in the years 1990 - 1994 were used. The data are out of of 144 experiments with first cut grass, 64 with grass of second and following cuts, 22 samples of a clover-grass-mixture, of alfafa or rye grass. With these experiments, the crude nutrients of fresh material and silage (dry matter DM, crude ash CA, crude protein CP, crude fiber CF and crude fat CL) were determined. The fermentation parameters in silage like the acids, pH and NH3 were also measured. By weighing the bags before and after ensiling the losses (or recovery = 100 - loss) of DM were calculated, taking into account the DM content in FF and silage. Each pair of forage (fresh and the corresponding silage) consisted of the control (without addidive) of up to 6 variants, treated with additives. Additionally, from farmers in a region in southern Bavaria, a set of 26 pairs of grass (second or following cuts) of the year 2000 were sampled and the crude nutrients (without CL) in grass and silage analysed. The crude nutrients are presented in table 1. They agree well with the samples from practical farms.

**Table 1.** Crude nutrient contents in the fresh forage and the silage (n = 226, CL n = 200)

| | Fresh forage | | | Silage | | |
|---|---|---|---|---|---|---|
| | Mean | s | Range | Mean | s | Range |
| Dry matter DM g/kg | 360 | 76 | 186..554 | 354 | 69 | 185..543 |
| Crude ash CA g/kg DM | 93 | 15 | 54..170 | 101 | 15 | 65..173 |
| Crude protein CP g/kg DM | 161 | 40 | 95..251 | 165 | 36 | 99..252 |
| Crude fiber CF g/kg DM | 237 | 28 | 186..303 | 247 | 27 | 182..323 |
| Crude fat CL g/kg DM | 25 | 4 | 15..38 | 38 | 9 | 20..60 |

### Results and discussion

By comparing the crude nutrients in the fresh forage (at ensiling) and in the corresponding silage, the changes of the nutrient contents are shown. Equations for estimating the nutrients in silage with regression techniques were developed.

Dry matter DM

The processes in the silo lead to DM losses, reducing the DM content. At the basis of the mass equation (1 g glucose delivers 0.6 g water), and depending on the extent of DM loss or DM recovery ( = 100 – DM loss) the expected DM content in silage can be calculated with the formula:

DM in silage (calculated) = DM recovery / (DM recovery + DM loss * 0.6 + water in grass) (1)

The average DM recovery in the forage conservation experiments was 92.5 %, in the following a DM recovery of 92 % (= 8 % DM loss) is assumed. The measured DM content in the silage (g/kg) is estimated by the following equation:

DM in silage (measured) = 48 + 0.85 * DM content in grass (g/kg) (2)

In table 2, for three levels of DM in the fresh forage, the DM in silage – calculated at the basis of a 92 % recovery - and the measured DM, using equation (2), is shown.

**Table 2.** DM in silage depending on DM in forage (g/kg)

| | | | |
|---|---|---|---|
| DM in fresh forage | 200 | 350 | 500 |
| DM in silage (calculated), recovery 92 % (1) | 185 | 326 | 467 |
| DM in silage (measured) (2) | 218 | 346 | 473 |

With higher DM contents in forages (more than 400 g/kg) the measured DM in silage is nearly the calulcated one, with lower DM contents in fresh forage (less than 300 g/kg) the DM in silage is higher than calculatid. It seems, that water flows off and as a consequence the DM content increases. The accuracy of the equation (2) for estimating DM in silage can be seen in table 3, it is shown with the standard deviation of the difference being 27 g/kg.

Crude ash CA
Because the minerals are not degraded by the ensiling process, the content of crude ash is expected to increase inversely to the decrease of DM recovery (100 / DM recovery). With the recovery of 92 % the factor is 1.087 and the equation is as follows:

CA in silage (expected) = 1.087 * CA in fresh forage (g/kg DM) (3)

This estimation equals, on average, with the measured ash content in silage, the difference has a standard deviation of 8 g/kg DM with extemes of –20 and + 31 g/kg DM (table 3).

Crude protein CP
The crude protein is partially degraded by the ensiling process to NH3. Usually, the samples of silage are first dried, so protein is analysed without the volatile ammonium. The content of crude protein in silage can be estimated by calculating its increase due to the DM loss and substracting the protein equivalant of NH3 (CP NH3 = NH3 * 5.16). For an average content of 160 g CP/kg DM in grass with the recovery of 92 % the CP will be 174 g CP/kg DM. The avarage content of CP NH3 was 11 g/kg DM, so the analysed CP in silage was 163 g CP/kg DM (= 174 – 11). Because of the higher CP content of the samples, the CP NH3 was higher too, thus the CP content can be estimated with following equation:

CP in silage (expected) = 11 + 0.95 * CP content in grass (g/kg DM) (4)

The accuracy of this equation is discribed with the standard deviation from the difference of measured and estimated CP values being 12 g/kg DM (table 3). This includes the sampling error of grass and silage and the error of estimation.

Crude fiber CF
The crude fiber content of the fresh forage samples was, on average, 237 g/kg DM, with a range from 186 to 303. The content of crude fiber in silage corrected for a recovery of 92 % was 12 g CF/kg DM higher, but this was 9 g CF/kg DM lower than the expected CF with a recovery of 92 %. So, one can assume an average degradation of 9 g CF/kg DM. With higher CF content the degradaton of the CF was higher too. The estimation of CF can be formulated with the equation:

CF in silage (expected) = 12 + 1.0 * CF content in grass (g/kg DM) (5)

With this equation an accuracy of 12 g/kg DM (standard deviation of the difference of measured and estimated CF values) can be obtained. The maximum differences reached from -30 to +43 g CF/kg DM.

Crude fat CL
The crude fat has been analysed in the conservation experiments. The average fat content increases from 25 g/kg DM in grass to 38 g/kg DM in silage. For samples of roughage from farmers crude fat is not analysed to avoid extra costs. So for further calculations, a content of 40 g CL in silage is assumed. The standard deviation of this value to the analysed CF was 9 g/kg DM.

## N-free extract NfE

In the Weende analysis, the NfE are defined as the rest of dry matter, written with the formula:
NfE = 1000 – CA – CP – CF – CL (g/kg DM) (6)

The NfE in a sample is computed with the crude nutrients, measured or estimated. The results are used for further calculations like estimation of energy content.

**Table 3.** Estimated crude nutrients (formula) and differences to measures in silage (n = 226)

| | Estimated nutrient contents | | | Difference | | |
|---|---|---|---|---|---|---|
| | Mean | s | Range | Mean | s | Range |
| Dry matter DM g/kg (2) | 354 | 65 | 206..519 | 0 | 27 | -90..+110 |
| Crude ash CA g/kg DM (3) | 101 | 16 | 59..185 | 0 | 8 | -20..+ 31 |
| Crude protein CP g/kg DM (4) | 164 | 38 | 101..249 | -2 | 12 | -34..+ 29 |
| Crude fiber CF g/kg DM (5) | 249 | 28 | 198..315 | +2 | 12 | -30..+ 43 |

## Conclusions

For the estimation of the content of crude nutrients in silage, at the basis of the contents in the fresh forage equations have been developed and their precision is indicated. The advantage, to get the results earlier, has to be weighted against the errors of prediction.

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# Forage Quality from Sequential Sampling Dates of Grasses and Legumes

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## Abstract

Nutrient concentration in consumed dry matter (in roughage above all) is the most topical problem of animal nutrition in C.R.. Seven sequential samplings of 8 grass species and 3 legumes in weekly intervals (May 5 - June 17, two years) during the 1st growth period at two localities (Jevíčko, Hladké Životice) were done. Changes in fodder quality were characterized by mean values of NEL, PDIN, PDIE and fibre in kg of dry matter.

## Introduction

Production of roughage characterized by high nutrient concentration in dry matter is one of the most topical problems of ruminant nutrition. Selection process utilizing species and line hybridization was used for production of new grass and legume varieties. The evaluation of quality of these varieties during the 1st growth is the subject of this contribution.

## Materials and methods

Eight promising varieties of grasses and three varieties of red clover were chosen for the evaluation of quality during vegetation: 1. cv. BEČVA (Lolium multiflorum x Festuca arundinacea), 2.cv. HYKOR (L. multiflorum x F. arundinacea), 3. cv. SPORT (Lolium perenne), 4. cv. MUSTANG (L. perenne – tetraploid reygrass), 5. cv. ROŽNOVSKÁ (Festuca pratensis), 6. cv. KORA (Festuca arundinacea), 7. cv. NIVA (Dactylis glomerata), 8. cv. TACIT (Bromus uniloides -(Willd.) Beauv.), 9. cv. Vesna (Trifolium pratense), 10. cv. Radegast (Trifolium pratense), 11. cv. Dolina (Trifolium pratense). Studied varieties of forages were grown at two sites, in two years of growth and harvests (twice in 1st utility year, once in 2nd utility year) in four replications. 1848 samples were collected during the evaluated period that were put into 462 samples according to replications. These samples were analyzed with Weende method and tested on digestibility with OM method in situ. Spectra received from NIRS instrument were stored, too.

## Results and discussion

In the tables 1 and 2 are given acquired values of fibre, NEL, PDIN and PDIE for each variety from sequential collections (after 6 determinations). Presented values are expressed in the form of diagrams 1-7 that are attached to the text. The diagrams show gradual decrease of nutrients concentration (NEL, PDIN and PDIE) in the dry matter of forages. And increase of fibre concentration as a marker of forage ageing.

From the differences among varieties in evaluated features it is possible to determine harvest dates to receive necessary concentration of nutrients with respect to the dates of collections, resp. harvests in the first cuts of studied species and varieties. The average changes of evaluated features in weekly intervals are given in table 1 for grasses and table 2 for legumes. For grasses, NEL decrease by 0.24 to 0.3 MJ per a week and fibre content increase in the dry matter by 16 to 23 g per a week was found out and also higher decrease of PDIN content in the dry matter in weekly intervals (9 – 12 g) and lower decrease of PDIE (3.8 – 4.6 g). Studied varieties of red clover also exhibited a similar trend.

## Conclusions

Reasonable timing of the grass harvest and preservation are the primary prerequisites for production of good-quality silage. Requirements approaching well-timed harvest can be derived from the relationship between crude fibre content and net energy concentration. Concentration of N-substances in grass (or ratio PDIN/PDIE) is also affected considerably by fertilization level (N-fertilization above all). Good understanding of agricultural principles and utilization of grass forage crops in nutrition would contribute to adequate nutrition level of animals.

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Tab. 1 Nutrient content of tested grass, 1. growth

| Date | Num. | n | In 1kg dry matter | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Be□va | | Hykor | | Sport | | Mustang | | Ro□novská | | Kora | | Niva | | Tacit | |
| | | | Fibre | NEL | Fibre | NEL | Fibre | NEL | Fibre | NEL | Fibre | NEL | Fibre | NEL | Fibre | NEL | Fibre | NEL |
| | | | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) | (g) | (MJ) |
| 5.5 | 1 | 6 | 182 | 6,70 | 227 | 6,05 | 192 | 6,78 | 187 | 6,85 | 229 | 6,03 | 230 | 5,87 | 220 | 6,26 | 221 | 6,54 |
| 17.6. | 7 | 6 | 311 | 5,15 | 335 | 4,65 | 322 | 5,12 | 328 | 5,10 | 352 | 4,45 | 329 | 4,60 | 352 | 4,58 | 332 | 5,11 |
| | | AVG | 242 | 5,95 | 280 | 5,34 | 245 | 6,05 | 245 | 6,10 | 298 | 5,08 | 284 | 5,11 | 294 | 5,32 | 288 | 5,72 |
| | | $s_x$ | 47 | 0,56 | 42 | 0,54 | 50 | 0,62 | 51 | 0,63 | 43 | 0,56 | 38 | 0,47 | 47 | 0,58 | 41 | 0,52 |
| high or abas. / week | | | 21 | -0,26 | 18 | -0,23 | 22 | -0,28 | 23 | -0,29 | 20 | -0,26 | 16 | -0,21 | 22 | -0,28 | 18 | -0,24 |
| | | | | | | | | | | | | | | | | | | |
| Date | Num. | n | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE | PDIN | PDIE |
| | | | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) |
| 5 5 | 1 | 6 | 94,8 | 92,7 | 104,9 | 93,1 | 111,6 | 96,8 | 107,0 | 96,6 | 109,7 | 92,4 | 105,3 | 92,1 | 112,7 | 93,4 | 121,9 | 98,6 |
| 7 6. | 7 | 6 | 41,4 | 70,2 | 45,6 | 67,8 | 48,4 | 72,4 | 47,4 | 71,5 | 44,3 | 65,9 | 46,4 | 67,8 | 45,1 | 66,0 | 47,4 | 72,3 |
| | | AVG | 62,4 | 80,8 | 69,6 | 79,5 | 70,7 | 83,7 | 68,8 | 83,5 | 68,8 | 76,7 | 69,5 | 77,5 | 71,5 | 78,1 | 75,5 | 83,2 |
| | | $s_x$ | 19,6 | 8,4 | 21,0 | 9,3 | 21,6 | 8,6 | 20,7 | 8,8 | 21,3 | 9,0 | 19,5 | 8,6 | 22,5 | 9,3 | 25,3 | 9,2 |
| abasement week | | | -8,9 | -3,8 | -9,9 | -4,2 | -10,5 | -4,1 | -9,9 | -4,2 | -10,9 | -4,4 | -9,8 | -4,1 | -11,3 | -4,6 | -12,4 | -4,4 |

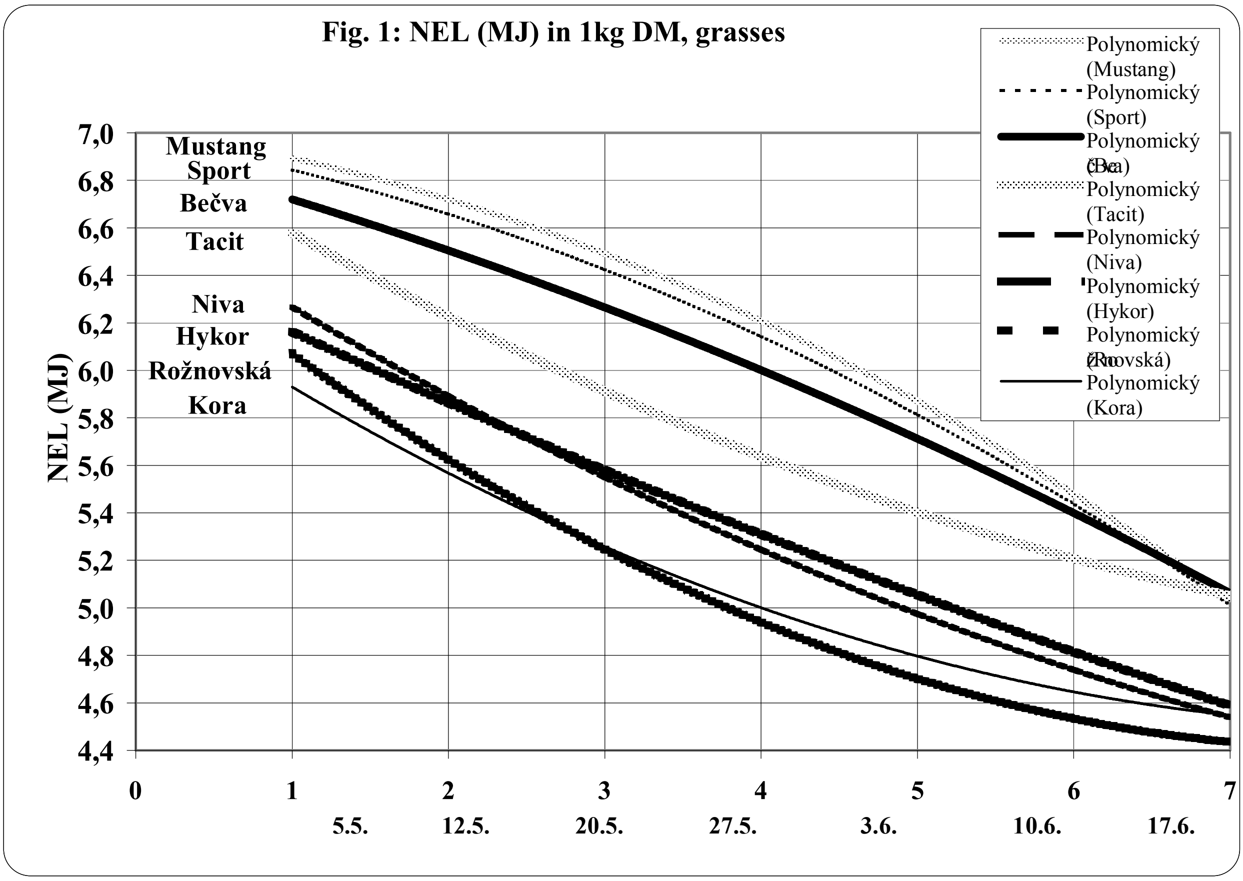


Fig. 1: NEL (MJ) in 1kg DM, grasses
Polynomický (Mustang)
Polynomický (Sport)
Polynomický (Bečva)
Polynomický (Tacit)
Polynomický (Niva)
Polynomický (Hykor)
Polynomický (Rožnovská)
Polynomický (Kora)
Mustang
Sport
Bečva
Tacit
Niva
Hykor
Rožnovská
Kora
NEL (MJ)
7,0
6,8
6,6
6,4
6,2
6,0
5,8
5,6
5,4
5,2
5,0
4,8
4,6
4,4
0 1 2 3 4 5 6 7
5.5. 12.5. 20.5. 27.5. 3.6. 10.6. 17.6.

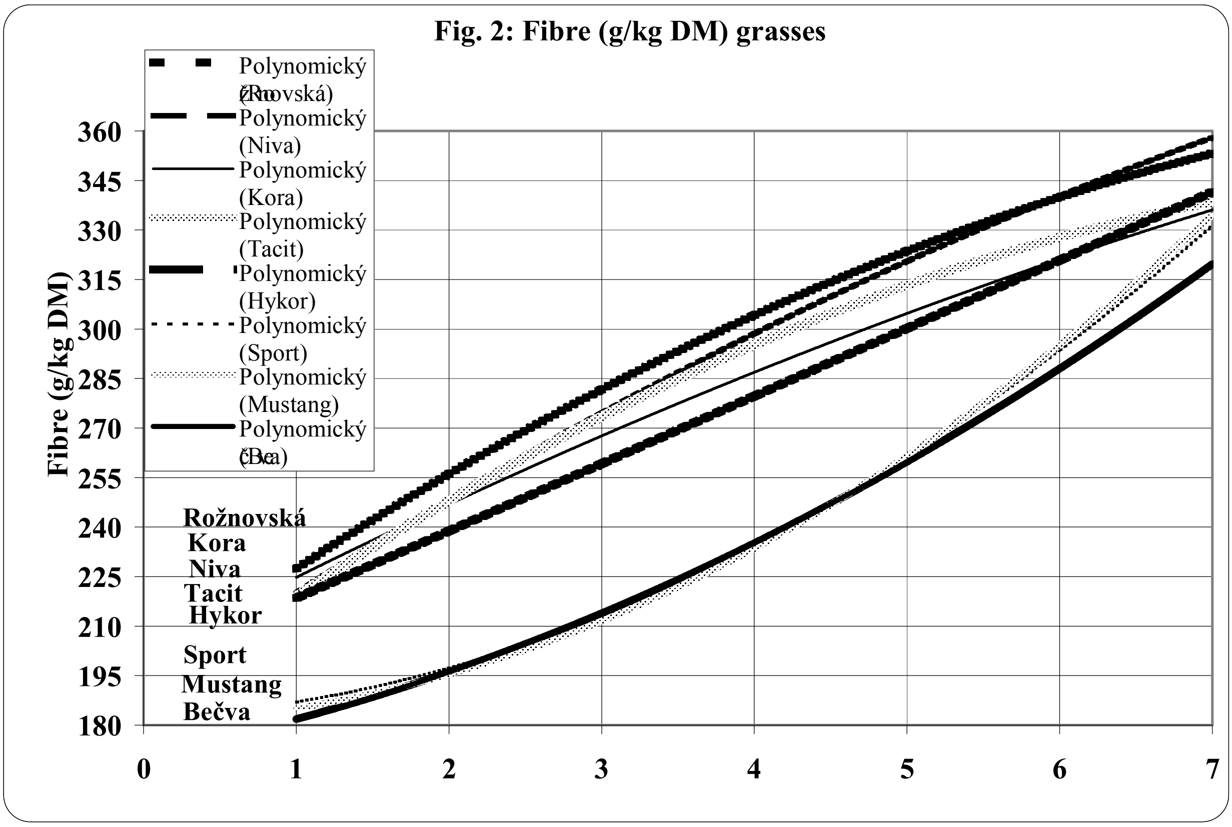


Fig. 2: Fibre (g/kg DM) grasses
Polynomický (Rožnovská)
Polynomický (Niva)
Polynomický (Kora)
Polynomický (Tacit)
Polynomický (Hykor)
Polynomický (Sport)
Polynomický (Mustang)
Polynomický (Bečva)
Fibre (g/kg DM)
360
345
330
315
300
285
270
255
240
225
210
195
180
Rožnovská
Kora
Niva
Tacit
Hykor
Sport
Mustang
Bečva
0 1 2 3 4 5 6 7

Fig. 3: NEL (MJ) in 1kg DM  legumes

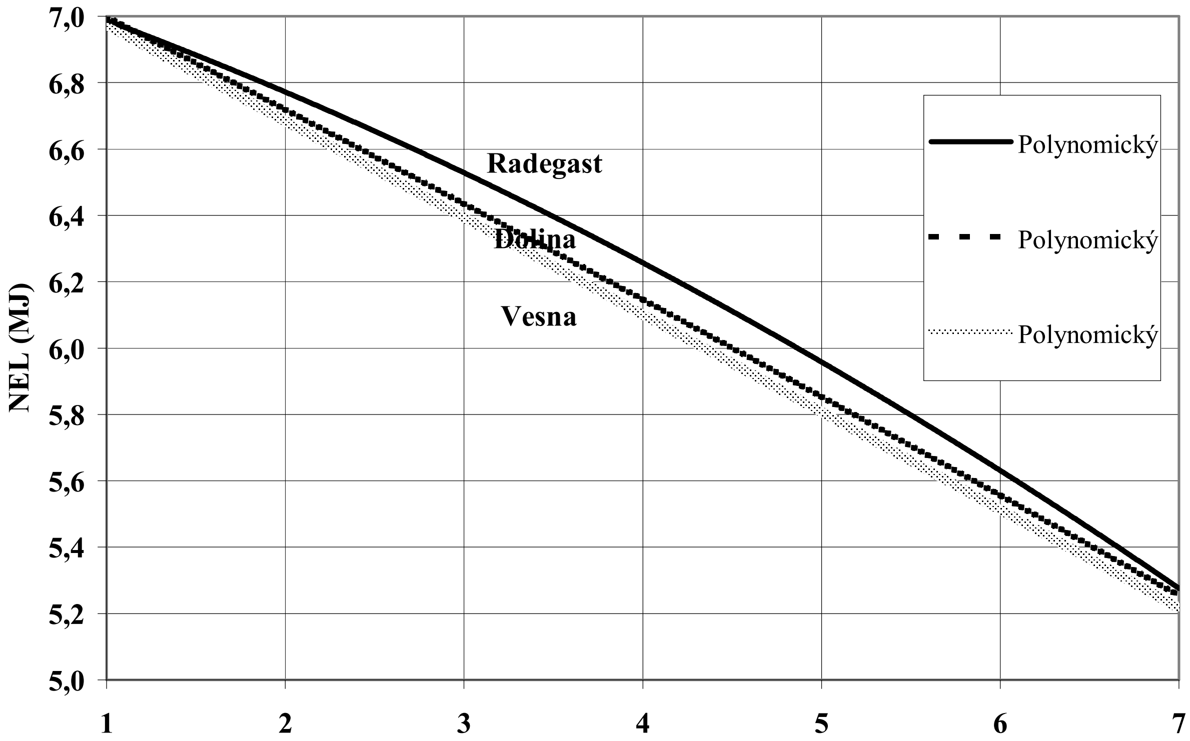



Fig. 4: Fibre (g/kg DM) legumes

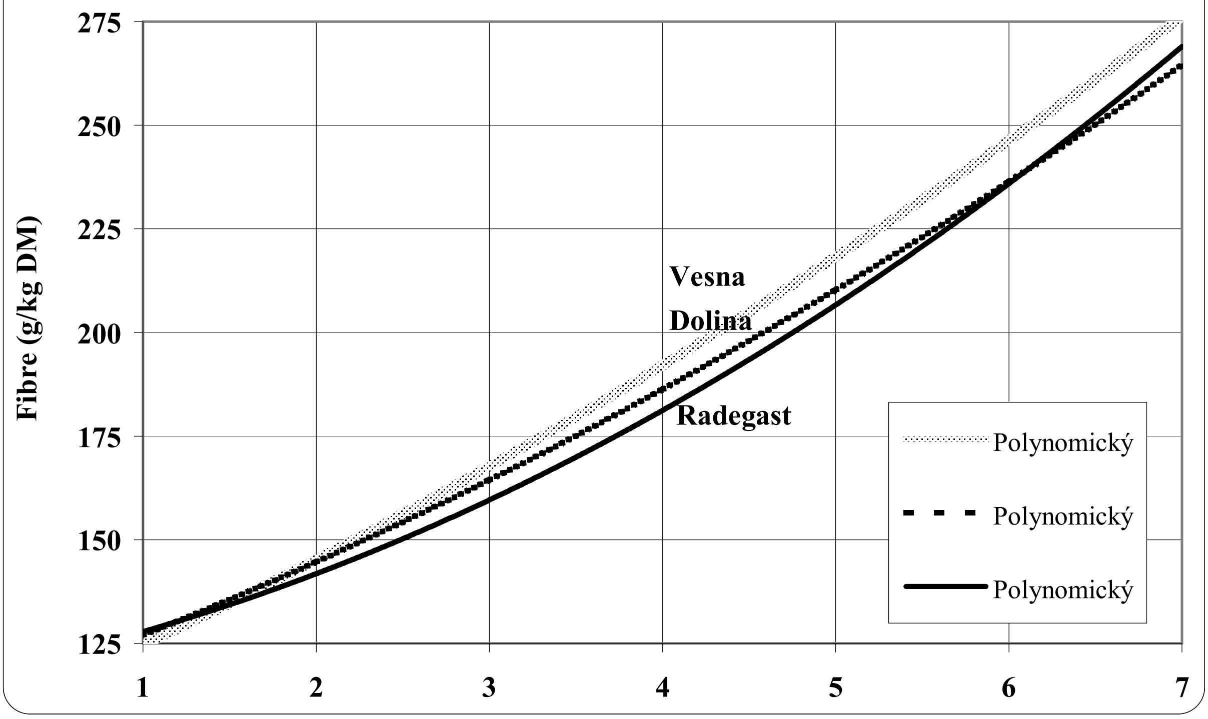


**Fig. 5: PDIN (g/kg DM), grasses**

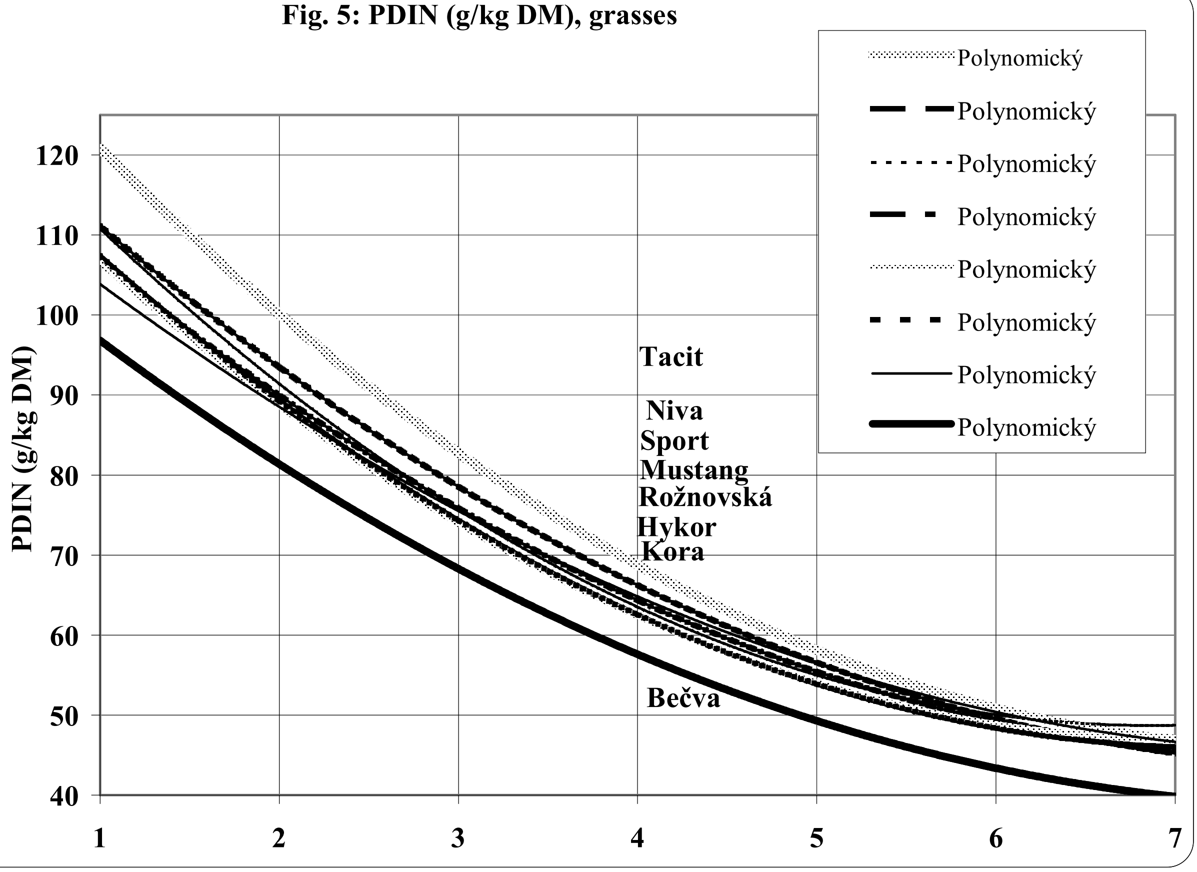



**Fig. 6: PDIE (g/kg DM), grasses**

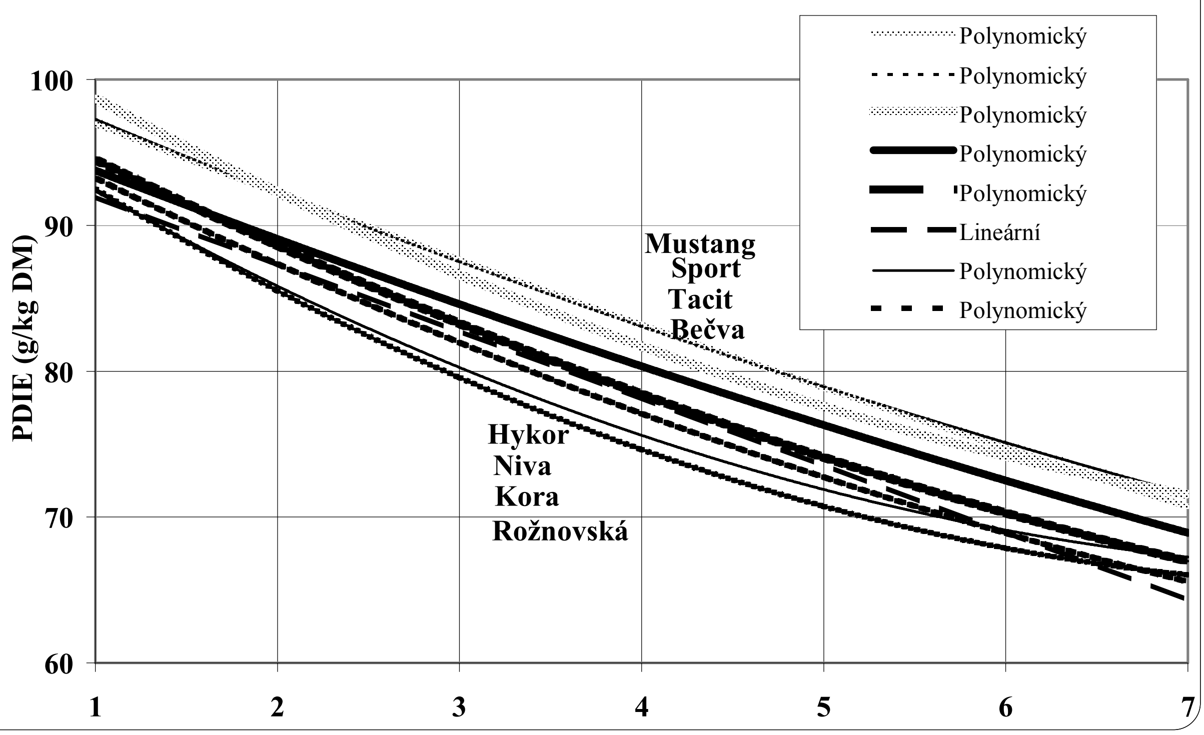
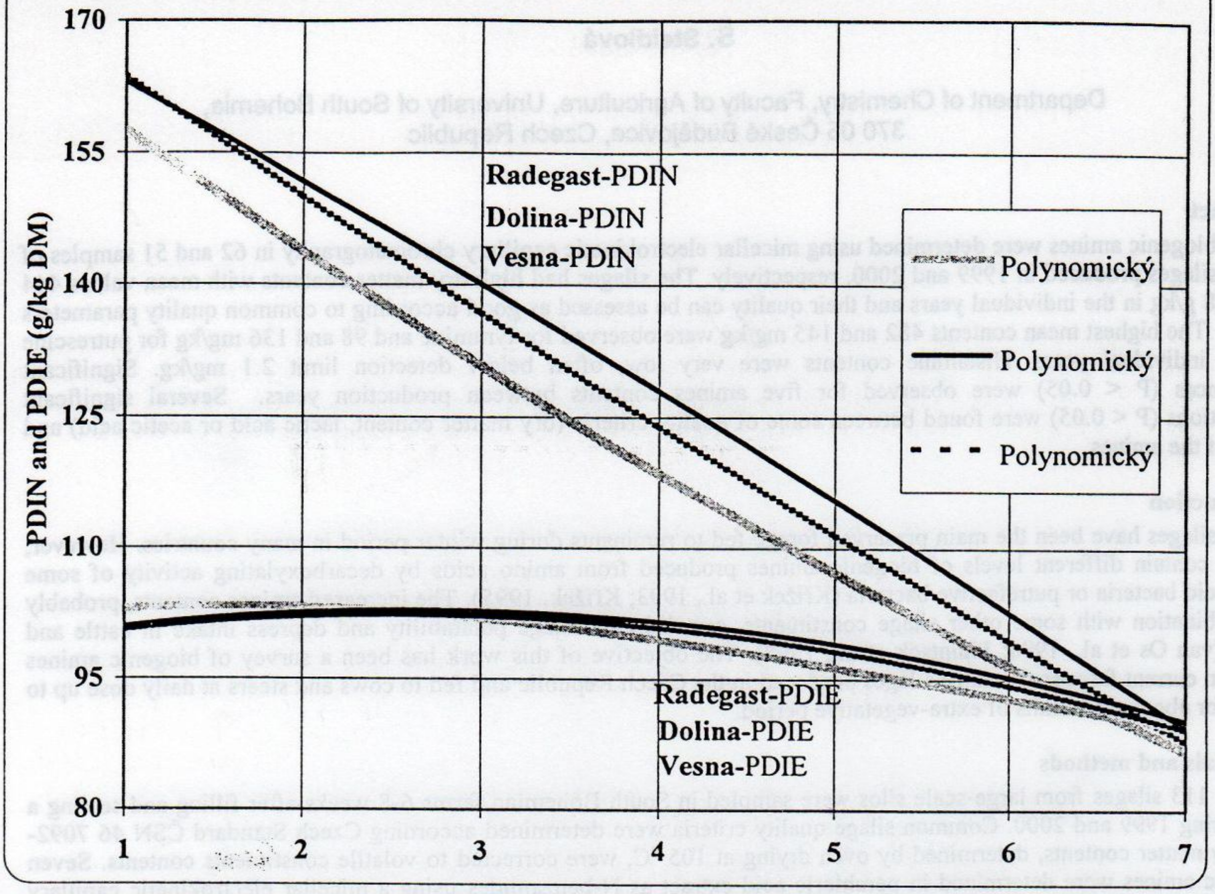


**Fig.7: PDIN and PDIE (g/kg DM), legumes**




**Tab. 2: Nutrient content of tested legumes, 1. growth**

| Date | Num. | n | In 1kg dry matter<br>Vesna<br>Fibre (g) | <br><br>NEL (MJ) | <br>Radegast<br>Fibre (g) | <br><br>NEL (MJ) | <br>Dolina<br>Fibre (g) | <br><br>NEL (MJ) |
|---|---|---|---|---|---|---|---|---|
| 5.5. | 1 | 6 | 128 | 6,94 | 128 | 6,98 | 129 | 6,99 |
| 17.6. | 7 | 6 | 269 | 5,28 | 261 | 5,32 | 254 | 5,33 |
| | | AVG | 196 | 6,10 | 189 | 6,20 | 190 | 6,14 |
| | | $s_x$ | 51 | 0,59 | 48 | 0,57 | 47 | 0,59 |
| high or abasement / week | | | 23 | -0,28 | 22 | -0,28 | 21 | -0,28 |
| **Date** | **Num.** | **n** | PDIN (g) | PDIE (g) | PDIN (g) | PDIE (g) | PDIN (g) | PDIE (g) |
| 5.5 | 1 | 6 | 154,9 | 103,7 | 161,6 | 101,3 | 161,8 | 101,4 |
| 17.6. | 7 | 6 | 90,7 | 90,1 | 93,1 | 90,7 | 91,4 | 90,0 |
| | | AVG | 120,2 | 98,0 | 127,2 | 98,9 | 124,8 | 98,2 |
| | | $s_x$ | 23,9 | 5,0 | 24,7 | 4,3 | 25,5 | 4,6 |
| abasement / week | | | -10,7 | -2,3 | -11,4 | -1,8 | -11,7 | -1,9 |

# Biogenic Amines in Farm – Scale Maize Silages

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## Abstract

Seven biogenic amines were determined using micellar electrokinetic capillary chromatography in 62 and 51 samples of maize silages produced in 1999 and 2000, respectively. The silages had high dry matter contents with mean values 444 and 378 g/kg in the individual years and their quality can be assessed as good according to common quality parameters levels. The highest mean contents 482 and 145 mg/kg were observed for tyramine and 98 and 136 mg/kg for putrescine in the individual years. Histamine contents were very low, often below detection limit 2.1 mg/kg. Significant differences ($P < 0.05$) were observed for five amines contents between production years. Several significant correlations ($P < 0.05$) were found between some of quality criteria (dry matter content, lactic acid or acetic acid) and some of the amines.

## Introduction

Maize silages have been the main preserved forage fed to ruminants during winter period in many countries. However, silages contain different levels of biogenic amines produced from amino acids by decarboxylating activity of some lactic acid bacteria or putrefactive bacteria (Křížek et al., 1993; Křížek, 1995). The increased amines contents, probably in combination with some other silage constituents, can decrease silage palatability and depress intake in cattle and sheep (van Os et al., 1996; Phuntsok et al., 1998). The objective of this work has been a survey of biogenic amines levels in current farm-scale maize silages produced in the Czech Republic and fed to cows and steers at daily dose up to 20 kg for about six months of extra-vegetative period.

## Materials and methods

Totally 113 silages from large-scale silos were sampled in South Bohemian farms 6-8 weeks after filling and sealing a silo during 1999 and 2000. Common silage quality criteria were determined according Czech Standard ČSN 46 7092-42. Dry matter contents, determined by oven drying at 105 $^{o}$C, were corrected to volatile constituents contents. Seven biogenic amines were determined in perchloric acid extract as N-benzamides using a micellar electrokinetic capillary chromatography (Křížek and Pelikánová, 1998). Detection limits ranged between 1.0 and 3.5 mg/kg for spermidine and tyramine, respectively.

## Results and discussion

Data on silage quality criteria and amines contents are given in Tables 1 and 2 separately for silages produced in 1999 and 2000. Values of amines are given only for samples with levels above detection limits.

**Table 1.** Silage quality criteria and biogenic amines contents (mg/kg) in 1999 (n = 62)

| Parameter | $x$ | $s_x$ | $x_{min}$ | $x_{max}$ | n > DL |
|---|---|---|---|---|---|
| Dry matter corr. (g/kg) | 444 | 74 | 323 | 584 | 62 |
| pH | 3.56 | 0.18 | 3.20 | 3.99 | 62 |
| Total acidity (mg NaOH/100 g) | 1050 | 255 | 683 | 1770 | 62 |
| Lactic acid (% w/w) | 2.13 | 0.46 | 1.36 | 3.04 | 62 |
| Acetic acid (% w/w) | 0.56 | 0.26 | 0.04 | 1.60 | 62 |
| Ethanol (% w/w) | 0.23 | 0.12 | 0.04 | 0.73 | 62 |
| Ammonia (mg/100 g) | 35.6 | 9.1 | 18.8 | 55.0 | 62 |
| Histamine | 2.6 | 8.0 | ND | 48.5 | 10 |
| Tyramine | 482 | 485 | 3.5 | 924 | 62 |
| Putrescine | 97.8 | 72.0 | 9.7 | 459 | 62 |
| Cadaverine | 48.3 | 56.0 | 6.9 | 282 | 62 |
| Tryptamine | 4.2 | 12.0 | ND | 92.4 | 44 |
| Spermidine | 16.6 | 6.0 | 1.6 | 43.0 | 62 |
| Spermine | 0.6 | 2.0 | ND | 8.0 | 9 |

n > DL … values above detection limit; ND … value below detection limit

**Table 2.** Silage quality criteria and biogenic amines contents (mg/kg) in 2000 (n = 51)

| Parameter | x | $s_x$ | $x_{min}$ | $x_{max}$ | n > DL |
|---|---|---|---|---|---|
| Dry matter corr. (g/kg) | 378 | 55.8 | 260 | 494 | 51 |
| pH | 3.64 | 0.16 | 3.20 | 4.10 | 51 |
| Total acidity (mg NaOH/100 g) | 1010 | 253 | 488 | 1700 | 51 |
| Lactic acid (% w/w) | 1.85 | 0.41 | 1.14 | 2.93 | 51 |
| Acetic acid (% w/w) | 0.61 | 0.34 | 0.10 | 1.96 | 51 |
| Ethanol (% w/w) | 0.31 | 0.20 | 0.06 | 0.94 | 51 |
| Ammonia (mg/100 g) | 39.6 | 18.3 | 12.3 | 93.3 | 51 |
| Histamine | 3.0 | 6.7 | ND | 41.1 | 18 |
| Tyramine | 145 | 46.4 | 9.5 | 238 | 51 |
| Putrescine | 136 | 53.6 | 3.2 | 290 | 51 |
| Cadaverine | 96.2 | 80.8 | 4.1 | 349 | 51 |
| Tryptamine | 2.5 | 2.8 | ND | 13.7 | 33 |
| Spermidine | 37.9 | 9.3 | 22.5 | 60.0 | 51 |
| Spermine | 2.8 | 2.5 | ND | 9.6 | 37 |

The differences between amines contents in silages produced in 1999 and 2000 were tested statistically using analysis of variance at significance level $P < 0.05$. Significantly higher levels were observed in putrescine, cadaverine, spermidine and spermine, while lower levels in tyramine contents for silages produced in 2000. However, reasons of those differences are not yet expainable.

Correlations between the individual quality parameters and amine contents were tested using t-test at significance level $P < 0.05$ separately for silages produced in 1999 and 2000. In 1999, the positive correlations were observed for lactic acid x spermidine, acetic acid x histamine and acetic acid x cadaverine and negative ones for dry matter content x histamine and dry matter content x cadaverine. In 2000, only negative correlations were found: dry matter content x putrescine, acetic acid x putrescine and acetic acid x tyramine.

These results differ from data reported by Křížek et al. (1993) for 54 maize silages with dry matter contents from 166 to 326 g/kg. Mean contents 435, 388, 341, 72, 25 and 5 mg/kg for tyramine, putrescine, cadaverine, histamine, spermidine and spermine, respectively were considerably higher than our results probably due to lower dry matter levels and thus different counts, species and strain proportion and activity of decarboxylating lactic acid bacteria.

No recommendation dealing with maximum amines levels in silages has been yet proposed. However, maize silages have been fed in large volumes during long-term winter period and further physiological research should be thus useful.

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# Plant Phenolics as Natural Inhibitors of Organic Matter Fermentation

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## Abstract

After addition of the extract of 8 herbs or one clover into PC- liquor with a grass of medium quality (Festuca rubra) or high quality fodder grass (Lolium perenne) or Trifolium pratense, individual species of meadow plants decreased OMD of tested samples almost in identical order with that one by WEISBACH (1998) during silage fermentation process. The decrease of OMD in Lolium and Trifolium was strongly in relation with IANP (after Scehovic) of corresponding herbal samples from which extracts were made.

## Introduction

Following the decrease of intensity of grassland and meadows management (esp. the level of fertilizing and the number of harvests, resp. grazing cycles) the number of plant species increases as well as the proportion of herbs. Some herbs contain secondary metabolites that can improve or worsen fodder quality (e. g. palatability, dry matter intake, nutritive value, use of nutrients in the animal body), and technological characteristics (e. g. ensilability, aerobic stability of silage). Many herbs had a very low content of fermentable carbohydrates, high buffering capacity or distinctive abiotic effects whereas other herbs did not (Weißbach, 1998). That makes herbs different from grasses because their silage characteristics among botanical species do not differ significantly. Meadow plants from families Asteraceae, Rosaceae and Plantaginaceae (Jeangros, Scehovic, Troxler, Bachmann, Bosset, 1999) exhibited specific activity.

Phenolics make a very numerous group that is well-represented in plants (Klejdus, Kubáň, 1999). They are usually changed by enzymatic degradation and chemical modification in animal rumen that they do not get into milk and cheese as such (Scehovic et al., 1998).

The model experiment determined the influence of inhibitors from selected plant species on pepsin-cellulases solubility of grasses and legumes in vitro. These results were discussed so that links to silage characteristics could be found in order to assess the significance of IANP (index of potentially negative activity of phenolics) and its availability for establishing more precise fodder value of individual species of meadow plants.

## Material and methods

Effect of plant extracts of 9 meadow plants was evaluated (with measured values of IANP) on the activity of proteases and cellulases in the digestive liquor in the form of determination of digestibility of organic matter in vitro (OMD) of three test samples (Figs. 1-3). Inhibitors were extracted from dry samples of meadow plants using the method by Scehovic (description in Míka et al., 1998) and these were added by the method of standard addition into digestive liquor with OMD determination in vitro (Jones, Hayward, 1995) of red fescue ´Táborská´ (from 1st cut), perennial ryegrass ´Talon´ (from 2nd cut of five-harvest year) and red clover ´Tábor´ (from 1st cut). The selection of species was according to Weißbach (1998) who presents them in descending order with a respect to positive influence on silage fermentation. The model experiment was to verify if inhibitory effects of individual species of meadow plants on digestion of medium and high quality grass and clover are similar.

The experiment was evaluated by Spearman´s test according to the order of species. Value $r_S = 1$ represents a complete identity of the order, $r_S = -1$ indicates just the opposite order.

## Results

The IANP value relation to the parameters of nutritive value of meadow plants fodder was mostly insignificant ($r < 0,1$; $n = 436$), as well as for families ( $r < 0,17$; $n = 60$) and so it is not mentioned.

After addition of the extract of 8 herbs or one clover (picture 1) into pepsin-cellulases liquor with a grass of medium quality (Festuca rubra) – Fig. 1, resp. high quality fodder grass (Lolium perenne) – Fig. 2, or Trifolium pratense (Fig. 3), individual species of meadow plants decreased OMD of tested samples almost in identical order with that one by Weißbach (1998) during fermentation process of silage ($r_S$ = 0,767, resp. 0,800 and 0,917). The decrease of OMD of Lolium perenne was strongly in relation with IANP of corresponding herbal samples from which extracts were made ($r = - 0,771^{*}$; $n = 9$) and for Trifolium pratense ($r = - 0,699^{*}$; $n = 9$), however for Festuca rubra insignificantly ($r = - 0,516$ N.S.; $n = 9$).

## Discussion

The fact that no herb stopped lactic fermentation during silage preparation is significant (Weißbach, 1998). The strongest positive influence on fermentation has Lotus corniculatus (a species with a relatively low value of IANP), the weakest influence has Hypericum perforatum (a species with a very high value of IANP).

Some species slow down degradation of lactic acid and creation of butteric acid. Positive influence on aerobic stability of ready silage showed leguminoses, next also Ranunculus sp., Galium sp., Filipendula ulmaria and Centaurea jacea. On the contrary unstable silage occurred when herbs from the families of Daucaceae and Polygonaceae were included in silage. Proteolysis in silage is significantly decreased by Alchemilla alpina, Filipendula ulmaria, Geranium pratense, Plantago lanceolata, and Sanguisorba officinalis, that is by species known for their positive influence on milk production. Ammonia occurs in such silage in unusual low concentration. It is possible that secondary metabolites included in them react also in rumen as substances protecting proteins from deamination (Weißbach, 1999).

Although species with a high value of IANP (Alchemilla vulgaris, Plantago lanceolata, etc.) can exhibit high value in vitro, this digestibility is definitely overestimated because of low concentration of dry matter and its dilution in fermentation condition of the method in vitro (Jones, Hayword, 1975) about 12 – 15 x compared to the concentration in the rumen of ruminants and as a result of activity of potentially active principles (Míka et al., 1998, Scehovic, written message). On the contrary a standard addition of extracts of these herbs to test samples of grasses and legumes with a high digestibility (Fig. 2, 3) caused significant decrease of activity of proteases and cellulases in digestive liquor.

To quantify these effects, Scehovic (1999) establishes Index of Potential Fermentation Activity (IAFP) determined on the basis of the amount of released gas during fermentation (extraction of the sample of tested species by artificial saliva and rumen fluid with added glucose) and pH decrease. Families rich in phenolics (phenolic acids, phenol polymers), e. g. Rosaceae and Geraniaceae, cause the most intensive inhibition. Presence of toxic organic acids in species from family Polygonaceae, resp. alkaloids from family Ranunculaceae and Chenopodiaceae, mucuses and terpenes from Plantaginaceae, Asteraceae, and Daucaceae partly explain their influence on fermentation, however the quantification is not simple.

The negative influence of substances diluted in extract is probably direct, whereas phenolics bound to matrix influence the process and results of fermentation indirectly (Scehovic, 1999). Families Poaceae and Viciaceae represent a group with a greatest stimulative effect on fermentation. In practice these effects will have to be studied also in mixture of botanical species in the rates occurring in mixed grasslands

## Acknowledgements

The paper was written as a part of a projects research of GA CR no. 521/99/0863 ”Chemical characteristics and biological activity of phenolics in meadow grasses ” and GA CR no. 521/99/DO91 ”Determination of biological activity of plant phenolics in grassland plants using a gasometric method”.

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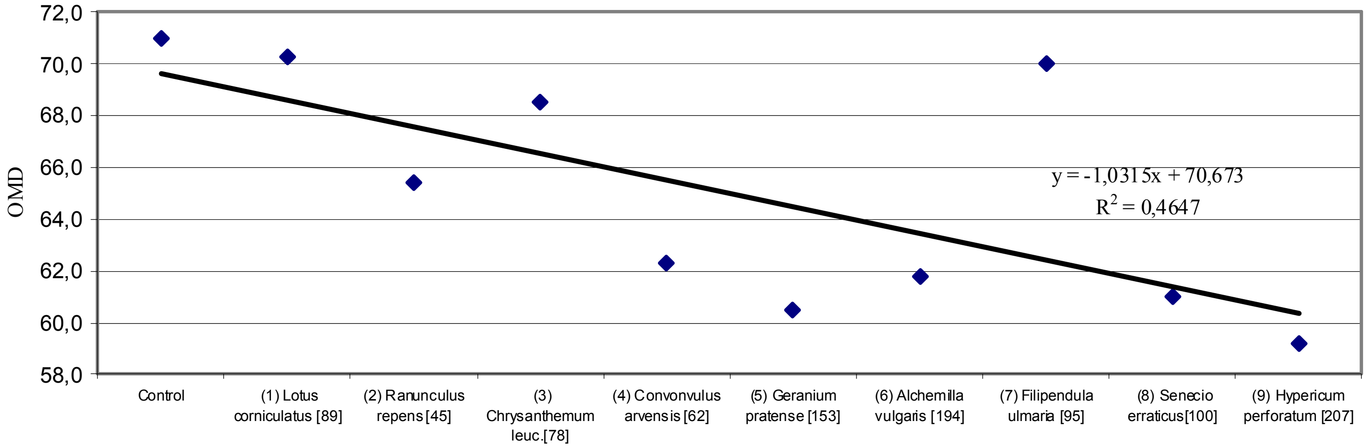
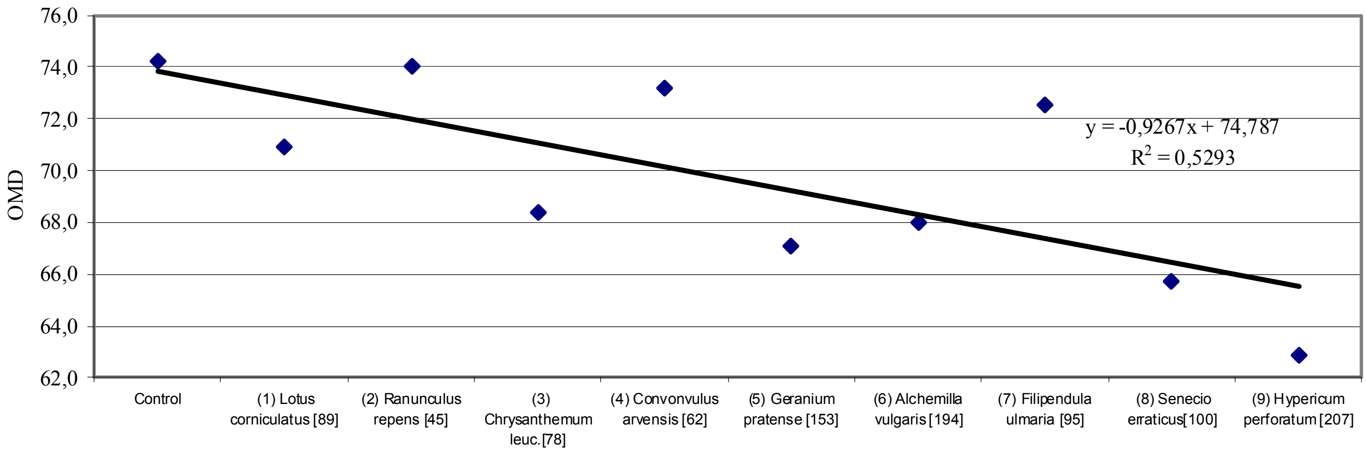
**Figure 1.** The influence of standard addition of inhibitors from 9 meadow plants on organic matter digestibility (OMD) in vitro *Festuca rubra* cv. Táborská



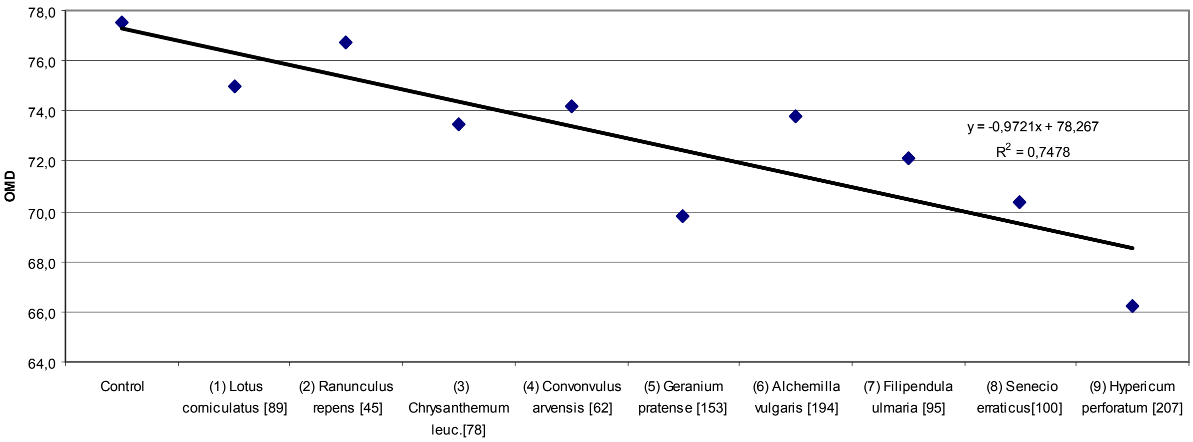

Used extracts from meadow plants: ( ) positive influence on silage fermentation in descending order according to Weißbach (1998); [ ] the IANP value of given sample from which the extracts was made.

**Figure 2.** The influence of standard addition of inhibitors from 9 meadow plants on organic matter digestibility (OMD) in vitro *Lolium perenne* , cv. Talon




Used extracts from meadow plants: ( ) positive influence on silage fermentation in descending order according to Weißbach (1998); [ ] the IANP value of given sample from which the extracts was made.

Figure 3: The influence of standard addition of inhibitors from 9 meadow plants on organic matter digestibility (OMD) in vitro *Trifolium pratense* cv. Tábor




**Used extracts from meadow plants: ( ) positive influence on silage fermentation in descending order according to Weißbach (1998); [ ] the IANP value of given sample from which the extracts was made.**

# Possibilities to Secure the Hygienic Quality of Whole Crop Barley

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### Abstract

The objective of this experiment was to investigate the factors influencing nutrient losses, fermentation and hygienic quality of whole crop barley silages (spring variety of Hordeum vulgare L). Crop maturity (330 ± 3,1 g $kg^{-1}$ of fresh weight), chop length (1 cm and 10 cm), silage density (130-150 kg $DM/m^3$, 180-200 kg $DM/m^3$ and 230-250 kg $DM/m^3$) and regulation of fermentation by using silage additives (5 additive + 2 control treatments) were tested. All silages were inoculated with Clostridium tyrobutyricum except the one-control treatment. Silages were stored 3, 10, 30 days in glass silos and 100-130 days in PVC laboratory silos. Chop length in combination with additives improved the fermentation process considerably whilst the effect of density was almost imperceptible. The chemical additives were more effective than bacterial ones. DM losses were significantly lower in chemically treated silages. The aerobic stability of additive treated silages was also improved compared to both control silages. The results indicated that application of silage additives on cut or chopped whole crop barley led to silages with low nutritive losses and increased aerobic stability in order to secure the good hygienic quality of these silages.

**Keywords:** Silage, barley, whole crop cereals, aerobic stability, additives

### Introduction

The ensiling of whole cereal plants presents an interesting and convenient method of preserving the forage, especially under less favourable conditions. It also gives a possibility to dilute high protein forages and reduce nitrogen emission from organic farms in Sweden. Whole crop-cereals typically have a lower concentration of crude protein, crude fat, water-soluble carbohydrate, digestible cell wall, metabolizable energy and a negative protein balance in the rumen when fed to cattle. On the other hand, whole crop-cereals have a higher concentration of starch. Many authors have published high concentrations of fermentation acids in whole crop cereal silages. However, whole crop cereal silages are a less stable than clover-grass silages (Ohlsson 1994). Weissbach & Haacker (1988) stated that whole crop cereals silage often contain high concentrations of butyric acid in spite of high DM concentration and low pH-value.

### Materials and Methods

The spring variety of barley (Hordeum vulgare L) was harvested at the beginning of dough stage (330 ± 8,9 g $kg^{-1}$FW, Ash=70±9,73 g $kg^{-1}$ DM; CP=104±5,44 g $kg^{-1}$ DM; WSC=50,7±4,9 g $kg^{-1}$ DM; $NO_3$-N=0,48 ±0,19 g $kg^{-1}$ DM). The forage was direct-cut, chopped to particle sizes of approx. 1cm and 10cm and mixed with the chemical additives and/or with the bacterial inoculates (see in Table 1). The silos were filled with three densities. Silos filled at the low density were compacted to 130-150 kg $DM/m^3$, the intermediate density to 180-200 kg $DM/m^3$, and the high density to 230-250 kg $DM/m^3$. The crop was ensiled in 1,7 litre glass silos, which were stored 3, 10, 30 days and in PVC laboratory silos (4,54 litre), which were stored an approximately 100-130 days at 25°C. The silos were weighed 3rd, 10th, 30th and 100th day of a storage. After that, the silos were opened and sampled. The following analyses were made on the samples: DM, pH, fatty acids and ethanol, nitrate and ammonia, nutrient losses. Furthermore, the number of yeast, mould and clostridia were determined. Silages opened after 100-130 days were examined on an aerobic stability (Silages ventilated with a fix amount of air and production of $CO_2$ was monitored).

### Results and discussion

The chemical and the microbial composition of the silages are presented in Table 2. All additives lowered pH and were effective in the reduction of DM losses. Also, the aerobic stability of all treated silages was received better than the control. This was due to an increased amount of acetic acid in most of silages particularly in silages treated with LAB. As a result of reduction of clostridia growth, concentrations of butyric acid were low in treated silages compared to the control. The silages treated with bacterial inoculates contained a high concentration of acetic acid and a very low concentration of residual WSC. They had significantly higher DM losses compared to silages treated with chemical additives. The application of Kofasil Life resulted in rapid decline of the pH value already on the 3rd day of fermentation compared to both control treatments. In spite of a very low concentration of nitrate in all treatments, significantly higher amounts were found in the additive treated silages compared to control and bacterial inoculates. Interesting results were obtained in control silages (chopped variant) inoculated only with a clostridia spore solution may be due to stimulation of epiphytic LAB after addition of water.

## Conclusions

Silage additives and the chop length are important factors effecting nutrient losses of whole crop silages and their aerobic stability. An appropriate combination of DM (stage of maturity), additive, density and chop length will result in whole crop barley silage with a good hygienic quality and high feeding value.

**Table 1.** Chemical composition of used additives and their application rates

| | Additives | Application rate | Spore solution applied |
|---|---|---|---|
| A. | Untreated – control | - | no |
| B. | Untreated – control - clostridia | - | yes |
| C. | Kofasil Ultra: nitrite, hexamine, Na- propionate,Na-benzoate | 5 l / ton FM | yes |
| D. | Kofa Grain pH 5: Na-benzoate, propionic acid,Na-propionate | 5 l / ton FM | yes |
| E. | Kofa Life: Lactic acid bacteria (LAB) | 5 l / ton FM ($4*10^5$ LAB/g FM) | yes |
| F. | Kofa Life + Na-benzoate (600g/t FM) | 5,6 l / ton FM ($4*10^5$ LAB/g FM) | yes |
| G. | Promyr : formic acid, propionic acid, ammonia | 4 l / ton FM | yes |

**Table 2.** Chemical and microbial composition of the silages.

| Treatment | Laceration | pH | WSC | NH3-N | NO3-N | LA | BA | AA | Losses | Clostr | Yeast |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g / kg DM | | | | | | | log cfu / g sam | |
| Control | Cut | 5,0 | 5,8 | 23,71 | 0,027 | 26,0 | 4,2 | 8,7 | 113,8 | 5,86 | 3,24 |
| Control | Chop | 4,6 | 6,8 | 26,03 | 0,032 | 39,7 | 19,0 | 5,1 | 122,0 | 6,17 | 0,76 |
| Clostridia | Cut | 5,0 | 3,7 | 24,09 | 0,025 | 24,9 | 5,4 | 9,4 | 112,4 | 6,03 | 1,78 |
| Clostridia | Chop | 4,2 | 8,8 | 19,49 | 0,039 | 52,2 | 2,9 | 9,2 | 60,7 | 3,43 | 2,58 |
| Kofasil Ultra | Cut | 4,4 | 16,8 | 15,14 | 0,423 | 43,4 | 0,5 | 6,8 | 37,9 | 1,11 | 0,76 |
| Kofasil Ultra | Chop | 4,3 | 13,5 | 18,84 | 0,415 | 47,8 | 0,5 | 11,7 | 48,3 | 2,00 | 1,11 |
| Kofa Grain | Cut | 4,3 | 19,4 | 12,01 | 0,393 | 39,8 | 0,5 | 6,6 | 52,3 | 0,76 | 0,76 |
| Kofa Grain | Chop | 4,2 | 11,8 | 16,49 | 0,418 | 48,5 | 0,5 | 10,6 | 46,2 | 1,53 | 0,76 |
| Kofasil Life | Cut | 4,5 | 1,8 | 18,56 | 0,021 | 35,0 | 0,5 | 20,8 | 73,8 | 1,13 | 0,76 |
| Kofasil Life | Chop | 4,5 | 0,6 | 22,40 | 0,031 | 34,3 | 0,6 | 28,8 | 75,0 | 2,53 | 0,76 |
| KofaLife+NaB | Cut | 4,6 | 1,7 | 18,09 | 0,018 | 28,9 | 0,6 | 23,4 | 76,0 | 1,15 | 0,76 |
| KofaLife+NaB | Chop | 4,5 | 0,6 | 19,53 | 0,054 | 32,9 | 0,5 | 26,0 | 67,1 | 1,09 | 0,76 |
| Promyr | Cut | 4,3 | 16,5 | 19,58 | 0,140 | 39,6 | 1,8 | 6,7 | 58,9 | 3,69 | 1,09 |
| Promyr | Chop | 4,1 | 9,2 | 20,58 | 0,500 | 50,5 | 0,5 | 9,2 | 38,4 | 0,96 | 0,84 |
| $LSD_{0,05}$ | | 0,1 | 2,1 | 1,41 | 0,045 | 5,0 | 2,3 | 1,9 | 12,8 | 1,01 | 0,70 |

WSC-water soluble carbohydrates, LA-lactic acid, BA-butyric acid, AA-acetic acid Losses-weight loss during storage (g/kg DM of silage)

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# Stage of Maturity at Harvest Affects the Nutritive Value and Sugestibility of Organic Matter of Maize Hybrids

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## Abstract

The aim of our research was to compare 35 hybrids in two stages of maturity (at the two-thirds of the milkline 28.8.2000, and at the start of the black layer 19.9.2000) from the nutrition point of view. The small differences in content of energy NEL 6.46 ± 0.14 MJ/kg DM among individual tested maize hybrids were found, the different result was in the case of content of crude protein 79.2 ± 4.8 g/kg DM. Digestibility of organic matter (DOM) was in a close relation to the ratio of cobs to the whole plant and also in the relation to the content of energy, mainly in the stage at the start of black layer. DOM of the whole plant was 72,3 ± 1,2 %, higher in cobs that were harvested on the 19$^{th}$ September, than in those harvested on the 28$^{th}$ August (83,4 ± 0,7 %, vs. 82,0 ± 0,9 %).

## Introduction

The stage of maturity in the time of harvest and mechanical processing affects the nutritive value of maize silage. The change in the nutritive value of maize silage as a function of maturity advance can be measured by animal digestion and macro in situ degradation studies. The aim of our research was to compare 35 hybrids in the two stages of maturity and make choice of the best maize hybrid for breeding from the nutrition point of view. The digestibility of organic matter is a highly discussed current theme. Farmers would like to know not only the yield of maize hybrids, but also their real nutrition value.

## Materials and methods

There were chosen 35 out of 120 maize hybrids available in The Czech Republic in the year 2000, sorted from 210 to 360 degrees of FAO. Then 35 control plots (0.25 ha each) of different maize hybrids were founded in our Institute area in Prague Uhrineves. The whole plant (also cob separately) was harvested at the two-thirds of the milkline (28$^{th}$ August 2000), and at the start of the black layer (19$^{th}$ September 2000) stages to evaluate the effects of the maturity on the nutritive value and digestibility of organic matter. Samples of these 35 hybrids from 9 companies were analysed using Weendese methods in the laboratory of the Res. Inst. of Animal Production in Prague. The digestibility of organic matter was tested by in vivo method (e.g. putting plastic bags with examples into rumen) in the laboratory of the Res. Inst. of Cattle Breeding in Rapotin.

## Results and discussion

It was found that harvesting maize at the two-thirds of the milkline stage yields 94,2 ± 8,2 g/kg DM of protein and at the start of the black layer stage yields 96,6 ± 7,0 g/kg DM of protein in a cob. But if you evaluate the whole plant, you can see the content of protein coming down from 80,1 ± 5,3 to 78,3 ± 4,0 g/kg DM.

The small differences in the content of energy NEL 6.46 ± 0.14 MJ/kg DM among individual maize hybrids tested were found. The different result was in the case of the content of crude protein (79.2 ± 4.8 g/kg DM). We recommend to evaluate and to breed maize hybrids on the basis of the content of protein instead of to the content of energy.

The higher DOM was in a cob than in the other part of the whole plant (82,7 ± 1,1 %, vs. 58,6 ± 1,9 %). DOM of the whole plant was 72,3 ± 1,2 %, higher in cobs that were harvested on the 19$^{th}$ September, than those harvested on the 28$^{th}$ August (83,4 ± 0,7 %, vs. 82,0 ± 0,9 %). The similar result was found by Cammell at al. (2000), Johnson at al. (1999), Phipps at al. (2000) and others.

## Conclusions

The stage of maturity at the harvest time affects the nutritive value and digestibility of organic matter of maize hybrids.

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*Research was supported by NAZV QD0176.*

**Table 1.** The average values of feed units of maize hybrids (n = 35)

| Part of plant | Unit | DM | In 100% DM (g/kg DM) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | g/kg | Protein | Fat | Fibre | NPEM | Ash | OM |
| Corn Cob | AVG1+2 | 565,7 | 95,4 | 54,6 | 83,9 | 747,1 | 29,0 | 971,0 |
| | Sx | 58,3 | 7,7 | 8,8 | 7,0 | 13,6 | 1,6 | 1,6 |
| | AVG1 | 520,4 | 94,2 | 52,6 | 88,7 | 745,7 | 28,8 | 971,2 |
| | Sx1 | 37,9 | 8,2 | 10,1 | 5,7 | 15,5 | 1,8 | 1,8 |
| | AVG2 | 611,0 | 96,6 | 56,6 | 79,1 | 748,6 | 29,1 | 970,9 |
| | Sx2 | 35,3 | 7,0 | 6,8 | 4,5 | 11,1 | 1,2 | 1,2 |
| Whole plant | AVG1+2 | 399,3 | 79,2 | 35,6 | 189,5 | 650,5 | 50,8 | 949,2 |
| | Sx | 51,1 | 4,8 | 5,3 | 11,2 | 13,9 | 4,2 | 4,2 |
| | AVG1 | 360,1 | 80,1 | 33,7 | 194,5 | 644,3 | 52,7 | 947,3 |
| | Sx1 | 34,8 | 5,3 | 5,4 | 9,0 | 13,4 | 4,6 | 4,6 |
| | AVG2 | 438,5 | 78,3 | 37,5 | 184,5 | 656,6 | 49,0 | 951,0 |
| | Sx2 | 30,5 | 4,0 | 4,3 | 10,9 | 11,5 | 2,7 | 2,7 |

Index 1 = harvesting on 28.8., Index 2 = 19.9.2000, DM = dry matter,
OM = organic matter, NPEM = non protein essential matter

**Table 2: The average values of energy a PDI units in DM**

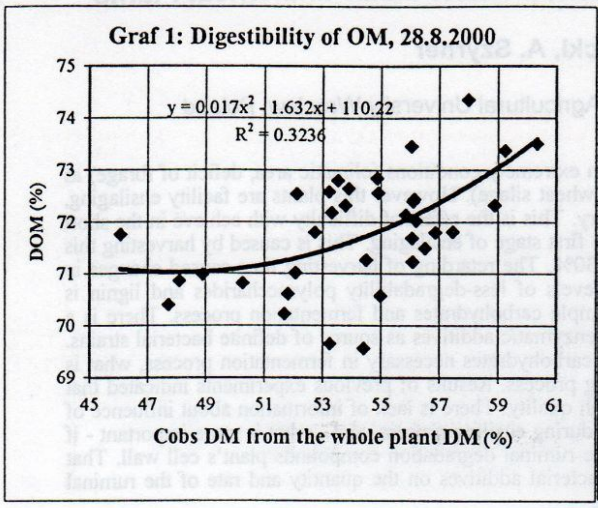
| Part of plant | Unit | BE (MJ) | ME (MJ) | NEL (MJ) | NEV (MJ) | m ME/BE | UDP (g/kg) | PDIA (g/kg) | PDIN (g/kg) | PDIE (g/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Corn Cob | AVG1+2 | 19,04 | 12,44 | 7,71 | 8,05 | 0,653 | 36,8 | 33,6 | 65,0 | 99,3 |
| | Sx | 0,1 | 0,2 | 0,1 | 0,2 | 0,0 | 2,0 | 1,9 | 5,0 | 2,0 |
| | AVG1 | 19,03 | 12,34 | 7,63 | 7,95 | 0,648 | 36,6 | 33,3 | 64,1 | 98,5 |
| | Sx1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,0 | 2,2 | 2,0 | 5,3 | 2,0 |
| | AVG2 | 19,04 | 12,54 | 7,79 | 8,15 | 0,659 | 37,1 | 34,0 | 65,9 | 100,0 |
| | Sx2 | 0,0 | 0,1 | 0,1 | 0,1 | 0,0 | 1,8 | 1,7 | 4,5 | 1,6 |
| Whole plant | AVG1+2 | 18,52 | 10,68 | 6,46 | 6,51 | 0,574 | 32,6 | 28,0 | 52,8 | 85,3 |
| | Sx | 0,08 | 0,20 | 0,14 | 0,18 | 0,010 | 1,5 | 1,3 | 3,1 | 1,7 |
| | AVG1 | 18,49 | 10,58 | 6,39 | 6,42 | 0,570 | 33,2 | 28,3 | 53,2 | 85,1 |
| | Sx1 | 0,1 | 0,2 | 0,1 | 0,1 | 0,0 | 1,7 | 1,4 | 3,5 | 1,7 |
| | AVG2 | 18,55 | 10,77 | 6,53 | 6,60 | 0,577 | 32,1 | 27,8 | 52,4 | 85,5 |
| | Sx2 | 0,1 | 0,2 | 0,1 | 0,2 | 0,0 | 1,1 | 1,0 | 2,6 | 1,6 |

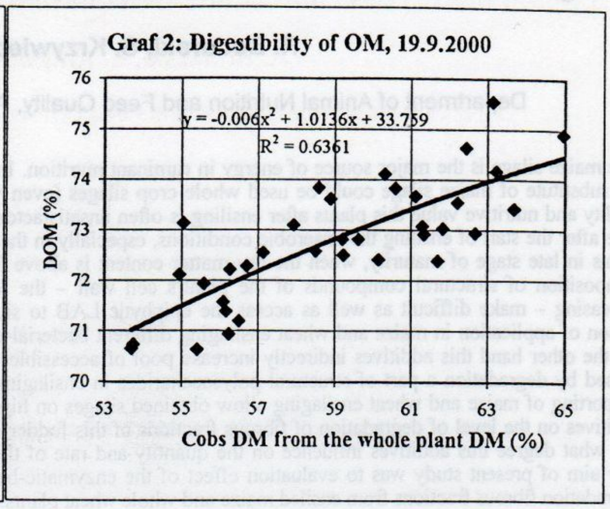
**Table 3: The average values of OM digestibility**

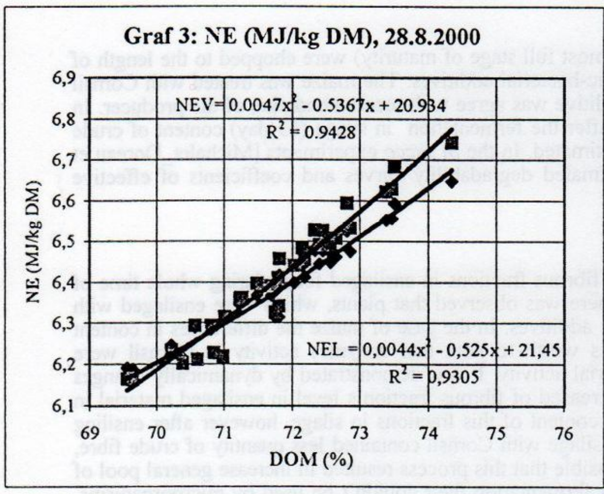
| Part of plant | Unit | OHz % | deg % | dsi % |
|---|---|---|---|---|
| Corn Cob | AVG1+2 | 82,7 | 61,3 | 82,2 |
| | Sx | 1,1 | 1,0 | 0,5 |
| | AVG1 | 82,0 | 61,1 | 82,0 |
| | Sx1 | 0,9 | 1,1 | 0,5 |
| | AVG2 | 83,4 | 61,5 | 82,5 |
| | Sx2 | 0,7 | 0,9 | 0,4 |
| Whole plant | AVG1+2 | 72,3 | 57,7 | 76,3 |
| | Sx | 1,2 | 0,7 | 0,6 |
| | AVG1 | 71,8 | 57,8 | 76,0 |
| | Sx1 | 1,1 | 0,8 | 0,5 |
| | AVG2 | 72,8 | 57,7 | 76,7 |
| | Sx2 | 1,2 | 0,6 | 0,6 |

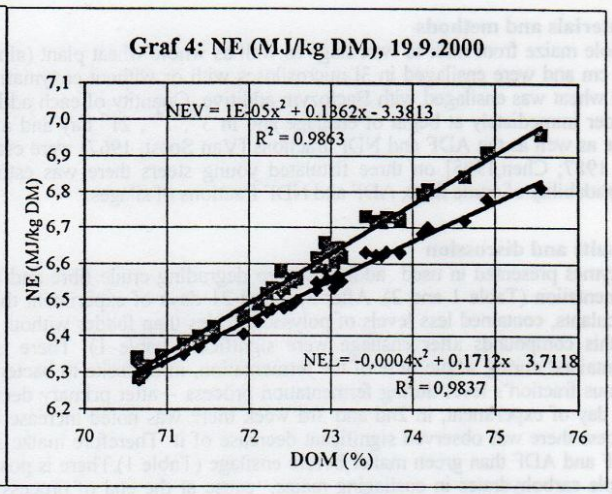
**Table 4: The average yields of maize hybrids and cob ratio**

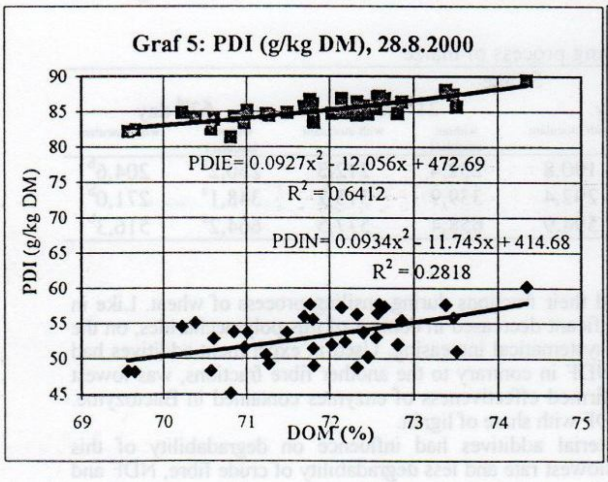
| Unit | Yeild of whole plant (t/ha) | | | Yeild of cob (t/ha) | | | Cob proportion from the whole plant (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | DM | OM | DOM | DM | OM | DOM | DM | OM | DOM |
| AVG1+2 | 18,3 | 17,3 | 12,5 | 10,3 | 10,0 | 8,3 | 56,6 | 57,8 | 66,2 |
| Sx | 1,6 | 1,5 | 1,1 | 1,0 | 1,0 | 0,9 | 4,0 | 3,9 | 4,2 |
| AVG1 | 18,2 | 17,2 | 12,4 | 9,8 | 9,5 | 7,8 | 54,2 | 55,4 | 63,3 |
| Sx1 | 1,6 | 1,6 | 1,1 | 0,8 | 0,8 | 0,6 | 3,2 | 3,2 | 3,3 |
| AVG2 | 18,4 | 17,5 | 12,7 | 10,8 | 10,5 | 8,8 | 59,0 | 60,2 | 69,0 |
| Sx1 | 1,6 | 1,5 | 1,1 | 0,9 | 0,9 | 0,8 | 3,1 | 3,0 | 2,8 |

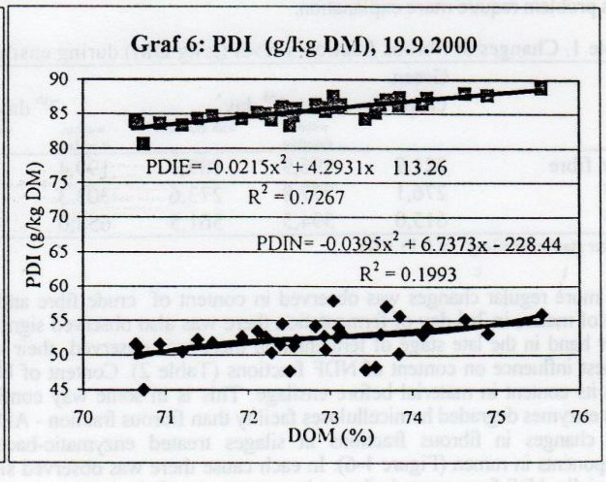

Graf 1: Digestibility of OM, 28.8.2000
y = 0.017x² - 1.632x + 110.22
R² = 0.3236
DOM (%)
Cobs DM from the whole plant DM (%)


Graf 2: Digestibility of OM, 19.9.2000
y = -0.006x² + 1.0136x + 33.759
R² = 0.6361
DOM (%)
Cobs DM from the whole plant DM (%)


Graf 3: NE (MJ/kg DM), 28.8.2000
NEV= 0.0047x² - 0.5367x + 20.934
R² = 0.9428
NEL = 0,0044x² - 0,525x + 21,45
R² = 0,9305
NE (MJ/kg DM)
DOM (%)


Graf 4: NE (MJ/kg DM), 19.9.2000
NEV = 1E-05x² + 0.1362x - 3.3813
R² = 0.9863
NEL = -0,0004x² + 0,1712x 3,7118
R² = 0,9837
NE (MJ/kg DM)
DOM (%)


Graf 5: PDI (g/kg DM), 28.8.2000
PDIE= 0.0927x² 12.056x + 472.69
R² = 0.6412
PDIN= 0.0934x² - 11.745x + 414.68
R² = 0.2818
PDI (g/kg DM)
DOM (%)


Graf 6: PDI (g/kg DM), 19.9.2000
PDIE= -0.0215x² + 4.2931x 113.26
R² = 0.7267
PDIN= -0.0395x² + 6.7373x - 228.44
R² = 0.1993
PDI (g/kg DM)
DOM (%)

# Effect of the Enzymatic-Bacterial Additives on the Quantity and Rate of the Ruminal Degradation of the Fibrous Fractions from Ensiled Whole Maize and Wheat Plants

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The maize silage is the major source of energy in ruminant nutrition. In extremely conditions (climatic area, deficit of forage) as the substitute of maize silage could be used whole crop silages (even wheat silage). However this plants are facility ensilaging, quality and nutritive value this plants after ensiling is often unsatisfactory. This is the effect of difficulty with achieve in the short time after the start of ensiling the anaerobic conditions, especially in the first stage of ensilaging. This is caused by harvesting this plants in late stage of maturity, when the dry matter content is above 30%. The retarding of harvesting time caused changes in composition of structural compounds of the plant's cell wall – the levels of less-degradability polysaccharides and lignin is increasing – make difficult as well as access the epiphytic LAB to simple carbohydrates and fermentation process. There is a reason of application in maize and wheat ensilaging different bacterial-enzymatic additives as source of definite bacterial strains. On the other hand this additives indirectly increase pool of accessible carbohydrates necessary in fermentation process, what is caused by degradation a part of structural polysaccharides in ensilaging process. Results of previous experiments indicated that supporting of maize and wheat ensilaging allow obtained silages on high quality. There is lack of information about influence of additives on the level of degradation of fibrous fractions of this fodder during ensiling process, and - what is more important - if and what degree this additives influence on the quantity and rate of the ruminal degradation compounds plant's cell wall. That why aim of present study was to evaluation effect of the enzymatic-bacterial additives on the quantity and rate of the ruminal degradation fibrous fractions from ensiled maize and whole wheat plants.

**Materials and methods**

Whole maize from milk to wax stage as well as whole wheat plant (almost full stage of maturity) were chopped to the length of 1,5 cm and were ensilaged in 3l microsiloses with or without enzymatic-bacterial additives. The maize was treated with Cornsil and wheat was ensilaged with Bactozym additive. Quantity of each additive was agree with recommendation of the producer. In fodder immediately at begin of ensilage and in 3rd, 7th, 21st day and after the fermentation in silage (63 day) content of crude fibre as well as the ADF and NDF fractions [Van Soest, 1967] were estimated. In the in sacco experiments [Michalet_Doreau et al., 1987; Chen,1995] on three fistulated young steers there was estimated degradability curves and coefficients of effective degradability of crude fibre, ADF and NDF fractions of silages.

**Results and discussion**

Enzymes presented in used additives were degrading crude fibre and fibrous fractions in ensilaged feeds during whole time of fermentation (Table 1 and 2). After 3, 7 and 21 days of experiment there was observed that plants, which were ensilaged with inoculants, contained less levels of polysaccharides than fodder without additives. In the case of maize the differences in content of this compounds after ensilage were significant (table 1). There is worth to note that enzymes activity in Cornsil were maintained during whole time of the fermentation, in opposite to bacterial activity. It was demonstrated by dynamically changes fibrous fraction's level during fermentation process – after primary decreased of fibrous fraction's level in ensilaged material in 3rd day of experiment, in 2nd and 3rd week there was noted increase content of this fractions in silage, however after ensiling process there was observed significant decrease of it. Therefore maize silage with Cornsil contained less quantity of crude fibre, NDF and ADF than green matter before ensilage (Table 1).There is possible that this process resulted in increase general pool of simple carbohydrates in ensilaging maize, 'cause at the end of process fermentation their couldn't be used by microorganisms. This problem require more explanation.

**Table 1.** Changes in fibrous fraction's level (g/kg DM) during ensiling process of maize

| | Green crops | Silage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 3rd day* | | 7th day | | 21st day | | 63rd day | |
| | | without inoculant | with inoculant | without inoculant | with inoculant | without inoculant | with inoculant | without inoculant | with inoculant |
| crude fibre | 221,9 | 196,9 | 189,1 | 199,4 | 190,8 | 232,4 | 212,3 | 250,2[a] | 204,6[b] |
| ADF | 276,1 | 277,8 | 273,6 | 303,3 | 292,4 | 339,9 | 313,2 | 348,1[a] | 271,0[b] |
| NDF | 615,0 | 594,5 | 561,5 | 658,0 | 594,9 | 658,4 | 577,5 | 664,2[a] | 516,3[b] |

*) after start of ensiling a, b $P \leq 0,05$

The more regular changes was observed in content of crude fibre and their fractions during ensiling process of wheat. Like in case of maize, in 3rd day of fermentation there was also observed significant decreased in content of this polysaccharides, on the other hand in the late stage of fermentation there was observed their systematical increasing. Used in experiment additives had highest influence on content of NDF fractions (Table 2). Content of NDF in contrary to the another fibre fractions, was lowest than its content in material before ensilage. This is in some way confirmed effectiveness of enzymes contained in Bactozyme. This enzymes degraded hemicelluloses facility than fibrous fraction - ADF with share of lignin.

The changes in fibrous fractions in silages treated enzymatic-bacterial additives had influence on degradability of this components in rumen (Figure 1-6). In each cause there was observed slowest rate and less degradability of crude fibre, NDF and especially ADF from treated silages. In compare to plants ensilaged without inoculants, degradation of maize treated Cornsil was lowest about 20% and for wheat with additive of Bactozym degradation was lowest about 10%. This observation was connected with highest levels of lignin in ADF fractions, which are almost completely undigested in rumen. There was worth to note, that differences in the effectiveness of degradation of crude fibre, ADF and NDF between silages were lowest in wheat with compare to maize. There is possible, that activity of enzymes from Bactozyme couldn't be exploit, what was resulted by different disposition fibrous fractions in wheat harvested in late stage of maturity.

**Table 2.** Changes in fibrous fraction's level (g/kg DM) during ensiling process of wheat

| | Green crops | Silage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 3rd day* | | 7th day | | 21st day | | 63rd day | |
| | | without inoculant | with inoculant | without inoculant | with inoculant | without inoculant | with inoculant | without inoculant | with inoculant |
| crude fibre | 256,4 | 254,6 | 239,8 | 268,4 | 251,8 | 284,0 | 268,1 | 322,2$^{a}$ | 280,0$^{b}$ |
| ADF | 289,3 | 285,2 | 275,9 | 310,8 | 281,9 | 311,2 | 298,8 | 339,9$^{a}$ | 320,8$^{b}$ |
| NDF | 630,3 | 578,9$^{a}$ | 545,1$^{b}$ | 582,5$^{a}$ | 554,2$^{b}$ | 606,5$^{A}$ | 560,3$^{B}$ | 617,4$^{a}$ | 593,9$^{b}$ |

*) after start of ensiling a, b P≤0,05 A,B P≤0,01

Effect. degr. without inoc. = 55,06 % Effect. degr. with inoc. = 40,45%

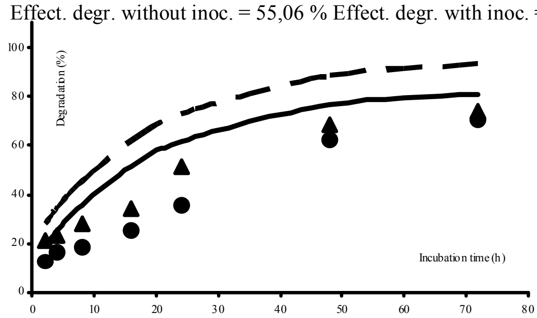


**Fig.1.** The crude fibre's rumen degradability curves of the maize silages

Effect. degr. without inoc. = 43,35 % Effect. degr. with inoc. = 39,93 %

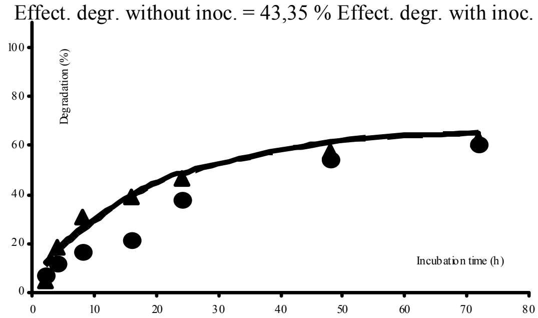


**Fig.2.** The crude fibre's rumen degradability curves of the wheat silages

Effect. degr. without inoc. = 55,19 % Effect. degr. with inoc. = 34,54%

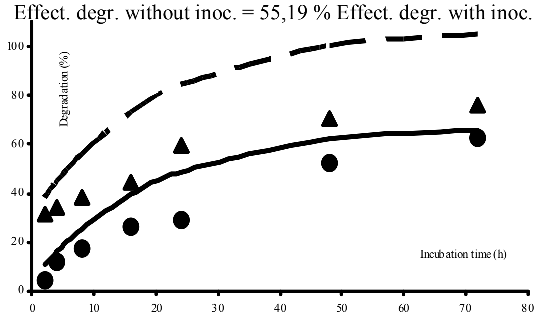


**Fig.3.** The ADF's rumen degradability curves of the maize silages

Effect. degr. without inoc. = 54,95 % Effect. degr. with inoc. = 46,58%

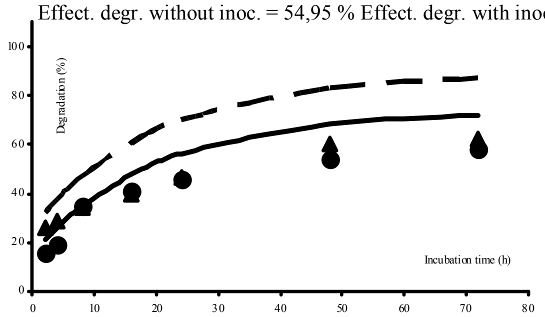


**Fig.4.** The ADF's rumen degradability curves of the wheat silages

Effect. degr. without inoc. = 72,56 % Effect. degr. with inoc. = 51,47%

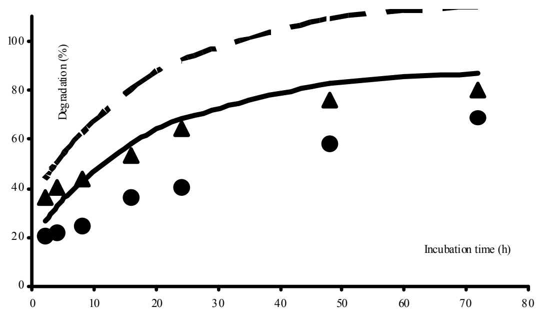


**Fig.5.** The NDF's rumen degradability curves of the maize silages

Effect. degr. without inoc. = 43,35 % Effect. degr. with inoc. = 39,93 %

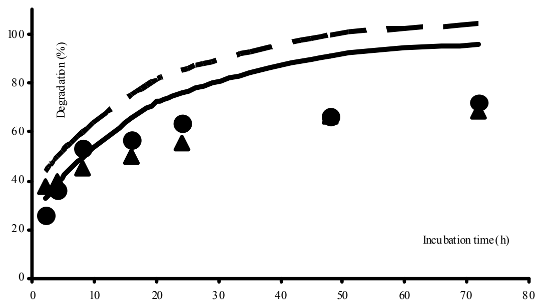


**Fig.6.** The NDF's rumen degradability curves of the wheat silages

▲ Observed values for silage without inoculant
● Observed values for silage with inoculant
— — Fitted values for silage without inoculant
—— Fitted values for silage with inoculant

## Conclusion

The enzymatic-bacterial additives used in ensilaging process of maize and wheat harvested in late stage of maturity decreased content of crude fibre, ADF and NDF fractions in silages. Rate of the rumen degradability this polysaccharides from treated silages was lowest as well as lowest was also their effective degradability.

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# Effect of Level of Surface Spoilage on the Nutritive Value of Whole-crop Maize Silage Diets

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## Abstract

The objective of this study was to determine the effect of level of surface spoilage in the diet on feed intake and nutrient digestibilities in growing steers fed whole-crop maize silage-based diets. Twelve crossbred steers, fitted with ruminal cannulas, were used in the study, which consisted of two, 17-day periods. Irrigated, Pioneer 3394 maize was harvested at the 80% milkline stage of maturity, contained 28% dry matter (DM), and chopped to a 10mm particle length. A pilot-scale bunker silo, 0.9 m in depth, and a 2.7 m diameter and an AgBag® were filled with alternating loads of chopped forage. After 90 days, the bunker was sealed with a single sheet of polyethylene, and this silage was designated "spoiled". The silage in the AgBag was designated "normal". The four experimental diets contained 90% silage and 10% supplement (DM basis), and the proportions of silage in the diets were A) 100% normal, B) 75% normal: 25% spoiled; C) 50% normal: 50% spoiled; and D) 25% normal: 75% spoiled. The DM content decreased and the amounts of ash and fiber increased as the proportion of spoiled silage increased in the diet. Feed intake decreased in a linear manner as the proportion of spoiled silage increased from 0 to 75%. Steers consuming the normal silage diet had higher DM, organic matter, and neutral and acid detergent fiber digestibilities than those fed the three diets that contained spoiled silage. The addition of spoiled silage also had negative associative effects on nutrient digestibilities, and the integrity of the forage mat in the rumen was partially destroyed by even the lowest level of surface spoilage in the diet.

## Introduction

Whole-crop maize silage is a major source of energy in most lactating dairy cattle and growing beef cattle diets in North America. An important silage management practice, which is in the control of cattle producers and that is often poorly implemented or overlooked entirely, is the discarding spoiled silage. Plastic sheeting was first used to protect the surface of small "clamp" silos from air and rain or snow in Europe in the 1950s (Shukking, 1976). By the 1960s, sheets were usually made from polyethylene and ultra-violet stabilizers to prevent the material from disintegrating in sunlight. The great benefits of plastic sheeting were that air movement in and out of the silo could be reduced and surface waste could be minimized as a result. But sealing with a polyethylene sheet weighted with old tires is not 100 percent effective, and aerobic spoilage occurs to some degree in virtually all sealed silos (Bolsen et al., 1993). The objective of this study was to determine the effect of including three levels of "surface spoiled silage" on the nutritive value of whole-crop maize silage-based diets.

## Materials and Methods

Twelve crossbred steers, fitted with ruminal cannulas, were used in the study. A single source of irrigated maize (Pioneer 3394) was harvested at the 80% milkline stage of maturity and 38% DM and chopped to a 10 mm particle length. Three pilot-scale bunker silos, 0.9 m deep, and a 6.0 m section of a 2.7 m diameter AgBag® were filled with alternating loads of chopped forage. After 90 days, the bunkers were sealed with single sheets of 0.6 mil polyethylene, and these silages were designated "spoiled". The silage in the AgBag® was designated as "normal". The four experimental diets contained 90% silage and 10% supplement (on a DM basis), and the proportions of silage in the diets were: A) 100% normal, B) 75% normal:25% spoiled; C) 50% normal:50% spoiled, and D) 25% normal:75% spoiled. The diets were fed once daily at 0700, and the amount fed was adjusted so that approximately 10% of the as-fed diet was in the feed bunk at the end of each 24-hr period.

## Results and Discussion

The pH and chemical composition of the whole-plant maize silages fed in the metabolism trial are shown in Table 1. The composition of the spoiled silage is reported for each of the two distinct visual layers, designated as the original top 45 cm and bottom 45 cm, and for a composite of the two layers after they were mixed, which represents the spoiled silage as it was actually fed in rations B, C, and D. With ash content as the internal marker, the estimated proportion of the original top 45 cm and bottom 45 cm spoilage layers in the spoiled composite silage was 23.8 and 76.2%, respectively. The normal maize silage had higher DM and OM contents and slightly lower starch and CP contents than the spoiled composite silage. The normal maize silage also had lower NDF and ADF percentages, which reflect the high proportion of grain in the ensiled crop. The high ash and fiber contents of the composite silage are associated with poor preservation efficiency and large OM losses during the aerobic, fermentation, and storage phases.

The original top 45 cm layer was visually quite typical of an unsealed layer of silage that has undergone several months of exposure to air and rainfall. It had a foul odor, was black in color, and had a slimy, "mud-like" texture, and its extensive deterioration during the 90-day storage was also reflected in very high pH, ash, and fiber values. The original bottom 45 cm layer had an aroma and appearance usually associated with wet, high-acid maize silage, e.g., a bright yellow to orange color, a low pH, and a very strong acetic acid smell.

The original depth of the packed, whole-crop maize in the bunker silos was about 90 cm; however, the final depth of the spoiled silage was only about 56 cm, with about 18 and 38 cm in the top and bottom depths, respectively. This settling of the ensiled crop that occurred during the 90 days the bunker silo was unsealed, e.g., approximately 34 cm, is typical of settling depths observed in unsealed bunker, trench, or drive-over pile silos.

The addition of spoiled silage had large negative associative effects on feed intake and DM, OM, NDF, and ADF digestibilities (Table 2), and the largest reduction in nutritive value occurred with the first increment of spoilage. The spoiled silage also destroyed the "forage mat" in the rumen. The results clearly indicated that feeding surface spoilage had greater negative impacts on the nutritive value of maize silage-based diets than were expected.

Future research should focus on the effect of feeding this surface spoilage on livestock performance and on the potential hazards to livestock health.

**Table 1.** pH and Chemical Composition of the Whole-crop Maize Silages fed in the Metabolism Trial

| Silage | pH | DM | OM | Starch | CP | NDF | ADF |
|---|---|---|---|---|---|---|---|
| | | % | ---------------- % of the DM ---------------- | | | | |
| Normal | 3.90 | 38.0 | 94.7 | 22.3 | 6.9 | 42.6 | 23.4 |
| Spoiled top layer, composite of the original top 90 cm | 4.79 | 26.4 | 90.9 | 24.3 | 9.9 | 48.9 | 31.0 |
| Spoilage layers | | | | | | | |
| Original top 0 – 45 cm (slime layer) | 8.22 | 19.1 | 80.0 | 2.7 | 17.7 | 57.6 | 48.3 |
| Original top 45 – 90 cm (acidic layer) | 3.67 | 27.6 | 94.3 | 26.1 | 6.7 | 48.5 | 25.5 |

**Table 2.** Effect of the Level of Spoiled Silage on Nutrient Digestibilities for Steers fed the Four Whole-crop Maize Silage Diets

| | Diet[1] | | | |
|---|---|---|---|---|
| Item | A (0) | B (5.4%) | C (10.7%) | D (16.0%) |
| DM intake, kg/day | $7.95^{a}$ | $7.35^{b}$ | $6.95^{b,c}$ | $6.66^{c}$ |
| DM intake, % of body weight | $2.36^{a}$ | $2.22^{b}$ | $2.10^{b,c}$ | $2.04^{c}$ |
| | ------------------------- Digestibility, % ------------------------- | | | |
| DM | $74.4^{a}$ | $68.9^{b}$ | $67.2^{b}$ | $66.0^{b}$ |
| OM | $75.6^{a}$ | $70.6^{b}$ | $69.0^{b}$ | $67.8^{b}$ |
| CP | $74.6^{a}$ | $70.5^{b}$ | $68.0^{b,c}$ | $62.8^{c}$ |
| NDF | $63.0^{x}$ | $56.0^{y}$ | $52.5^{y}$ | $52.3^{y}$ |
| ADF | $56.1^{a}$ | $46.2^{b}$ | $41.3^{b}$ | $40.5^{b}$ |

[1]The amount of the "slime" layer spoilage in the diets (DM basis) is shown in parentheses.
[a,b,c]Means within a row with no common superscript differ (P<.05).
[x,y]Means within a row with no common superscript differ (P<.10).

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# Effect of Feeding of Propylene Glycol on Selected Ruminal, Blood and Milk Constituents of Dairy Goats

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## Abstract

The aim of this work was to study the effect of feeding of Propylene glycol on concentrations of the selected ruminal, blood and milk constituents. For this study, 12, dairy goats from first to fourth lactation were used. They were allocated to two groups, control (n=6 goats) fed on the basal diet only and propylene glycol (PG)-supplemented group (n=6 goats) fed on 40.0 g of Propylene glycol mixed with the concentrate mixture. The rumen, blood and milk samples from each animal were collected before supplementation and 4, 6 and 8 weeks after supplementation of propylene glycol was begun.. The results have shown that there were no significant differences in molar proportions of ruminal individual and total volatile fatty acids between groups. While, concentrations of plasma and milk urea in addition to milk ketones were decreased within the group receiving propylene glycol, however, the milk citric acid was significant increased in PG-treated goats than in the control.

## Introduction

In ruminants, glucose given parent rally is readily available for metabolism. While, if glucose given orally, is relatively ineffective because rumen fermentation converts carbohydrates to short - chain volatile fatty acids (VFA) and therefore ruminants do not absorb appreciable amounts of glucose from their GIT, (Leng 1970). Search for suitable gluconeogenic precursors has focused on three and four- carbon compounds that share common properties of palatability, ease of mixing with grain-based concentrates, reasonable- cost factors and resistance to microbial fermentation in the rumen. Among these are propylene glycol (PG) and glycerol showing the most promising results in palatability, ease of handling, glucogenicity and economy. Effectiveness of Propylene glycol in ruminant nutrition can be explained by characteristics of its metabolism, (Emery et al. 1964). The aim of the current study was to investigate the influence of propylene glycol feeding on selected ruminal, blood and milk constituents of dairy goats.

## Materials and methods

This work was carried out in a goat farm for milk and cheese production during the lactation months of April and June. 12, clinically healthy Czech-breed dairy goats were classified into two groups. The first group was a control and fed a basal diet without feed additions, and the second one was supplemented group fed a diet containing 40.0 g, propylene glycol 63 (PG). The basal diet was formulated to contain 13.85 % CP and composed of 35.29 % (DM basis) concentrate mixture, 26.30 % grass haylage and 38.41% grass hay. Ruminal, blood and milk samples were collected from each goat before supplementation and 4, 6 and 8 weeks after supplementation of propylene glycol was begun. The selected ruminal, blood and milk parameters were measured. The statistical analysis of the data was performed using analysis of variance (ANOVA) as outlined in STATGRAPHICS (STSc Inc. and Statistical Graphics Corp., 1985).

## Results and Discussion

### 1. Ruminal parameters

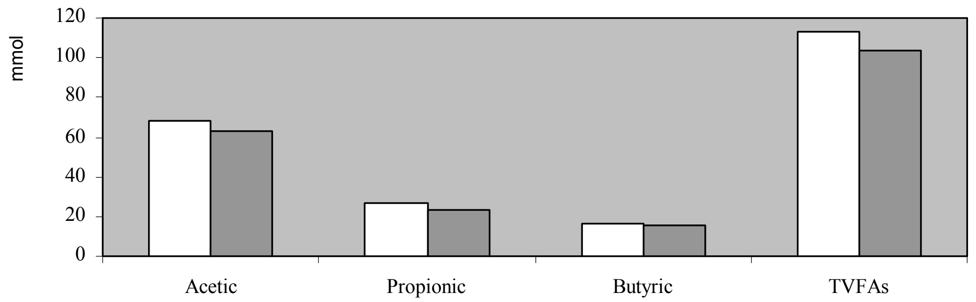


**Fig. 1. Effect of dietary supplementation of PG on the ruminal volatile fatty ac**

Control PG

There were no significant differences (Fig.1) in molar proportions of ruminal individual and total volatile fatty acids between control and PG-treated goats. Our observations did not correlate well with those published by Emery et al. (1964). Propylene glycol has no negative impact on volatile fatty acid production and their proportional supplying in ewes and cows, (Brnuska et al. 1989).

## 2. Blood parameters

There was a significantly decreased ($p<0.01$) in the plasma glucose level in treated group as compared with those in control one. However, the plasma cholesterol level was significantly increased in the supplemented group ($p<0.05$) than those in control. There was no significant decrease in the levels of blood total ketones between groups. Propylene glycol was proved as anti-ketogenic and glucogenic agents in high-yielding dairy cows, (Illek & Matejiček 2001). The significantly higher total cholesterol levels in the plasma of PG-treated goats suggest that energy balance was improved by the treatment, (Emery et al. 1964). Our observations on propylene glycol treated and untreated goats were in excellent agreement with those published by Khaled & Illek (1999). Significant increase ($p<0.01$) in plasma levels of total protein and globulin were observed in dairy goats supplemented with PG in comparison to control, (Table 1). However, no significant differences in serum albumin and creatinine were found between the groups. A plasma urea concentration decrease within the group receiving propylene glycol indicates that these animals had better nutritional status than control animals (Khaled & Illek 1999).

**Table 1.** Effect of propylene glycol supplementation on concentrations of blood metabolites of goats

| Variables | | Control group | PG-supplemented group | Sig. level |
|---|---|---|---|---|
| Plasma glucose | $mmol.l^{-1}$ | 3.92 ± 0.13 | 3.28 ± 0.15 | ** |
| Plasma cholesterol | $mmol.l^{-1}$ | 2.31 ± 0.14 | 2.67 ± 0.09 [a] | * |
| Blood total Ketones | $mmol.l^{-1}$ | 0.87 ± 0.03 | 0.85 ± 0.04 | NS |
| Plasma Total protein | $g.l^{-1}$ | 71.59 ± 1.03 | 74.79 ± 0.47 | ** |
| Serum Albumin | $g.l^{-}$ | 37.95 ± 0.40 | 37.75 ± 0.72 | NS |
| Plasma Globulin | $g.l^{-}$ | 33.63 ± 0.73 | 37.04 ± 0.74 | ** |
| Plasma Urea | $mmol.l^{-1}$ | 7.60 ± 0.59 | 7.29 ± 0.43 | NS |
| Plasma Creatinine | $\mu mol.l^{-1}$ | 91.95 ± 1.76 | 92.15 ± 2.14 | NS |

NS: Not significant * $p<0.05$ ** $p<0.01$ *** $P<0.001$

## 3. Milk parameters

**Table 2.** Effect of propylene glycol supplementation on milk constituents of goats

| Variables | | Control group | PG-supplemented group | Sig. level |
|---|---|---|---|---|
| Citric acid | $mmol.l^{-1}$ | 3.70 ± 0.20 | 5.68 ± 0.35 | *** |
| Urea | $mmol.l^{-1}$ | 7.93 ± 0.66 | 7.52 ± 0.48 | NS |
| Total Ketones | mmol.l-1 | 5.19 ± 0.41 | 3.43 ± 0.15 | *** |
| Oxidized Ketones | µmol.l-1 | 29.17 ± 2.85 | 22.67± 1.88 | NS |

Milk concentrations of oxidized ketones and milk urea were not significant decreased in treated goats against control. (Table 2). While, the milk total ketones were significant decreased ($p< 0.001$) in PG- supplemented goats. However, milk citric acid was significant ($p<0.001$) increased in treated goats in comparison to control. The lower milk urea levels observed in group receiving propylene glycol provide further evidence that nutritional status was better for these animals than for controls, (Khaled & Illek 1999). The decrease in concentration of citric acid in addition to increase in urea and ketones in goat's milk during the first lactation months indicated negative energy balance (Khaled, Illek and Gajdusek 1999) in dairy goats. Thus an increase in milk citric acid observed in treated goats with propylene glycol provides improvement of energy balance, (Khaled & Illek 1999). A decrease in milk ketones in goats receiving propylene glycol as compared to control was correlated with the results of Emery et al. (1964).

## Conclusion

Using propylene glycol as feed additive for dairy goats had no negative impact on volatile fatty acid production and their proportional supplying. The plasma and milk urea in addition to milk ketones concentrations were decreased within the group receiving propylene glycol indicates that these animals had better nutritional status than control animals. An increase in milk citric acid observed in treated goats with propylene glycol provides improvement of energy balance. Propylene glycol was proved as anti-ketogenic and glucogenic agents in addition to healthy safety as feed additive.

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# Nutritive Value of Silage from Seminatural Grassland Preserved with Addition of Probiotics

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## Abstract

In 1999, the effects of probiotic additives (Lactibiose, Lalsil, Goldzym, Microsil) on quality, nutritive value and nutrient digestibility of silage made from seminatural grassland were studied. Herbage was harvested at the 1st cut and ensiled at dry matter (DM) content of 250 g $kg^{-1}$. The research comprised 6 treatments, 4 of them treated with the probiotics, 1 control plus 1 control with 0.3% formic acid applied. The addition of probiotics showed positive effects on the quality of silage and significantly decreased the content of acetic acid, ammonia and proteolysis. The best quality of silage was found in the treatments with microbial – enzymatic additives applied (Goldzym, Lactibiose). The significantly highest parameters of protein digested in small intestine (PDIE and PDIN) were recorded at the silage treated with Lactibiose, and the highest values of net energy for lactation (NEL) and of net energy of intake (NEV) were found at the treatment with Goldzym added. There was a significant difference in the content of digestible nutrients between the control and the additive treatments. The highest nutrient digestibility was found in the treatment with Goldzym added and in the control treated with 0.3% formic acid. Positive correlations were found between digestible organic matter (OM) and silage quality ($r = 0.5488^{++}$) as well as between digestible crude protein (CP) and silage PDI ($r = 0.5985^{++}$).

## Introduction

The advancement of biotechnology in agriculture enables to use the new knowledge also in forage production.. In recent years, besides the chemical preservatives, biological additives were introduced to control the fermentation process in silage. These additives improve the quality of silage and reduce protein degradation significantly (Setälä, 1989). Yan et al. (1996), Žiláková et al. (1998) and Žiláková et al. (1999) reported increased content of lactic acid, decreased content of ammonia ($NH_3$), reduced proteolysis better nutritive value and higher digestibility of dry matter (DM) in the treated silage. The objective of the research was to investigate the effects of biological additives on quality, nutritive value and nutrient digestibility of grass silage.

## Materials and methods

A research trial was conducted to ensile herbage from seminatural grassland harvested from the 1st cut at 250 g $kg^{-1}$ DM content. All the additives were applied in agreement with the instruction of their respective manufacturers and the research treatments were as follows: Goldzym, Lactibiose (bacterial and enzymatic ones), Microsil, Lalsil (bacterial ones), formic acid (0.3 %) and the untreated control. Herbage was ensiled in 50-l PVC containers (n = 10). The contents of DM, CP, fat and ash were determined in both the fresh and the ensiled herbage in compliance with the Slovak technical standard (STN 46 7093). In the effluent leached from preserved herbage, the following parameters were analysed : pH (electrometric), lactic, acetic and butyric acids (isotachophoresis – Agrofor), free $NH_3$ (acidimetry), free amino acids (formol titration). Nutrient digestibility of the preserved herbage was determined in vivo in a group of 5 wethers (“Cigaja” breed) in agreement with the classical balance methods for assessing digestibility trials. Metabolisable energy (ME), net energy for lactation (NEL), net energy of intake (NEV) and protein digested in the intestine (PDIE, PDIN) were determined by chemical analyses and calculated using the equations defined by Sommer et al. (1994).

## Results and discussion

The parameters of fermentation given in Table 1 showed that the quality of silage treated with the biological additives and with 0.3 % formic acid was very good, because the content of lactic acid was high, acetic acid content was low and butyric acid was not found. The significantly highest content of lactic acid was found in the silages treated with Goldzym and Lactibiose. In the silages, the significantly lowest $NH_3$ content as well as the proportion of ammonia in total nitrogen ($N – NH_3$) were recorded. The significantly highest concentration of $NH_3$ (2.07 g $kg^{-1}$ DM) and the most intensive proteolysis (9.01 %) were found in the untreated control. There was a strong negative correlation ($r = -0.5129^{++}$) between $NH_3$ content and silage quality. The high $NH_3$ content was related to increased intensity of fermentation and, consequently, to higher DM losses (Žiláková et al., 1999) as $r = -0.6101^{++}$. High content of $NH_3$ in silage significantly reduced DM digestibility ($r = -0.8379^{++}$, Fig. 1), CP digestibility ($r = -0.6613^{++}$), crude fibre (CF) digestibility ($r = -0.5694^{++}$) and OM digestibility ($r = -0.7995^{++}$, Fig. 2). Differences in digestibility of nutrients were significant between all the treatments. A positive correlation between OM and silage quality was found ($r = 0.5488^{++}$), as presented in the earlier reports (Žiláková et al., 1999). The highest PDIE and PDIN values were found at the treatment with Lactiobiose and the significantly highest NEL, NEV and ME were recorded with Goldzym added. The differences between the treatments were statistically significant. A positive correlation was found between digestible CP and PDI ($r = 0.5985^{++}$).

**Table 1.** Silage quality (g kg$^{-1}$ DM), digestibility coefficients (%) and nutritive value

| | Control | Control with HCOOH(0.3%) | Lactibiose | Lalsil | Goldzym | Microsil |
|---|---|---|---|---|---|---|
| DM in fresh herbage | 226.14 a | 240.41 ab | 258.28 b | 236.07 a | 256.47 b | 242.76 b |
| Lactic acid | 37.03 a | 46.03 a | 49.43 ab | 40.63 a | 61.80 b | 39.46 a |
| Acetic acid | 20.51 a | 16.36 a | 15.82 a | 14.74 a | 18.82 a | 15.37 a |
| Butyric acid | 0 | 0 | 0 | 0 | 0 | 0 |
| PH | 4.12 ab | 4.05 a | 4.22 ab | 4.31 b | 4.16 ab | 4.33 b |
| $NH_3$ | 2.07 b | 1.31 a | 1.21 a | 1.86 b | 1.34 a | 1.59 ab |
| N - $NH_3$ (%) | 9.01 c | 6.06 ab | 5.14 a | 8.09 bc | 6.04 ab | 7.00 abc |
| Points | 78 a | 92 b | 93 b | 92 b | 94 b | 88 ab |
| Quality rank | II | I | I | I | I | I |
| DM digestibility | 68.54 a | 73.40 b | 71.92 ab | 69.48 a | 73.07 b | 71.06 ab |
| CP digestibility | 65.54 a | 73.68 b | 67.92 ab | 65.68 a | 69.46 b | 68.34 ab |
| CS digestibility | 72.92 a | 75.42 ab | 76.42 b | 75.32 ab | 81.00 c | 77.38 b |
| OM digestibility | 71.38 a | 75.64 b | 73.78 ab | 71.86 a | 75.64 b | 73.04 ab |
| PDIE (g.kg$^{-1}$ DM) | 81.06 ab | 82.74 ab | 84.28 b | 80.78 a | 83.02 ab | 82.36 ab |
| PDIN (g.kg$^{-1}$DM) | 87.10 d | 81.80 a | 88.90 f | 87.40 e | 83.90 b | 86.10 c |
| NEL (MJ.kg$^{-1}$ DM) | 6.57 a | 7.07 bc | 6.90 abc | 6.64 ab | 7.22 c | 6.77 abc |
| NEV (MJ.kg$^{-1}$ DM) | 6.64 a | 7.32 bc | 7.12 abc | 6.75 ab | 7.49 c | 6.91 abc |
| ME (MJ.kg$^{-1}$ DM) | 10.87 a | 11.51 bc | 11.23 abc | 10.94 ab | 11.70 c | 11.12 abc |

Mean values indicated with different letters are significantly different ($P < 0.05$)

**Figure 1.** Correlation between DM digestibility and $NH_3$ $NH_3$ content in silage

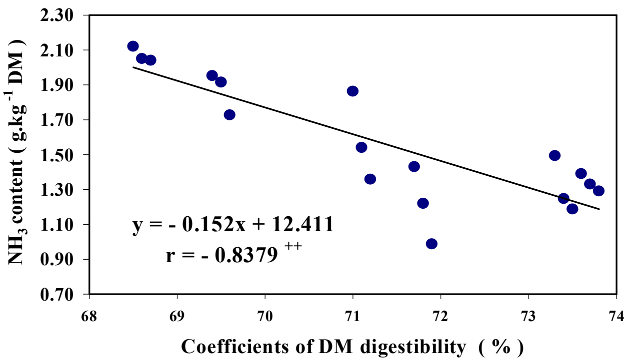
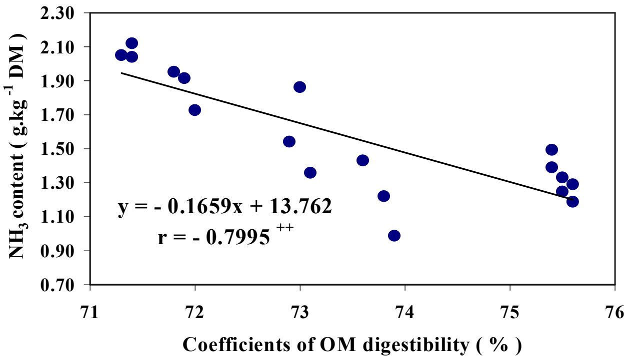



**Figure 2.** Correlation between OM digestibility and content in silage




## Conclusions

The research was carried out to assess the effects of probiotics (Goldzym, Microsil, Lalsil, Lactibiose) on quality, nutrient digestibility and nutritive value of silage made from seminatural grassland in 1999. The addition of probiotics showed positive impact on silage quality (a significant decrease in acetic acid content, ammonia and proteolysis), on digestibility of all the nutrients and on nutritive value of grass silage. There were correlations between digestible OM and silage quality ($r = 0.7499^{++}$) as well as between digestible CP and PDI ($r = 0.5985^{++}$). The best quality of silage was found in the treatments with Goldzym and Lactibiose. The highest digestibility coefficients of DM, CF and OM were recorded at the Goldzym treatment. The significantly highest parameters of nutritive value (PDIE, PDIN) were found at Lactibiose treatment and the significantly highest values of NEL, NEV and ME were recorded at the treatment with Goldzym.

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# The Ensilage of Wet Pressed Grain, Pea and Maize Grain by Chemical Preservation

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## Abstract

Preservation by the means of ensilage of pressed grain, pea and maize grain is based on chemical treatment by formic and propionic acid. The grain of 45% to 30% moisture is harvested then pressed and conserved. It is stored in silage bags, clamps or towers. The chemical preservative works fungicidally and bactericidally and with a dosage of 3 - 4 litres also selectively and, consecutively lactic fermentation takes place. Although silages have a high content of carbohydrates, after chemical preservation they are sufficiently stable.

## Introduction

Grain feeds require the most efficient way of preservation. We took Finland as a model. They press damp grain in special pressing machines MURSKA manufactured by a Finnish company AIMO KORTTEEN KONEPAJA OY. This method is also used in Great Britain, Russia, Poland and can be adopted in the conditions of the Czech republic as well. In the last two years laboratory experiments were carried out as well as operational experiments in agricultural enterprises and farms.

The chemical way of preservation is based on instant reduction of pH and elimination of negative epiphyte microflora of the feed. The amount of yeast and mould is minimized this way. There occurs the starting up of the fermentative process (that is but then partially reduced by chemical preservation) and the expansion of lactic fermentation.

## Material and Methodology

Laboratory experiments based in 1999
Laboratory experiments were based always in double repetition. A Finnish press (crimping machine) Murska 700S was used for pressing the grain and preservative CRIMPSTORE 2000 was applied in amount of 3 - 5 litres per ton according to the dry matter of grain. Probiotic preparation, probiotic preparation with enzymes (cellulose and hemicellulose) and a control variant without preservative were included for comparison.
Experiments were carried out on triticale, pea, barley and maize.

***Laboratory experiments based in 2000***

Correspondingly to year 1999, experiments were based on barley and wheat. The impact of preparation CRIMPSTONE was compared to the probiotic (dose 1kg/ 100t) and to the control variant without preservative. The samples were analysed not only for basic nutrients with fermentative process but also for watersoluble carbohydrates (WSC). And the percentage of losses caused by outflow of gas was determined by weighing.

The test of weigh losses in cereals and maize harvested by the method of pressed silaged grain after the "in situ" cultivation

The aim was to determine the degrability of organic matter in rumen after "in situ" cultivation lasting 4 and 24 hours. These two periods of time were determined on the basis of earlier given analysis of watersoluble carbohydrates primarily in cereals. Roughly pressed maize conserved by a probiotic and then two variants of maize conserved by the preparation CRIMPSTONE (dose 3 - 4 litres per ton) were included in the experiment. As for cereals, wheat (dose 3 litres per ton) and two samples of triticale (dose 3 litres per ton) were chosen. For comparison, rough-ground triticale, wheat and maize were included.

The analysis was carried out by the laboratory EKO-LAB s.r.o. Žamberk and the test of weight losses by VÚCHS Rapotín.

## Results and Discussion

Laboratory experiments based in 1999
In the experiment with triticale no significant divergences were found out in basic nutrients. There was a difference in the fermentative process where with CRIMPSTORE occurred a reduction. With probiotic and probiotic with enzymes,

the fermentative process took place successfully and the content of lactic acid was more than 30% higher than in the control variant. The mycological examination was similar with all samples in the range of 2.5 x $10^4$ KTJ/g of fresh matter.

No significant divergences in basic nutrients were found out in the experiments with pea. Very good values were determined in NEL approx. 7.84 MJ. This value is higher than in the experiment with barley where the average value was 7.72 MJ. With probiotic and probiotic with enzymes, the fermentative process took place very well and the content of lactic acid was almost 50% higher than in the control variant. Mycological examination was evaluated very well, above all with CRIMPSTORE, where the number of KTJ was lower than $10^1$ g of the fresh matter. With probiotically treated pea the number of KTJ ranged from 3.7 - 5x $10^2$ of fresh matter. Also the check test showed a low number of KTJ - $10^3$ of fresh matter.

The analysis of barley and maize showed similar results as triticale.

***Laboratory experiences based in 2000***

The dry matter in barley grain ranged from 531g - 549.8g. Moderate diminution of acids occurred in the fermentative process with CRIMPSTORE and in the check test as against the grain treated with probiotic. pH values were low in all analysis and ranged from 3.63 - 3.95. the biggest differences were registered with watersoluble carbohydrates. The average values of the grain treated with probiotic and the untreated check test were 35.42g - 36.06g, whereas the average value of watersoluble carbohydrates in the grain treated with CRIMPSTORE was 76.49g. The losses caused by the outflow of gas in the grain treated with CRIMPSTORE were approx. 0.438%. The values of the losses in the grain treated with probiotic and in the check test were 0.681% and 0.67%. The experiments with the wheat grain were of a similar nature as those of barley grain.

The test of weigh losses in cereals and maize harvested by the method of pressed silaged grain after the "in situ" cultivation

After "in situ" cultivation lasting four hours, the lowest loss was shown in the maize grain treated with probiotic preparation - 20.54%. In roughly pressed maize corn, the loss was 34.75%. In finely pressed maize corn it was 47.08%. In cereals, silaged, preserved and also rough-ground, the loss ranged from 74.31% to 80.14%. In maize groats it was 32.36%.

After cultivation lasting 24 hours, the lowest loss was shown in the maize grain treated with probiotic - 53.61%. In roughly pressed maize corn, the loss was 69.01%. In finely pressed maize corn it was 84.23%. In cereals, both preserved and rough-ground, the loss ranged from 91.34% to 93.66%. In maize groats it was 56.48% similarly as in the maize preserved by a probiotic.

## Conclusion

As a result of this we can say that the new method of ensilage of the wet pressed grain feeds shows the way to efficiently and economically store and feed these feeds. Primarily with cattle a higher content of carbohydrates has an impact on the use of quickly soluble and degradable nitrogenous substances. In practice it will mean a decrease in requirements for expensive proteinaceous components and in feeding expenses per unit of production.

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|---|---|
| Name publication: | Forage Conservation |
| Type publication: | Conference proceedings |
| Author's publication: | Collective authors accord content |
| Type-setting | RNDr. S. Rudolfova |
| Amount pages: | 181 |
| Bur: | 150 articles |
| Format: | A4 |
| Published by | © MUAF Brno |
| Print: | RIAP Praha Uhrineves |
| | |
| Date and location: | 10$^{td}$ - 12$^{th}$ September 2001, Brno |

The individual contributions in this publication remain the responsibility of the authors.
Internal publication for purpose participants 10$^{th}$ International Conference Forage Conservation

ISBN 80-7157-528-3