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THE MIXED SILAGE OF MAIZE AND DENDROMASS AS A POTENTIAL FEED FOR WILD RUMINANTS

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ABSTRACT

The aim of this study was to evaluate the mixed silage of maize and dendromass – twigs of broadleaf and conifer trees – as palatable feed for wild ruminants, rich in energy and of sufficient structural crude fibre content. In the experiment, we compared nutrient content of the M1 feed mixture (70 % maize + 30 % Dendro 1) and the M2 feed mixture (70 % maize + 30 % Dendro 2). Two variants of dendromass were used in the feed mixtures: Dendro 1 (75 % oak twigs, 25 % spruce twigs) and Dendro 2 (50 % oak twigs, 50 % spruce twigs). Spruce and oak twigs had higher dry matter content than maize. This was reflected also in the ensilaged mixtures made by combining maize and dendromass, in which the dry matter content was higher by 34.16 and 58.31 g per kilogram of fresh feed than in maize due to the addition of dendromass. Concentrations of crude protein and saccharides matched the character of the feed and were lower in the mixture of maize and dendromass compared to maize. As the crude fibre content in dendromass was 367.25 and 345.65 $g.kg^{-1}$ of dry matter and the entire fibre complex content was significantly higher than in maize, a significant increase in the content of all components of the fibre complex was determined. Fermentation process in the maize silage was more intense compared to mixture silages of maize and dendromass. It can be recommended to use the silage production of such mixtures to wild ruminant keepers in winter and at higher crude protein content also in summer. This method of biological protection of forests provides the necessary nutrients to the wild ruminants. Utilization of dendromass as feed is also considered as a partial recycling of logging waste.

Key words: maize; dendromass; silage; feed; wild ruminants

INTRODUCTION

Damages caused by wild ruminants on forestry and agriculture in Slovakia are intensive. The population numbers of cloven-hoofed game in Slovakia reached their historic peaks. According to statistical data, the spring stock of main cloven-hoofed game species (before calving) in year 2015 was: roe deer – 106 906, red deer – 65 126, fallow deer – 15 807, mouflon – 13 350, and boar – 41 591 (Hunter Statistical Yearbook, 2015).

The Slovak legislative orders to hunters to feed game in such manner as to not cause damage to health of the animals (Directive NR SR no. 274/2009, 2009).

Supplementary feeding of wild ruminants is one of the possible methods to reduce damages to the forests caused by wild ruminants. When the nutritional requirements of the animals are covered by supplementary feeding, the need to cover these requirements by forest tree browsing is decreased. Several authors (Missbach, 1975; Ueckermann *et al*., 1977; Pheiffer and Hartfiel, 1984; Putman and Staines, 2004; Rajský *et al*., 2008) demonstrated that proper supplementary feeding markedly decreased the rate of the forest

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tree browsing. Importance of proper supplementary feeding to decrease bark browsing by deer in forests is supported in the reports of Reimoser (2004) and Konôpka and Hell (2004). At present, the advantages and disadvantages of supplementary feeding of wild game are being discussed, for example, by Katona *et al*. (2014) and Milner *et al*. (2014).

The papers of Webster *et al*. (2001), Jeon *et al*. (2003), Galló *et al*. (2017) and others describe the utilization of ensilaged feeds in wild ruminant nutrition. Maize is an easy to ensilage roughage, and high-quality maize silage is a good source of structural as well as non-structural carbohydrates (Vršková and Bencová, 2011). Quality of maize silage is well-investigated (Bíro *et al*., 2016; Tyrolová *et al*., 2016; Rajčáková *et al*., 2013). However, it differs from the traditional food sources for wild ruminants by its nutritional characteristics. Twigs of broadleaves and conifer tree species represent natural food for free-living ruminants. The ensilaged mixture of maize and twigs from forest tree species, as a potential feed for ruminants, will enrich the maize silage with structural fibre and other nutrients by addition of this natural food. This is a prerequisite for attractive feed rich in energy and with adequate content of structural crude fibre. Questions of nutrition and impact on the environment are interesting in connection with high population density of free-living ruminants. There is little relevant information on ensilaging mixtures of maize and dendromass.

The aim of this study was to evaluate the possibility of ensilaging a mixture of maize and dendromass – twigs of broadleaf and conifer trees, and to monitor the influence of the fermentation process on the nutritional value of the produced ensilaged feed mixtures.

MATERIAL AND METHODS

In the first part of the experiment, fresh mixtures were prepared by combining whole maize plants and 50-70 cm long twigs of oak and spruce. Maize was harvested at the stage of wax ripeness and it represented 70 % of the mixture (fresh matter content). The remaining 30 % (fresh matter content) was dendromass – twigs of oak and spruce. Twigs harvesting was matched to the date of maize harvesting, in first week of September. Maize and twigs were cut to a size below 3 cm and the mixtures were homogenized.

Two variants of dendromass were used in the mixtures: Dendro 1 (75 % oak twigs, 25 % spruce twigs) and Dendro 2 (50 % oak twigs, 50 % spruce twigs). Two variants of a mixture were prepared: mixture 1 (M1) (70 % maize and 30 % Dendro 1) and mixture 2 (M2) (70 % maize and 30 % Dendro 2).

Samples of maize, Dendro 1 and Dendro 2, as well as samples of the M1 and M2 were analysed. By the organic analysis of all samples the following parameters were determined: dry matter, crude protein, crude fibre, saccharides, ash, fat and starch, according to the Decree of the MP SR no. 2145 /2004-100 (2004); acid detergent and neutral detergent fibre – according to Van Soest *et al*. (1991).

In the second part of the experiment, experimental silages were produced. Maize, M1 and M2 were filled into 1.7-liter glass laboratory silos. No ensilaging additives were used. Each variant of the silage was produced six times. The filled experimental silos were stored in a dark room with stable temperature at 22 ± 1 °C. During the fermentation process, changes in weight were monitored, and based on those, loses of dry matter weight were calculated in percentages. After 180 days from ensilaging the experiment was terminated.

In addition to the basic parameters of organic analysis like in fresh matter in first part of experiment, the following parameters of fermentation process were also determined for the silage samples: pH in the aqueous extract was determined using electrometric method, lactic acid and total volatile fatty acid content was determined by gas chromatography and alcohol content by micro-diffusion method. All chemical analyses were performed according to the Decree of the MP SR no. 2145 /2004-100 (2004).

RESULTS AND DISCUSSION

In the experiment, the nutrient contents and fermentation processes were compared among maize, dendromass, mixture 1 (70 % maize and 30 % Dendro 1) and mixture 2 (70 % maize and 30 % Dendro 2).

Nutrient content in the maize plants, dendromass and in mixtures composed by combining maize and dendromass before ensilaging is presented in Table 1. Spruce and oak twigs had higher dry matter content. This was reflected also in the feed mixtures of maize and dendromass for ensilaging, in which the dry matter content was determined to be higher by 34.15 and 58.31 g per kilogram of fresh feed, than in maize, due to the added dendromass. Concentrations of crude protein and saccharides corresponded with the character of the feed, and they were lower in the feed mixtures compared to maize. As the crude fibre content in dendromass was 367.25 (Dendro 1) and 345.65 g.kg^{-1} (Dendro 2) of dry matter and the entire fibre complex content was significantly higher than in maize, a significant increase in the content of all components of the fibre complex was revealed. Due to the lower ratio of maize, starch content was significantly lower in the feed mixtures compared to maize. Of the other monitored nutrients, an increase in the concentration of fat and ash in the feed mixtures compared to maize should be mentioned. Based on calculations it was determined that nitrogen-free extract content was lower in the feed mixtures compared to maize.

In the feed mixtures for ensilaging, twigs of oak and spruce were used. Twigs of forest trees are the natural food source for wild ruminants, and their nutritional content is sufficient as maintenance feed for wild ruminants. Wild ruminants prefer in their nutrition the youngest parts of twigs, which also have the highest content of utilizable nutrients. Each species of wild ruminants is adapted to a qualitatively different food source, which allows for utilization of all natural food sources and lowers competition (Hofmann, 1995). Further from the end of the twig the biomass is older and, therefore, also the nutritional value is lower due to the increasing crude fibre content and increasing levels of indigestible components.

Roe deer requires feed with high concentration of nutrients and lower fibre content, therefore, it consumes only 3-5 cm long ends of twigs and occasionally, depending on the thickness of the twig, only buds. In case of thin twigs, for example from a willow or a beech, roe deer can consume twigs up to 7-10 cm long (Rajský *et al*., 2017). In comparison, red deer consumes longer spring shoots, up to 20-25 cm long, therefore, also biomass with higher crude fibre content. Rajský *et al*. (2015) determined high nutritional content of the dry matter in twigs (20-25 cm long) consumed by wild ruminants. The following values of a crude protein content were determined: oak 12.47 %, spruce 12.84 %, willow 15.63 %, maple 13.55 %,

Table 1. The nutrient content of tested biomass before the production of silage in g.kg^{-1} dry matter

Parameters	Maize	M 1	M 2	Dendro 1	Dendro 2
Dry matter in g.kg^{-1} FW	287.32	321.48	329.01	485.98	457.69
Organic matter	952.51	951.93	946.49	947.81	940.39
Crude protein	78.37	75.02	78.28	63.50	76.29
Crude fibre	190.41	230.67	223.72	367.25	349.56
ADF	213.47	278.04	265.61	447.63	429.86
NDF	512.64	573.41	564.02	602.00	528.99
Hemicelluloses	299.17	295.37	298.41	154.37	99.13
Nitrogen-free extract	659.14	619.83	613.65	489.37	474.28
Total sugars	110.25	90.45	94.44	39.78	39.82
Reduced sugars	106.32	88.36	83.95	31.78	38.84
Starch	245.50	167.43	192.31	0.00	0.00
Fat	24.59	26.41	30.84	27.68	40.25
Ash	47.49	48.07	53.51	52.19	59.61

FW – fresh weight, ADF – acid detergent fibre, NDF – neutral detergent fibre; M 1 – mixture 1: 70 % maize + 30 % Dendro 1; M 2 – mixture 2: 70 % maize + 30 % Dendro 2; Dendro 1 – dendromass mixture in rations of 75 % oak twigs and 25 % spruce twigs; Dendro 2 – dendromass mixture in rations of 50 % oak twigs and 50 % spruce twigs beech 11.71 %, European aspen 17.68 %, elderberry 28.23 %. The authors further determined the fat content in the dry matter of oak (2.32 %), fir (5.21 %), spruce (4.35 %), silver poplar (4.33 %), European aspen (4.05 %) and elderberry (3.48 %). Mineral content was also high in the dry matter of select trees: elderberry - 9.99 %, ash - 8.67 %, oak - 6.48 % and spruce - 3.32 %. End parts of twigs of broadleaf and conifer trees generally provide high nutritional value to wild ruminants.

In the experiment, twigs longer than 20-25 cm were used – 50-70 cm long – therefore also the crude protein content in the dry matter was lower (Dendro 1 - 6.35 %, Dendro 2 - 7.63 %) compared to the abovementioned values. If younger tree parts were used, the crude protein content in the silages would be higher as well.

Fermentation process without a silage additive in the maize silage was more intense compared to ensilaged mixtures M 1 and M 2, which were also made without silage additive (Table 2). This is proven by the lower pH value and higher lactic acid content with the differences being highly significant. High significance of the differences between the experimental silages was determined also in the alcohol content and propionic acid content. Total content of total volatile fatty acids reached similar levels in all silages and no significant differences were determined. The maize silage, evaluated as Class I, was considered as a high quality silage. The addition of dendromass to maize at the ratio of 30 % increased the dry matter content in the ensilaged matter, which influenced also the fermentation. The concentration of fermentation products in M 1 and M 2 was decreased. Despite that, according to the evaluation of the fermentation process, M 1 was evaluated to be of Class I, as high quality silage too and M 2 to be of Class II, as good quality silage (The Decree of the MP SR no. 39/1/2002-100, 2002).

Successful fermentation process was reflected also in the nutritional composition of the resulting silages. Measured values are presented in Table 3. Similarly to the original matter, also in the resulting silages the level of fibre complex and ash was higher in the feed mixtures than in maize silage and the starch content, as well as nitrogen-free extract content, was lower. Determined differences were statistically highly significant. Losses of dry matter during fermentation were higher in all silages, determined to be from 8.14 to 9.98 %. Although the lowest losses were determined for maize silage, there was no statistically significant difference.

Ensilaged mixture 1 with the higher oak ratio and ensilaged mixture 2 with balanced ratios of oak and spruce are utilizable in nutrition of wild ruminants in winter, when their crude protein requirements decrease. Fat content of M 2 was higher due to higher spruce ratio compared to M 1.

Table 2. Parameters of fermentation process in tested silages

Parameters n = 6	Maize		M 1		M 2	
	x̄	SD	x̄	SD	x̄	SD
pH	3.74^{a}	0.02	4.13^{b}	0.09	4.27^{b}	0.06
Acids in g.kg^{-1} dry matter						
- lactic	67.05^{a}	1.60	45.31^{b}	3.12	36.26^{c}	3.21
- acetic	18.85	1.08	18.10	1.23	19.69	1.76
- propionic	0.18^{a}	0.02	0.52^{b}	0.14	1.18^{c}	0.24
- butyric + isob.	1.08^{a}	0.32	1.34^{ab}	0.38	1.69^{b}	0.20
- valeric + isov.	0.14^{a}	0.02	0.23^{a}	0.05	0.05^{b}	0.01
- capronic + isoc.	0.10^{a}	0.01	0.03^{b}	0.01	0.03^{b}	0.01
Total volatile fatty acids	20.35	1.35	20.22	1.58	22.64	2.83
Total acids	87.40^{a}	1.34	65.53^{b}	6.09	58.90^{b}	5.85
Alcohol in g.kg^{-1} dry matter	5.17^{a}	0.33	6.26^{b}	0.56	7.89^{c}	0.64

Different superscripts within a row mean statistical difference ($P \leq 0.01$); ^{ab} vs ^{a,b} is not different

Table 3. The nutrient content of tested silages in g.kg^{-1} dry matter

Parameters n = 6	Maize		M 1		M 2	
	x̄	SD	x̄	SD	x̄	SD
Dry matter v g.kg^{-1} FW	266.60^{a}	2.69	295.71^{b}	4.38	299.75^{b}	5.09
Dry mater losses in %	8.14	1.03	9.23	1.36	9.98	1.58
Organic matter	953.31^{a}	0.32	948.66^{b}	1.61	946.71^{b}	2.34
Crude protein	79.14	1.17	78.05	2.09	80.30	0.89
Crude fibre	204.03^{a}	5.94	260.16^{b}	3.55	272.19^{c}	5.84
ADF	252.37^{a}	4.56	304.08^{b}	8.77	330.71^{c}	6.12
NDF	497.59^{a}	6.67	534.16^{b}	10.52	558.65^{c}	8.75
Hemicelluloses	245.22^{a}	3.13	230.08^{b}	5.94	227.94^{b}	3.27
Nitrogen-free extract	639.77^{a}	5.22	580.65^{b}	7.82	561.78^{c}	4.56
Total sugars	3.93^{a}	1.26	1.46^{b}	0.01	3.82^{a}	0.55
Reduced sugars	2.01^{ab}	1.13	1.01^{a}	0.01	2.43^{b}	0.95
Starch	313.77^{a}	4.33	231.63^{b}	11.33	203.53^{b}	23.16
Fat	30.37	1.12	29.80	0.91	32.44	0.70
Ash	46.69^{a}	0.32	51.34^{b}	1.61	53.29^{c}	2.34

FW – fresh weight, ADF – acid detergent fibre, NDF – neutral detergent fibre; M 1 – mixture 1: 70 % maize + 30 % Dendro 1, M 2 – mixture 2: 70 % maize + 30 % Dendro 2; Different superscripts within a row mean statistical difference ($P \leq 0.01$); ^{ab} vs ^{a,b} is not different

This data corresponds with the knowledge that twigs of conifer trees have higher fat content in dry matter compared to broadleaf trees. The starch content in the mixture silages was 231.63 (M 1) and 203.53 (M 2) g.kg^{-1} of dry matter, which provides sufficient energy to wild ruminants. This energy in combination with crude fibre at 260.16 (M 1) and 272.19 (M 2) g.kg^{-1} of dry matter in effective structural form, which predetermines this feed for *ad libitum* intake.

The topic of dendromass silage production was previously discussed by Montes Pérez *et al*. (2015). The authors evaluated ensilaging of *Brosimum alicastrum* and *Leucaena leucocephala* trees for the purposes of feeding white-tailed deer and they determined negative causality between the crude fibre content and silage intake. Sánches *et al*. (2007) obtained good results by feeding dairy goats with a silage containing tree species of *Albizia lebeck* and *Piscidia piscipula*. Hatt and Clauss (2001) utilized *Salix alba* and *Populus Canadensis* dendromass in the Rotterdam ZOO. Mbatha and Bakera (2018) describe the use of dendromass silage in farming of wild ungulates in Southern regions of Africa. They determined good fitness of the animals and, in addition to their nutritional value, the silages served also as a source of water.

One of the factors, which may limit the increase of the dendromass ratio in feed mixtures, is the content of anti-nutrients, such as condensed tannins, alkaloids and terpenes. Nde and Philile (2017) state, that tannin content in feeds has negative effect on ruminant feed intake and digestion. However for farmed wild ruminants, which have limited access to browsing of trees, dendromass silages represent a source of the aforementioned anti-nutrients, which are at certain dozes beneficial to their health (Mbatha and Bakare, 2018). Tannins, for example, have a potential to mitigate iron overload disorder in wild ungulates (Lavin, 2012). Influence of condensed tannins, applied by feeding *Acacia nilotica*, *Eblica officinalis*, *Syzygium cuminii*, *Grewia optiva*, *Mangifera indica* dendromass, on elimination of digestive tract parasite *Haemonchus contortus* in goats in India, is described by Azad *et al*. (2017). Browse is an important dietary item of browsers, thus, insufficient nutrients due to deficient browse supply may result in diseases, abnormalities, under-performance and eventually death (Clauss *et al*., 2008). Rogosic *et al*. (2007) described adaptation of microbes in the gut of a wild ruminants to tannins.

CONCLUSION

We evaluated the possibility of ensilaging a mixture of oak and spruce twigs and maize under laboratory conditions. The addition of dendromass to maize increased the dry matter content, fibre complex content, fat and ash content in the mixture silage and decreased the starch and total sugar content when compared to maize. Despite this, the fermentation process in the resulting mixture silages was adequate, and it is possible to recommend the silage production of such mixtures to game keepers in winter and at higher crude protein content also in summer, when the female nutritional requirements increase. This method allows to meet the nutritional requirements of the wild ruminants. Also utilization of dendromass for feeding purposes can serve as a method of logging waste recycling. The results indicate that it is possible to consider also other variants of ensilaged feed mixtures.

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