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Original Paper

Energy content of hybrid *Rumex patientia* L. × *Rumex tianschanicus* A.Los (Rumex OK 2) samples from spring months and June

Michal Rolinec[1]*, Dzhamal Rakhmetov[2], Daniel Bíro[1], Miroslav Juráček[1], Milan Šimko[1], Branislav Gálik[1], Ondrej Hanušovský[1]
[1]*Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Department of Animal Nutrition, Slovak Republic*
[2]*M.M. Gryshko National Botanical Garden of Ukraine National Academy of Sciences in Kyiv, Ukraine*

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Aim of this study was to determine the gross energy concentration of fresh, wilted and ensiled Rumex OK 2 (*Rumex patientia* L. × *Rumex tianschanicus* A.Los.) from spring months and June. Samples were collected in spring months and June of the year 2018. The plant of Rumex OK 2 consist in March mainly from rosette of leaves and the stalk is not higher than leaves, from April is stalk higher than rosette of leaves. The height of Rumex OK 2 during analysed months was following, March 60.96 ±5.22 cm; April 114.70 ±35.15 cm, May 168.31 ±39.74 cm and June 197.41 ±48.44 cm. Rumex OK 2 silage was made from wilted matter, with or without of addition of dried molasses. Gross energy was determined as the heat released after combustion of a sample (Leco AC 500) in MJ per kilogram of dry matter (DM) of the sample. The dry matter and gross energy concentration of fresh Rumex OK 2 increased during study, dry matter from 7.42% in March to 56.97% in June and gross energy from 18.00 MJ kg^{-1} of DM in March to 18.88 MJ kg^{-1} of DM in June. Statistically significant (P <0.05) higher concentration of dry matter, as well as gross energy was detected in wilted Rumex OK 2 samples and silages from May compared to April. Addition of dried molasses to wilted Rumex OK 2 did not affected concentration of gross energy in silages (P >0.05). From all analysed Rumex OK 2 samples the highest concentration of gross energy had silage from May with addition of dried molasses, 19.04 MJ kg^{-1} of DM. The utilisation of Rumex OK 2 from spring months can by neither for bioenergy production as a source of renewable energy, or after evaluation of nutritive value as a source of energy and nutrients in animal nutrition in form of pasture and silage. Rumex OK 2 from summer months seems to be utilized only as a source of heat via direct combustion.

Keywords: Rumex OK 2, silage, gross energy, dry matter

1 Introduction

Production of biomass is desired for bio-energy production. Planting of Rumex OK 2 has been considered as critical point of providing sufficient amount of biomass, mainly in areas with soil that has lower potential for agricultural crops. On the other hand there is ongoing demand for replacement of fossil fuel. Biomass is considered as a renewable source of energy (Petříkova, 2006). Advantage is, that production of green energy from Rumex OK 2 do not compete with food producing agricultural crops. During summer months is available also the straw from Rumex OK 2. Petříková (2006) published energy concentration of straw from Rumex OK 2 with value 19.17 MJ kg^{-1} of dry matter, which equals to heating capacity of 17.89 MJ kg^{-1} of dry matter. Straw from Rumex OK 2 is more valuable fuel than straw from cereals and show higher power. The next advantage is that Rumex OK 2 can be combusted also by dry matter concentration 70%, whereas straw from cereals by dry matter concentration at least 80% (Petříková, 2006). Other possible was for utilization of Rumex OK 2 in bioenergy industry is via fresh biomass or in form of silage. Fresh biomass or silage from Rumex OK 2 can be used also as a feed for animal, mainly ruminants. As it was published previously, Rumex OK 2 produced during autumn months interesting amount of energy in form of biomass (Rolinec et al., 2018). Research of energy concentration in Rumex OK 2 plants was realized also in spring months and June of the year 2018, and results are presented in this article.

***Corresponding Author:** Michal Rolinec, Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Department of Animal Nutrition, Trieda Andreja Hlinku 2, 94976 Nitra, Slovak Republic, e-mail: michal.rolinec@uniag.sk

2 Material and methods

Methodoltogy of this study is similar to study of energy concentration of Rumex Ok 2 during autumn months of the year 2017 published in article (Rolinec et al., 2018). Rumex OK 2 (*Rumex patientia* L. x *Rumex tianschanicus* A. Los.) was used for this study. Plants of Rumex OK 2 were grown in experimental fields under Institute of Biodiversity Conservation and Biosafety (SUA in Nitra). Samples of fresh matter were collected in the year 2018, during months March, April, May and June (in March at the end of month, and in other months around 15th day of the month). During sampling, the height of leaves and stalk with flowers and/or seeds was measured in centimetre from ground (together were measured 26 samples in March, 76 samples in April, 67 samples in May and 63 samples in June. Fresh samples were wilted for three days. Wilting was realized in indoor conditions, by the open windows and without heating. After wilting, Rumex OK 2 plants were cut to the theoretical length of cut 1.5 cm and ensiled. First variant (Rumex OK 2 silage) was ensiled without additives. Second variant (Rumex OK 2 silage + molasses) was ensiled with a 1.0% addition of dried molasses to wilted Rumex OK 2 matter. All samples prepared for ensiling were stored in plastic bags without air (hermetic sealed). During fermentation process, which last for five weeks, plastic bags with silage samples were stored in room without light and at 20 °C. Fresh, wilted and silage samples were prepared for dry matter and energy concentration determination. Dry matter was determined by drying at 103 ±2 °C to constant weight. Gross energy concentration was determined by Calorimeter LECO AC 500 (Leco Corporation, USA). Each sample was analysed in triplicate. Gained results were statistically processed with IBM SPSS v. 20.0. Differences of means between months within type of sample were tested by Tukey HSD test. Differences of means between silages samples (with or without an addition of dried molasses) within month were tested by independent samples *T*-test. A P <0.05 was considered as significant.

3 Results and discussion

Compared to autumn months, the average surface air temperature during spring months increases, which is good for plants with early spring growth as for example Rumex OK 2. Crop growth rate is besides temperature, soil moisture content and nutrition affected by many factors (Hric et al., 2013; Hric et al., 2018). At the end of March consist Rumex OK 2 from leaves and stalk, which one is not higher than leaves. The height of Rumex OK 2 in the end of March was 60.96 ± 5.22 centimetres that is higher than average of all autumn samples (Rolinec et al., 2018). In following months the stalk with flowers or seeds of Rumex OK 2 is higher than rosette of leaves. During maturity Rumex OK 2 has 4 to 6 stalks with average height 235 cm (Usťak, 2007; Bazhay-Zhezherun and Rakhmetov, 2014). The average height of Rumex OK 2 was in April 114.70 ±35.15 centimetres, in May 168.31 ±39.74 centimetres and in June 197.41 ±48.44 centimetres, which is similar to publication of Usťak (2004). Concentration of dry matter and gross energy of Rumex OK 2 in spring months and June is shown in Table 1. Concentration of dry matter in fresh Rumex OK 2 increases and the peak reached in last analysed month, June. Similar development of dry matter revealed all crops and plants growing outdoors (Gálik et al., 2016). In March was dry matter concentration (Table 1) similar to that in November (Rolinec et al., 2018). With increase of dry matter increase the gross energy concentration too. Highest gross energy concentration of fresh matter was detected in June, when Rumex OK 2 reached maturity and stalk contains a mature seeds that increases energy concentration of whole plant. Hejduk and Doležal (2004 and 2008) wilted *Rumex obtusifolius* for 24 hour and reached dry matter 16.84%. Despite low concentration of dry matter of Rumex OK 2 fresh matter in March and April is wilting, as well as ensiling problematic. As published Bíro et al. (2014) and Skládanka et al. (2014) low concentration of dry matter of wilted matter causes outflow of silage effluent during fermentation and problems during fermentation process. Statistically

Table 1 Energy value of different Rumex OK 2 samples from March, April, May and June (MJ kg^{-1} of DM)

Month of the year 2018	Fresh Rumex OK 2		Wilted Rumex OK 2		Rumex OK 2 silage		Rumex OK 2 silage + molasses		SEM
	DM	GE	DM	GE	DM	GE	DM	GE	GE
March	7.42^{a}	18.00	–	–	–	–	–	–	0.007
April	9.99^{a}	18.49	12.51^{a}	18.01^{a}	12.06a	18.09^{a+}	13.20^{a}	18.20^{a+}	0.014
May	16.91^{a}	18.28	18.99^{b}	18.72^{b}	18.33^{b}	19.03$^{b□}$	18.85^{b}	19.04$^{b□}$	0.330
June	56.97^{b}	18.88	–	–	–.	–	–	–	0.132

DM – dry matter concentration of sample in %; GE – gross energy concentration of sample in MJ kg^{-1} of dry matter; SEM – value of standard error of the mean for gross energy in that month; *abc* – means within a column bearing different superscript differ significantly at P <0.05; $^{+□}$ difference of mean values of GE between Rumex OK 2 silage and Rumex OK 2 silage + molasses were within month nonsignificant (P >0.05)

significant (P <0.05) higher concentration of dry matter, as well as gross energy was detected in wilted Rumex OK 2 samples and silages from May compared to April (Table 1). Addition of 1% of dried molasses did not affect the concentration of gross energy in analysed silage samples (P >0.05). All four analysed Rumex OK 2 silage samples from April and May (Table 1) contains more gross energy than Rumex OK 2 silage samples from autumn months (Rolinec et al., 2018). Higher energy concentration of Rumex OK 2 samples in April and May was due to presence of stalk with flowers and seeds, whereas autumn Rumex OK 2 samples consisted only from rosette of leaves (Rolinec et al., 2018). Fresh Rumex OK 2 from summer months is used for direct combustion and production of heat. The lowest concentration of dry matter in Rumex OK 2 for combustion is 70% (Petříková, 2006). The average dry matter concentration of fresh Rumex OK 2 in June was 56.97%, however some plants had dry matter 70%. Harvesting of Rumex OK 2 at the end of June could increase dry matter concentration and thereby also the production of heat. On the other hand it depends on weather condition and rainfall totals during harvesting. Energy concentration of Rumex OK 2 fresh matter in June was 18.88 MJ kg^{-1} of dry matter (Table 1), which is less than published (Petříková, 2006) 19.17 MJ kg^{-1} of dry matter.

4 Conclusions

Rumex OK 2 is in agricultural condition of V4 countries unknown plant. Results of this article bring closer look on development of dry matter and energy concentration of fresh Rumex OK 2 in early spring and next in each month to June. Different types of samples were analysed, fresh, wilted matter and silage. The utilisation of Rumex OK 2 from spring months can by neither for bioenergy production as a source of renewable energy, or after evaluation of nutritive value as a source of energy and nutrients in animal nutrition in form of pasture and silage. Rumex OK 2 from summer months seems to be utilized only as a source of heat via direct combustion.

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