SPRING BARLEY OVER-GROUND BIOMASS DIGESTIBILITY *IN VITRO*

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Abstract. Spring barley over-ground biomass digestibility *in vitro* trials were established at Experimental station and *Tempus* laboratory of Lithuanian University of Agriculture. Spring barley *Hordeum vulgare* L. was harvested at stem elongation, heading early milk, milk, late milk-early dough, dough and hard stages of maturity. Digestibility *in vitro* of spring barley organic matter in the dry matter depended on spring barley stage of maturity. The highest digestibility in vitro was established at growth stage of stem elongation 73–78% (except 1998) while at later growth stages it decreased. Digestibility of spring barley whole-plant biomass at stem elongation was fewer just compared with barley grain digestibility at dough and hard stages of maturity. The highest digestibility *in vitro* (till 89%) was established of grains at hard stage of spring barley maturity. Digestibility *in vitro* of spring barley insufficiently matured grains of dough stage was lower by 2.1-6.4% compared with hard one (except 1999). Spring barley metabolizable energy (MJ kg^{-1} DM) directly depended on barley growth stages and fodder organic matter digestibility *in vitro*. Correlation coefficients were $r = 0.995$-0.998 at $P < 0.0001$. Metabolizable energy in spring barley biomass at different growth and maturity stages can be sufficiently exactly determined according regression equations based on digestibility *in vitro* as correlation coefficients are nearer to one. The change of spring barley over-ground biomass digestibility *in vitro* by 1% induced change of metabolizable energy by 0.19-0.21 MJ kg^{-1} DM.

Keywords: spring barley, over-ground biomass, growth stages, digestibility *in vitro*.

VASARINIŲ MIEŽIŲ ANTŽEMINĖS BIOMASĖS VIRŠKINAMUMAS *IN VITRO*

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Santrauka. Vasarinių miežių *Hordeum vulgare* L., nuimamų bamblėjimo, plaukėjimo, pieninės brandos pradžios, pieninės, pieninės-vaškinės, vaškinės ir kietosios brandos tarpsniuose, antžeminės biomasės virškinamumo *in vitro* tyrimai atlikti Lietuvos žemės ūkio universiteto Bandymų stotyje ir „Tempus“ laboratorijoje. Miežių sausosios masės virškinamumas *in vitro* priklausė nuo brandos tarpsnių. Geriausio virškinamumo pasiekta bamblėjimo laikotarpiu – iki 73–78 proc. (išskyrus 1998 m.), vėlesniuose miežių augimo tarpsniuose virškinamumas prastėdavo. Viso vasarinių miežių augalo virškinamumas bamblėjimo tarpsnyje buvo prastesnis tik už jų grūdų virškinamumą vaškinėje ir kietojoje brandoje. Geriausias virškinamumas *in vitro* (iki 89 proc.) nustatytas vasarinių miežių kietosios brandos grūdų. Nevisiškai subrendusių vasarinių miežių vaškinės brandos grūdų virškinamumas *in vitro* buvo 2,1–6,4 proc. blogesnis nei kietosios brandos grūdų (išskyrus 1999 m.). Nustatyta tiesinė vasarinių miežių biomasės apykaitos energijos (MJ kg^{-1} SM) priklausomybė nuo organinės masės virškinamumo *in vitro* skirtinguose vasarinių miežių augimo tarpsniuose. Gauti tiesinės koreliacijos koeficientai: r=0,995–0,998, kai p<0,0001. Vasarinių miežių biomasės apykaitos energija skirtinguose augimo ir brandos tarpsniuose gana tiksliai gali būti apskaičiuota pagal organinės medžiagos virškinamumo *in vitro* regresijos lygtis, kai koreliacijos koeficientas artėja prie vieneto. Vasarinių miežių antžeminės biomasės virškinamumo *in vitro* pasikeitimas 1 proc. pašaro apykaitos energijos pokyčius nulemia 0,19–0,21 MJ kg^{-1} SM.

Raktažodžiai: vasariniai miežiai, antžeminė biomasė, augimo tarpsniai, virškinamumas *in vitro*.

Introduction. Green crop cereals may be grown alone or in mixtures with more than one species of plants. Such green crops may be cut and conserved as hay or silage (Bruno-Soares et al., 1998). Unacceptable losses of dry matter (DM) and a decline in nutritive value of the ensiled crop can occur during conservation and feed-out (Hill, Leaver, 2002). There is a marked reduction in the digestibility of the ensiled whole-crop wheat forage compared to fresh forage, dependent on maturity of the forage, but no differences in digestibility are observed between urea treated forage and fresh forage (Hill, Leaver, 1999). Growing time and stage of maturity at harvest greatly affect the forage yield and quality (Mustafa, Seguin, 2004). The concentrations of nutritional elements and the estimated digestibility of the barley forage cut at the seed coat ripe, early dough stage, soft dough and grain ripe stages of growth declined with increasing growth stage index and the beginning of grain maturity (Hargreavesa et al., 2009). In our experiment, spring barley biomass chemical composition harvested at seven growth stages sustained similar tendency (Pilipavičius, 2004) as received by Hargreavesa et al., 2009 at four stages of barley growth. Ensiling spring barley biomass harvested at early milk, milk, late milk-

early dough and dough stages of maturity, silage chemical composition as well depended on cereal stage of maturity. Whole plant silage produced from cereals of later stages of maturity – late milk-early dough and dough stages of maturity, has less crude protein and crude ash concentration, lower digestibility *in vitro* by ruminants and fewer accumulated metabolizable energy MJ kg^{-1} of silage dry biomass (Pilipavičius, 2007). Nykänen et al. (2009) reported the highest organic matter digestibility in peas (710–800 g kg^{-1}), vetches and spring barley had an organic matter digestibility of 670 g kg^{-1}, while the other spring cereals had the lowest values (550–610 g kg^{-1}). The highest organic matter digestibility of spring barley silage was found processing silage from biomass of earlier stage (milk) of spring barley maturity (Pilipavičius, 2007).

The aim of the research was to establish spring barley over-ground biomass digestibility *in vitro* and its influence on spring barley biomass metabolizable energy MJ kg^{-1} in the dry matter.

Material and Methods. Spring barley *Hordeum vulgare* L. harvested at stem elongation, heading early milk, milk, late milk-early dough, dough and hard stages of maturity, over-ground biomass digestibility *in vitro* trials were established at the Experimental station and *Tempus* laboratory of Lithuanian University of Agriculture.

The trials were carried out in the period of 1997–1999. The agrochemical characteristics of arable soil were: pH_{KCl} 7.08–7.25, humus 2.22–2.45%, mobile P_2O_5 245.0–251.3 mg kg^{-1} and mobile K_2O 93.6–110.5 mg kg^{-1}. Agrochemical soil properties were established at the LUA's Experimental Station using the IR ray spectrometer PSCO/ISI IBM-PC 4250. Spring barley fore crop was winter wheat (1997), spring barley (1998) and cultural amaranth (1999). Spring barley was fertilized in autumn by mineral phosphorus P_{60} and potasium K_{60} fertilizers and in spring by mineral nitrogen fertilizers N_{60}. In 1999, nitrogen fertilizers were not applied. Spring barley *Roland* was sown at the first ten day period of May, sowing 200 kg ha^{-1} of seeds. Herbicides were not applied in the trial field. At stem elongation, heading, early milk, milk and late milk-early dough stages of maturity spring barley was harvested by frontal reaper *KSF-1.6* and at dough and hard stages of maturiy by harvester *Sampo Rosenlew 500*. During all three experimental years meteorological conditions often varied. However, average data of meteorological conditions were similar to long-term meteorological data, except for the arid summer in 1999.

Spring barley over-ground biomass digestibility *in vitro* was established at the *Tempus* laboratory of agronomical and zootechnical analyses at Lithuanian University of Agriculture by the methods of Hohenheim University according to *Wender* fodder analysis (Naumann, Bassler et al., 1988). Digestibility *in vitro* of organic matter in the dry matter of spring barley over-ground biomass fodder for ruminants (cows) was established depending on gas production (CO_2 and CH_4) *in vitro* by the Hohenheim fodder value test. 200 mg of fodder sample with cow rumen fluid, micro- and macro-elements, buffer- and reduction-solutions is placed in the special test-tube and incubated in a rotory thermostat by 39°C for 24 hours. The data quality of laboratorial analyses was determined by the differences between parallels (3 replications) depending on matter concentration found in analysed sample. The results of analyses were established at 95% level of probability within permissible limits of error (Naumann, Bassler et al., 1988).

For evaluation of the data on spring barley over-ground biomass digestibility *in vitro* influence on fodder metabolizable energy, the correlation–regression analysis was applied. The degrees and directions of interdependent phenomena were determined. Dependence reliability was evaluated by the *P* test. The data were evaluated using *SigmaPlot 8.0* programmes (SPSS Science, 2000).

Results and Discussion. Using cereal as the whole-plant for forage, not only bigger yield but also its quality which depends on the intake is important. Spring barley dry matter digestibility was established using *in vitro* method and expressing the results in per cents of digested organic matte. The highest digestibility *in vitro* (77.9%) of spring barley over-ground biomass at stem elongation growth stage in 1997 was established, except separate grain digestibility at dough and hard stages of barley maturity (Table 1).

Further maturing spring barley, its biomass digestibility *in vitro* gradually decreased till 66.8% at early milk stage of maturity. At milk and late milk-early dough stages of spring barley maturity digestibility *in vitro* slightly increased. In 1999, the results of spring barley biomass digestibility *in vitro* were analogous to those received in 1997. During the vegetation season of 1998 spring, barley biomass digestibility *in vitro* increased from 68.4% at stem elongation growth stage till 73.9% at late milk-early dough stage of maturity. Comparing digestibility of spring barley grains and straw at dough and hard stages of maturity during all three years of experiment, it was established, that grain digestibility increased at hard stage of maturity comparing with dough one; except in 1999 when because of too dry weather during the period of grain maturity, grain parched up and lost part of its fodder value. However, straw digestibility decreased at hard stage of spring barley maturity during all three years of experiment comparing with the dough one (Table 1).

In this study, the available data (Pilipavičius, 2000, 2004) on spring barley biomass metabolizable energy (MJ kg^{-1} DM) were used to identify its dependence on fodder digestibility *in vitro*. The highest concentration of metabolizable energy in dry matter (MJ kg^{-1} DM) was established at spring barley stem elongation growth stage. Later, the concentration of metabolizable energy in spring barley over-ground biomass gradually decreased. However, the concentration of metabolizable energy in grains was much higher than in the whole plant biomass, but with ripening grains, the quality of straw became worse (Pilipavičius, 2004). Other researchers have obtained comparable results: metabolizable energy of 9.56 MJ kg^{-1} DM at heading stage of maturity and

metabolizable energy of grain 12.93 MJ kg^{-1} DM and straw 6.80 MJ kg^{-1} DM at hard stage of spring barley maturity (Martin and Seibold, 1997). It was in conformity with the data of spring barley biomass digestibility *in vitro* (Table 1). Presumable relationship was examined statistically with correlation-regression analysis. It was proven reliable direct linear dependence of spring barley digestibility *in vitro* on concentration of metabolizable energy in spring barley biomass (Figs 1–3). During three years of experiment coefficient of correlation varied near functional dependence, in 1997 it was 0.996*** (Fig. 1), in 1998 – 0.995*** (Fig. 2) and in 1999–0.998*** (Fig. 3). According to the equations of regression, the change of spring barley over-ground biomass digestibility *in vitro* by 1% induced change of metabolizable energy by 0.19–0.21 MJ kg^{-1} DM (Figs 1–3).

Table 1. **Spring barley different maturity over-ground biomass organic matter digestibility *in vitro* (%) for ruminants** (cows)[#]**, 1997–1999**

Growth stages	Digestibility *in vitro* %		
	1997	1998	1999
Stem elongation	77.96	68.45	72.81
Heading	75.67	68.72	66.93
Early milk	66.82	72.55	64.50
Milk	67.34	72.59	66.83
Late milk-early dough	67.86	73.94	68.26
Dough	-	-	-
Grain	86.72	82.04	83.54
Straw	59.76	55.40	58.11
Hard	-	-	-
Grain	88.82	88.45	78.96
Straw	58.45	49.08	53.82

Note. [#] *- the results of analyses were established at 95% level of probability (Naumann, Bassler et al., 1988)*

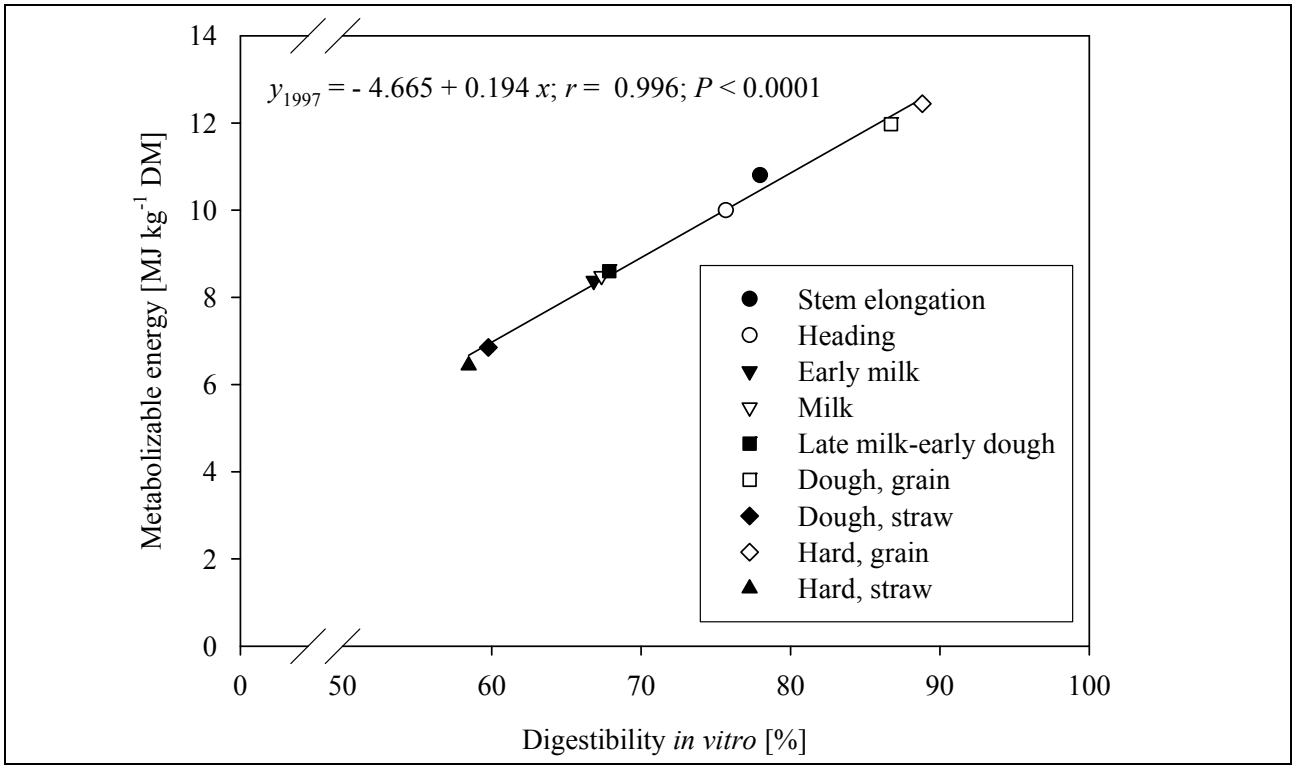

Fig. 1. **Spring barley metabolizable energy dependence on fodder organic matter digestibility *in vitro* in relation to spring barley growth stages, 1997**

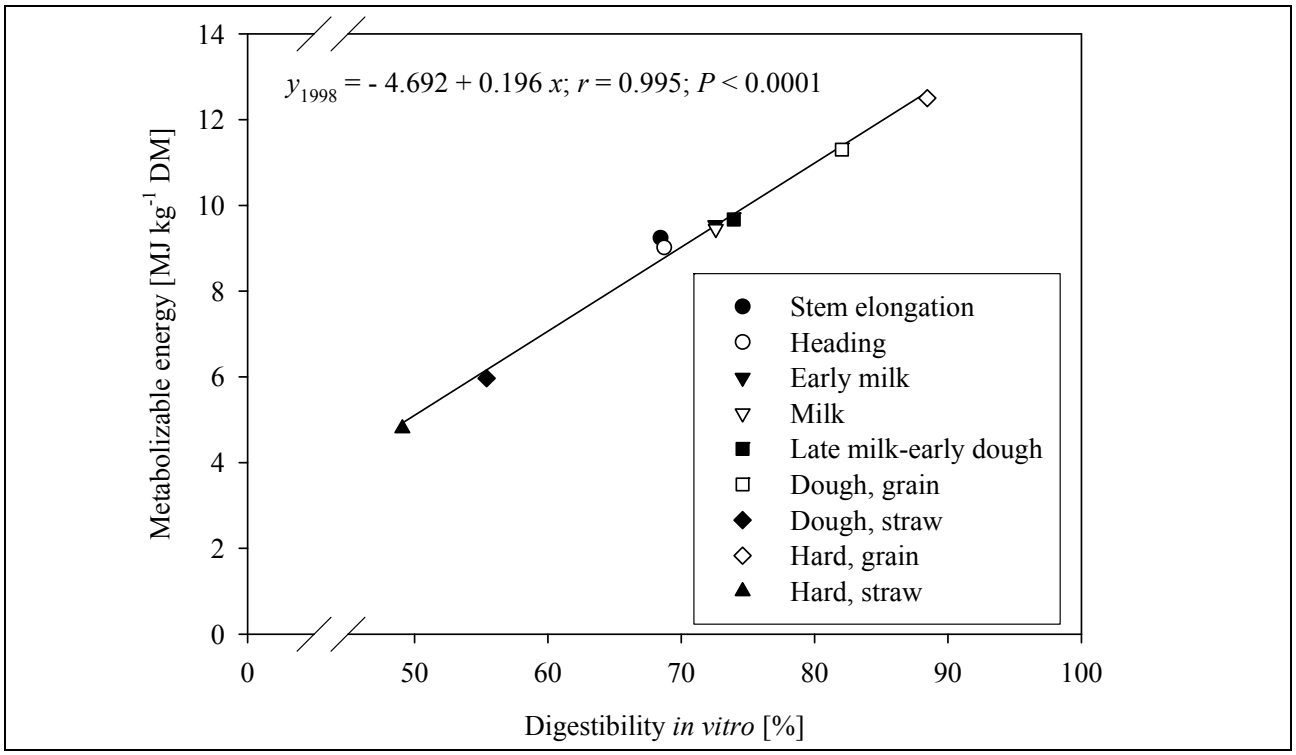

Fig. 2. **Spring barley metabolizable energy dependence on fodder organic matter digestibility *in vitro* in relation to spring barley growth stages, 1998**

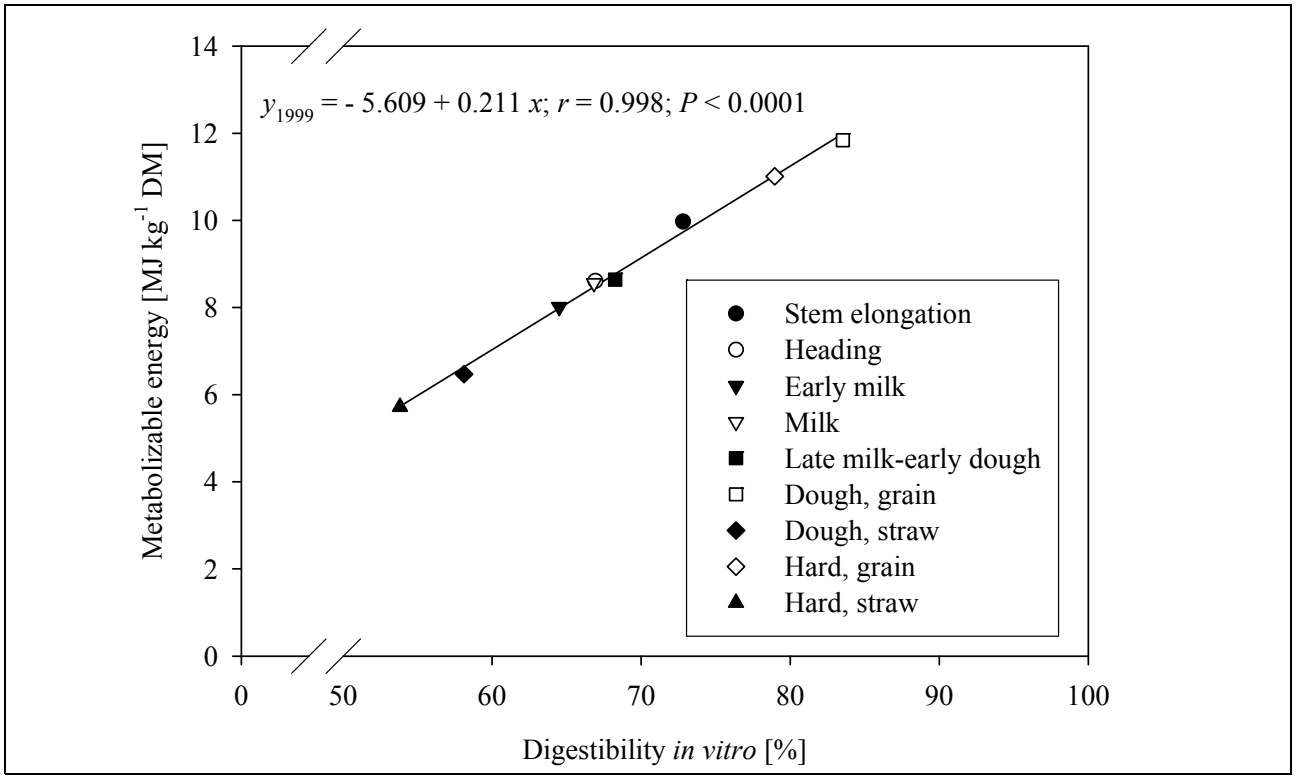

Fig. 3. **Spring barley metabolizable energy dependence on fodder organic matter digestibility *in vitro* in relation to spring barley growth stages, 1999**

The highest grain digestibility *in vitro* was established at hard stage of spring barley maturity. Immature grain digestibility *in vitro* declined at dough stage of spring barley maturity comparing with hard one. As a consequence of nutritional element concentration increase in grains and decrease in straw (Pilipavičius, 2004),

digestibility of straw at dough and hard stages of spring barley maturity was the least. Total over-ground biomass of spring barley reached the highest digestibility *in vitro* at early stages of spring barley growth, i.e. at stem elongation and heading. Spring barley at early milk, milk and late milk-early dough growth stages over-ground biomass digestibility *in vitro* strongly declined and according to the equations of regression significantly decreased concentration of metabolizable energy (Figs 1–3).

Conclusions

Digestibility *in vitro* of spring barley organic matter in the dry matter depended on spring barley stage of maturity. The highest digestibility *in vitro* was established at growth stage of stem elongation 73–78% (except 1998) and at later growth stages it decreased. Digestibility of spring barley whole-plant biomass at stem elongation was fewer just compared with barley grain digestibility at dough and hard stages of maturity (digestibility *in vitro* till 89%).

Spring barley metabolizable energy (MJ kg^{-1} DM) directly depended on barley growth stages and fodder digestible organic matter in the dry matter digestibility *in vitro*. Correlation coefficients were $r = 0.995$-0.998 at $P < 0.0001$. Metabolizable energy in spring barley biomass of different growth stages of maturity can be sufficiently exactly determined according regression equations based on digestibility *in vitro* as correlation coefficients are nearer to one.

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