NUTRITIONAL VALUE AND DIGESTIBLE ENERGY OF DIFFERENT GENOTYPES OF OATS IN THE HORSES NUTRITION

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Abstract. Oats are grown for both grain and forage for livestock feeding over a long time in many parts of the world. In comparison with other cereals, oat grain is characterised by a larger amount of total protein and crude fat and a smaller one of crude fibre. The characteristic feature of protein is its good amino acid composition with a high nutritive value. The aim of this study was to evaluate the nutritive value and content of digestive energy for horses of different oats varieties grown in Lithuania. Fifteen different genotypes of oats, with their know growth conditions were analysed by the following methods: chemical analyses (dry matter, crude protein, crude fat, crude ash, calcium, phosphorus) were determined according to Pašarų tyrimo metodai (2003), crude fiber, NDF, ADF and ADL - by Fibertec™ 2021/2023 FiberCap™ system; horses digestible energy calculated by Pagan (1998) method. The results showed that the average of values was: dry matter – 91.07% DM, crude protein – 11.85% DM. crude fat – 4.16% DM, crude ash – 2.74% DM, crude fiber – 9.63% DM, ADL – 3.11% DM, ADF – 13.82% DM, NDF – 28.67% DM. Digestible energy for horses – 13.67 MJ/kg DM.

Keywords: oats, nutrition value, digestible energy, horses

Introduction

Oats (Avena sativa L.) rank seventh in world cereal production (about 23 million metric tons in 2013), following maize, rice, wheat, barley, sorghum and millet (Faostat, 2015). They have many uses as food cereal, feed grain, and green or conserved forage, and also in topical skincare products. Livestock grain feed is the primary use, accounting for about 74% of the world's total production (Webster and Wood, 2011). In comparison to other cereals, these are characterized constitute large amount of total protein, carbohydrate (primary starch content), crude fat, dietary fibre (non-starch), unique antioxidants and considerable vitamins and mineral content. A good taste and an activity of stimulating metabolic changes in the body make nutritive value of oats high for both people and animals (Peltonen-Sainio et al., 2004; Peterson, 2004). Total carbohydrate content (including cellulose and non-starch polysaccharides).

Owing to its particular chemical composition and nutritive and physiological values, oat grain is the object of extensive studies. Oat grain is characterised by a good taste, dietetic properties and an activity stimulating metabolic changes in the body. All this makes its nutritive value high for both people and animals (Lia et al., 1997; Peterson, 2004).

Oat forage yield and quality are determined by numerous variable factors such as genotype, environment and management practices (Kim et al., 2006). Grain oat cultivars/ genotypes were used as forage in some investigation (Chapko et al., 1991). Chapko et al. (1991) indicated that distinctive breeding program for forage quality cannot be continued and then grain oat genotypes may satisfy forage needs. Most of the previous studies were showed that late-maturing genotypes had higher forage yield than early-maturing genotypes (Aydın et al., 2010). Aydın et al. (2010) indicated a positive association between forage and plant height, while Riveland et al. (1977) notified that both tall and short genotypes produced high forage yields. Also, some researcher indicated that no relationship between forage yield and grain yield (Chapko et al., 1991). Aydın et al. (2010), however, reported a negative association between forage yield and quality. Stage of maturity at harvest for forage has the greatest effect on forage yield and quality of cereals (Juskiw et al., 2000).

Oats are moderate in energy, and protein, and the high fiber content of oats (over 10%) makes them reasonably safe for horses, particularly where management is limited.

In order for the enzymatic processes of the small intestine to properly function, there has to be a limited acid concentration. This partly depends on the starch content of the feed. When a high ratio of starch arrives in the small intestine, the contents of the small intestine become more acidic, to facilitate the digestion of this starch. However, below a pH of 6 (too acidic) the enzymatic breakdown doesn't always happen, and things like gas and ulcers can occur. This is more likely to occur when feeding large quantities of cereals that contain starch, which is difficult to break down, such as corn and barley. The enzymatic consequences of feeding large amounts of corn and barley is a disruption

of the pH of the small intestine, which leads to the transition of undigested starch into the large intestine. Which leads us to oats, which have 90% starch digestibility, compared to around 30-35% for barley and corn. When oats are fed (in appropriate amounts), they are easily broken down in the small intestine, and the enzymatic processes are not disturbed (Welz, 2004).

The nutrient value of oats varies with weight. Oat groats, oats from which the hulls have been removed, are excellent for use in foal rations, but are expensive. High quality oats are plump, heavy, clean (free of dust, broken seeds, dirt, weed seeds, etc.), bright in color, smell good, and have a low husk:kernel ratio. Whole oats are easily digested by most horses.

The aim of this study was to evaluate the nutritive value and content of digestive energy for horse of different oats varieties grown in Lithuania.

Materials and methods

Samples. Clean and uncontaminated samples of fifteen cultivars of oats (*Circle*; *Viva DS*; *Rajtar*; *Scorpion*; *Flamingsprofi*; *Migla DS*; *Mina DS*; *Abel*; *Horizont*; *Edit*; *Jaugila*; *Skaistūnės*; *Girūnės*; *Symphony*; *Paseidon*) were taken for nutritional value analyses. All cultivars were grown in experimental fields of Institute of Agriculture at LRCAF (Lithuania). The fertilization of oats was NPK 16-16-16.

Milling

Oats samples were milled using a Laboratory Mill 120 (Perten Instruments AB, Sweden), with minor flow changes. Grains were poured into a plastic funnel mounted on vacuum feed control and milled 1 mm homogeneous sample was collected in a nylon bag.

Chemical analyses of oat samples. Different genotypes of oats, with their growth conditions known were analysed by the following methods: dry matter was determined as the difference between moist and dry grain, drying for 3h at 105°C (Pašarų tyrimo metodai, 2003). Crude protein was examined following Kjeldahl analysis method, determining nitrogen concentration in a sample (Pašarų tyrimo metodai, 2003). Crude fat was calculated after samples had been extruded with ether (Pašarų tyrimo metodai, 2003). Crude ash was calculated on the basis of sample residue after its organic matters were incinerated at the temperature of 550°C (Pašarų tyrimo metodai, 2003). Calcium and phosphorus content was determined with atomic absorption method (Pašarų tyrimo metodai, 2003).

Fibre analysis. Crude fibre was determined as the residue after sequential treatment with hot H_2SO_4 (conc. 1.25 %) and hot NaOH (1.25 %) according to Weende method. Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) were analysed using the Fibertec™ 2021/2023 FiberCap™ system (FOSS Analytical AB, Sweden) according to the manufacturer's instructions with modifications adapted from Goering and Van Soest (1970) and Kitcherside et al. (2000). Nitrogen-free extract (NEM) was calculated as follows: NEM = dry matter quantity – crude protein quantity – crude fat quantity – crude fibre quantity – crude ash quantity. The content of cell wall structural carbohydrates hemicellulose and cellulose was calculated as the differences: cellulose = ADF − ADL and hemicellulose = NDF − ADF (Hindrichsen et al., 2006).

Horses digestible energy (DE) calculated by Pagan (1998) method:

DE (MJ/kg DM) = 8.86 + 0.05097 × Crude protein (g/kg) – 0.0392 × ADF – 0.0160 × (NDF-ADF) + 0.197 × Crude fat + 0.085 × (100-Crude protein-NDF-Crude fat-Crude ash) – 0.110 × Crude ash

Statistical analysis. The results of the experiment were analyzed using the 1-way ANOVA test, and significant differences between groups were determined by Duncan's multiple range test. Statistica 8.0. for Windows TM software was used. Differences were considered significant at $P<0.05$.

Results and discussion

The amount of crude proteins (Table 1) in analysed cultivars of oats varied from 10.47% DM to 14.24% DM. The average amount of crude fat in analysed oats cultivars was 4.16% DM. This amount in analysed cultivars varied from 3.13% DM to 5.62% DM. The highest amount of crude fat was determined in *Horizont* (5.62% DM), *Symphony* (5.31% DM) and *Girūnės* (5.19% DM) cultivars, the smallest amount was determined in *Mina DS* (3.13% DM), *Paseidon* (3.15% DM) and *Skaistūnės* (3.26% DM) cultivars of oats. The amount of crude ash in analysed oats cultivars varies from 2.40% DM to 3.46% DM. The average amount of NEM in analysed oats cultivars was 62.68% DM. This amount in analysed cultivars varied from 51.36% DM to 68.73% DM. The amount of Ca in analysed oats cultivars varied 0.061% DM to 0.075% DM and P varied from 0.286% DM to 0.359% DM.

The results of the present study for composition of different fifteen genotypes of oats grain are in agreement and comparable to those reported by Sauvant et al. (2004), Rodehutscord et al. (2016). However other researches (Usman et al., 2010; Sterna et al., 2015) determined higher content of chemical components than presented in our studies. The highest constituents were crude protein (15–17%), crude fat (4.5%), crude fibre (12%) and crude ash (3.5%).

One of the most important measures of a horse feed's value is its energy content. Energy density determines how much feed must be fed to meet an animal's energy requirement. Level of intake in turn dictates the concentration of all other nutrients in the feed. Therefore, horse feeds cannot be properly formulated without knowledge of their energy contents (Pagan, 1998).

By analysing the DE for horses the highest amount was determined in cultivars *Rajtar* and *Horizont*, the smallest amount was determined in *Girūnės* and *Mina DS* cultivars of oats. Average of digestive energy of different oats

genotypes for horses is 13.67 MJ/kg DM. Washington (1989) claim that digestible energy of oat for horses are from 11.92 MJ/kg to 13.39 MJ/kg.

Table 1. **The chemical composition of oats grown in Lithuania % DM and digestible energy of different oats genotypes for horses, MJ/kg DM**

Genotypes	%							MJ/kg DM
	Dry matter	Crude protein	Crude fat	Crude ash	NEM	Ca	P	DE
Circle	90.05	10.47	4.11	2.62	62.79	0.064	0.331	13.73
Viva DS	90.84	11.62	4.33	2.53	62.64	0.065	0.320	13.44
Rajtar	93.18	10.96	4.17	2.72	66.56	0.067	0.329	14.19
Scorpion	90.45	10.70	4.19	2.62	61.92	0.062	0.335	13.51
Flamingsprofi	90.25	14.24	4.60	3.46	58.83	0.069	0.381	13.83
Migla DS	90.37	10.93	3.90	2.71	63.27	0.066	0.384	13.72
Mina DS	90.40	12.47	3.13	2.69	62.85	0.064	0.301	13.36
Abel	90.69	13.62	4.15	2.98	61.01	0.065	0.359	13.53
Horizont	89.53	13.59	5.62	2.41	60.67	0.065	0.362	14.13
Edit	90.58	11.95	3.51	2.73	62.93	0.064	0.306	13.67
Jaugila	93.45	11.08	3.83	2.40	65.64	0.057	0.286	13.71
Skaistūnės	93.95	11.00	3.26	2.76	67.15	0.063	0.299	13.65
Girūnės	83.50	12.69	5.19	3.29	51.36	0.075	0.316	13.28
Symphony	94.02	11.81	5.31	2.75	63.80	0.063	0.307	13.86
Paseidon	94.74	10.69	3.15	2.45	68.73	0.061	0.307	13.46
Average	**91.07±0.7**	**11.85±0.3**	**4.16±0.2**	**2.74±0.1**	**62.68±0.5**	**0.065±0.0**	**0.328±0.0**	**13.67±0.1**

Making feed formulations for horses, it is important to know not only the amount of crude fiber, but concentrations of NDF, ADF, ADL as well. So in present studies there are presented separated data of crude fiber composition.

Table 2. **The amount of crude fibre and its composition of oats grown in Lithuania, % DM**

Total of Samples = 15	Crude fiber	ADL	ADF	NDF	Celullose	Hemicelullose
Average	9.63	3.11	13.82	28.67	10.70	14.85
Minimum	7.24	2.34	8.04	24.11	5.7	11.29
Maximum	11.02	3.73	17.19	32.01	14.28	19.06

Concentration of NDF is considerably important, because the amount of metabolisable energy in cereal depends on its concentration. After examination of crude fiber content and its components in different genotypes of oats (Table 2), the highest amount was determined in *Scorpion* (11.02% DM), *Girūnės* (10.97% DM) and *Jaugila* (10.50% DM) varieties, the lowest – in *Horizont* (7.24% DM), *Rajtar* (8.77% DM) and *Abel* (8.93% DM) cultivars of oats. Palmgren Karlsson et al. (2000) reported only 10% of fibre in the husked oats growing in the climate of Sweden. The smallest amount of ADL was determined in cultivars *Horizont* (0.34% DM), *Rajtar* (2.64% DM) and *Viva DS* (2.91% DM); the highest amount – in cultivars *Jaugila* (3.73% DM), *Edit* (3.49% DM) and *Scorpion* (3.39% DM). The highest amount of ADF was determined in *Viva DS* cultivars (17.19% DM), the smallest amount was in *Horizont* cultivars (8.04% DM). In the remaining groups of cultivars, this indicator varied from 12.82 to 15.17% DM. The highest amount of NDF was determined in oats cultivars of *Girūnės* (32.01% DM), *Viva DS* (30.88% DM) and *Paseidon* (30.70% DM), while in *Rajtor* (24.11% DM) and *Flamingsprofi* (25.36% DM) the amount of NDF was lower. Rodehutscord et al. (2016) determined that oats NDF is 26.1–34.1%, ADF – 11.1–16.7%, ADL – 7.38–34.5%.

The highest amount of celullose was determined in the cultivars of *Viva DS* and *Girūnės* and compound 14.28% DM and 12.13% DM, respectively in comparison with others cultivars of oats. While in *Horizont, Mina DS* and *Jaugila* were correspondingly less 5.70% DM, 10.01% DM and 10.08% DM respectively in comparison with others cultivars of oats. Content of celullose in different cereals varies and is about 14% in oats (Usman et al., 2010).

The smallest amount of hemicelullose was determined in cultivars *Rajtar* (11.29% DM) and *Flamingsprofi* (11.54% DM); the highest amount – in cultivars *Horizont* (19.06% DM), *Mina DS* (17.43% DM) and *Paseidon* (17.36% DM).

Conclusions

The present study confirmed that different genotypes of oats substantially differ in their chemical composition. The different oats varieties grown in Lithuania characterized by the high content of crude protein, crude fiber and NDF, i.e.

9.44–13.57% DM, 3.90–5.27% DM and 24.11–28.67% DM respectively. Digestible energy of different oats genotypes for horses depending on the oats genotype comprises from 13.28 MJ/kg DM to 14.19 MJ/kg DM.

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Received 22 June 2016
Accepted 08 July 2016