THE CHEMICAL COMPOSITION OF DIFFERENT BARLEY VARIETIES GROWN IN LITHUANIA

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Abstract. The objective of the study was to evaluate the range variation in chemical composition and anti-nutritional factors of 6 spring and 6 winter barley varieties grown in Lithuania. Grain samples of different varieties were analysed for crude protein, crude fat, crude ash, crude fibre and β-glucans. The content of crude protein in spring barley varieties was higher than in winter varieties and ranged between 10.35% DM and 12.38% DM. Variety *Michelle* accumulated the highest content of crude protein. Content of crude fat in both spring and winter barley varieties ranged between 1.09% DM and 2.00% DM and crude ash ranged between 1.94% DM and 2.40% DM. The NFE content varied from 65.45% DM to 69.08% DM in the analysed varieties of barley. The mean β-glucan content was lower in spring barley samples (1.64% DM, ranging between 1.09% DM and 2.36% DM in different varieties), and in winter barley samples, it was 2.89% DM (ranging between 2.19% DM and 3.95% DM in different varieties). We found the high variation in β-D-glucan content within winter barley varieties, and the results indicate that varieties *KWS Meridian* and *Lorely* had the highest levels of β-D-glucan (> 3% DM).

The present study showed considerable differences in chemical composition between spring and winter barley varieties grown in Lithuania. The winter varieties of barley accumulated the highest amount of β-glucan, as an anti-nutritional factor in nutrition of monogastric animals.

Keywords: barley, β-glucans, chemical composition, variety

Introduction. Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop worldwide, after wheat, corn and rice, belonging to family Poaceae (*Gramineae*) (Marwat et al., 2012). In most European countries, barley is the most important raw material for beer production and is used in formulation of compound feed for poultry and farm animals. Barley can substitute wheat in feeds as it contains more fibre and less protein. Barley is easily digestible (due to low gluten contents) and has superior nutritional qualities, high concentrations of lysine, thiamine and riboflavin (Marwat et al., 2012). Barley grain is an excellent source of vitamins and minerals (Kerckhoffs et al., 2002).

Barley contains a relatively high concentration of β-glucans (anti-nutritional factor in nutrition of monogastric animals), compared with other grains. The (1-3, 1-4)-β-D-glucans (commonly referred to as beta-glucans) content of barley cereals has been shown to range from 3.9% to 4.9% (Zhang et al., 2001), but β-glucans concentration can reach from 8% to 10% (Izydorczyk et al., 2000).

Barley grains are fed to farm animals as an energy source and supply protein, vitamins and minerals. Because of high digestibility of barley, it can be used most effectively in pig ruminants and poultry feeding (Bleidere and Grunte, 2007).

Many studies have been conducted to determine the chemical composition and physical characteristics of cereal grains used in livestock feeding. The environmental factors, such as rainfall, temperature, soil conditions, fertilisation and genetic factors, can contribute to variations in the chemical composition and physical characteristics of cereal grains (Metayer et al., 1993; Rodehutscord et al., 2016). Thus, characterisation of variations in the nutritional value of cereal grains that result from such factors may help to define appropriate breeding objectives for improving the feeding value of cereal grains for livestock nutrition (Rodehutscord et al., 2016).

It is important to investigate the nutritional value of barley in a given geographic location because their nutritional value depends on the variety, fertilisation and environmental conditions. The objective of this study was to evaluate the chemical composition and anti-nutritional factors of 6 spring and 6 winter varieties of barley grown in Lithuania.

Material and methods. Sample collection and preparation. Grain samples of the varieties of winter and spring barley were collected from Kaunas Plant Variety Testing Station (PVTS). Twelve barley varieties were used for this study: varieties of spring barley *Explorer, Iron, Luoke, Michelle, Milford* and *Propino,* and varieties of winter barley *Cinderella, Fridericus, KWS Keeper, Lorely, Marissa* and *KWS Meridian.* Winter barley fertilisation was applied as $N_{11}P_{22}K_{55}$ and, additionally,

$N_{68.8}+N_{68.8}$. Spring barley fertilisation was applied as $N_{16}P_{38}K_{76}$ and, additionally, N_{75}. The parameters of the soil were as follows: humus 1.65%, pH 7.6, P_20_5 140 mg kg^{-1}, and K_20 327 mg kg^{-1}. During the experimental year (2014), the average temperature ranged from 8.9 °C at tillering to 18.5 °C at the waxy maturity stage of cereals. The rainfall level was between 1 and 100.2 mm during different development stages of the cereals.

Chemical analysis. Grain samples were taken and analysed in accordance with the Commission regulation (EU) No 691/2013 of 19 July 2013 amending Regulation (EC) No 152/2009 as regards methods of sampling and analysis. Grain samples with 3 subsamples for chemical analyses were ground in an Ultra Centrifugal Mill model ZM 100 (Retsch GmbH, Germany) with 1.0 mm sieve. Dry matter of grain samples was determined by drying the sample in an oven at 105 °C until a constant weight was obtained and dry matter yield was calculated. Crude protein content was determined by the Kjeldahl method, and a conversion factor of 6.25 was used to convert total nitrogen to crude protein. Crude fat was extracted with petroleum ether (boiling range of 40−60 °C) by the Soxhlet extraction method. Crude ash was determined by incineration in a muffle furnace at 550 °C for 3 h (Commission Regulation (EC) No. 152/2009). 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 the Weende method. The samples were subjected to the fibre component analyses for ANKOM 220 Fiber Analyzer (ANKOM Technology, USA): acid detergent fibre (ADF) and neutral detergent fibre (NDF), acid detergent lignin (ADL) using a cell wall detergent fractionation method according to van Soest (Faithfull, 2002). Nitrogen-free extract (NFE) was calculated as follows: NFE (%) = 100 − (moisture % + crude protein % + crude fat % + ash % + crude fibre %). 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).

β-glucans analysis. β-glucans were determined using a *Megazyme* test kit, which uses specific enzymes and follows the method of McCleary and Glennie-Holmes (1985) and McCleary and Codd (1991). Fermented β-glucans detection kit (K-BGLU 11/07) was obtained from *Megazyme* (Ireland). Details of the method are available at www.megazyme.com.

Statistical analysis. Statistical significance was evaluated using one-way analysis of variance (ANOVA), and the data were reported as a mean of standard deviation. Mean comparison and separation were done using the Duncan *t* test ($P<0.05$). ANOVA was conducted using the statistical package SPSS 22.

Results and discussion

The chemical composition of different varieties of spring and winter barley grains is presented in Table 1.

The highest amount of crude protein was determined in spring variety *Michelle* (12.38% DM), and the lowest amount of crude protein was determined in variety *Iron* (10.35% DM) ($P>0.05$). The winter barley varieties accumulated less crude protein, and it ranged between 10.37% DM (*KWS Keeper*) and 11.93% DM (*Fridericus*) ($P>0.05$). The concentrations of crude protein in barley were in general agreement with the values (7.50–12.12% DM) of Jood and Kalra (2001). Such a difference could be ascribed to the specificity of variety and environmental conditions (Oscarsson et al., 1996). Other studies have also found that protein content of barley is highly dependent on the cultivar (Qi et al., 2006) and differs with growth conditions, particularly with the rate and timing of nitrogen fertilisation (Arendt and Zannini, 2013).

The mean crude fat concentration ranged from 1.58% DM in the varieties of spring barely to 1.71% DM in the winter varieties. Crude fibre in all barley varieties (Table 1) ranged between 3.57% DM (*Propino*) and 5.12% DM (*Cinderella*). Crude fat values in barley varieties were lower than determined in earlier studies (Šterna et al., 2015). The results showed that the lowest crude ash content was in spring variety *Iron* (1.94% DM) and the highest in variety *Milford* (2.39% DM). The obtained results of the chemical composition in barley grains are comparable with those reported by Makeri et al. (2013), Biel and Jacyno (2013). Kliseviciute et al. (2016) found that the crude protein concentration in barley varieties ranged from 9.44% DM to 13.57% DM and crude fat from 1.14% to 1.40% DM.

The content of different fibre fractions in grains is presented in Table 2. The highest NDF (24.15% DM) and ADL (1.56% DM) content in spring variety *Explorer* were measured. The highest amount of NDF was determined in winter variety *KWS Keeper* (22.64% DM) and the lowest amount of NDF was determined in variety *Fridericus* (18.97% DM).

The ADF and NDF values are important because they relate to the ability of an animal to digest feed, and they reflect the amount of feed animals can consume. In our study, the concentrations of NDF were in general agreement with other reports (Grove et al., 2003; Žilić et al. 2011). Meanwhile, the lowest quantity of ADF and ADL in variety *Michelle* was observed.

The mean ADL value was highest for winter varieties (1.37% DM). A higher content of ADL fraction in winter barley grains was found by Kowieska et al. (2011). Rodehutscord et al. (2016) found that in winter barley varieties the ADF mean was 5.55% DM, NDF 18.7% DM, and ADL 0.77% DM. However, Kliseviciute et al. (2016) reported that different varieties of barley had lower content of NDF, ADF, and ADL (18.39% DM, 6.12% DM, 1.40% DM, respectively) than estimated in the present study.

Table 2 presents the results of β-glucan amount in 12 different varieties of barely grains. β-glucan content among the different genotypes of barley ranged between 1.09% DM (*Iron*) and 3.95% DM (*Lorely*). It was found that the mean values of β-glucans were 1.64% DM in spring varieties and 2.89% DM in winter varieties. Havrlentová and Kraic (2006) reported that mean β-glucan level in barley cultivars was 4.16% DM (in the range 1.86–5.37% DM). Rodehutscord et al. (2016) noted that the mean level of barley β-glucans was 4.67% DM in different winter varieties. As the results of our study indicate, spring varieties of barley accumulate less content of β-glucans than winter varieties. In nutrition of monogastric animals, β-glucans act as anti-nutritional factors, reducing the digestibility of compound feed.

Table 1. **The chemical composition of barley grains (87% dry matter)**

Variety denomination	Crude protein	Crude fat	Crude fibre	NFE	Crude ash
Spring barley					
Explorer	11.68	1.55	4.21	67.30	2.27
Iron	10.35	1.39	4.23	69.08	1.94
Luoke	11.43	1.73	4.29	67.29	2.27
Michelle	12.38	1.46	3.71	67.17	2.07
Milford	11.68	1.65	4.04	67.24	2.39
Propino	10.66	1.71	3.57	68.83	2.22
Mean SD	11.36 ±0.74	1.58 ±0.14	4.01[a] ±0.30	67.82 ±0.89	2.19 ±0.16
Winter barley					
Cinderella	10.55	1.77	5.12	67.47	2.09
Fridericus	11.93	2.00	4.53	65.45	2.12
KWS Keeper	10.37	1.82	5.03	67.60	2.17
Lorely	10.63	1.09	4.92	68.03	2.34
Marissa	10.64	1.63	4.69	67.63	2.40
KWS Meridian	10.75	1.93	4.60	66.97	2.00
Mean SD	10.81 ±0.56	1.71 ±0.33	4.82[b] ±0.24	67.19 ±0.92	2.19 ±0.15
[a, b] Means within a row with different superscripts differ significantly (P<0.05)					

Table 2. **Different fibre fractions and β-glucan content of barley grains (87% dry matter)**

Variety denomination	NDF	ADF	ADL	Cellulose	Hemicellulose	β-glucans
Spring barley						
Explorer	24.15	6.88	1.56	5.33	17.26	1.27
Iron	18.73	6.23	1.38	4.85	12.51	1.09
Luoke	13.07	6.74	1.37	5.37	6.33	2.26
Michelle	18.60	5.82	1.17	4.65	12.78	2.23
Milford	19.00	6.26	1.29	4.97	12.75	1.66
Propino	19.02	5.93	1.19	4.74	13.09	1.32
Mean SD	18.76 ±3.51	6.31[a] ±0.43	1.33 ±0.14	4.99[a] ±0.30	12.45 ±3.50	1.64[a] ±0.50
Winter barley						
Cinderella	20.98	7.46	1.44	6.02	13.51	2.81
Fridericus	18.97	7.09	1.24	5.85	11.87	2.32
KWS Keeper	22.64	6.61	1.49	5.12	16.03	2.19
Lorely	21.01	6.60	1.40	5.20	14.41	3.95
Marissa	21.42	6.88	1.37	5.51	14.55	2.99
KWS Meridian	20.20	6.54	1.27	5.27	13.66	3.10
Mean SD	20.87 ±1.23	6.86[b] ±0.36	1.37 ±0.10	5.50[b] ±0.37	14.01 ±1.38	2.89[b] ±0.63
[a, b] Means within a row with different superscripts differ significantly (P<0.05)						

Conclusions

The present study showed considerable differences in chemical composition between spring and winter barley varieties grown in Lithuania. In spring and winter varieties, the crude protein of 11.36% DM and 10.81% DM, respectively, was found, but they had high content of NDF. In winter barley, NDF content of 20.87% DM was determined. In our study, it was found that different varieties of barley accumulated different amounts of β-glucans. The highest amount of β-glucans (2.89% DM), as an anti-nutritional factor in nutrition of monogastric animals, was accumulated in winter varieties of barley.

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