COMPARISON OF HULLED AND HULLESS BARLEY COMPOSITION FROM PIG FEEDING POINT OF VIEW

Vita Sterna, Imants Jansons, Mara Bleidere, Margita Damskalne, Sanita Zute

Institute of Agricultural Resources and Economics, Dižstende, Latvia

Abstract

Barley is the main fodder crop in pig production. Feeding barley diets to finisher pigs can improve pork quality compared with feeding corn. Barley has a lower fat and linoleic acid content than corn, resulting in firmer pork fat. Hulless barley offers economic benefits compared to hulled barley because is not necessary pretreatment, saves space and logistics costs. Hulless barley have higher content of protein which is essential in the feeding of pigs. The aim of the study was to compare new hulles barley breeding line's chemical composition with hulled barley cultivars. Evaluation of protein composition showed 4-14% higher protein content, 6% higher sumo of essential amino acids in hulles barley samples in comparison with hulled barley. Data of study shows that fat, ash, calcium and phosphorus are not different, in turn total fibre, ADF, NDF significantly differed between hulless and hulled barley samples. Total fibre in hulless barley was determined from 2.08% līdz 2.18%, but in hulled barley samples from 4.04% to 5.45%. Based on chemical composition GE was calculated, it was from 15.07 to 15.58 MJ/kg for hulless barley and 14.69 – 15,08 MJ/kg for hulled barley.

Keywords: *feed, grain cultivars, protein, amino acids*

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is the fourth in quantity produced and cultivation area in the world (Arendt&Zannini, 2013) and second most important cereal in the European Union for feed and food production after wheat (Eurostat, 2020). Hulless barley cultivars compared to hulled ones have increased nutritional value, especially higher content of protein (Ehrenbergerova et al., 2003; Baik, Ullrich, 2008; Bleidere et al., 2013; Sterna et al., 2017; Sturite et.al., 2019), which allow their use for food and feed production. Studies have shown that besides higher protein content, hulless barley has higher amino acids content, digestibility and energy content and lower fibre than hulled barley (Barley Grain, 2015; Huang et.al., 2003)

Pig diets in the Latvia and Europe traditionally are made up of wheat, barley grain and soybean meal (Degola et.al., 2021). Barley is usually included in diets for growing and finishing pigs in western Canada, but the development of hulless barley varieties will likely result in increased usage it in diets for young pigs (Huang et.al., 2003).

The daily feed intake, the feed-to-gain ratio, the dressing percentage, carcass length, mean backfat thickness, and loin eye area of pigs fed the hulless barley diet were not significantly different from those of pigs fed the corn diet also in the digestion trial, the apparent digestion coefficients of dry matter and energy of pigs fed the hulless barley diet were not significantly different from those of pigs fed the corn diet, but the coefficient for nitrogen tended to be lower for hulless barley than for corn ($P<0.07$). From these results, hulless barley is concluded to be a potential alternative energy source for use in swine diets (Wu et.al., 2000)**.**

An accurate supply of energy and nutrients is essential for optimizing pig production. Therefore, accurate information about both energy and nutrient requirements of pigs and the nutritive values in feed ingredients and diets are required (Kil et.al., 2013).

Growing hulless barley is highly popular in Canada and USA, same as in Japan and Australia but in Europe, although available on the market, hulless barley cultivars have not gained so high popularity either for forage or for food. Hulless barley development and potential for various end uses is attracting growing attention both in Latvia where are several hulless barley cultivars developed and

other countries. Along with cultivars 'Irbe' and 'Kornelija' which are appropriate for functional food because high dietary fibre potential, breeding line 'ST 13053' is being developed for feed end uses in Latvia. Many factors influence the nutritive value of barley, including environmental conditions, fertilizer application and main of them cultivar's potential.

Taking into account mentioned above the aim of the study was to compare new hulles barley breeding line's chemical composition and gross energy with hulled barley cultivars.

2. MATERIALS AND METHODS

2.1. Materials

Two hulled barley cultivars 'Kristaps' and 'Propino' that are widely grown in Latvia, and, 'Anakin' and 'Austris' – bred exacly as feed barley varieties, and one advanced hulless breeding line – 'ST13053K' were included in this study.

2.2. Methods

The field trials were set up at the Stende Research Center (Stende) of the Institute of Agricultural Resources and Economics (57˚11'20"N, 22˚33'43"E) and at the Latgale Agricultural Research Center Ltd. (Vilani) (56˚34'10"N, 26 ˚58'01"E) from 2018 to 2020.

2.2.1. Experimental design

Field experiments were carried out using a block design with four replicates and plot size was 20m^2. The soil type in the conventional field was Stagnic Retisol (loamic), content of organic matter in Stende: 18-25 mg kg^{-1}; Vilani: 26-41 mg kg^{-1}; pH_{KCl} Stende: 4.9-5.7, Vilani:6.1-6.6; available phosphorus (P_2O_5) Stende: 105-182 mg kg^{-1}, Vilani: 94-112 mg kg^{-1}; potassium (K_2O) Stende – 140-233 mg kg^{-1} ; Vilani: 51-83 mg kg^{-1}. In Vilani, soil agrochemical characteristics such as *organic matter content and soil reaction* are more favorable for nutrient uptake. While in Stende, soil nutrients such as *phosphorus* and *potassium* were more balanced. In Vilani, higher proportions of these two nutrients are applied in the fertilizer.

Soil available nutrients in Stende N100, P60, K80 kg ha^{-1} and in Vilani N100 P85 K100 kg ha^{-1} were provided by fertilization, where the complex mineral fertilizer was used as a basic fertilizer where nitrogen was split-applied at sowing (N60) and at the end of tillering stage (N40) of the crop.

In general, 2018 was characterized by shortage of moisture in both growing sites throughout the vegetation period. In the vegetation season of 2019, Vilani had more favorable conditions for receiving both basic and additional fertilizers, while in Stende the moisture regime improved only at the end of May, when additional fertilizer was applied. Overall, in 2019, conditions were favorable for crop production, coarse grain and protein production. Also in 2020, soil moisture conditions in Vilani were relatively better for nutrient uptake by plants. In general, favorable conditions for starch accumulation in grains at both sites of the field experiment. Sum of monthly precipitation both locations during the growing season showed in table 1, and average temperatures showed in table 2.

Sites	**Stende**						**Vilani**					
Year	**April**	**May**	**June**	**July**	**August**	**September**	**April**	**May**	**June**	**July**	**August**	**September**
	Precipitation,											
2018	47.7	14	28.5	32.6	94.1	52.8	27.5	13.6	42.3	35.4	93.0	29.4
2019	8.4	30.7	52.1	117	21.1	50.7	0.0	69.8	48.4	92.9	105.4	63.2
2020	20.3	37.3	42.7	60.2	33.9	32.4	27.1	84.7	73.1	66.3	60.0	43.3
Long term date	36	50	71	89	88	62	32	52	75	81	71	62

Table 1. Monthly precipitation during the growing season from 2018 to 2020

Sites	**Stende**						**Vilani**					
Year	**April**	**May**	**June**	**July**	**August**	**September**	**April**	**May**	**June**	**July**	**August**	**September**
	Temperature, ºC											
2018	7.5	15.6	15.5	19.5	18.6	14.1	8.3	15.4	15.6	19.2	18.0	13.9
2019	7.6	11.2	18.3	15.7	16.8	12.2	8.1	12.3	18.9	15.3	15.8	11.4
2020	5.2	9.0	17.4	16.0	17.0	14.0	5.2	9.7	18.7	16.3	16.7	13.6

Table 2. Average temperatures during the growing season from 2018 to 2020

2.2.2. Chemical composition

Chemical composition of hulles and hulled barley samples was tested out at the Laboratory of Cereal Technology and Agricultural Chemistry of the Institute of Agricultural Resources and Economics.

Protein, β-glucans, starch and volume weight of barley samples (0.5 kg) were measured by Infratec NOVA. Collected barley grain samples of each replicates (4) were dried at 60°C, ground in mill with a 1.0 mm sieve and collected for further analysis of fat, ash, calcium, phosphorus, fibre, acid detergent fibre (ADF), neutral detergent fibre (NDF) and amino acids.

Fat determined using Soxlet equipment in agreement with ISO 6492:1999, ash by ISO ISO 2171:2010, calcium LVS EN ISO 6969: 2002 and phosphorus by ISO 6491: 1998.

Content of fibre was determined by ISO 5498:1981, ADF by EN ISO 13906:2008 and NDF by ISO 16472:2006. Amino acid profile determined by HPLC where sample preparation made using LVS EN ISO 6498:2012 method.

The sum of essential amino acids (∑EAA) was calculated as a total amount of histidine, tyrosine, valine, methionine, cysteine, isoleucine, leucine, phenylalanine and lysine in dry matter. The critical amino acid value (CAAV) calculated as sum of tyrosine, methionine, cysteine, thriptophane and lysine in protein.

Comparison of traits significant for pigs feeding was made using average values of cultivars in both sites each year and also average of hulled cultivars was calculated. Gross energy of barley samples was calculated taking into account its chemical composition and in agreement with formula recommended by INRA (Noblet J., Tran G. 2004),

GE= 0.225xProtein+0.317xFat+0.172xStarch+0.032xNDF+0.163xResidue

where residue after deduction of protein, fat, fibre, starch and fibre from dry matter was included.

2.2.3. Statistical analysis

The obtained results were statistically processed using methods of descriptive statistics (sample mean and standard deviation) and factor analysis (Anova: Two-Factor Without Replication) at IBM SPSS 20 programs. Statistical significance was declared at $p < 0.05$.

3. RESULTS

The most important traits for feeding are protein and starch. The results of protein, starch, β-glucans and bulk mass of hulless and hulled barley samples were showed in table 3.

Year	Barley type	Protein	β-glucans	Starch	Volume weight
			%		g L^{-1}
2020	Hulless	13.3±1.1	4.2±0.1	62.7±1.1	81.6±2.6
	Hulled	12.3±1.0	4.0±0.1	61.8±1.1	73.2±1.1
2019	Hulless	15.2 ±0.8	4.7± 0.3	61.1 ±0.7	81.3 ±2.2
	Hulled	13.3±1.0	4.0 ±0.2	60.9 ±0.8	72.0 ±2.0
2018	Hulless	14.9±0.6	4.7±0.2	62.0±0.8	-
	Hulled	13.7±0.6	4.3±0.2	60.0±0.6	-

Table 3. Comparison of hulless and hulled barley key indicators from 2018 to 2020

The content of protein significantly differed among years, but every year it is 8-14% higher in samples of hulless barley. Similarly β-glucans, starch and bulk mass are determined higher in hulless barley. The highest protein content – 15.2% and highest difference between hulless barley breeding line 'ST13053K' and average result of hulled barley were observed in 2019.

In the animal feed tables (AFZ, 2017) mentioned, that average barley protein content is 11% and starch content 59.9% in dry matter, in comparison with that the results of protein and starch of this study are higher in hulless same as hulled barley samples.

The protein content is not the same for all hulled cultivars, therefore protein content of each cultivar used in this study compared in figure 1.

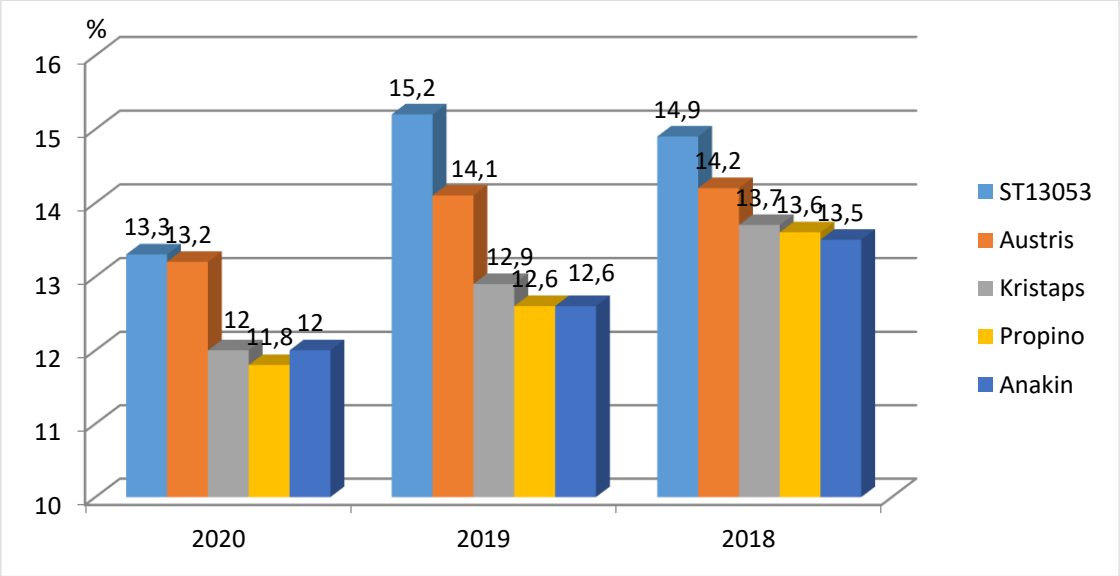


Fig.1. Comparison of protein content of barley cultivars from 2018 to 2020 years

As it is concluded from data assumed in figure 3, protein content of hulled barley 'Austris' bred exactly as feed barley is significantly (< 0.05) higher than other hulled cultivars each year and was not differed ($p<0.05$) from hulles barley 'ST13053K' in 2020.

Some investigations showed that an increase in protein content was accompanied by a decrease in essential amino acids, mainly lysine (Arendt & Zannini, 2013; Shewry, 2007). The results of amino acid composition of barley assumed in table 4.

Parameters	Hulless barley (ST13053K)				Hulled barley (average)			
	2018	2019	2020	average	2018	2019	2020	average
The sum of amino acids g/kg	146.9	148.1	109.4	134.8	139.1	134.0	96.03	123.1
The sum of essential amino acids g/kg	82.08	77.71	71.65	77.10	82.85	69.59	61.98	71.47
Essential amino acids in protein %	27.36	24.12	29.92	27.13	30.32	23.70	29.05	27.69
Content of lysine in protein, %	2.64	2.45	3.13	2.74	2.86	2.43	3.23	2.84
Content of methionine in protein, %	1.11	1.11	1.49	1.24	1.19	1.07	1.44	1.23
CAAV*, %	9.30	12.53	12.73	11.52	10.04	11.43	12.68	11.38

Table 4. Comparison of hulless and hulled barley amino acids composition

As with most nutrients in barley, other than fibre, removal of the hull has the effect of increasing the protein and amino acid levels in the remainder of the kernel. In particular, hulled barley protein is slightly higher in lysine than that of hull-less barley (Newman and Newman, 2005). Our data are in line with this tendency, an average concentration of lysine, methionine and sum of essential amino acids in protein determined higher in hulled barley 2.84%; 1.24% and 27.69% in comparison with hulless one –

2.74%; 1.23% and 27.13%, respectively. The content of lysine, methionine and CAAV significantly ($p<0.05$) differed among years, but average values of hulled and hulless barley were not differed ($p>0.05$). The highest content of lysine was in cultivars ‘‘ST13053K’ (4.1±0.26g/kg), ‘Austris’(4.1±0.32g/kg) comparing with ‘Propino’(3.7±0.35g/kg) and ‘Anakin”(3.8±0.28g/kg).

Next significant components of feed after protein and starch as energy source are fat and macroelements, these results are assumed in table 5.

Year	Barley type, cultivar	Fat	Ash	Phosphorus	Calcium
				%	
2020	Hulless barley ST15053K	2.20	2.00	0.35	0.09
	Hulled barley (average)	2.31	2.14	0.36	0.09
	Kristaps	2.3	2.13	0.36	0.09
	Austris	2.3	2.16	0.36	0.10
2019	Hulless barley ST15053K	1.75	2.50	0.33	0.08
	Hulled barley(average)	1.80	2.52	0.31	0.11
	Kristaps	1.82	2.52	0.30	0.11
	Austris	1.79	2.57	0.32	0.09

Table 5. Comparison of fat, ash, phosphorus and calcium in hulless and hulled barley

Fat content of tested barley samples varied from 1.75 to 2.3%, ash from 2.00 to 2.57% and difference between hulless and hulled barley was not significant, but significantly varied by years. These results are in line with other studies since content of lipids in barley reported 2-3% and ash 1.5-3% (Arendt & Zannini, 2013; AFZ 2017). The results of phosphorus and calcium were not different by years not by varieties. The content of phosphorus determined in barley samples varied from 0.30% to 0.36% and was in line with mentioned in feed tables – 3.9g/kg (0.39%) same as calcium content in this study determined 0.08-0.11% was in line with mentioned in feed tables – 0.8g/kg (0.08%) (AFZ 2017) but strongly different with other studies, where calcium content for hulled barley showed 0.03% (Arendt & Zannini, 2013).

The characteristic of barley fibre and energy are assumed in table 6.

Year	Barley type	Fibre	ADF	NDF	GE
			%		MJ/kg
2020	Hulless barley	2.09	2.04	13.09	15.58
	Hulled barley	4.14	4.38	17.34	15.08
	Kristaps	4.21	4.38	17.54	15.07
	Austris	4.04	4.36	17.07	15.07
	Propino	4.00	4.30	17.20	-
	Anakin	4.00	4.41	17.45	-
2019	Hulless barley	2.18	2.22	26.93	15.33
	Hulled barley	5.32	5.67	33.14	14.83

Kristaps	5.11	5.68	34.79	14.69
Austris	5.45	5.62	31.94	14.82
Propino	5.14	5.61	32.00	-
Anakin	5.10	5.70	33.11	-

Table 6. Comparison of fibre, ADF, NDF and GE in hulless and hulled barley.

The results of study shows that Hulless barely has significantly smaller content of fibre same as NDF and ADF and unsignificantly higher gross energy (table 6). NDF content was not differed ($p<0.05$) among hulled cultivars.

Gross energy of barley mentioned in feed tables – 18.3 MJ/kg in dry matter or 16MJ (as fed) (AFZ 2017) is higher than calculated for hulless and hulled barly in our study 14.69-15.58 MJ/kg. Same studies reported, that the digestible energy contents in the hulless barleys ranged from 14.01 to 14.60 MJ kg^{-1} while the contents in the hulled barleys are lower: ranged from 13.05 to 13.16 MJ kg^{-1} (as-fed) (Huang et.al., 2003).

4. DISCUSSION

Evaluation of feed fibre is a complex topic where there is really no consensus about its impact because its heterogenity. An indicator NDF essentially measures the cellulose, hemicellulose and lignin content of ingredient and ADF measures cellulose and lignin. Very much discussions regarding β-glucans and its impact on digestibility of feed was find in reviews. In other hand the need for fibre is different for pigs, piglets, fattening pigs or sows. Therefore it cannot be evaluated are more appropriate is hulled or hulless barley, each of them has its advantages, which must be taken into account when compiling rations for pigs.

The feed including hulless breeding line ‘ST15053K’ was studied in comparison with feed including hulled barley in fattening pigs feeding trial and concluded that results in higher live weight gain for pigs, although the differences was not significant. (Degola et.al., 2021).

5. CONCLUSIONS

Hulless breeding line ‘ST15053K’ showed the same potential in terms of pig feed in comparison with hulled cultivars and in addition in some indicators – protein, starch, lysine - superior. The content of protein significantly differed among years, but every year it is 8-14% higher in samples of hulless barley. The content of lysine, methionine and CAAV significantly differed among years, but average values of hulled and hulless barley were not differed. The results of phosphorus and calcium were not different by years not by varieties. Total fibre, ADF, NDF significantly differed betwen hulless and hulled barley samples. Total fibre in hulless barley was determined from 2.08% to 2.18%, but in hulled barley samples from 4.04% to 5.45%.

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