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Effect of replacement of coated barley grain with hulless barley in diet on growth, carcass and meat quality traits of fattening pigs

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Abstract. A amount of experimental pigs were 40 crossbred pigs (Yorkshire × Landrace). The initial body weight of pigs were average 27.0 kg. The goal of research was to assess the effect of replacement of coated barley grain with hulless barley in diet on pig growth, carcass and pork quality indices. Experimental groups of pigs on the holding were conducted according to age and sex. For trial group of pigs, a compound feed with hulless barley (38.9–45.4%) was prepared, for the control with coated barley (39.3–43.3%). The feed recipes made according the pigs age. The other feed ingredients were not changed and were wheat, soybean meal and oil, premivit, and from 20 till 70 kg liveweight also fish meal. Diets were formulated with the same of metabolizable energy and crude protein content. During the study the live weight of pigs was monitored and the feed consumption was counted. At the end of the study all pigs slaughtered, determined carcasses traits and took samples of loin muscle for chemical analyses. The results showed that pig fattening indices (daily liveweight gain were in control pig group 0.686 ± 0.183 and trial 0.716 ± 0.174) did not differ significantly between groups ($P > 0.05$), although its were slightly lower in the control group pigs by 4.37%. Feed consumption for live weight gain in both groups ranged from 3.14 to 3.25 kg. Carcasses scores showed significant differences in lean meat and chops ($P < 0.05$). There were also differences in the backfat thickness. The thickness of backfat was 2.62 mm less in the control pig group, which indicates that when feeding coated barley to fattening pigs, the carcasses have a higher proportion of lean meat (62.1 ± 0.7%). Pigs were slaughtered reaching a live weight of 110 to 114 kg. The meat yield 71.7% and moisture level (70.2–75.2%), as well as protein (22.3–22.9%) indicators showed that fattening pigs are sold at the optimal age. In conclusion, results from this study suggest that feeding hulless barley to fattening pigs results in higher live weight gain. Carcass indicators showed a significantly higher proportion of lean meat and weight of chops when pigs eating coated barley. Chemical composition of pork in groups without significant differences.

Key words: hulless barley, fattening pigs, growth performance.

INTRODUCTION

In a pig farms, feed costs represent 60 to 75% of the total cost of production, therefore, it is important for a producer to formulate diets on a least - cost basis, without reducing production. Pig diets in the Latvia and Europe traditionally are made up of wheat, barley grain and soybean meal. Barley is widely used as a feedstuff for pigs. Barley can be either two - rowed or six - rowed, covered or hulless, awned or awnless. Hullessness is mentioned as one of the desirable characteristics of forage barley, because it has been formed that the hulless - barley has a significant higher content of digestible energy than covered barley. It is mainly connected with the reduced NCP (no-starch polysaccharide) content in hulless barley, because a large part of them is located in hulls (Degola, 2007). The other researchers before considered that hulless barley may be a good alternative energy source for use in pig diets (Jih-FangWu et al., 2000; Degola, 2007). Therefore, the our study was aimed at investigating the effect of hulless barley as replacement of covered barley in pig's diet on growth, carcass and meat quality traits of fattening pigs.

MATERIALS AND METHODS

Animals and experimental design

The experimental 40 crossed pigs (Yorkshire × Landrace) were housed in accordance with the pig welfare requirements Cabinet of Ministers Regulation No. 743. The initial body weight of pigs were average 27.0 kg. The both trial groups completed according to their age and sex, in each group were 20 pigs. Pigs were selected from a commercial pig farm. The experiment lasted 122 days. The dietary treatments were: for trial group of pigs, was prepared a compound feed with local hulless barley, for the control group with local coated barley. The feed recipes made according the pigs age and were three for each group. The other feed ingredients were not changed and were local wheat, soybean meal and oil, as additives, used premivit, and from 20 till 70 kg liveweight also fish meal. The amount of ingredients and choice of mixed feed were adjusted continuously over time depending on the actual weights of pigs are shown in Table 1.

Table 1. Ingredients of compound feed

Ingredients, %	Control group			Trial group		
Pigs liveweights, kg	20–40	40–70	70–105	20–40	40–70	70–105
Wheat	39.31	40.09	43.28	38.96	40.98	45.41
Coated barley	39.32	40.1	43.27	-	-	-
Hulless barley	-	-	-	38.96	40.98	45.41
Extracted soybean meal	15.61	14.28	9.16	16.9	12.78	4.9
Soybean oil	1.0	1.0	1.0	0.5	0.76	1.0
Fish meal	1.0	1.0	-	1.0	1.0	-
Premivit Result or 3% Bacon*	3.76	3.53	3.29	3.68	3.5	3.28

*for growing period used Premivit Result and for fattening period Premivit 3% Bacon.

All nutrients in diets were formulated according the recomendation of NRC (2012). Pigs eated the compound feed *ad libitum*. Each pen was equipped with nipple of drinker. According to the growth phase of the pigs, the feed was changed (Table 1). The live

weight of the pigs was monitored during experimental periods. Feed consumption was recorded throughout the all study period and feed efficiency was calculated as the amount of compound feed consumed per unit of liveweight gain.

Chemical analyses

The analysis of the composition of the feedstuffs were done in the accredited Scientific laboratory of Agronomic analysis of Latvia. Samples of feed were milled through a 1-mm screen before analysis. Dry matter (DM), crude protein (CP), crude fiber (CF), fat, calcium (Ca), phosphorus (P), contents were analysed based on standard methodology (Degola et al., 2019). Amino acids were detected using amino analyzer. The identity and quantitave analysis of the amino acids were assessed by comparison with the retention times and peak areas of the standard amino acid mixture. The metabolizable energy (ME) were calculated based on tested parameters in accordance with McDonald et al. (2002). The chemical compositions of the feed mixtures are presented in Table 2. The pork samples were tested by quality parameters - pH, moisture and protein content (LVS ISO 1443:1973), cholesterol content (BIOR-T-012-132-2011), unsatured fatty acids (BIOR-T-012-131-2011) in laboratory of Food and Environmental Investigations (BIOR) in Latvia, but amino acids contents of pork determined in Eurofins GfA laboratory in Germany with methods ISO 13903:2005, IC-UV for all amino acids and for tryptophan used method EU 152/2009, LC-FLD.

Table 2. Chemical composition of compound feed (in dry matter)

Nutrients	Control group			Trial group		
Pigs liveweights, kg	20–40	40–70	70–105	20–40	40–70	70–105
Dry matter, %	89.9	88.7	89.5	89.8	88.7	89.3
Crude protein, %	19.9	17.4	16.8	20.9	18.2	16.7
Crude fiber, %	4.3	3.1	4.5	3.0	3.1	2.5
Fat, %	3.6	3.2	3.6	3.2	2.9	3.1
ME, MJ kg	13.1	13.4	13.3	13.1	13.3	13.2
Ca, g	9.5	9.1	9.1	11.5	8.9	8.8
P, g	5.8	5.2	5.1	6.7	5.2	5.5
Lysine, g 100 g^{-1}	0.95	0.84	0.74	1.04	0.82	0.72
Methionine, g 100 g^{-1}	0.34	0.36	0.29	0.36	0.37	0.28
Cystine, g 100 g^{-1}	0.35	0.27	0.28	0.37	0.28	0.29
Treonine, g 100 g^{-1}	0.59	0.54	0.47	0.65	0.54	0.48
Valine, g 100 g^{-1}	0.71	0.66	0.65	0.76	0.69	0.63

The chemical content in dry matter of used coated and hulless barley in feed mixtures also were tested. The crude protein, β-glucans and starch in coated and hulless barley were with small difference, respectively 13.3 ± 1.0%, 4.0 ± 0.2% and 60.9 ± 0.8% in coated barley, but hulless barley grain contained CP 15.1 ± 0.9%, β-glucans 4.7 ± 0.3% and starch 61.2 ± 0.7%. The amino acids content were - lysine 4.1, methionine 1.7, cystine 2.2, treonine 4.7 g kg DM in coated barley, but hulless barley contained a little bit more, respectively 4.3,1.8, 2.3, 5.0 g kg DM. In the other research the chemical results of different varieties of barley were the same as: levels of total β-glucan, ADF, CP, and starch (90% DM) in the 20 barley samples ranged from 2.7 to 4.5%, 4.5 to 9.2%, 10.8 to 15.1%, and 42.3 to 53.4%, respectively (Fairbairn et al., 1999). The chemical content of barley cultivars influence many factors.

Slaughter and carcass quality measurements

The all experimental pigs at the 110–114 kg were slaughtered in commercial slaughterhouse. Each pig carcass weight was recorded, backfat depth (F) was measured at the head of the last rib, 6 cm from the mid back line, using a Intrescope Optimal Probe (Latvia Regulations of the Cabinet of Ministers Nr.307). The individual percentage of lean meat was calculated by formula: 66.6708–0.3493 × F and estimated by European standard for classification of lean meat in pig carcasses. The letters SEUROP designations are used to refer muscle development. Muscle eye area was measured with the planimeter (Degola &Jonkus, 2018). Carcass yield was calculated by dividing the hot carcass weight by the live body weight. Left side of carcases were divided into parts for determination weight of ham. After 24 hours of pig slaughter, meat samples were taken from the *musculus longissimus lumborum et thoracis*.

Statistical analyses

All data generated in this experiment were subjected to the general linearized model procedures of the SAS/STAT 9.22 software package (2010). The *t-test* was used to compare the means of the indices of control and trial groups. Variability in the data was showed as the pooled standard error. Statistical significance was declared at $P < 0.05$.

RESULTS AND DISCUSSION

The growth rate and the efficiency of feed conversion of pigs fed barley rations are often inferior to those of pigs fed diets based on lower fibre grains such as corn or wheat. Influence of our experimental diets on pig performance showed that pig average liveweight gains in research period for both groups were medium high, without significant difference ($P > 0.05$) between pig groups (Table 3), although, the fattening rates were slightly higher by 4.37% of pigs in the trial group which fed hulless barley. Hulless barley, therefore, is of interest and was studied as early as 1924 by Joseph, who found it equal to wheat. Later, the others researchers compared a hulless and covered barley and obtained pig performance equal to that of pigs fed wheat rations, but inferior to corn. Researchers Newman & Eslick, 1970 found no differences between corn, covered and hulless barleys in starter and grower diets of pigs, but corn and hulless barley were better than covered barley during the finishing period (Mitchall et al., 1976).

Table 3. Pig fattening results ($n = 40$)

Traits	Control group $x \pm SD$	Trial group $x \pm SD$
Liveweight at begining of fatttening, kg	26.9 ± 0.82	27.0 ± 0.88
Liveweight at the end of experiment, kg	110.7 ± 15.18	114.5 ± 14.33
Liveweight gain per fattening period, kg	83.7 ± 15.28	87.4 ± 14.54
Daily liveweight gain, kg	0.686 ± 0.183	0.716 ± 0.741*

*$P > 0.05$.

In the other researhers publications could find the similar results to ours. For example, the average daily gain of pigs fed the hulless barley diet was significantly higher than of pigs fed the corn diet during the grower period, but during the finishing and all trial periods were not significantly different average daily gain (Wu et al., 2000).

Feed consumption in our research (Table 4) in both groups was also similar. There were daily gain from 1 kg feed 0.307 and 0.318 kg. The same results we found in Wu et al., 2000 publication, where the daily feed intake of pigs fed the hulless barley diet was not significantly different from that pigs which fed the corn diet during all periods. Also same results were for feed consumption to liveweight gain in pig growing period (Wu et al., 2000). But during the finishing and over all periods the pigs which fed the hulless barley diet required less feed per unit of liveweight gain than pigs fed the corn diet. Nevertheless, that fattening pigs in our research did not received corn, we got the same results, pigs which fed hulless barley required less feed per 1 kg liveweight gain (Table 4). Advantage of using hulless barley instead of hulled barley as a energy source in pig diets is that a reduction feed costs. In the research of Thacker et al., 1987 we found out, that most cost effective grain to include in pig diets would be hulless barley, assuming a similar purchase price for hulless and hulled barley. This research also demonstrated that level of soybean meal supplementation could be reduced. Feeding different barley cultivars in experiment (Castell & Bowren, 1980), when used pigs from 25 to 93 kg liveweight, growth rates, efficiencies of feed conversion and carcass measurements were not signicantly ($P > 0.05$) affected by cultivar. However, the trend for diets based on two-row cultivars to be superior in feed conversion was supported by their higher apparent digestibilities of energy and of nitrogen in the diets. A palatability study using these diets indicated the pigs preference for two-row over six-row barleys (Castell & Bowren, 1980)

Table 4. Feed consumption

Indices	Control group	Trial group
Fattening days	122	122
Feed consumption for one pig, kg	272.2	274.5
Feed per day, kg	2.23	2.25
Feed conversion, kg	3.25 ± 0.264	3.14 ± 0.062*
Daily gain from 1 kg feed, kg	0.307 ± 0.0221	0.318 ± 0.0158*

*$P > 0.05$.

In the other research before wrote that diets containing 0, 20, 40, 60, or 80% barley were fed to pigs with initial body weight 67.9 kg for 8 weeks, results were: feeding diets with increasing levels of barley resulted in a linear decrease in daily gain ($P < 0.01$) and backfat thickness ($P < 0.01$). Dressing percentage linearly decreased with length of barley feeding ($P < 0.05$), but the concentration of saturated fatty acids in backfat increased (linear, $P < 0.05$) the longer the barley diet was fed, without no effect of barley on loin muscle quality and barley did not consistently change fat color (Beob et al., 2014). In our experiment carcass traits showed (Table 5) significant differences in lean meat and chops weight ($P < 0.05$). There were also differences in the backfat thickness, 2.62 mm less backfat thickness in the control group, which indicates that when feeding coated barley for fattening pigs, the carcass has a higher proportion of lean meat. Carcass yield in both pig groups were 71.7%, but in publication of Wu et al., 2000 the carcass yield and length, backfat thickness and muscle eye area of pigs fed the hulless barley diet were not significantly different from pigs which fed the corn diet.

Table 5. Pig carcass measurements

Measurements	Control group $x \pm SD$	Trial group $x \pm SD$
Carcass weight, kg	79.4 ± 6.39	82.1 ± 11.5
Backfat thickness, mm	7.63 ± 3.231	10.25 ± 3.073*
Lean meat, %	62.13 ± 0.701*	61.45 ± 0.683
Muscle-eye area, cm^2	52.3 ± 7.62	51.4 ± 3.73
Ham weight, kg	8.9 ± 0.64	8.0 ± 0.37
Chops weight, kg	2.43 ± 0.091*	2.07 ± 0.182

*$P > 0.05$.

Chemical composition of pork without significant differences (Table 6). Pigs were slaughtered reaching a live weight of 110 to 114 kg, when high meat yield and moisture, as well as protein content indicated that fattening pigs are sold at the optimal (of 5.5 till 6 month) age (Table 6). The same results we found in italian researchers (Prandini et. al., 2015) publication where they evaluated the effect of diets based on hulled or hulless (normal and low amylose) barley varieties on growth performance and carcass characteristics in heavy growing-finishing pigs for the production of protected designation of origin (PDO) Italian products. Four diets were formulated: corn-based diet (control), control diet with 80% of a normal-amylose hulled barley variety named Cometa (Cometa), control diet with 80% of a normal-amylose hulless barley variety named Astartis (Astartis), and control diet with 80% of a low-amylose hulless barley variety named Alamo (Alamo). The researchers found that no difference in carcass characteristics among treatments ($P > 0.05$). This study showed that diets based both on hulled and hulless barley might be suitable for the heavy pig breeding intended to the production of Italian PDO products (Prandini et al., 2015). It indicates that hulled or low-amylose hulless barley could be valuable to support maximum pig growth performance without affecting carcass composition.

Table 6. Influence of diets on pork chemical content

Indices	Control group $x \pm SD$	Trial group $x \pm SD$
Moisture, %	70.3 ± 0.2	75.2 ± 0.2
Protein, %	22.3 ± 0.3	22.9 ± 0.3
pH	5.41 ± 0.03	5.44 ± 0.03
Cholesterol, mg 100 g^{-1}	62.6 ± 15.7	62.7 ± 15.7
Unsaturated fatty acids, %	56.8 ± 2.5	49.5 ± 2.1
Tryptophan, g 100 g^{-1}	0.282 ± 0.028	0.301 ± 0.030
Hydroxyproline, g 100 g^{-1}	0.0880 ± 0.018	0.0710 ± 0.014
Tryptophan:Hydroxyproline ratio	3.20 ± 0.016	4.24 ± 0.019

According to the SEUROP carcass classification system of pork, all pig carcasses were evaluated by the (S) class, where the lean meat was more 60 percent.

CONCLUSIONS

Feeding hulless barley to fattening pigs, results in higher live weight gain for pigs, although the differences with the inclusion of coated barley in pig feed are not significant. Carcass indicators show a significantly higher proportion of lean meat and

weight of chops when pigs eating coated barley in diets. The chemical composition of pork does not differ significantly.

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