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Influence of local extruded soybean cake and imported soybean meal on fattening pig productivity and pork quality

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Abstract. The aim of this study was to determine the influence of feeding local and imported soybean protein feeds to fattening pigs and examining it impact on the quality of pork. The trial was created with 40 pigs divided in two groups (20 in each). Pigs in the control group received imported soybean meal, in the trial group local farm grown in Latvia extruded soybean cake mixed in the compound feed. The diets were designed to be nutritionally equivalent. For fattening pigs each diet were available on an ad libitum basis to pens. During the study pigs were weighed three times at 84, 140 and 190 days at age. Feed consumption, pig carcass traits and meat chemical composition were determined. The final live weight in control group was 108.33 ± 2.904 kg and in trial group was 111.88 ± 2.793 kg there were no significant difference ($P > 0.05$). Average daily live weight gain in the all experimental period in control group was 0.779 ± 0.096 kg and in trial group was 0.822 ± 0.103 kg, there were no significant difference ($P > 0.05$). Feed consumption per kg of live weight in control group was 2.39 kg in trial group was 2.24 kg. Pig carcass traits and meat chemical composition were similar for both groups without significant differences ($P > 0.05$). Soybeans grown and processed in Latvia were equivalent to imported soybeans and gives good rates of pig growth and quality of pork.

Key words: fattening pig, pork quality, soybean protein.

INTRODUCTION

Precision feeding is a major breakthrough in pig nutrition and it is one of the most promising avenues to promote high-quality and safe pork, high animal welfare, and minimal impact on the environment (Pomar & Remus, 2019). Economic and environmental concerns have been forced the development of low crude protein (CP), amino acid (AA) fortified diets that deliver performance equivalent to diets with intact protein sources. However, shown in some studies, low CP diets have led to decreased performance, particularly in heavy weight finishing pigs. Decreasing dietary CP below 13% may compromise finishing pig growth and carcass performance (Soto et al., 2019). Amino acids given in excess will be deaminated and the resulting urea will be excreted in the urine. Finding a good balance between amino acids supply and amino acids requirement is very important for different reasons (Milgen & Dourmad, 2015). Soybean

meal has long been considered an outstanding source of supplemental protein in diets for livestock and poultry. In fact, soybean meal is very often referred to as the 'gold standard' because other protein sources are compared to it. Soybean meal is rich in highly digestible protein, and the protein is composed of a superior blend of amino acids, the building blocks of body protein for livestock and poultry (Stein et al., 2013; Cromwell, 2017). Soybean meal represents two-thirds of total world output in protein feedstuffs (Oil-World, 2010). It is estimated that soybean accounts 85% of the protein supplements fed to pigs (Cortamira et al., 2000).

Several factors influence the concentration of amino acids present in soybean grains, such as climatic changes, weather, temperature, genetics, topography, and soil fertility (Degola et al., 2019).

Soybean growing in Latvia is a new growing industry with many challenges. The results of chemical composition of soybeans grown in different regions of Latvia showed that protein content in soybean samples determined from 32.7 to 40.7% fat content from 18.4 to 21.4% and significantly differed ($p < 0.05$) among growing places. Metabolizable energy calculated for pigs varied from 13.2 to 17.6 MJ kg^{-1} (Degola et al., 2019).

Dietary protein intake stimulates muscle protein synthesis. The muscle protein synthetic response to protein intake can vary substantially between different dietary protein types or sources (Gorissen et al., 2018). Dietary supplementation of protein and amino acids is important to promote normal and optimal growth for pigs (Son et al., 2019). Beyond their nutritional role as the source of amino acids for protein synthesis, they are instrumental in the regulation of food intake, glucose and lipid metabolism, bone metabolism and immune function (Jahan-Mihan et al., 2011). Nutritionally, amino acids are classified as essential or nonessential for animals based on their traditional role in protein synthesis. However, the critical regulatory roles for amino acids in metabolism have long been ignored. In fact, amino acids and their metabolites are regulators of cellular signal transduction, gene expression and the protein post-translational modification, especially in the intestine (Mou et al., 2019).

The term ideal protein can be defined as the protein which containing the minimum quantity of essential amino acids with maximum utilization to meet the exact nutritional amino acid requirements (Wang & Fuller, 1989). It refers to determine the required amounts of amino acids relative to lysine for maintenance, protein accretion, and growth performance of pigs (Milgen & Dourmad, 2015; Recharla et al., 2017). There is general agreement that ileal rather than fecal digestibility measurements represent more accurate estimates of amino acids availability in pig feeds (Sweich, 2017). Different ideal protein profiles have been proposed in in scientific literature for growing pigs and sows (Milgen & Dourmad, 2015).

Well balanced amino acid composition reduces odor by modulating the gut microbial community. Administration of pig diet formulated with the ideal protein concept may help improve gut fermentation as well as reduce the odor causing compounds in pig manure (Recharla et al., 2017).

Growth performance of pigs, carcass composition and quality of pork and pork products depend on multiple interactive effects of genotype (genetic background, presence of major genes hal and RN-), rearing conditions (feeding level, housing and environmental conditions, production system), preslaughter handling, and carcass and meat processing (Lebret, 2008). There are many factors affecting muscle fibre characteristics, including welfare, breed, gender, age, and others (Rehfeldt et al., 2004; Jeong et al., 2012;

Joo et al., 2013). One of the extrinsic factors is nutrition (Bee et al., 2007; Jeong et al., 2012). Although meat quality traits tend to be better in the group fed ad libitum (Lebedova et al., 2019).

Pigs on a high amino acid diet in late finishing pigs able to compensate to a large extent for amino acid restriction in growing and early finishing. Amino acid content in late finishing determined carcass quality (Millet et al., 2011).

The aim of the study was to compare feed with imported soybean protein to feed with soybean protein grown and produced in Latvia, determine the impact of feed on the quality of carcasses and meat.

MATERIALS AND METHODS

Animals and housing

The estimations were based on the ethical guidelines research was carried out in accordance with the Pig welfare requirements Cabinet Regulation No. 743. Yorkshire × Landrace cross breeds fattening pigs with start body weight 25 kg were selected for the trial. With the aim to carry out the studies two groups of pigs were formed 20 pigs in each group, per pen balanced for body weight and sex (10 female and 10castrated male). Pigs were selected from a commercial pig farm. Pigs were kept on concrete floors bedding was sawdust. Nipple drinker and 2 hole feeder were placed in each pen. The body weight of pigs was individually measured at the 84, 140 and 190 days at age. Diets in bouth groups at the trial was provided all times on an ad libitum basis to pens. The bodyweight and feed intake were determined to evalute average daily gain and average daily feed intake.

Dietary treatments and Performance Measures

The control diet included imported soybean meal, but in the trial group diets extruded soybean cake was made at the farm. Extruded soybean cake at farm was made from soya variety with early ripening ability (group 000) suitable for regions with lower (1,500–1,800 °C) sum of effective temperatures – 'Laulema' with crude protein content 43.36% (Degola et al., 2019). In the trial were calculated and prepared three diets for each group similar in crude protein content and to be isoenergetic for metabolizable energy. The rations contained barley, wheat, canola or soybean oil, fish meal, salt and trace element vitamin premix, phytase, depending of pig liveweight and age. Their amounts and choice of mixture were adjusted continuously over time depending on the actual weights of the pigs Table 1. The chemical compositions of the feed mixtures are presented in Table 2. Protein profiles in diets were calculated as the ratio of Lysine (Lysine 100%) to other amino acids.

Chemical analyses

Feed samples were tested in the 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 fibre (CF), fat, calcium (Ca), phosphorus (P), contents were analysed based on standard methodology (Degola et al. 2019). Amino acids were detected using amino acids analyzer. The identity and quantitative 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 Mc Donald et al., (2002). The meat samples were tested and quality parameters – pH, water, crude protein, fat (LVS ISO 1443:1973) content, and cholesterol content (BIOR-T-012-132-2011) were determined in laboratory of Food and Environmental Investigations (BIOR) in Latvia.

Table 1. Composition of diets for growing and fattening pigs

Traits	Control group			Trial group		
Pigs liveweights, (kg)	20–40	40–65	65–110	20–40	40–65	65–110
Ingredients,%						
Local wheat	64.8	67.16	72.13	39.31	40.0	43.28
Local barley	16.22	16.79	18.03	39.32	40.1	43.27
Imported soybean meal	12.22	9.55	6.14	-	-	-
Local extruded soybean cake	-	-	-	15.61	14.28	9.16
Fish meal	2.5	2.5	-	1.0	1.0	-
Premivit	3.2	3.0	3.2	3.76	3.53	3.29
Canola oil	1.0	1.0	0.5	-	-	-
Local soybean oil	-	-	-	1.0	1.0	1.0

Table 2. Chemical composition of diets for growing and fattening pigs

Traits	Control group			Trial group		
Pigs liveweights, (kg)	20–40	40–65	65–110	20–40	40–65	65–110
Nutrients						
Dry matter, (%)	87.8	87.8	87.6	88.8	88.7	88.3
Crude protein, (%)	18.8	17.9	15.4	18.2	17.4	15.2
Crude fiber, (%)	2.8	2.7	2.6	3.2	3.1	3.0
Fat, (%)	3.4	3.4	2.7	3.3	3.2	2.9
ME MJ, kg	13.5	13.5	13.3	13.4	13.4	13.3
Ca, (g)	8.4	7.9	8.2	9.6	9.1	8.5
P, (g)	4.8	4.6	4.1	5.3	5.2	4.9

Slaughter and carcass quality measurements

To determine carcass and meat parameters the finisher pigs at the 110 kg liveweight were slaughtered in commercial slaughterhouse. Carcass weights were fixed. Backfat depth (F) was measured at the head of the last rib, 6 cm from the mid back line, using a Introscope Optical Probe (Latvia reg.of the Cabinet of Ministers Nr. 307). For each individual pig the percentage of lean meat was calculated as: 66.6708–0.3493×F. Muscle eye area was determined with the planimeter (Degola & Jonkus, 2018). The lenght of carcass was measured in a straight line from the forward edge of the first rib to the forward edge of the aitch bone and muscle eye area with the planimeter (Degola & Jonkus, 2018). Left side of carcases was divided into parts for determine weight of ham. For quality testing 24 hours after slaughter meat samples were taken from the *musculus longissimus lumborum et thoracis*.

Statistical analysis

Statistical analysis was performed according to the SAS/STAT 9.22 software package (2010). Data were reported as arithmetic means with the pooled SEM. The results of investigation were compared using Student's t-test. Statistical significance was evaluated at $P < 0.05$.

RESULTS AND DISCUSSION

Comparison of feed with imported soybean meal and feed with soybean cake grown and produced in Latvia, was made by determining the impact of feed on the quality of carcasses and meat. Pigs in the control group received imported soybean meal from 12.22% to 6.14% in the trial group local farm grown in Latvia extruded soybean cake 15.61% to 9.16% mixed in the compound feed. The diets were designed to be nutritionally equivalent.

The total amount of amino acids showed no essential difference in growing and fattening periods (Table 3).

Table 3. Composition of amino acids in diets for growing and fattening periods (% in dry matter)

Traits	Control group	Trial group	Control group	Trial group
Pigs liveweights, (kg)	40–65	40–65	65–110	65–110
Indispensable amino acid, (%)				
Arginine, (%)	0.86	0.87	0.80	0.83
Histidine, (%)	0.37	0.38	0.34	0.35
Izoleicine, (%)	0.58	0.60	0.53	0.55
Phenylalanine, (%)	0.75	0.76	0.68	0.69
Leicine, (%)	1.06	1.07	0.95	0.98
Lysine, (%)	0.88	0.94	0.79	0.92
Methionine, (%)	0.36	0.36	0.34	0.35
Threonine, (%)	0.57	0.57	0.51	0.53
Valine, (%)	0.72	0.71	0.64	0.70
Total Lys+Met+Thre	1.81	1.87	1.64	1.8
Total indispensable amino acids, (%)	6.15	6.26	5.58	5.9
Dispensable amino acid, (%)				
Alanine, (%)	0.68	0.67	0.62	0.63
Aspartic, (%)	1.16	1.22	1.04	1.12
Cysteine, (%)	0.26	0.27	0.23	0.23
Glycine, (%)	0.82	0.72	0.74	0.71
Glutamic, (%)	3.75	3.65	3.49	3.38
Histidine, (%)	0.37	0.38	0.34	0.35
Proline, (%)	1.24	1.25	1.21	1.21
Serine, (%)	0.74	0.73	0.67	0.68
Tyrosine, (%)	0.47	0.47	0.42	0.42
Total dispensable amino acids (%)	9.49	9.36	8.76	8.73
Total amino acids	15.27	15.24	14.0	14.28

It is also important to evaluate the individual results of the limiting essential amino acids in soybean-based poultry and swine feeds, i.e., methionine, lysine, and threonine (Goldflus, 2006).

Composition of indispensable amino acids amount in diets for growing and fattening periods at control and trial groups were similar for grower (40–65 kg) feed for finisher (65–110 kg) feed. Same relevance were founded for amount of dispensable amino acid in control and trial groups The sum of main limiting amino acids Lysine, Threonine and Methionine were similar for grower feeds in control group 1.81% in trial

feed were1.86%. Sum of main limiting amino acids for finisher feeds in control group were 1.64% it was by 0.16% less than in trial group 1.80%.

Well known that the total amino acid amount from feedstuffs cannot be equally absorbed by the animal digestive tract is necessary evaluate composition of amino acids and amount of essential amino acids. In the ideal protein concept, researchers recommend the precise amount of digestible amino acids. In estimation was used InraPorc (Milgen & Dourmad, 2015) ideal protein profile for comparison composition of protein profiles in diets.

Table 4. Comparison of standardized Ileal digestibility protein profiles in diets with ideal protein profiles

Traits	Control group			Trial group			InraPorc[1]
Liveweight, (kg)	20–40	40–65	65–105	20–40	40–65	65–105	20–140
Lysine	100.0	100.0	100.0	100.0	100.0	100.0	100
Threonine	63.1	65.9	67.9	63.3	64.1	65.6	65
Methionine	43.3	46.2	40.0	42.4	43.0	36.0	30
Methionine+Cysteine	75.8	81.4	83.8	73.1	74.7	74.1	60
Tryptophan	23.1	24.2	26.0	23.5	24.0	24.6	18
Valine	78.1	82.3	88.8	77.5	79.3	87.5	70
Isoleucine	68.1	71.3	75.9	65.7	43.0	72.9	55
Leucine	112.9	130.4	143.0	122.2	124.9	137.4	100
Histidine	41.8	43.8	48.4	41.5	42.3	46.3	32
Phenylalanine	85.4	90.3	103.5	85.2	87.2	98.6	50
Phenylalanine +Tyrosine	141.3	148.7	167.6	140.7	143.7	160.7	95
Tyrosine	55.9	58.3	64.1	55.5	56.5	62.1	–
Cysteine	32.5	35.3	43.8	30.7	31.7	38.2	–

InraPorc[1] Ideal protein profile (Milgen & Dourmad 2015).

Results obtained of protein profiles in diets for growing and fattening periods in grower (40–65 kg) feeds showed threonine were less in control and trial groups compared to ideal protein profiles (InraPorc). In other groups threonine was in optimal relation. Threonine is often the second limiting amino acid in conventional commercial diets, and feeding pigs amino acid deficient diets limit protein deposition and affects tissue protein composition. The results of researchers Remus et al. (2019) show than amino acids requirements vary between individual pigs and cannot be accurately estimated based on traditional amino acids:Lysine ratio studies. The results of this trial indicate that pigs have great capacity to deal with excess and limited amino acids resources, by limiting protein deposition and changing amino acids composition differently among body tissues. Under limiting amino acids conditions, pigs modulate to some extent the utilization and retention of the limiting resource in order to maintain its natural functions in a normal manner.

Comparison of standardized Ileal digestibility protein profiles in diets with ideal protein profiles showed in trial group for feed (20–40 kg) Isoleucine was inadequate ratio it was insufficient. Milgen & Dourmad (2015) concluded valine deficiency decreases feed intake to a great extent and consequently gain. The same observation can be made for isoleucine. The content of the other amino acids was higher than that reported by InraPorc ideal protein profile.

All animals were maintained healthy and consumed provided experimental diets well. At the beginning of the investigation, the average pig start liveweight mass did not show any essential differences between groups, respectively in control group was 25.7 ± 0.31 kg and in trial, was 25.5 ± 0.23 kg.

At the age of 140 days the average liveweight of control group pigs was 66.56 ± 2.74 kg in the trial group was 68.88 ± 1.79 kg. Pigs from trial group in average were heavier by 3.5%. At the age of 190 days the average liveweight of control group pigs was 108.33 ± 2.74 kg, but in the trial group was 111.88 ± 1.79 kg. Pigs from trial group were heavier by 3.3%. There were no significant diferences on pigs average liveweight ($P > 0.05$).

Influence of diets on average daily gains showed, at period from 84 to 140 days in the control group was 0.743 ± 0.049 kg in trial group was by 6.0% higher 0.788 ± 0.031 kg average daily gain. The daily gain indices in fattening period from 140 to 190 days in control group was 0.853 ± 0.050 kg in trial group was by 2.9% higher 0.877 ± 0.032 kg. In all period of investigation from 84 to 190 days daily gain in control group was 0.779 ± 0.026 kg in trial group was by 5.5% higher 0.822 ± 0.026 kg.

At the final, the pigs which fed soybean cake grown in Latvia, showed by 3.3% higher live weight than pigs which fed mixed feed with imported soybean meal, there were no significant diferences on pigs average daily gain.

In estimation pigs from trial group consumed feed less by 2.70 kg than pigs in control group. Feed consumption per kg of liveweight gain for control group was 2.39 kg d^{-1} in trial group was by 6% better. Diets showed no significant effect on pig feed consumption and feed conversion rates between groups (Table 5).

Table 5. Influence of diets on feed consumption

Traits	Control group	Trial group
Feeding days	106	106
Feed consuption, (kg)	197.4	194.7
Feed consuption at day,(kg)	1.86	1.84
Feed conversion, (kg d^{-1})	2.39	2.24

The obtained values carcass weight, leght of carcass, muscle–eye area and ham weight (Table 6.) show better results at the trial group significant differences were not found between groups ($P > 0.05$).

Table 6. Influence of diet on pig carcass and meat traits

Traits	Control group	Trial group
Carcass weight, (kg)	78.5 ± 6.09	82.1 ± 6.47
Lenght of carcass, (cm)	103.2 ± 3.63	104.3 ± 4.89
Backfat, (mm)	11.0 ± 3.0	9.6 ± 2.5
Lean meat,(%)	61.60 ± 0.80	62.00 ± 0.72
Muscle-eye area, (cm^2)	62.40 ± 10.05	68.20 ± 14.93
Ham weight, (kg)	8.02 ± 1.23	8.65 ± 0.57
Moisture, (%)	72.50	72.40
Protein, (%)	22.40	22.20
Fat, (%)	4.05	4.65
pH	6.01	5.59
Cholesterol, (%)	50.50	45.90
Tryptophan, (g $100g^{-1}$)	0.282	0.294
Hydroxyproline, (%)	0.11	0.12
Tryptophan : Hydroxyproline ratio	2.56	2.45

According to the classification of pork, all pig carcasses were evaluated by the 'S' class. The meat analyses showed cholesterol countent in trial group was by 5% less than in control group. The others determined meat parameters between the groups were similar. Meat quality was not influenced by diets.

CONCLUSIONS

The results of the study showed that using of soybean cake grown and processed in Latvia can produce equivalent pig feed rations as using of imported soybean meal. Soybean grown in Latvia and processed in soybean cake can use in feed ration for pig during growing and fattening periods. The replacement of imported soybean protein by soybean protein grown in Latvia did not showed any negative impact on pig growth rates, quality of carcasses and meat traits. Economic evaluation is necessary to determine the effectiveness of soy produced in Latvia.

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