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Extrusion Technology of Soybeans and Obtained Product Feeding Effect on Lactating Sows and Their Offsprings Productivity.

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Abstract **- The aim of study was to estimate the processing technology of soybeans produced in Latvia and to compare the possibilities of using the obtained soybean cake with imported soybean meal in the feeding of lactating sows and their offspring. From soybeans, which were processed into animal feed, we obtained a product with a high content of protein. The control group of sows and fattening pigs received the imported soybean meal mixed into the compound feed, but the trial groups compound feed was mixed with soybean cake grown and processed in Latvia. Fattening pigs were weighed regularly. Feed consumption was counted and feed conversion was calculated. Was determined meat quality, carcases weight, carcases length. The chemical composition of the manure was analysed. Statistical analysis of data was performed with SAS / STAT 9.22 software package. The inclusion of soy cakes grown and processed in Latvia in lactating sow feed increased sow milk yields traits by 3.9% at 21 day of piglet age. At the end of experiment higher live weight by 3.42% were found in the trial group. Carcass quality indicators and chemical composition of meat did not show significant differences. Was observed a tendency to decrease in manure the content of organic matter in the trial group by 3.25%, decrease levels of total phosphorus and ammonium nitrogen compared to the control group. Using soybean cakes grown and processed in Latvia is possible to develop feed rations that showed similar pig growth results to imported soybean meal.**

Keywords - extrusion technology, soybean cakes, pig feeding.

I. INTRODUCTION

Soybean cultivation in Latvia is a new industry with many challenges. On 2019 in Latvia were declared 320 ha with soybean sowings. In Latvia soybeans is used for oil production, food and livestock feeding. Soybean meal is one of the most important protein sources in animal nutrition and is widely used in pig feeding. It has high biological value and digestibility, and considerable energy content. Unfortunately, in recent years, soybean meal has become so expensive [1], [2], [3], [4]. In Latvia, opportunities are being sought to grow soybeans and process them into feed to provide pigs with high-quality protein and reduce feed costs.

Even though they are a great source of amino acids the impairment of legumes' nutritional value is attributed in part to the presence of different compounds classically known as toxic and/or antinutritional factors, which act as direct or indirect antagonists of nutrient availability [4], [5]. For soybean seeds, trypsin inhibitor and lectin are considered to be the major proteins responsible for poor nutritional value [6], they cannot be consumed raw. The reason for that is because they also consist of anti-nutritional factors such as trypsin inhibitors, urease and lectins that adversely affect digestive efficiency. To reduce the anti-nutritional factors to minimum levels acceptable to your livestock, poultry, pet food or aqua species, the soybean needs to be processed [7].

Trypsin inhibitors are sensitive to denaturation by heat treatment. The vast majority of soybean products used for livestock feeds are heat-treated in order to eliminate any anti-nutritional effects associated with feeding raw soybeans [8].

Extrusion may be used to increase the nutritional value of feed ingredients or diets fed to pigs [9], [10]. The use of

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a combination of heat, pressure, and moisture that is applied to the feed during extrusion may gelatinize starch and improve apparent ileal digestibility of starch in feed ingredients [11] although duration of the extrusion procedure may influence the degree of gelatinization. Extrusion of cereal grains also increased concentrations of metabolizable energy in corn, and sorghum and extrusion may increase the apparent total tract digestibility of gross energy in high fiber diets [10] indicating that the increase in energy digestibility may be caused not only by increased starch digestibility but also by solubilization of fiber[11].

There are many factors that go into extruding soybeans properly such as using the correct temperature, equipment, resources, etc. With proper extrusion of soybeans, there are multiple additional benefits aside from already reducing anti-nutritional factors such as: reducing bitter flavors, denatures protein, frees the oil by rupturing plant cell walls, deactivating fat enzymes to promote stability/ shelf life [7].

Extrusion is a unique processing operation that uses high temperature and pressure over a short time, in which high shear forces are applied to produce a feed product with distinct physical and chemical characteristics. Extrusion as the most efficient energy intensive feed process gives better cooking effect of the starch and proteins than any other commercial processes. [12].

The aim of study was to estimate the processing technology of soybeans produced in Latvia and to compare the possibilities of using the obtained soybean cake with imported soybean meal in the feeding of lactating sows and their offspring.

II. MATERIALS AND METHODS

The study was conducted on a commercial farm at year 2020. In the extrusion process were include complete all soybean processing steps – separation of soybean husks, separation of oil from full-fat soya, extrusion the core of soybean and, cooling of soybean cakes. Soybeans were processed in the working body of the extruder 25 to 40 seconds the pressure generated heat in the extruder barrel was 130-140°C. Production volume was 500 kg per hour.

The estimations of lactating sows were based on the ethical guidelines. Research was carried out in accordance with the Pig welfare requirements Regulations of the Cabinet of Ministers No. 743 [13]. Were completed 2 groups control group and trial group 18 sows in each. In both groups were included pregnant sows inseminated with the following: 8 sows Yorkshire x Landrace (M1), 2 Yorkshire and 4 Landrace inseminated with a Pietren boar and 4 Landrace sows inseminated with a Yorkshire boar.

In the control groups diet was included imported soybean meal mixed with compound feed, and the experimental group included soybean cakes grown and extruded by the local farm. The other feed additives and feed nutrients were the same. In the experiment were calculated and prepared 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, soybean meal or soybean cakes, salt and trace element vitamin premix, phytase. The compound feeds were fed to the sows in a dry, flowing manner.

The chemical composition of feed was determined with follows methods; protein content was determined (LVS NE ISO 5983-2:2009).Fat content was ISO 6492:1999. Amino acids 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. Ash were determined using ISO 5984: 2002/Cor1: 2005, calcium determined using LVS EN ISO 6869:2002, phosphorus using ISO 6491:1998, crude fibre determined using ISO 5498: 1981, methods [14].

During the study, the live weight of the piglets was regularly monitored by weighing on days 1, 21 and when they were weaned from the sows on the day 28, the dead piglets were counted.

In order to evaluate the impact of imported soybean meal and local soybean cake on the growth and quality indicators of fattening pigs, two groups were completed with 40 animals in each. Piglets were taken from sows in a previous experiment. Pigs were regularly weighed at 28, 66, 115, and at the end of the experiment at 168 days of age, when they reached the realization end weight. Feed consumption was counted and feed conversion was calculated.

Carcasses weight was determined and carcasses length from the anterior tip of the aitch bone to the anterior edge of the first rib and next to the vertebra was measured [15]. The lean meat content in the carcases was detected by the ZP two-point method [16]. For quality testing 24 hours after slaughter meat samples were taken from the *musculus longissimus lumborum et thoracis*. Amino acids in meat samples were determined by ISO 13903: 2005, total protein LVS ISO 937: 1978, total fat content LVS ISO 1443: 1973IC-UV, cholesterol, BIOR-T-012-132-2011, moisture LVS ISO 1442: 1997, pH LVS ISO 2917: 2004, tryptophan (total) EU 152/2009, LC-FLD methods[17].

Manure samples were taken from each group included in the study. The chemical composition of manure was determined by standard methods in the laboratory of SIA "Vides audits"; dry matter LVS EN 13040: 2008, total nitrogen LVS EN 13654-1: 2003 / NAC: 2004, total potassium LVS ISO 11466: 1995, LVS ISO 9964-3: 2000, total phosphorus LVS 398: 2002, environmental reaction, pH (KCl) pH LVS ISO 10390: 2006, organic matter content LVS EN 13039: 2012, ammonium nitrogen LVS ISO 5664: 2004 L / NAC: 2007, pH level LVS EN 13037: 2012 methods.

Statistical analysis of data was performed with SAS / STAT 9.22 software package. Standard errors of the means (SEM) was calculated. The results of the study was compared using a t-test. Statistical significances was assessed at ($P < 0.05$).

III. RESULTS AND DISCUSSION

The geographical area of production of the soybeans might affect the protein quality and nutrient content of the corresponding soybean meal. However, the feed compound industry has paid little attention to the influence of the country of origin of the beans on the chemical composition, amino acid (AA) profile and protein quality of the SBM [18].

Comparing the chemical composition of average indicators of soybeans grown and extruded in Latvia with the research results of Ibáñeza et al., where was included the data obtained from 18 published papers from 2002 to 2018 with a total of 1944 samples in which the chemical composition and protein quality of soybean meal of different origins were compared [18], we found that Latvian soy cakes had lower protein, starch calcium and phosphorus contents, higher content of crude fiber than those presented by Ibáñeza et al (Table 1).

Data from the meta-analysis suggest that the chemical composition, protein quality and nutritive value of the soybean meal depend on the country of origin of the bean. Consequently, different matrices should be used in feed formulation for commercial SBM obtained from beans of different origins [18].

TABLE 1 SOYBEAN CAKE AND SOYBEAN MEAL CHEMICAL ANALISES

Traits	Soybean products		
	Full fat soybean cakes	***Soybean cakes***	***Soybean meal****
Protein, %	36.44	42.94	46.4
Fat, %	19.59	7.02	16.6
Ash, %	6.67	7.12	6.51
Crude fiber, %	5.53	5.43	4.65
Starch, %	2.80	3.27	4.34
Calcium, %	0.21	0.22	0.35
Phosphorus, %	0.53	0.57	0.64

*Ibáñeza et al. 2020. [18]

The energy and nutrient requirements of the lactating sows depends on her weight, milk yield and composition, and to a lesser extent, the environmental conditions under which she is housed. [19]. Lactation is the most demanding stage of the reproductive cycle, and milk production requires significantly more energy, which has a negative effect on the short- and long-term productivity of sows and affects the growth and development of piglets. Lactating sows should be full-fed during lactation to obtain maximum milk production, minimize weight loss and improve rebreeding performance [20]. During our study, the growth rates of suckling piglets were similar in both groups (Table 2), were not observed significant differences ($P > 0.05$).

TABLE 2 PIGLET GROWTH AND RETENTION RATES (MEAN ± SEM)

Traits	Groups	
	Control group	***Trial group***
Birth weight, kg	1.42 ± 0.25	1.38 ± 0.29
Live weight in 28 days, kg	6.99 ± 0.60	7.07 ± 1.15
Live weight gain per day, kg	0.198 ± 0.019	0.203± 0.035
Number of live born piglets per litter	10.70 ±1.13	11.00±1.08
Number of piglets per litter at the age of 28 days	9.40±1.77	9.50±1.42
Retention of piglets at the age of 28 days, %.	87.5	86.4

Between live born piglets per litter, number of piglets per litter at the age of 28 days and retention of piglets at the age of 28 days were no significant differences ($P > 0.05$).

The relative milk yield of sows was determined based on litter weight at 21 days old (Table 3). The milk yield of sows depends on the number of piglets and their individual weight at 21 days old, and is correlated directly with litter weight at birth.

TABLE 3 IMPACT OF MILK YIELDS ON PIGLETS AT 21 DAY (MEAN ± SEM)

Traits	Groups	
	Control group	***Trial group***
Number of piglets in a litter at the age of 21 days.	9.60±1.45	9.70±1.41
Piglet live weight at 21 days of age, kg	5.51±0.59	5.70±1.12
Litter weight of piglets at 21 days of age, kg	53.60±10.96	55.7±13.64

The careful management of sow feeding during lactation can markedly increase feed intake and facilitate greater milk yields.

This represents an opportunity commercially to maximize the weaning weights of all piglets, including low birth weight piglets. Furthermore, improved sow lactation nutrition can significantly reduce pre weaning mortality of low birth weight animals. This, in turn, will greatly increase the number of animals weaned, improving output and profitability at farm level [21]. Therefore, by weighing all litters at 21 days of age, sows' milk can be monitored. The inclusion of soy cakes grown and processed in Latvia in lactating sow feed increased sows milk yield traits by 3.9% at 21 day of piglet age. There were no significant differences between groups. That indicated that the sows were fed with similar nutrients, soybean cakes and soybean

meal were equally absorbed in the digestive tract of both groups of sows. Were provided all the nutrients and produced similar amounts of milk. Local soybean cakes and imported soybean had a similar feeding efficiency to suckling piglets.

Feed effects on fattening pig growth traits and carcasses performance was made in this study. The study lasted 140 days from weaning of piglets at 28 days of age until the end of the fattening period. Live weight rates for pigs in both groups at 28, 66, and 115 days of age were similar (Table 4).

TABLE 4 PIGS LIVE WEIGHTS AND LIVE WEIGHT GAINS (MEAN ± SEM)

Traits	Groups	
	Control group	***Trial group***
Live weight at the age of 28 days, kg	9.50±0.14	9.10±0.15
Live weight at the age of 66 days, kg	27.05±0.57	27.58±0.55
Live weight at the age of 115 days,kg	64.46±1.15	64.94±1.25
Live weight at the age of 168 days, kg	100.95±1.95	104.40±2.33
Live weight gain per day for the period from 28 to 66 days of age, kg	0.48±0.02	0.47±0.02
Live weight gain per day for the period from 66 to 115 days of age, kg	0.76±0.03	0.76±0.03
Live weight gain per day for the period from 115 to 168 days of age, kg	0.69±0.04	0.70±0.04
Live weight gain per day for the period from 28 to 168 days of age, kg	0.66±0.04	0.68±0.02
Live weight gain, kg	92.28±2.36	94.92±2.02

The final weight of pigs at the trial group was 104.4 kg, which was 3.4% higher than the control group pigs but it is not significant difference (P > 0.05) between live weights in pigs groups.

Live weight gain per day for the period from 28 to 66 days, 67 to 115 days, and 116 to 168 days were similar between groups and showed no significant differences (P > 0.05) Throughout the fattening period from the age of 28 days until the end of the fattening period at the age of 168 days, was found 3.42% higher live weight of the pigs in the trial group. No significant differences (P > 0.05) were found between live weight gains in pigs groups.

The feed consumption of fattening pigs, which were fed with soy cakes bred and processed in Latvia, was 3.48% lower compared to the control group (Table 5). On average, one animal from the trial group consumed 70 grams less feed per day than the control group of pigs.

TABLE 5 FEED CONSUMPTION AND CONVERSION

Traits	Groups	
	Control group	***Trial group***
Feed consumption per animal, kg	314.9	304.3
Feed consumption per day, kg	2.24	2.17
Feed conversion kg, kg	3.41	3.21

Accordingly, feed conversion, feed consumed per kg of live weight gain in the trial group was by 200 grams or 5.87% better than in the control group of pigs.

The carcass weight of the trial group pigs was on average 2.57 kg or 3.3% higher than the control group pigs (Table 6). The lean meat content and carcases length were similar between the groups. Carcases quality indicators did not show significant differences (P > 0.05) between the groups of imported and locally produced soy products.

When evaluating the results of chemical analyzes of muscle tissue, the observed amino acid content was similar, significant differences were not observed between the groups. Content of all determined amino acids was slightly higher in the samples of the trial group. The amount of intramuscular fat in the muscle tissue of the trial group of pigs was 4.15%, which was 2.6% lower than in the muscle tissue of the control group of pigs. The cholesterol content in the muscle tissue of the experimental group pigs was 16.9% lower. The pH of the muscle tissue was similar.

Feeding fattening pigs, with feed were included soybeans cakes grown and processed in Latvia, was observed a tendency to decrease the organic matter content in the trial group by 3.25%, (Table 7) as well as lower levels of total phosphorus, ammonium nitrogen (N / NH4) in manure compared to the control group.

TABLE 6 PIGS CARCASES TRAITS AND CHEMICAL COMPOSITION OF MEAT (MEAN ± SEM)

Traits	Groups	
	Control group	***Trial group***
Carcass weight, kg	74.57±1.56	77.14±1.85
Lean meat content,%	61.30±0.18	60.82±0.19
Carcass length from the first rib, cm	80.50±0.74	80.80±0.85
Hydroxyproline <0.05 (LOQ) g 100 g^{-1};	<0.05	<0.05
Alanine, g 100 g^{-1}	1.26	1.30
Arginine, g 100 g^{-1}	1.38	1.43
Aspartic acid, g 100 g^{-1}	2.06	2.11
Cysteine + Cystine, g 100 g^{-1}	0.23	0.24
Phenylalanine, g 100 g^{-1}	0.94	0.95
Glycine, g 100 g^{-1}	0.98	1.09

Traits	Groups	
	Control group	***Trial group***
Glutamic acid, g 100 g^{-1}	3.23	3.35
Histidine, g 100 g^{-1}	0.92	0.94
Isoleucine, g 100 g^{-1}	0.99	1.02
Leucine, g 100 g^{-1}	1.80	1.85
Lysine, g 100 g^{-1}	1.94	1.99
Methionine, g 100 g^{-1}	0.57	0.57
Proline, g 100 g^{-1}	0.81	0.89
Serine, g 100 g^{-1}	0.88	0.90
Threonine, g 100 g^{-1}	1.01	1.02
Valine, g 100g^{-1}	1.06	1.07
Cholesterol, mg 100g^{-1}	81.50	67.75
Total fat content,%	6.75	4.15
Humidity,%	71.10	72.55
Protein, %	21.30	21.95
pH	5.47	5.44
Tryptophan, g 100 g^{-1}	0.29	0.29
Ornithine <0.01 (LOQ) g 100 g^{-1}	<0.01	<0.01
Hydroxyproline <0.05 (LOQ) g 100 g^{-1};	<0.05	<0.05

TABLE 7 CHEMICAL COMPOSITION OF MANURE

Traits	Groups	
	Control group	***Trial group***
Dry matter, %	22.95	24.45
Total nitrogen, (N)%	0.90	0.99
Total potassium, (K2O)%	0.26	0.27
Total phosphorus, (P2O5)%	0.75	0.67
Environmental reaction pH, (KCl) pH unit.	6.86	6.55
Organic matter content,%	19.36	16.16
Ammonium nitrogen, N / NH4%	0.18	0.17
Environmental reaction pH, (H2O) pH unit.	6.75	6.52

By feeding local soy cakes to fattening pigs was possible to reduce environmental pollution.

IV. CONCLUSIONS

The inclusion of soybean cakes grown and processed in Latvia in lactating sow diet increased sow milk yields traits by 3.9% at 21 day of piglet age, piglet weaning weights at age of 28 days were similar between groups, retention of piglets was 1.1% lower. Local soybean cake using in the diet of lactating sows showed insignificant differences on the growth rates of piglets compared with imported soybean meal diets.

Live weights and live weight gain of weaned piglets and fattening pigs showed similar rates between groups. Pigs fed soybean cakes grown and processed in Latvia found a 3.48% lower feed consumption and feed conversion was 5.87% better. The carcass weight of the trial group was on average 3.3% higher. Carcass quality indicators did not show significant differences between groups. The amino acid content of muscle tissue was similar. The muscle cholesterol content of the pigs of the trial group was 16.9% lower. Feeding local soybean cakes to fattening pigs reduce environmental pollution by organic matter, total phosphorus and ammonium nitrogen.

Using soy cakes grown and processed in Latvia, it was possible to develop feed rations for lactating sows and fattening pigs, which showed similar results for the use of imported soybean

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