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The nutrition value of soybeans grown in Latvia for pig feeding

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Abstract. Soybean products are excellent sources of protein for pigs because their amino acid profiles complement those of cereal grains. Soy protein is rich in the limiting amino acids lysine, threonine, and tryptophan that are present in relatively low concentrations in the most commonly fed cereal grains. Amino acids in soy protein are more digestible than amino acids in most other plants proteins, which results in less nitrogen being excreted in the manure from pigs fed diets containing soybean meal than if other protein sources are used. The phosphorus in soy products is bound to phytic acid, which has a low digestibility to pigs, but the digestibility of phosphorus in soy products may be increased to more than 60% if diets are supplemented with microbial phytase. There are no much results about nutrition value of soybean growing in Latvia. Therefore the aim of study was determined chemical composition of soybeans growing in Latvia and evaluates their potential in pig feeding.
Research object were soybeans growing in Latvia. In the studied samples content of protein, fat, ash, fibre, composition of amino acids were determined and metabolizable energy were calculated. Evaluated that protein content varied from 32.7 till 40.7%, fat content was from 18.4–21.4% and significantly differed ($p < 0.05$) among growing places, but the sum of essential amino acids in the soy beans determined 115–125 g kg^{-1}, and were not differed significantly by varieties. The content of lysine in protein were determined 5.1–5.5 g 100 g^{-1}. Concluded that soy bean growing in Latvia provides equilibrium high metabolizable energy for pigs – from 13.2 to 17.6 MJ kg^{-1} and could be used in feed.

Key words: feed, amino acids, extruded soy bean.

INTRODUCTION

Soybeans are one of the most important protein sources in animal nutrition and are widely used in pig feeding. In the EU this crop is produced mainly in Italy (33%), Romania (18%), Croatia (14%), Austria, Hungary and France (all 9%) (EIP-AGRI report, 2014).

Several factors influence the chemical composition including concentration of amino acids present in soybeans, such as climatic changes, genetics, topography, and soil fertility (Wolf et.al., 1982; Grieshop & Fahey, 2001; Grieshop et al., 2003; Carrera et al., 2011). Park & Hurburgh (2002) found that soybean meal samples from the European Union and United States had the greatest content of protein and the least amount of fiber compared with soybean meal from India, Brazil, Argentina, and China.

In the other research (Wang et al., 2011), the chemical analysis values showed that soybean meal from the United States had greater content of protein solubility and reduced concentration of crude fiber and ether extract compared with those from Brazil or India. Westgate et al. (2000) demonstrated that high environmental temperatures favor protein synthesisin the soybeans in detriment of oil production. Maximum oil accumulation in the soybeans occurs at 25–28 °C, according to experiments carried out by Piper & Boote (1999).

Soybeans are the gold standard of high quality protein for pigs because their amino acid profile complements the amino acid profiles of several cereal grains and have highest digestibility comparing with other proteins herbal origin (Stein et al., 2013). In particular, soybean protein is rich in lysine, threonine, and tryptophan. These are the most limiting amino acids in corn, wheat and barley. Despite the low levels of sulfur amino acids, soybean is the main source of lysine in swine diets (Goldflus, 2006), and could be complemented by barley or wheat in diet formulation. It is now well known that crude protein or the total amino acid amount from feedstuffs cannot be equally absorbed by the animal's digestive tract therefore it 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. 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; Cervantes-Pahm & Stein 2010). Standardized ileal digestibility of amino acids (NRC, 2012) are: lysine is near 90%, methionine 90%, threonine 85% and tryphtofane 90%, but in canola and sunflower meal amino acids digestibility are lower, 73–80%.

Productivity and rentability of livestock sector is strongly depending from availability and costs of feed, therefore in Latvia, same as in Baltic states and EU the role of local protein sources increasing. Some of farmers have started to grow soya beans to reduce imported feed and be safe about origin in last years but there are no much results about nutrition value of soybean growing in Latvia. Therefore the aim of study was determined chemical composition of soybean growing in Latvia and evaluate their potential in pig feeding.

MATERIALS AND METHODS

Experimental design. The research was conducted at the different places of Latvia – at Stende, Vilani and farms Rubuli, Jaunkalejini. Climatic conditions in 2018 determined untipically high temperature and low precipitation amount – sum of effective temperatures (> +10 °C) were calculate 2015 °C at Stende and 2019 °C at Vilani. It is necessary 350–500 mm precipitation for optimal soya development especially at germinating and leg formation period. In the mentioned period dripping 150 and 190 mm in Stende and Vilani, respectively.

The material consisted of soya varieties with early ripening ability (group 000) suitable for regions with lower (1,500–1,800 °C) sum of effective temperatures – 'Abelina', 'Lajma', 'Laulema', 'Maja', 'Viola', 'Merlins', 'Mavka', 'Violetta', 'Madlena', 'Alexa', 'Tiguan', 'Paradis', 'Touttis'. The field treatments were laid out in a randomized complete block design (the plot size 10 m^2, four replicates) in Stende and Vilani, but in farms samples were taken from different places of 2 ha field. Mean samples from all (4) replications (0.5 kg) were taken for laboratory testing.

Chemical analyses

Protein content was determined as total nitrogen content by Kjeldahl method and using coefficient 6.25 for calculation (LVS NE ISO 5983-2:2009).Fat content was determined by Soxlet method ISO 6492:1999.

Amino acids. Dried, defatted soya bean samples were hydrolysed with 6N HCl in sealed glass tubes at 110 °C for 23 h. 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. For statistical analysis purposes, essential amino acids (EAA) were considered the sum of arginine, phenylalanine, histidine, isoleucine, leucine, lysine, methionine, threonine, valine and tryptophan.

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, ADF using LVS EN ISO 13906:2008, NDF using LVS EN ISO 16472:2006 methods. Metabolizable energy was calculated (Morgan et al., 1975).The obtained results were statistically processed using methods of descriptive statistics. Most data was reported as aritmetic means with the pooled SEM. Statistical significance was considered at probability $p < 0.05$.

RESULTS AND DISCUSSION

The results of chemical composition of soybeans grown in different regions of Latvia are assumed in Table 1.

Table 1. Chemical composition of soybeans grown in different fields

	n	Crudeprotein, %	Fat, %	Fibre, %	Ash, %	P, %	Ca, %
Stende C	22	32.7 ± 2.44	21.4 ± 1.45	11.8 ± 0.73	6.74 ± 0.28	0.58 ± 0.05	0.23 ± 0.02
Stende B	13	32.8 ± 2.90	20.9 ± 1.80	11.2 ± 0.73	6.70 ± 0.40	0.29 ± 0.05	0.29 ± 0.03
Rubuli C	4	40.7* ± 3.02	19.3 ± 2.04	11.5 ± 0.10	5.96 ± 0.08	0.49 ± 0.01	0.24 ± 0.02
Vilani C	14	35.7 ± 2.97	20.0 ± 1.21	11.5 ± 0.82	6.03 ± 0.50	0.42 ± 0.04	0.25 ± 0.02
Jaunkalejini	3	35.0 ± 1.70	18.4* ± 2.04	9.6 ± 1.10	6.14 ± 0.11	0.59 ± 0.03	0.21 ± 0.02

*$p < 0.05$.

The results assumed in Table 1. 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} Preliminary results in Stende in 2015 showed similar composition of soya been seeds. Results showed that protein content in soy samples were determined from 35.9% to 40.9%, fat 16.6–19.3%, fibre 10.3–11.3% and ash 4.25–5.55% (Report, 2015). Must be concluded that as a result of weather conditions was higher content of ash (5.96–6.74%) and fiber (9.06–11.8%) in soya samples of year 2018 in comparison with results obtained in 2015 at Stende.

Pork producers often used unprocessed soy flour and data obtained from other investigations show that average crude protein in soy flour varied from 36–38% and fat content varied from 19 to 20% (Stein et al., 2013) similar results are obtained in Latvia in 2018.

The raw soybeans contains anti-nutrients, including phytic acid (from phytates), which binds and prevents mineral absorption, especially zinc, calcium, and magnesium (Humer et al., 2015).

The soybeans for pig feeding must be processed with aim avoid of anti-nutrients. Contents of secondary plant metabolites and α-galactosides may be reduced or eliminated by different processing methods, such as physical treatments (e.g. dehulling, soaking), heat treatments (e.g. extrusion, cooking) or biological methods (e.g. germination, enzyme supplementation). According to some studies (Stein & Bohlke, 2007) processing of soybeans and other grain legumes has been proven to efficiently improve starch and protein digestibility in pigs, which can be attributed, at least in part, to a reduction of secondary plant metabolites.

Composition of extruded fullfat soybean and low fat soybean samples prepared in this investigation showed in Table 2.

Table 2. Chemical composition of extruded soybeen samples

	Crude protein, %	Fat, %	Ash, %	Fibre, %	ADF, %	NDF, %	P, %	Ca, %
Full-fat soybean	37.02	21.13	6.78	5.46	9.84	10.23	0.49	0.38
Low fat soybean	43.36	6.71	7.81	5.75	8.07	12.00	0.56	0.39

Crude protein content in the extruded full fat soybean samples in this investigation were determined 37.02%, but in the extruded low fat soy samples 43.36%. The imported soybean meal in Latvia contains the 43.2% till 50.5% of crude protein (Latvian Feed tables, 2013) and depends on the country from which the feed is purchased. Results of other investigations showed the average crude protein on a dry matter basis, in soybean meal from China, the US, Brazil and Argentina was 50.2%, 49.4%, 51.1% and 48.8%, respectively. The chemical composition of the soybean meal sources was variable. The coefficient of variation of ether extract, crude fat, calcium and oligosaccharides was > 10% (Zhongchao et al., 2015).

Crude protein content is not the main indicator of quality of feed, more importantly is composition of amino acids. The analyzed levels of essential amino acids were not always directly related to the protein concentrations of the samples (Goldflus, 2006). Average daily mean air temperature and cumulative solar radiation during seed filling, precipitation minus potential evapotranspiration during the whole reproductive period, as well as combinations of these climatic variables, are significant explanatory variables for all amino acids. Each amino acid behaves differently according to environmental conditions, indicating compensatory effects among them (Carrera et al., 2011).

In the investigation determined composition of amino acids in soy samples obtained in Latvia in 2018 is showed in Table 3.

Amount of essential amino acids was determined 115–125 mg kg^{-1}.The ratio of essential amino acids to all was calculated 0.62–0.64 and it is higher than determined in faba beans and peas grown in Latvia.

The 10 essential amino acids that must be provided in pig diets are: lysine, threonine, tryptophan, methionine (and cystine), isoleucine, histidine, valine, arginine, and phenylalanine (and tyrosine). Most cereal grains are limiting in lysine, tryptophan, and threonine. Therefore, when evaluating feed ingredients, these amino acids, especially lysine, are most important in determining protein quality. Lysine the first limiting amino acid in typical pig diets. Lysine is a substrate for generating body proteins, peptides, and non-peptide molecules, while excess lysine is catabolized as an energy source. Lysine can also affect the metabolism of other nutrients. Total amount of lysine in soya bean samples was determined 12.4–17.8 mg kg^{-1}.

Table 3. Composition of amino acids in soybean samples

Amino acids	Amount, mg kg^{-1}	Average, mg kg^{-1}	Amino acids	Amount, mg kg^{-1}	Average, mg kg^{-1}
Aspargic acid	22.1–33.2	28.01 ± 3.49	Valine	8.8.–12.3	11.46 ± 1.54
Serine	9.6–14.9	12.19 ± 1.57	Methionine	**2.7–3.9**	**3.29** ± 0.40
Glutamic acid	35.8–54.0	44.32 ± 5.73	Isoleucine	8.6–13.6	11.10 ± 1.52
Proline	9.71–15.7	12.19 ± 1.60	Leucine	15.2–22.5	19.1 ± 2.43
Glycine	8.6–12.6	10.44 ± 1.30	Tyrosine	6.1–11.0	8.71 ± 1.47
Alanine	9.1–12.6	10.52 ± 1.28	Phenylalanine	9.7–14.9	12.53 ± 1.73
Histidine	5.07–6.83	15.97 ± 0.70	Lysine	**12.4–17.8**	**15.2** ± 1.77
Arginine	14.3–20.9	17.61 ± 2.10	Threonines	8.1–11.2	9.96 ± 1.17
Cysteine	2.9–4.0	3.63 ± 0.46	Triptophane	2.8–3.6	3.3 ± 0.36

More often for feed quality characterization is calculated content of amino acid in protein, in this investigation content of lysine in proteine was 5.1–5.5%. Average content of lysine in soybean meal reported 6.0 g per 16g N (Hawhorne, 2006).

Soybeans importance as arginine source should not be disregarded, since arginine is a conditionally functional essential amino acid, amount of arginine in this investigation was determined 14.3–20.9 mg kg^{-1}

Formulators have already taken the opportunity to reduce CP content in European pig rations, going for a more concentrated formula through protein reduction and lysine incorporation. For example, between 2008 and 2013, the average lysine/CP percentage in piglet feeds went from 6.5 percent to 6.73 percent. Formulator's responsiveness to those new practices varies between EU countries.

Comparison of extruded full-fat soybean and low-fat soybean with data of USDA database is showed in Fig. 1.

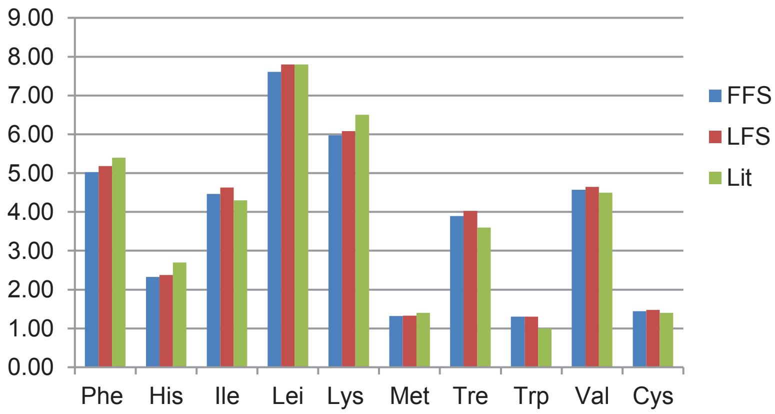

Figure 1. Content of essential amino acid in protein (g per100 g), comparison of extruded full-fatsoybean (FFS) and low-fat soybean (LFS) grown in Latvia and data of USDA (Lit).

Content of essential amino acid in protein showed no significant difference in the extruded soybean grown and processed in Latvia compared to literature date. Content of isoleucine, threonine and tryptophan were determined higher than listed in database USDA. Moreover threonine and tryptophan along with methionine, cysteine and lysine are Critical Amino acids in pig feeding, Evaluation of first year data showed that in Latvia is possible to grow soybeans and produce an equivalent soybean meal according to the average values of the amino acid in the world.

CONCLUSIONS

Concluded that soy beans growing in Latvia provides equilibrium high metabolizable energy for pigs – from 13.2 to 17.6 MJ kg^{-1} and could be used in feed. Protein content in soybean samples determined from 32.7 to 40.7% and significantly differed ($p < 0.05$) among growing places The ratio of essential amino acids to all was calculated 0.62–0.64 and it is higher than determined in faba beans and peas grown in Latvia. Content of lysine in protein was calculated 5.1–5.5% and it is high. Considering that these are one year results investigations must be continued.

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